



JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS K 6410-2 : 2011

(JRMA/JSA)

**Elastomeric seismic-protection
isolators for buildings—
Part 2: Test methods**

ICS 83.140.99;91.120.25

Reference number : JIS K 6410-2 : 2011 (E)

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Date of Establishment: 2011-08-22

Date of Public Notice in Official Gazette: 2011-08-22

Investigated by: Japanese Industrial Standards Committee
Standards Board

Technical Committee on Chemical Products

JIS K 6410-2:2011, First English edition published in 2013-07

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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Printed in Japan

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal for establishment of Japanese Industrial Standard submitted by The Japan Rubber Manufacturers Association (JRMA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

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Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public or utility model right. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public or the utility model right.

JIS K 6410 series consists of the following 2 parts under the general title “*Elastomeric seismic-protection isolators for buildings*”:

Part 1: Specifications

Part 2: Test methods

Elastomeric seismic-protection isolators for buildings—Part 2: Test methods

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **ISO 22762-1** published in 2010 with some modifications of the technical contents.

The portions given continuous sidelines or dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with the explanations is given in Annex JC.

1 Scope

This Standard specifies the test methods for elastomeric seismic isolators used to provide buildings with protection from earthquake damage.

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 22762-1:2010 *Elastomeric seismic-protection isolators—Part 1: Test methods* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are **IDT** (identical), **MOD** (modified), and **NEQ** (not equivalent) according to **ISO/IEC Guide 21-1**.

Warning: Persons using this Standard should be familiar with normal procedures related to testing of elastomeric isolators and rubber materials. This Standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 7502 *Micrometer callipers*

JIS B 7507 *Vernier, dial and digital callipers*

JIS B 7512 *Steel tape measures*

JIS B 7516 *Metal rules*

JIS B 7517 *Vernier, dial and digital height gauges*

JIS B 7526 *Squares*

JIS B 7721 *Tension/compression testing machines—Verification and calibration of the force-measuring system*

NOTE : Corresponding International Standard: ISO 7500-1 *Metallic materials—Verification of static uniaxial testing machines—Part 1: Tension/compression testing machines—Verification and calibration of the force-measuring system* (MOD)

JIS K 6200 *Rubber—Vocabulary*

JIS K 6250 *Rubber—General procedures for preparing and conditioning test pieces for physical test methods*

NOTE : Corresponding International Standard: ISO 23529 *Rubber—General procedures for preparing and conditioning test pieces for physical test methods* (MOD)

JIS K 6251 *Rubber, vulcanized or thermoplastics—Determination of tensile stress-strain properties*

NOTE : Corresponding International Standard: ISO 37 *Rubber, vulcanized or thermoplastic—Determination of tensile stress-strain properties* (MOD)

JIS K 6253 *Rubber, vulcanized or thermoplastic—Determination of hardness*

NOTE : Corresponding International Standard: ISO 48 *Rubber, vulcanized or thermoplastic—Determination of hardness (hardness between 10 IRHD and 100 IRHD)* (MOD)

JIS K 6256-2 *Rubber, vulcanized or thermoplastic—Determination of adhesion test—Part 2: Adhesion to a rigid substrate—90 degree SIGN peel method*

NOTE : Corresponding International Standard: ISO 813 *Rubber, vulcanized or thermoplastic—Determination of adhesion to a rigid substrate—90 degree peel method* (MOD)

JIS K 6257 *Rubber, vulcanized or thermoplastic—Determination of heat ageing properties*

NOTE : Corresponding International Standard: ISO 188 *Rubber, vulcanized or thermoplastic—Accelerated ageing and heat resistance tests* (MOD)

JIS K 6259 *Rubber, vulcanized or thermoplastics—Determination of ozone resistance*

NOTE : Corresponding International Standard: ISO 1431-1 *Rubber, vulcanized or thermoplastic—Resistance to ozone cracking—Part 1: Static and dynamic strain testing* (MOD)

JIS K 6261 *Rubber, vulcanized or thermoplastic—Determination of low temperature properties*

NOTE : Corresponding International Standard: ISO 812 *Rubber, vulcanized or thermoplastic—Determination of low-temperature brittleness* (MOD)

JIS K 6394 *Rubber, vulcanized or thermoplastic—Determination of dynamic properties—General guidance*

NOTE : Corresponding International Standard: ISO 4664-1 *Rubber, vulcanized or thermoplastic—Determination of dynamic properties—Part 1: General guidance* (MOD)

JIS K 6410-1 *Elastomeric seismic-protection isolators for buildings—Part 1: Specifications*

NOTE : Corresponding International Standard: ISO 22762-3 *Elastomeric seismic-protection isolators—Part 3: Applications for buildings—Specifications* (MOD)

JIS Z 8401 *Guide to the rounding of numbers*

ISO 11346 *Rubber, vulcanized or thermoplastic—Estimation of life-time and maximum temperature of use*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS K 6200** and **JIS K 6410-1** and the following apply.

3.1 compressive-shear testing machine

machine used to test elastomeric isolators, which has the capability of shear loading (shear deformation) under constant compressive load

3.2 shear-block test piece

specimen for shear test with rubber adhered between the layers of metallic plates

4 Symbols

For the purpose of this Standard, the symbols given in **JIS K 6410-1** and table 1 below apply.

Table 1 Symbols

Symbol	Unit	Description
T	°C or K	temperature
α	—	coefficient of linear thermal expansion
ε_{cr}	—	creep strain

5 Rubber material tests

5.1 General

The rubber material tests shall be performed using test pieces made of unvulcanized rubber of the same composition as the material of the product elastomeric isolator according to the method specified by the manufacturer, in order to determine physical properties and adhesion properties between rubber and steel plates.

5.2 Test conditions and test pieces

The test conditions and test pieces of rubber material test that are not specified in this Standard shall be in accordance with **JIS K 6250**.

5.3 Tensile properties test

The tensile properties test shall be performed in accordance with **JIS K 6251**. The test pieces used shall be No. 3 dumbbell shape test pieces.

5.4 Heat ageing properties test

The heat aging properties test shall be performed on inner rubbers and cover rubber in accordance with method A in 4.3 of **JIS K 6257**, and their tensile strength and elongation at break shall be measured according to **JIS K 6251**.

The heat aging test conditions shall be as follows.

- a) For rubber materials mainly composed of natural rubber:
70 °C × 168 h
- b) For rubber materials mainly composed of that other than natural rubber:
100 °C × 72 h

5.5 Hardness test

The hardness test shall be performed in accordance with **JIS K 6253**.

5.6 Adhesion properties test

The adhesion properties test shall be performed in accordance with **JIS K 6256-2**.

5.7 Brittleness point test

The brittleness point test shall be performed in accordance with clause 5 of **JIS K 6261**.

5.8 Ozone resistance test

The ozone resistance test shall be performed in accordance with **JIS K 6259**.

The ozone concentration, elongation of test piece, test temperature and test duration shall be as follows.

- Ozone concentration: 50 mPa (50 pphm)
- Elongation of test piece: elongation of 20 %
- Test temperature: 40 °C
- Duration: 96 h

6 Elastomeric isolator tests

6.1 Test pieces

6.1.1 Types of test pieces

The test pieces shall be as specified in table 2. Since the performance of elastomeric isolators is dependent on its shape and dimensions, full-scale isolators should be used as test pieces for the tests. Where this is difficult due to factors such as the number of required test pieces and capacity of the testing machine, scaled-model isolators may be used. When using a scaled-model isolator for tensile test, the flange shape shall be determined based on the out-of-plane deformation of the flange so that the properties of the full-scale isolator can be estimated. When using a scaled-model isolator in creep test, the test piece used may be equivalent in first shape factor and not equivalent in second shape factor. In the test of temperature dependency of shear properties, where the properties are only dependent on rubber materials, the shear-block test piece (SBS) specified in Annex JB may be used.

When the properties of isolators are dependent on the deformation hysteresis, a large shear deformation may be previously given to the test piece in order to stabilize the properties. This shear deformation is referred to as pre-deformation. In the case of products that are delivered after being pre-deformed, test piece for the type test shall receive the same pre-deformation as the actual products.

The results in the type test that have already been obtained may be used if all of the following conditions are met.

- a) Test piece is manufactured using the same rubber material and the same method as the already tested test piece.
- b) The outer diameter of the test piece is within $\pm 10\%$ of the relevant diameter of the already tested test piece.
- c) The inner diameter of the test piece is not less than -30% but not greater than $+10\%$ of the relevant diameter of the already tested test piece.
- d) The first shape factor of test pieces is not less than -20% but not greater than $+30\%$.
- e) The second shape factor of the test piece is less than 5.0 and within $\pm 10\%$ of that of the already tested test piece, or second shape factor of the test piece is 5.0 or greater and -10% or greater of that of the already tested test piece.

In the test of compressive stress dependency of shear properties and the ultimate properties test, in addition to the above conditions in **a)** to **e)**, the following conditions **f)** and **g)** shall also be met.

- f) For the test of compressive stress dependency of shear properties (see **6.3.2**), the values of both S_1 and S_2 of the test piece are greater than those of the already tested test piece.
- g) For the ultimate properties test (see **6.4**), the value of σ_{nom} of the test piece is smaller than that of the already tested test piece, and values of both S_1 and S_2 are greater than those of the already tested test piece.

6.1.2 Number of test pieces

The number of test pieces used for compressive properties and shear properties tests shall be two, and for the shear strain dependency and compressive stress dependency tests among various dependencies of shear properties shall be two, and for other properties tests, one.

NOTE : When the same test pieces are used for each of the tests, attention should be paid to the effect of repetition hysteresis.

Table 2 Test pieces of elastomeric isolators

Property	Test items	Test piece
Compressive properties	Compressive stiffness	Full-scale isolator
Shear properties	Shear stiffness Equivalent damping ratio	Full-scale isolator
Tensile properties	Tensile stress at yield	Full-scale isolator or scaled-model isolator B
Dependency of shear properties	Shear strain dependency	Full-scale isolator or scaled-model isolator C
	Compressive stress dependency	Full-scale isolator or scaled-model isolator C
	Frequency dependency	Scaled-model isolator A
	Repeated loading dependency	Full-scale isolator or scaled-model isolator B
	Temperature dependency	Scaled-model isolator A or SBS
Ultimate properties	Ultimate shear strain	Full-scale isolator or scaled-model isolator B
	Ultimate compressive strain	Full-scale isolator or scaled-model isolator B
Durability	Heat aging property	Scaled-model isolator A
	Creep	Scaled-model isolator A
Scaled-model isolator A: for those with circular cross-section, the diameter shall be 150 mm or over; for those with square cross-section, a side length shall be 100 mm or over; for both cases, thickness of a rubber layer shall be 1.0 mm or over; for those with outside diameter 250 mm or under, material other than the steel material specified in 6.2 of JIS K 6410-1 may be used. Scaled-model isolator B: for those with circular cross-section, the diameter shall be 450 mm or over, and the reduction rate shall be 1/2 or over. for those with square cross-section, a side length shall be 400 mm or over, and the reduction rate shall be 1/2 or over; for both cases, thickness of a rubber layer shall be 2.5 mm or over. Scaled-model isolator C: for those with circular cross-section, the diameter shall be 800 mm or over, and the reduction rate shall be 1/2 or over; for those with square cross-section, a side length shall be 750 mm or over, and the reduction rate shall be 1/2 or over; for both cases, the thickness of a rubber layer shall be 4.4 mm or over. SBS: the shear-block test pieces specified in Annex JB, applicable to NRB or HDR. Thickness of reinforcing steel plates of scaled-model isolator: where the specified reduction rate is difficult to be met, the reduction rate may be determined based on consideration of the effect on the properties.		

6.2 Compressive properties and shear properties tests

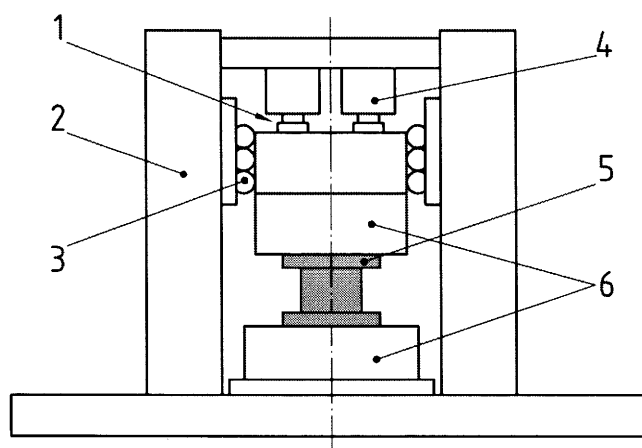
6.2.1 Compressive properties test

6.2.1.1 Principle

The compressive force is applied to a test piece, and the compressive stiffness of the elastomeric isolator is determined from the compressive force-vertical displacement relation.

6.2.1.2 Test machine

The test machine, shown schematically in figure 1, shall be capable of compressing the elastomeric isolator under controlled conditions. The machine shall maintain the parallelism of the upper and lower loading platens for the test piece attachment during the test. A Class 1 machine, as defined in clause 7 of **JIS B 7721**, is recommended. It shall also provide a method of measuring the compressive force and compressive displacement to an accuracy of less than or equal to 1 % of the maximum values recorded. The force calibration shall be based on clause 6 of **JIS B 7721**.



- 1 load cell (compression force)
- 2 frame
- 3 bearing
- 4 actuator
- 5 test piece
- 6 upper and lower loading platens

Figure 1 Example of compression testing machine

6.2.1.3 Test piece

Test piece to be used shall be as specified in table 2.

6.2.1.4 Test conditions

6.2.1.4.1 Test temperature

The temperature of the laboratory should preferably be in accordance with **6.1** of **JIS K 6250**. When this is difficult and the test is conducted at another temperature, the test temperature shall be measured and recorded.

6.2.1.4.2 Conditioning time for test piece

Test pieces with height 250 mm or under shall be left for at least 30 h after vulcanization. Thicker isolators shall be left for at least 54 h. Before a test, the test piece shall be left for 6 h or longer in the test environment, and the surface temperature of the laminated rubber portion of the test piece shall be recorded.

6.2.1.4.3 Compressive force

The compressive force used for the test shall be a force equivalent to nominal compressive stress σ_{nom} . Tolerance on the compressive force shall be $\pm 5\%$.

6.2.1.4.4 Input wave

The input wave shall be a sine wave or a triangular wave.

6.2.1.4.5 Vibration frequency

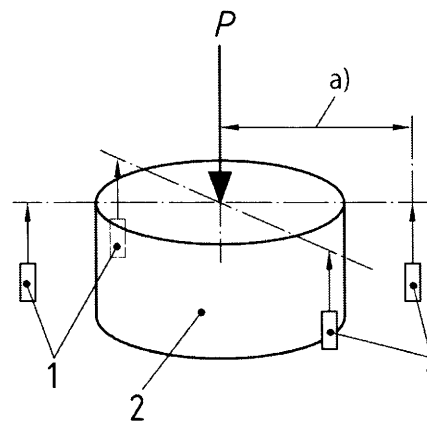
The vibration frequency shall be not less than 0.001 Hz.

6.2.1.5 Procedure

6.2.1.5.1 Attachment of test piece and compressive displacement gauges

The test piece shall be attached to a testing machine by the same or a mechanically equivalent manner as in the actual application. Compressive displacement gauges shall be attached to the periphery of the test piece. The compressive force at this time shall be zero, and the value of compressive displacement shall be zero. If it is difficult to set a stable zero pressure because of machine controllability, the compressive force at which the compressive stress is 0.5 N/mm^2 or under may be regarded as “zero”, and the compressive displacement at this time shall be zero.

For precise measurement of the displacement of the isolator, place two or more displacement gauges so that they are at an equal distance from the centre of the isolator attached to the testing machine (see figure 2). The average of these displacement gauges shall be taken as the measured displacement.



- P compressive force
1 displacement gauge
2 test piece

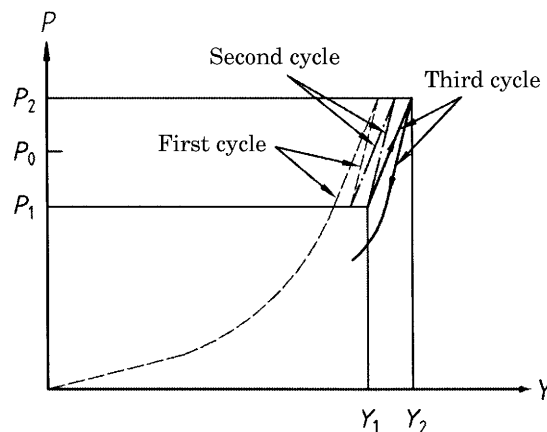
Note ^{a)} The distance from the core of the test piece to each displacement gauge (should be constant).

Figure 2 Placement of compression displacement gauges

6.2.1.5.2 Loading

The loading shall be as follows.

- Load the test piece with the compressive force as specified in 6.2.1.4.3. This compressive force is P_0 .
- Load the test piece with three cycles of compressive force between P_0 and force equivalent to $P_0 \pm 30 \%$, so that sequence of one cycle is $P_0 \rightarrow P_2 \rightarrow P_1 \rightarrow P_0$ (see figure 3).



Y compressive displacement
 P compressive force

Figure 3 Compressive properties

6.2.1.6 Expression of results

The amount of compressive displacement under compressive force shall be measured and the compressive stiffness, K_v , calculated using equation (1):

$$K_v = \frac{P_2 - P_1}{Y_2 - Y_1} \dots\dots\dots (1)$$

where, P_1 : the smaller compressive force in the third cycle (N)
 P_2 : the larger compressive force in third cycle (N)
 Y_1 : the smaller displacement in third cycle (mm)
 Y_2 : the larger displacement in third cycle (mm)

The compressive stiffness obtained shall be rounded off according to the method in **JIS Z 8401**, and expressed in three significant figures. Where several equivalent test pieces are used, the average value of these test pieces shall be recorded as the result.

6.2.1.7 Test report

The test report shall include the following matters.

- Number of this Standard (**JIS K 6410-2**)
- Type and classification, shape and dimensions, first shape factor and second shape factor of test piece
- Name of testing machine (model, etc.)
- Test temperature and surface temperature of the laminated rubber portion of the test piece
- Compressive force or compressive stress (central value plus larger and smaller values)
- Input wave and vibration frequency (when triangular wave is used, the test speed shall also be recorded.)

- g) Compressive stiffness
- h) Compressive force-compressive displacement curve
- i) Result of visual check
- j) Test date
- k) Other matters to be noted

6.2.2 Shear properties test

6.2.2.1 Principle

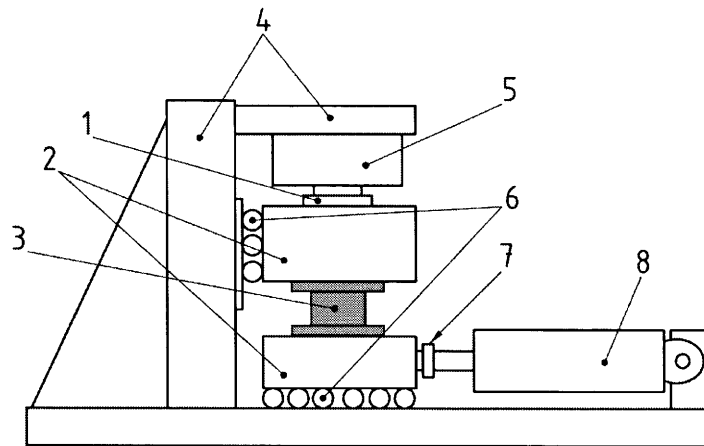
A test piece is loaded with a constant compressive force and subjected to a shear displacement. Shear force, shear displacement, compressive force and compressive displacement are measured. From the measured data, shear properties (shear stiffness and equivalent damping ratio) are determined.

6.2.2.2 Testing machine

The machine, shown in figure 4, shall be capable of compressing and shearing the elastomeric isolator under controlled conditions. The machine shall maintain the parallelism of the upper and lower loading platens for the test piece attachment during the test. A Class 1 machine, as defined in table 2 in clause 7 of **JIS B 7721** is recommended.

They shall provide a method of measuring the compressive force, compressive displacement, shear force and shear displacement to an accuracy of 1 % of the maximum values recorded. The force calibration of the machine shall be based on clause 6 of **JIS B 7721**. Despite the test piece height change, the test machine should keep the compressive force constant or within the specified tolerance which can be regarded as constant during compression-shear testing.

Warning: Fragment(s) of a test piece are likely to fly when a test piece fractures. Therefore, it is strongly recommended that a protective barrier be put into place in the shear load direction of the test piece. It is also strongly recommended that barriers, etc. be set up to prevent access to the test machine during a test. Particular attention should be given to this when an ultimate property test is conducted.



- 1 load cell (compressive force)
- 2 upper and lower platens
- 3 test piece
- 4 frame
- 5 actuator
- 6 bearing
- 7 load cell (shear force)
- 8 actuator

Figure 4 Example of compression-shear testing machine

6.2.2.2.1 Correction of inertia force and friction force

Inertia force in the shear direction of the testing machine shall be corrected in accordance with Annex B, and friction force generated in the movable part of the testing machine shall be corrected in accordance with Annex C. However, this correction is not necessary if force measurement excluding the inertia and friction force is possible by attaching a load cell or the like directly to the test piece, or the inertia and friction force are less than 1 % of the apparent shear force.

A load cell type sensor is recommended to measure the load force. This is because, when the test machine uses an internal pressure measuring type sensor that is influenced by the sliding resistance of an actuator, it is necessary to calibrate the force in the direction of actual use.

6.2.2.3 Test piece

The test piece shall be as specified in table 2.

6.2.2.4 Test conditions

6.2.2.4.1 Test temperature

The test temperature shall be as specified in **6.2.1.4.1**.

6.2.2.4.2 Conditioning time for test piece

The conditioning time for test piece shall be as specified in **6.2.1.4.2**.

6.2.2.4.3 Compressive force

The compressive force used for the test shall be a force equivalent to nominal compressive stress σ_{nom} . The tolerance on the compressive force at the start of shear deformation shall be $\pm 5\%$. The variation of the compressive force during shear deformation shall be $\pm 5\%$ of the compressive force at the start of shear deformation. Where the variation of the height of the test piece during testing is large and maintaining the compressive force constant is impossible, necessary measures shall be taken such as lowering the shear deformation speed.

6.2.2.4.4 Shear strain amplitude

The test shear strain amplitude shall be the nominal shear strain, γ_{nom} . The tolerance on the amplitude shall be $\pm 5\%$ of the shear strain. For HDR, pre-deformation may be given to the test piece before the application of nominal shear strain.

6.2.2.4.5 Input wave

The input wave shall be a sine wave or a triangular wave.

6.2.2.4.6 Variation frequency

The test variation frequency shall be in the range of 0.001 Hz to 0.5 Hz.

6.2.2.5 Procedure

6.2.2.5.1 Attachment of test piece

The test piece shall be attached to the test machine by the same or a mechanically equivalent manner as in the actual application.

6.2.2.5.2 Loading

Loading shall be as follows.

- Load the test piece with the compressive force specified in 6.2.2.4.3.
- Load the test piece with three cycles of shear deformation as specified in 6.2.2.4.4, 6.2.2.4.5 and 6.2.2.4.6 under application of compressive force.
- In the type inspection of square isolator, load the test piece in the side direction and diagonal direction of the test piece.

6.2.2.6 Expression of results

The shear properties values shall be obtained using the shear force-shear displacement curve (hysteresis loop) given in the loading test, and from the hysteresis loop in the third cycle.

The typical hysteresis loops for NRB, HDR and LRB are shown in figure 5 and figure 6. In the case of NRB, the shear stiffness K_h , and in the case of HDR, the shear stiffness K_h and equivalent damping ratio h_{eq} , and in the case of LRB, the post-yield stiffness K_d and characteristic strength Q_d shall be obtained from equations (2) to (5) as shear properties values. In addition to these, shear properties can be determined from the tangential stiffness (see Annex E).

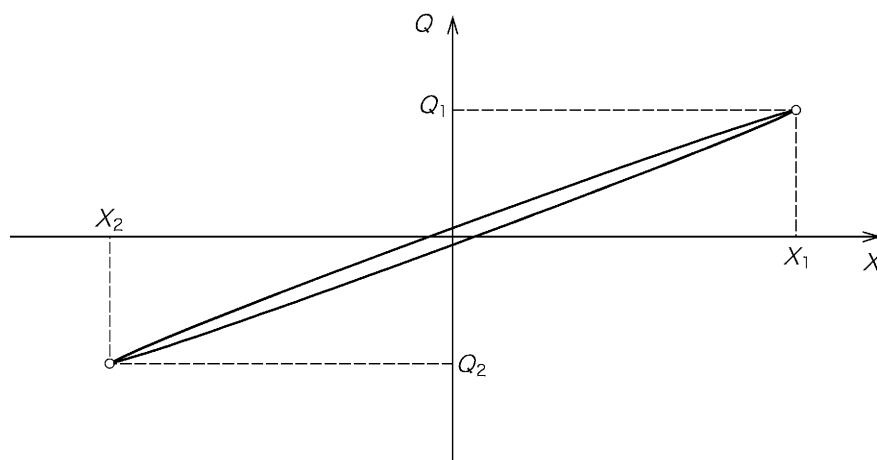
$$K_h = \frac{Q_1 - Q_2}{X_1 - X_2} \dots\dots\dots (2)$$

$$h_{eq} = \frac{2 \times W_d}{\pi \times K_h (X_1 - X_2)^2} \dots\dots\dots (3)$$

$$K_d = \frac{1}{2} \left(\frac{Q_1 - Q_{d1}}{X_1} + \frac{Q_2 - Q_{d2}}{X_2} \right) \dots\dots\dots (4)$$

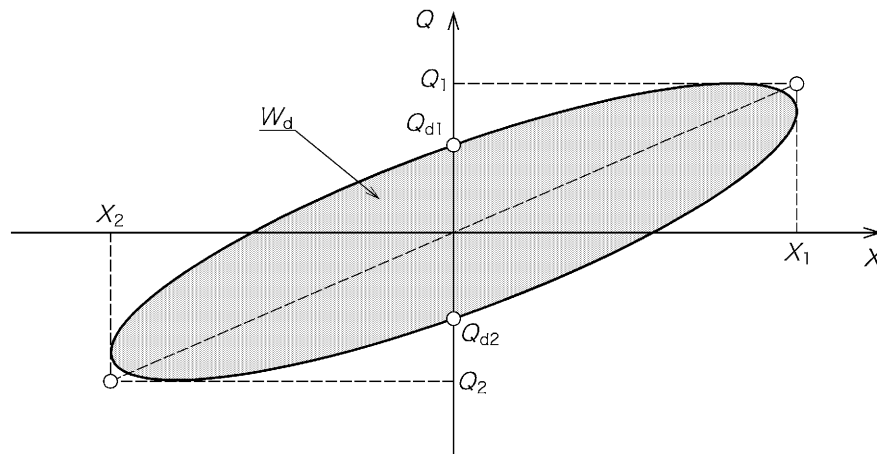
$$Q_d = \frac{1}{2} (Q_{d1} - Q_{d2}) \dots\dots\dots (5)$$

- where, Q_1 : maximum shear force (N)
 Q_2 : minimum shear force (N)
 X_1 : maximum displacement $X_1 = n \times t_r \times \gamma$ (mm)
 X_2 : minimum displacement $X_2 = n \times t_r \times (-\gamma)$ (mm)
 Q_{d1} : the points where the loop crosses the shear-force axis, on the positive side (N)
 Q_{d2} : the points where the loop crosses the shear-force axis, on the negative side (N)
 W_d : energy dissipated per cycle (N·mm)
(equivalent to the area enclosed by the hysteresis loop)



X shear displacement
 Q shear force

Figure 5 Determination of shear properties of NRB



X shear displacement

Q shear force

W_d energy dissipated per cycle (equivalent to the area enclosed by the hysteresis loop)

Figure 6 Determination of shear properties of HDR or LRB

The shear properties obtained shall be rounded off according to the method in **JIS Z 8401**, and expressed in three significant figures. Where several equivalent test pieces are used, the average value of these test pieces shall be recorded as the result.

The standard test temperature shall be 23 °C, but when performing the test at other temperature, the obtained result shall be corrected to the value at 23 °C by the correction formula for material test or other means if necessary.

The shear properties values obtained may be corrected to the value at variation frequency 0.33 Hz if necessary.

6.2.2.7 Test report

The test report shall include the following matters.

- a) Number of this Standard (**JIS K 6410-2**)
- b) Type and classification, shape and dimensions, first shape factor and second shape factor of test piece
- c) Name of test machine (model, etc.)
- d) Test temperature and surface temperature of the laminated rubber portion of test piece
- e) Compressive force, shear displacement, or compressive stress and shear strain
- f) Input wave and vibration frequency (when triangular wave is used, the test speed shall also be recorded.)
- g) Direction of the shear deformation applied to a test piece (for square isolators)
- h) Shear properties
- i) Shear force-shear displacement curve (hysteresis loop)
- j) Result of visual check
- k) Test date

l) Other matters to be noted

If required, the following matters shall be also recorded.

m) Compressive displacement-shear displacement curve

n) Compressive force-shear displacement curve

6.3 Dependency tests of shear properties

6.3.1 Shear strain dependency test of shear properties

6.3.1.1 Principle

A test piece is attached to a compression-shear testing machine and subjected to a constant compressive force. In this state, the test piece is subjected to multiple levels of shear strain (shear displacement). By means of these measurements, the dependency of the shear properties on shear strain is determined.

6.3.1.2 Testing machine

The testing machine shall be as specified in **6.2.2.2**.

6.3.1.3 Test piece

The test piece shall be as specified in table 2.

6.3.1.4 Test conditions

6.3.1.4.1 Test temperature

The test temperature shall be as specified in **6.2.1.4.1**.

6.3.1.4.2 Conditioning time for test piece

The conditioning time for test piece shall be as specified in **6.2.1.4.2**.

6.3.1.4.3 Compressive force

The test compressive force shall be as specified in **6.2.2.4.3**.

6.3.1.4.4 Shear strain amplitude

The shear strain amplitude shall be $\pm 50\%$, $\pm 100\%$, $\pm 150\%$, $\pm 200\%$ and $\pm 250\%$ and if the nominal shear strain γ_{nom} is not included among these, $\pm \gamma_{\text{nom}}$ shall be added. However, the test of the shear strain that is $\frac{2}{3}$ or more the ultimate shear strain shall not be performed. The tolerance on amplitude shall be $\pm 5\%$ of the shear strain.

6.3.1.4.5 Input wave

The input wave shall be as specified in **6.2.2.4.5**.

6.3.1.4.6 Vibration frequency

The test vibration frequency shall be as specified in **6.2.2.4.6**. The maximum speed should be the same for each of the shear strain conditions given in **6.3.1.4.4**.

6.3.1.5 Procedure

6.3.1.5.1 Attachment of test piece

The attachment of test piece shall be as specified in **6.2.2.5.1**.

6.3.1.5.2 Loading

Loading shall be as follows.

- a) Load the test piece with the compressive force specified in 6.3.1.4.3.
- b) Load the test piece with three cycles of shear strain at the input wave and vibration frequency as specified in 6.3.1.4.5 and 6.3.1.4.6 in the increasing order of shear strain.
- c) In the type inspection of square isolator, load the test piece in the side direction and diagonal direction of the test piece.

6.3.1.6 Expression of results

With the method specified in 6.2.2.6, determine each property value for each test shear strain. The shear strain dependency shall be expressed with the change rate with respect to the nominal shear strain γ_{nom} . The change rate shall be rounded off according to the method in **JIS Z 8401**, and expressed in three significant figures. Where several equivalent test pieces are used, the average value of these test pieces shall be recorded as the result.

6.3.1.7 Test report

The test report shall include the following matters.

- a) Number of this Standard (**JIS K 6410-2**)
- b) Type and classification, shape and dimensions, first shape factor and second shape factor of test piece
- c) Name of test machine (model, etc.)
- d) Test temperature and surface temperature of the laminated rubber portion of test piece
- e) Compressive force, shear displacement, or compressive stress and shear strain
- f) Input wave and vibration frequency (when triangular wave is used, the test speed shall also be recorded.)
- g) Direction of the shear deformation applied to a test piece (for square isolators)
- h) Shear properties
- i) Shear strain dependency
- j) Shear force-shear displacement curve (hysteresis loop)
- k) Result of visual check
- l) Test date
- m) Other matters to be noted

6.3.2 Compressive stress dependency of shear properties

6.3.2.1 Principle

A test piece is attached to a compression-shear testing machine and subjected to multiple levels of constant compressive force. In this state, the test piece is subjected

to shear displacement, and compressive stress dependency of shear properties is determined.

6.3.2.2 Test machine

The test machine shall be as specified in **6.2.2.2**.

6.3.2.3 Test piece

The test piece shall be as specified in table 2.

6.3.2.4 Test conditions

6.3.2.4.1 Test temperature

The test temperature shall be as specified in **6.2.1.4.1**.

6.3.2.4.2 Conditioning time for test piece

The conditioning time for test piece shall be as specified in **6.2.1.4.2**.

6.3.2.4.3 Compressive force

The test compressive force shall be a force equivalent to the compressive stress 0, 0.5 σ_{nom} , 1.0 σ_{nom} , 1.5 σ_{nom} and 2.0 σ_{nom} . The tolerance on compressive force when not under shear deformation shall be $\pm 5\%$, and that during shear deformation shall be $\pm 10\%$. Where the variation of the height of the test piece during testing is large and maintaining the compressive force constant is impossible, appropriate measures shall be taken such as lowering the shear deformation speed.

6.3.2.4.4 Shear strain amplitude

The shear strain amplitude shall be as specified in **6.2.2.4.4**.

6.3.2.4.5 Input wave

The input wave shall be as specified in **6.2.2.4.5**.

6.3.2.4.6 Vibration frequency

The test vibration frequency shall be as specified in **6.2.2.4.6**.

6.3.2.5 Procedure

6.3.2.5.1 Attachment of test piece

The attachment of test piece shall be as specified in **6.2.2.5.1**.

6.3.2.5.2 Loading

Loading shall be as follows.

- a) Load the test piece with the compressive force specified in **6.3.2.4.3**. The compressive force shall be applied in the increasing order.
- b) For each of the compressive forces, load the test piece with three cycles of shear strain specified in 6.3.2.4.4 at the input wave and vibration frequency as specified in 6.3.2.4.5 and 6.3.2.4.6.
- c) In case of square isolator, load the test piece in the side direction and diagonal direction of the test piece.

6.3.2.6 Expression of results

With the method specified in **6.2.2.6**, determine each property value for each test shear strain. The compressive stress dependency shall be expressed with the change rate with respect to the nominal compressive stress σ_{nom} . The change rate shall be rounded off according to the method in **JIS Z 8401**, and expressed in three significant figures. Where several equivalent test pieces are used, the average value of these test pieces shall be recorded as the result.

6.3.2.7 Test report

The test report shall include the following matters.

- a) Number of this Standard (**JIS K 6410-2**)
- b) Type and classification, shape and dimensions, first shape factor and second shape factor of test piece
- c) Name of test machine (model, etc.)
- d) Test temperature and surface temperature of the laminated rubber portion of the test piece
- e) Compressive force, shear displacement, or compressive stress and shear strain
- f) Input wave and vibration frequency (when triangular wave is used, the test speed shall also be recorded.)
- g) Direction of the shear deformation applied to a test piece (for square isolators)
- h) Shear properties
- i) Compressive stress dependency
- j) Shear force-shear displacement curve (hysteresis loop)
- k) Result of visual check
- l) Test date
- m) Other matters to be noted

If required, the following matters shall be also recorded.

- n) Compressive displacement-shear displacement curve
- o) Compressive force or tensile force-shear displacement curve

6.3.3 Frequency dependency of shear properties

6.3.3.1 Principle

A test piece is attached to a compression-testing machine and subjected to constant compressive force. In this state, the test piece is subjected to shear deformation at multiple levels of frequencies, and frequency dependency of shear properties is determined.

6.3.3.2 Testing machine

The testing machine shall be as specified in **6.2.2.2**.

6.3.3.3 Test piece

The test piece shall be as specified in table 2.

6.3.3.4 Test conditions

6.3.3.4.1 Test temperature

The test temperature shall be as specified in **6.2.1.4.1**.

6.3.3.4.2 Conditioning time for test piece

The conditioning time for test piece shall be as specified in **6.2.1.4.2**.

6.3.3.4.3 Compressive force

The test compressive force shall be as specified in **6.2.2.4.3**.

6.3.3.4.4 Shear strain amplitude

The shear strain amplitude shall be as specified in **6.2.2.4.4**.

6.3.3.4.5 Input wave

The input wave shall be as specified in **6.2.2.4.5**.

6.3.3.4.6 Vibration frequency

The test vibration frequency shall be 0.01 Hz, 0.1 Hz and 0.33 Hz.

6.3.3.5 Procedure

6.3.3.5.1 Attachment of test piece

The attachment of test piece shall be as specified in **6.2.2.5.1**.

6.3.3.5.2 Loading

Loading shall be as follows.

- a) Load the test piece with the compressive force specified in **6.3.3.4.3**.
- b) For each of the vibration frequencies, load the test piece with three cycles of shear strain specified in 6.3.3.4.4 at the input wave and vibration frequency as specified in **6.3.3.4.5** and **6.3.3.4.6**. The frequencies shall be applied in the increasing order.

6.3.3.6 Expression of results

With the method specified in **6.2.2.6**, determine each shear property value for each frequency.

6.3.3.7 Test report

The test report shall include the following matters.

- a) Number of this Standard (**JIS K 6410-2**)
- b) Type and classification, shape and dimensions, first shape factor and second shape factor of test piece
- c) Name of test machine (model, etc.)
- d) Test temperature and surface temperature of the laminated rubber portion of the test piece