RULES FOR THE SURVEY AND CONSTRUCTION OF SHIPS OF FIBREGLASS REINFORCED PLASTICS

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF SHIPS OF FIBREGLASS REINFORCED PLASTICS

Rules for the Survey and Construction of Ships of Fibreglass Reinforced Plastics 2012 AMENDMENT NO.1

Guidance for the Survey and Construction of Ships Fibreglass Reinforced Plastics 2012 AMENDMENT NO.1

Rule No.56 / Notice No.88 15th November 2012

Resolved by Technical Committee on 27th July 2012

Approved by Board of Directors on 25th September 2012

ClassNK

NIPPON KAIJI KYOKAI

RULES FOR THE SURVEY AND CONSTRUCTION OF SHIPS OF FIBREGLASS REINFORCED PLASTICS

RULES

2012 AMENDMENT NO.1

Rule No.56 15th November 2012
Resolved by Technical Committee on 27th July 2012
Approved by Board of Directors on 25th September 2012

Rule No.56 15th November 2012
AMENDMENT TO THE RULES FOR THE SURVEY AND CONSTRUCTION OF SHIPS OF FIBREGLASS REINFORCED PLASTICS

"Rules for the survey and construction of ships of fibreglass reinforced plastics" has been partly amended as follows:

Chapter 1 GENERAL

1.2 Definitions

Paragraph 1.2.13 has been amended as follows.

1.2.13 Blending Proportion

The blending proportion is a ratio in weight of the applied ~~sclerotic~~ curing agents and accelerator to the resin or the ratio in weight of the curing agents used to the base resins of structural adhesives.

Paragraph 1.2.15 has been amended as follows.

1.2.15 Bonding

Bonding is an operation of connecting the *FRP* already advanced in cure with other *FRP* members, timbers, hard plastic foams, etc. by means of impregnating fibreglass reinforcements with resin or structural adhesives.

Paragraph 1.2.21 has been added as follows.

1.2.21 Structural adhesives

Structural adhesives are adhesives used to connect structural members to hull structures.

Chapter 2 CLASS SURVEYS

2.2 Classification Survey during Construction

Paragraph 2.2.3 has been amended as follows.

2.2.3 Plans and Documents to be submitted for Reference

1 Where intended for the classification survey during construction, the following plans or documents are to be submitted for reference, in addition to those for approval required in **2.2.2**:

(1) Specifications,
(2) Certificates of *FRP* material tests specified in **Chapter 4**,
(3) Moulding procedure,
(4) Calculation sheets and information with respect to structural strength,
(5) Where load lines are to be marked in accordance with the requirements in **Chapter 20**, the plans and documents specified in **2.1.3-1(4)**, **Chapter 2, Part B of the Rules for the Survey and Construction of Steel Ships**.

2 In cases where main structural members are connected by structural adhesives, the plans or documents to be submitted for reference, in addition to those required in the preceding **-1**, are as follows:

(1) Procedures for repairing defects in joints moulded by structural adhesives; and

(2) Procedures for repairing joints connected by structural adhesives.

~~**2**~~**3** Plans and documents other than specified in the preceding **-1** and **-2** may be required to be submitted, where deemed necessary by the Society.

Chapter 3 WORKSHOPS

3.3 Storage Facilities for Raw Materials

Paragraph 3.3.2 has been amended as follows.

3.3.2 Stores for Resins, etc.

The resins, ~~sclerotics~~ curing agents ~~and,~~ accelerators and structural adhesives are to be stored in cool and dark spaces.

Chapter 4 MATERIALS FOR HULL

Section 4.1 has been amended as follows.

4.1 General

4.1.1 Application

The requirements in this chapter are framed for *FRP* and their raw materials, etc. The metallic materials are to be in accordance with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

4.1.2 Raw Materials for Primary Structures

The fibreglass reinforcements, resins for laminates ~~and,~~ core materials for sandwich construction and structural adhesives to be used for *FRP* ships are to be tested and inspected in the presence of the Surveyor and to be accepted, except those approved by the Society in accordance with the requirements in **4.2**.

4.2 Approval

Paragraph 4.2.1 has been amended as follows.

4.2.1 Approval of Raw Materials

At the request of raw material manufacturers, the Society will examine the materials used, manufacturing methods, inspection standards in the workshop, quality control system, etc., for the raw materials listed in the following **(1)** to ~~**(3)**~~**(4)** and execute tests and inspections specified in this

Chapter on the test samples designated by the Society. Where the test samples have passed these tests and inspections, they are dealt with as the approved materials:
(1) Fibreglass reinforcements,
(2) Resins for laminates,
(3) Core materials for sandwich construction~~,~~, and
(4) Structural adhesives.

4.3 Raw Materials, etc.

Paragraph 4.3.8 has been added as follows.

4.3.8 Tests and Inspections of Structural Adhesives

The tests and inspections specified in **4.1.2** for structural adhesives used for the hull structures of *FRP* ships are to be conducted for the following **(1)** to **(7)** items. However, the test and inspection methods are to be as deemed appropriate by the Society.
(1) density,
(2) viscosity,
(3) glass transition temperature or durometer hardness,
(4) cure shrinkage,
(5) tensile shear strength,
(6) tensile shear fatigue strength, and
(7) peel strength.

Chapter 5 MOULDING

5.1 General

Paragraph 5.1.5 has been amended as follows.

5.1.5 Blending Proportion

1 The blending proportion between ~~sclerotics~~ curing agents and accelerators is to be determined suitable for obtaining *FRP* of good quality, in consideration of the environmental conditions of laminating shops, such as temperature, relative humidity, etc. and also the pot life and mat life resins.

2 The blending proportion of the base resin and curing agents of structural adhesives is to be the value specified by the structural adhesive manufacturer.

Paragraph 5.1.6 has been amended as follows.

5.1.6 Operation Manual

Before moulding, examinations are to be made in detail with respect to the items listed in the following **(1)** to ~~**(4)**~~**(5)** and moulding is to be proceeded on the basis of such examinations.
(1) Environmental conditions ~~of laminating shops~~, controlling system thereof, pot life and curing time of resins.
(2) Operation procedure ~~and~~, scheduled operation process and working hours,
(3) Kinds, cutting methods, overlap of joints, edge preparation and number of plies of fibreglass reinforcements,

(4) Kinds, amount, blending quantity at one time and blending procedures of resins used~~,~~

(5) Kinds, amount used, application methods and adhesive layer thicknesses of structural adhesives.

Paragraphs 5.1.8 to 5.1.12 have been renumbered to Paragraphs 5.1.9 to 5.1.13 respectively and Paragraph 5.1.8 has been added as follows.

5.1.8 Environmental Conditions of Work Spaces Using Structural Adhesives

1 The temperature and humidity of work spaces using structural adhesives are to be suitable for the use of the structural adhesives.

2 Trash, dust and harmful gases, etc. within the work space are to be eliminated as much as possible.

3 Careful consideration is to be given so that structural members are not subjected to direct sunlight.

Section 5.5 has been amended as follows.

5.5 Bonding and Fastening

5.5.1 Bonding

1 In cases where bonding using fiberglass reinforcements with resins is carried out, the following **(1)** to **(5)** requirements are to be complied with:

(1) Bonding is to be executed after making effective preparation such as sanding the surface to be bonded and thoroughly removing oils and sanding dusts.

~~**2**~~(2) Bonding is to be executed paying careful attention not to cause spring back of fibreglass reinforcements.

~~**3**~~(3) Bonding is to be carefully executed so as not to cause any deformation due to excessive exothermic effect.

~~**4**~~(4) Bonding is to be carefully carried out so as not to cause strength discontinuity at the joint.

~~**5**~~(5) *T*-joints and *L*-joints are to be laminated at the site.

2 In cases where bonding is carried out using structural adhesives, the following **(1)** to **(7)** requirements are to be complied with:

(1) Blending of base resins and curing agents is to be carefully carried out so as not to cause any air bubbles in the adhesive layer.

(2) Before bonding is carried out, effective preparations such as sanding the surface to be bonded and thoroughly removing any oils and sanding dust are to be performed as needed.

(3) Bonding is to be carefully carried out so as not to cause any condensation on the adhesive surface.

(4) Bonding is to be carefully carried out so as not to cause any spring back of structural members.

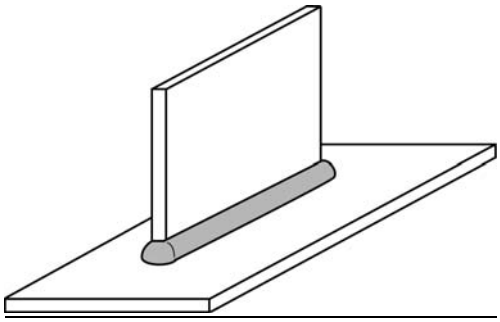
(5) Bonding is to be carefully carried out so as not to affect adhesive properties due to excessive exothermic effects.

(6) Bonding is to be carefully carried out so as not to cause any discontinuities in adhesive strength, except for cases where specified in **5.6.1-2(2)**. In addition, joint edges are to be appropriately treated as shown in **Fig. 5.1**.

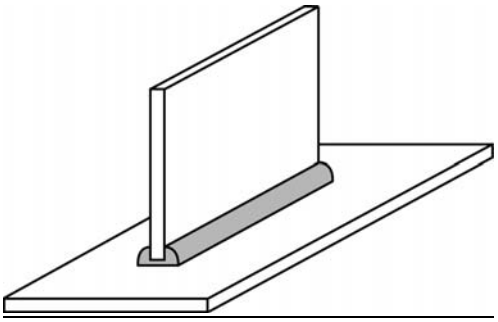
(7) Until structural adhesives sufficiently cured, adhesive joints are to be appropriately fixed to prevent any deformation.

Fig. 5.1 to Fig. 5.3(c) have been renumbered to Fig. 5.2 to Fig. 5.4(c) respectively and Fig. 5.1 has been added as follows.

Fig. 5.1 End Treatment of Joints



(a) Example of Appropriately Treated End



(b) Example of Inappropriately Treated End

5.6 Bonded Connections

Paragraph 5.6.1 has been amended as follows.

5.6.1 *T*-joints

1 In cases where fiberglass reinforcements with resins are used, *T*-joints are to be in accordance with the following requirements:

(1) The overlap width of *T*-joints of structural members are generally to be in accordance with **Fig. 5.~~1~~2**.

~~**2**~~(2) In *T*-joints of members of sandwich construction, the aggregated thickness of the inner laminate and the outer laminate of *FRP* may be used as the thickness (*t*) shown in **Fig. 5.~~1~~2**.

~~**3**~~(3) The form of laminating of *T*-joints is to be as shown in **Fig. 5.~~2~~3(a)** and **Fig. 5.~~2~~3(b)**.

~~**4**~~(4) Where the members such as engine girders, bulkheads, etc., which are subjected to considerably heavy load or vibration are connected, careful considerations are to be given in such a manner as to arrange structural members upon the laminates which are increased in thickness as shown in **Fig. 5.~~3~~4(a)**.

~~**5**~~(5) Where the members other than those specified in the preceding **-4**, that is, the members which are not deemed subjected to specially heavy load or vibration, are connected to the structural members, plastic foams or other similar materials are to be inserted between the member and the laminate as shown in **Fig. 5.3(b)** or the corners are to be sufficiently laminated by filling with soft resin puttys or other similar materials as shown in **Fig. 5.3(c)**.

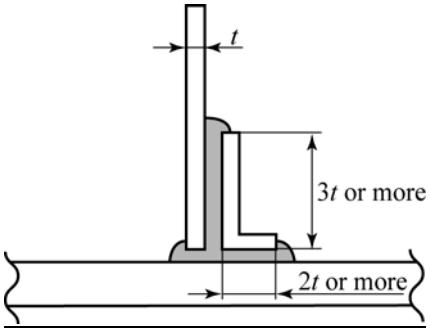
2 In cases where structural adhesives are used, *T*-joints are to be in accordance with the following requirements:

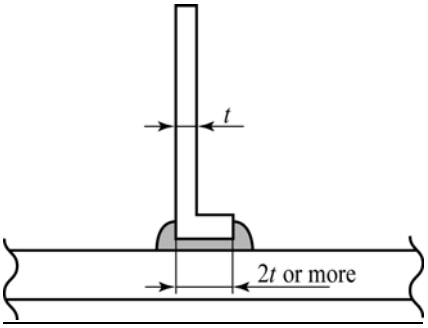
(1) Standard shapes and dimensions of *T*-joint structures are shown in **Fig. 5.3**. In the case of other joint shapes and dimensions, adhesive properties are to be considered and sufficient adhesion areas to account for loads and vibrations are to be provided.

(2) Where members which are subjected to considerably heavy loads or vibrations such as engine girders, bulkheads, etc. are connected, careful consideration is to be given to arranging such structural members on top of laminates whose thickness is increased as shown in **Fig. 5.4(a)**.

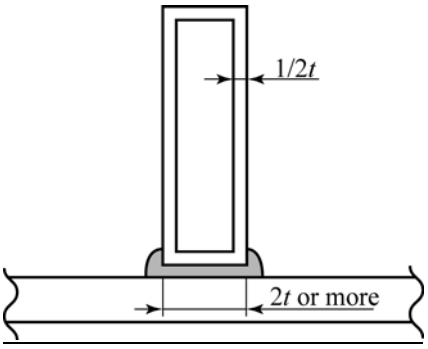
Fig. 5.5 has been added as follows.

Fig. 5.5 Joints Using Structural Adhesives（*T*-joints）

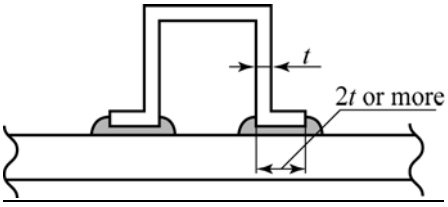




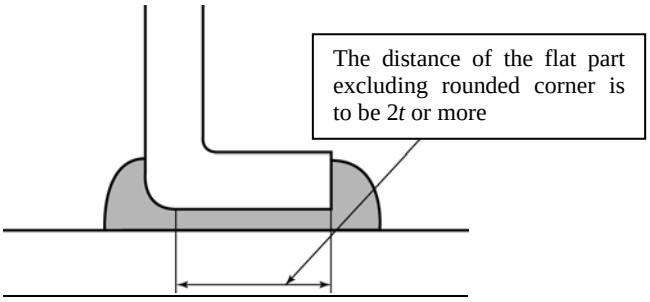
(a) Single Skin Bonding



(b) Plywood Sandwich Bonding



(c) Hat Shaped Structure Bonding



(d) Enlarged View of Rounded Corner

Chapter 14 DEEP TANKS

Paragraph 14.1.6 has been added as follows.

14.1.6 Consideration for Structural Adhesives

The adhesive properties of structural adhesives used for deep tanks are not to be harmfully affected by liquids being carried in the tanks.

Chapter 15 MACHINERY SPACES

15.2 Construction under Main Engines

15.2.1 Construction under Main Engines

Sub-paragraph -8 has been added as follows.

8 In cases where joints specified in **-7** are moulded by structural adhesives, sufficient adhesion areas are to be provided.

EFFECTIVE DATE AND APPLICATION

1. The effective date of the amendments is 15 November 2012.

GUIDANCE FOR THE SURVEY AND CONSTURCTION OF SHIPS OF FIBREGLASS REINFORCED PLASTICS

GUIDANCE

2012 AMENDMENT NO.1

Notice No.88 15th November 2012

Resolved by Technical Committee on 27th July 2012

Notice No.88 15th November 2012
AMENDMENT TO THE GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF SHIPS OF FIBREGLASS REINFORCED PLASTICS

"Guidance for the survey and construction of ships of fibreglass reinforced plastics" has been partly amended as follows:

Chapter 1 GENERAL

1.2 Definitions

Paragraph 1.2.15 has been amended as follows.

1.2.15 Bonding

Bonding is an operation of connecting the *FRP* already advanced in cure with other *FRP* members, timbers, hard plastic foams, etc. through scientific bonding procedure including the following **(1)** ~~and **(2)**~~ to **(3)**.

(1) Secondary bonding (an operation of laminating on the cured *FRP* laminate after sanding)
(2) Matting-in connection (an operation of inserting chopped mat impregnated with plastic resins between two cured *FRP* laminates)
(3) An operation of connecting the cured *FRP* laminates by applying and filling structural adhesives.

Chapter 2 CLASS SURVEYS

Section 2.3 has been added as follows.

2.2 Classification Survey During Construction

2.2.3 Plans and Documents to be submitted for Reference

In cases where joints other than the standard joints shown in **Fig. 5.5 of the Rules** are applied, stress assessments using direct strength calculations such as finite element analysis, etc. are to be submitted for joints moulded by structural adhesives.

Chapter 4 MATERIALS FOR HULL

4.1 General

4.1.2 Raw Materials for Primary Structures

Sub-paragraph -3 has been amended as follows.

3 Test and inspection of raw materials for primary structures

The test items at each test of raw materials for the primary structures are to be as given in **Table 4.1.2-1** to **Table 4.1.2-~~3~~4**. Test procedures are to be in accordance with the requirements in **-4**~~**, -5 and -6**~~ to **-7**.

Table 4.1.2-1 has been amended as follows.

Table 4.1.2-1 Test Items for Fibreglass Reinforcements

Test items		Type of test					
		Test per each ship specified in **4.1.2 of the Rules**		Approval test specified in **4.2 of the Rules**			
				At time of approval and every ~~4~~5 *years*		Annual test	
		M&SR	*R*	*M&SR*	*R*	*M&SR*	*R*
(1)	Appearance	O	O	O	O	O	O
(2)	Design weight per unit or unit length and maximum deviation	O	O	O	O	O	O
(3)	Ratio in weight of binders (including sizing)	O	O	O	O	O	O
(4)	Tensile strength of glassfibre reinforcements		O		O		O
(5)	Bending strength and modulus of bending elasticity obtained from laminates (in the standard condition)	O	O	O	O		
(6)	Bending strength and modulus of bending elasticity obtained from laminates (in wet condition)			O	O		
(7)	Tensile strength and modulus of tensile elasticity obtained from laminates (in the standard condition)	O	O	O	O		

Notes :
(Omitted)

Table 4.1.2-2 has been amended as follows.

Table 4.1.2-2 Test Items for ~~Regions~~Resins for Laminating

Test items		Type of test		
		Test per each ship specified in **4.1.2 of the Rules**	Approval test specified in **4.2 of the Rules**	
			At time of approval and every ~~4~~5 *years*	Annual test
(1)	Viscosity and thixotropy	O	O	O
(2)	Gel time, the minimum cure time and the peak exotherm temperature	O	O	O
(3)	Acid value	O	O	O
(4)	Water absorption rate of cast test specimens	O	O	O
(5)	Barcol hardness of cast test specimens		O	O
(6)	Rate of tensile elongation and tensile strength of cast test specimens	O	O	O
(7)	Load deflection temperature of cast test specimens	O	O	O
(8)	Barcol hardness of laminated test specimens	O	O	
(9)	Bending strength and modulus of bending elasticity obtained from laminated test specimens	O	O	
(10)	Tensile strength and modulus of tensile elasticity obtained from laminated test specimens	O	O	
(11)	High temperature characteristics obtained from laminated test specimens		O	

Notes :
(Omitted)

Table 4.1.2-3 has been amended as follows.

Table 4.1.2-3 Test Items for Sandwich Construction

Test items		Type of test					
		Test per each ships specified in **4.1.2 of the Rules**		Approval test specified in **4.2 of the Rules**			
				At time of approval and every ~~4~~5 *years*		Annual test	
		Rigid cellular plastic	Bulsa	Rigid cellular plastic	Bulsa	Rigid cellular plastic	Bulsa
(1)	Specific gravity	O	O	O	O	O	O
(2)	Water absorption rate	O		O		O	
(3)	Moisture content		O		O		O
(4)	Compressive strength and modulus of compressive elasticity	O	O	O	O	O	O
(5)	Softening temperature	O		O		O	
(6)	Tensile strength and modulus of tensile elasticity	O		O			
(7)	Bending strength and modulus of bending elasticity	O		O			
(8)	Shear strength obtained from laminated test specimens sandwich construction	O	O	O	O		

Notes :
(Omitted)

Table 4.1.2-4 to Table 4.1.2-9 have been renumbered to Table 4.1.2-5 to Table 4.1.2-10, and Table 4.1.2-4 has been added as follows.

Table 4.1.2-4 Test Items for Structural Adhesives

Test items		Type of test		
		Test for each ship specified in **4.1.2 of the Rules**[*1]	Approval test specified in **4.2 of the Rules**	
			At time of approval and every 5 *years*	Annual test
(a)	Density		O	O
(b)	Viscosity		O	O
(c)	Glass transition temperature [*2]		O	O
(d)	Durometer hardness [*2]		O	O
(e)	Cure shrinkage	O	O	O
(f)	Tensile shear strength	O	O	
(g)	Tensile shear fatigue strength	O	O [*3]	
(h)	Peel strength	O	O	

Notes:
The mark " O " denotes that tests and inspections are to be carried out.
[*1] In cases where the tests specified in **4.2 of the Rules** are conducted, this test is not required
[*2] Select either glass transition temperature or durometer hardness.
[*3] This test need only be conducted at the time of approval.

Sub-paragraph -4 has been amended as follows.

4 Testing procedures for fibreglass reinforcements
(1) Shape and selection of test specimens
(a) The shape and selection of test specimens used for tests of fibreglass reinforcements are to be in accordance with **Table 4.1.2-~~4~~5**.
(b) The manufacturing methods of laminated sheet used for tests (excluding rovings for spray-up laminating) are to be in accordance with the following **i)** through **v)**.
i) (Omitted)
ii) The laminate constitution and glass content are to be as **Table 4.1.2-~~5~~6**.
(iii) to v) are omitted)
(c) (Omitted)
(2) Test Procedures
The procedure of the tests given in **Table 4.1.2-1** is to be in accordance with the following **(a)** through **(f)**.
(a) Design weight per unit area or unit length and the maximum deviation
i) The test samples are to be in accordance with **Table 4.1.2-~~4~~5**.
(ii) and iii) are omitted)
(b) Ratio in weight of binder (including sheafing agents)
i) The test specimen are to be in accordance with **Table 4.1.2-~~4~~5**.
(ii) to iv) are omitted)
(c) Tensile strength of glassfibres in roving cloth
i) The test specimen are to be in accordance with **Table 4.1.2-~~4~~5**.

(ii) to iv) are omitted)

(d) Bending strength and modulus of bending elasticity obtained from laminates (in the standard condition)

i) The test specimen is to be in accordance with **Table 4.1.2-~~4~~5**.

(ii) to vi) are omitted)

(e) Bending strength and modulus of bending elasticity obtained from laminates

i) The test specimens are to be in accordance with **Table 4.1.2-~~4~~5**.

(ii) and iii) are omitted)

(f) Tensile strength and modulus of tensile elasticity obtained from laminates (in The tests are to be carried out after keeping the test specimen in the standard condition)

i) The test specimens are to be in accordance with **Table 4.1.2-~~4~~5**.

(ii) to vi) are omitted)

(3) Criteria

The acceptance criteria for the test results are to be in accordance with **Table 4.1.2-~~6~~7**.

Sub-paragraph -5 has been amended as follows.

5 Test procedures for resins for laminating

(1) Shapes and selection of test specimens

(a) The shape and selection of test specimens used for the tests of resins for laminating are to be in accordance with **Table 4.1.2-~~7~~8**.

(b) The manufacturing methods of cast test specimens are to be in accordance with the following **i)** to **iii)**.

i) The ~~sclerotics~~ curing agents and accelerators are to be as specified by the manufacturer of the resins.

ii) The size of cast sheet is to be such that all test specimens required in **Table 4.1.2-~~7~~8**. for the cast test specimen can be cut out of the sheet.

iii) The cure time, temperature and after cure are to be as specified by the manufacturer of resins.

(c) (Omitted)

(2) Test Procedures

The procedures for the tests given in **Table 4.1.2-2** are to be in accordance with the following **(a)** through **(k)**.

(a) Viscosity and thixotropy

i) The test resins are to be as given in **Table 4.1.2-~~7~~8**.

(ii) to ix) are omitted)

(b) Gel time, minimum cure time and peak exotherm temperature

i) The test resins are to be given in **Table 4.1.2-~~7~~8**.

(ii) to ix) are omitted)

(c) (Omitted)

(d) Water absorption rate of cast test specimens

i) The test specimens are to be in accordance with **Table 4.1.2-~~7~~8**.

(ii) to v) are omitted)

(e) (Omitted)

(f) Tensile elongation and tensile strength of the cast test specimens.

i) The test specimens are to be in accordance with **Table 4.1.2-~~7~~8**.

(ii) to v) are omitted)

(g) Load deflection temperature of cast test specimens

i) The test specimens are to be in accordance with **Table 4.1.2-~~7~~8**.

(ii) to vi) are omitted)

(h) (Omitted)

(i) Bending strength and modulus of bending elasticity obtained by laminate test specimens

i) The test specimens are to be in accordance with **Table 4.1.2-~~7~~8**.

ii) (Omitted)

(j) Tensile strength and modulus of tensile elasticity obtained by laminate test specimens.

i) The test specimens are to be in accordance with **Table 4.1.2-~~7~~8**.

ii) (Omitted)

(k) (Omitted)

(3) Criteria

The acceptance criteria for the test results are to be in accordance with **Table 4.1.2-~~8~~9**.

Sub-paragraph -6 has been amended as follows.

6 Test Procedures for Core Materials for Sandwich Constructions

(1) Shapes and selection of test specimens

(a) The shape and selection of test specimens used for the tests of core materials for sandwich construction are to be in accordance with **Table 4.1.2-~~9~~10**.

(b) (Omitted)

(2) Test procedures

(a) The test procedures for the hard plastics foam specified in **Table 4.1.2-3** are to be in accordance with the following **i)** through **vii)**.

i) Specific gravity

1) The test specimens are to be in accordance with **Table 4.1.2-~~9~~10**.

(2) to 5) are omitted)

ii) Water absorption rate

1) The test specimens are to be in accordance with **Table 4.1.2-~~9~~10**.

(2) to 7) are omitted)

iii) Compressive strength and modulus of compressive elasticity

1) The test specimens are to be in accordance with **Table 4.1.2-~~9~~10**.

(2) to 6) are omitted)

iv) (Omitted)

v) Tensile strength and modulus of tensile elasticity

1) The test specimens are to be in accordance with **Table 4.1.2-~~9~~10**.

2) The test procedure is to be in accordance with **-4.(2)(f)**.

vi) Bending strength and modulus of bending elasticity

1) The test specimens are to be in accordance with **Table 4.1.2-~~9~~10**.

(2) to 5) are omitted)

vii) Shearing strength of sandwich constructions

1) The test specimens are to be in accordance with **Table 4.1.2-~~9~~10**.

(2) to 5) are omitted)

(b) (Omitted)

Sub-paragraph -7 has been added as follows.

7 Test Procedures for Structural Adhesives

(1) Shapes and selection of test specimens

(a) The shapes and selection of test specimens used for the tests of structural adhesives are to be in accordance with **Table 4.1.2-11**.

(b) The manufacturing methods of test panels of *FRP* laminates used for the tests specified in **(2)(f)** and **(g)** are to be in accordance with the following **i)** through **iv)**:

i) Chopped mat and roving cloth are to be alternately laminated and surface layers are to be of chopped mat

ii) Design weight per unit area of chopped mat and roving cloth (g/m^2)

Chopped mat: 450

Roving cloth: 580

iii) Glass content by weight of chopped mat and roving cloth (%)

Chopped mat: 30 ± 3

Roving cloth: 50 ± 3

iv) Test panels are to be of sufficient size from which all test specimens needed for each test condition specified in **Table 4.1.2-11** can be taken.

(c) Aluminium test panels used for the tests specified in **(2)(f)** and **(g)** are to be the *A*5052*P* specified in *JIS H*4000 and use the surface anode oxide coating specified in *JIS H*8601

(2) Test procedures

The test procedures specified in **Table 4.1.2-4** are to be in accordance with the following **(a)** through **(h)** or with standards deemed appropriate by the Society.

(a) Density

The test method is to be in accordance with the density cup method or the pycnometry method specified in *JIS K*6833-1(2008).

(b) Viscosity

The test method is to be in accordance with the measurement method specified in *JIS K*6833-1(2008) using either a single cylinder rotational viscometer, coaxial-cylinder rotational viscometer or cone and plate viscometer.

(c) Glass transition temperature

The test method is to be in accordance with the differential thermal analysis or the differential scanning calorimetry specified in *JIS K*7121(1987).

(d) Durometer hardness

The test method is to be in accordance with *JIS K*7215(1986).

(e) Cure shrinkage

The test method is to be in accordance with the measurement method of moulding shrinkage specified in *JIS K*6911(2006) or the measurement method of cure shrinkage specified in *JIS K*6024(2008).

(f) Tensile shear strength

i) The test method is to be in accordance with *JIS K*6850(1999).

ii) The test specimens are to be *FRP* laminate test plates and aluminium test plates of the dimensions specified in **Table 4.1.2-11**.

iii) In cases where *FRP* laminate test plates are used, surface preparation equivalent to the actual construction is to be done before structural adhesives are applied.

iv) In cases where aluminium test plates are used, appropriate surface preparation is to be done before structural adhesives are applied.

v) Adhesive layer thickness and state adjustments are as follows:

1) Standard test

Adhesive layer thickness is to be not less than 3.0*mm* and test specimens are to be maintained at a temperature of 23 ± 2°C for 24 hours.

2) High humidity and high temperature exposure test

Adhesive layer thickness is to be not less than 3.0mm and test specimens are to be maintained at a temperature of 23 ± 2°C for 24 hours and then maintained at a temperature of 50 ±2°C and a relative humidity of 90 ± 10% for 500 hours.

vi) The method for recording failures is to be in accordance with **(3)**.

(g) Tensile shear fatigue strength

i) The test method is to be in accordance with *JIS K*6864(1999).

ii) The test specimens are to be *FRP* laminate test plates and aluminium test plates of the dimensions specified in **Table 4.1.2-11**.

iii) The test specimens are to be in accordance with the preceding **(f)**.

iv) Adhesive layer thickness is to be not less than 3.0*mm* and test specimens are to be maintained at a temperature of 23 ± 2°C for not less than 24 hours.

v) The test load is to be periodically applied at a maximum stress of 3.5*MPa* and a stress ratio of 0.1 for 10^6 cycles.

vi) The method for recording failures is to be in accordance with **(3)**.

vii) In cases where conducting tests is difficult due to device vibrations or *FRP* laminate strength decreases due to device heat, the frequency of cyclic load may be appropriately decreased.

(h) Peel strength

i) The test method is to be in accordance with *JIS K*6854-3(1999).

ii) The test specimens are to be cold rolled steel plates specified in *JIS G*3141(2011) of the dimensions specified in **Table 4.1.2-11**.

iii) Adhesive layer thickness is to be not more than 1.0*mm* and test specimens are to be maintained at a temperature of 23 ± 2°C for not less than 24 hours.

iv) The test speed is to be 100*mm/min*.

(3) Recording failures

(a) Observe the fracture surface and calculate the ratio of adherent failure for the entire adhesion area by visual inspection. In cases where the ratio of adherent failure is within the range, according to test condition, shown in the preceding **(f)v)**, calculate each area by the grid measurement method specified in the following **(c)** and determine the ratio of adherent failure.

i) The standard test specified in **(f)v)**: 35 ~ 45%

ii) The high humidity and high temperature exposure test specified in **(f)v)**: 20 ~ 30%

(b) Observe the fracture surface and calculate the total ratio of adherent failure and cohesion failure for the entire adhesion area by visual inspection. In cases where the total ratio of adherent failure and cohesion failure is within the range, according to test condition, shown in the preceding **(f)v)**, calculate each area by the grid measurement method specified in the following **(c)** and determine the total ratio of adherent failure and cohesion failure.

i) The standard test specified in **(f)v)**: 70 ~ 90%

ii) The high humidity and high temperature exposure test specified in **(f)v)**: 40 ~ 60%

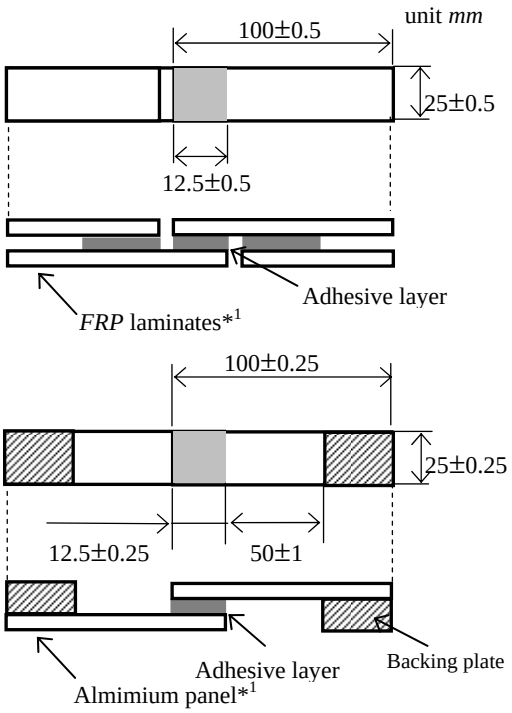
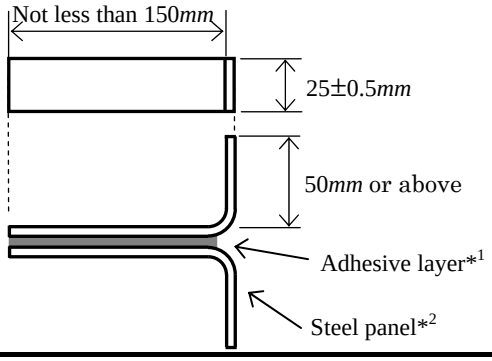
(c) Copy the fracture surface onto grided tracing paper and determine the total area of the fracture surface by counting the number of grids. In addition, determine the area of adherent failure and cohesion failure similarly and calculate the ratio of adherent failure and cohesion failure from the ratio of the area of adherent failure and cohesion failure to the area of fracture surface. Furthermore, regarding methods other than the grid measurement method, methods with a precision equal to or greater than the grid measurement method may be used.

(4) Criteria

The acceptance criteria for test results are to be in accordance with **Table 4.1.2-12**.

Table 4.1.2-11 has been added as follows.

Table 4.1.2-11 Structural Adhesive Test Specimens

Test items		Test specimen, sample shape and size	Quantity	Remarks
(a)	Density	· Adhesive base resin · Adhesive Curing agent(s)	3 each	
(b)	Viscosity	· Adhesive base resin · Adhesive Curing agent(s)	2 each	
(c)	Glass transition temperature	· Hardened materials	3	
(d)	Durometer hardness	· Hardened materials	5	
(e)	Cure shrinkage	· Adhesive base resin · Adhesive Curing agent(s) · Hardened materials	3 each	
(f)	Tensile shear strength		5 each	Adhesive layer thickness and state adjustment are to be in accordance with **4.1.2-7(2)(f)v)**.
(g)	Tensile shear fatigue strength	Test specimens specified in **(f)**	5 each	Adhesive layer thickness and state adjustment are to be in accordance with **4.1.2-7(2)(g)iv)**.
(h)	Peel strength		5	Adhesive layer thickness and state adjustment are to be in accordance with **4.1.2-7(2)(h)iii)**.

Notes:

*1: The thickness of *FRP* laminate is to be not less than 5.0*mm* and the thickness of alminium plates is to be not less than 2.0*mm*. In addition, thickness is to be sufficient so that deformation does not effect on the test results.

*2: The thickness of steel plates is to be not less than 0.5*mm*.

Table 4.1.2-12 has been added as follows.

Table 4.1.2-12 Structural Adhesive Evaluation Criteria

Test items		Evaluation Criteria
(a)	Density[*1]	Value specified by structural adhesive manufacturer
(b)	Viscosity[*1]	Value specified by structural adhesive manufacturer
(c)	Glass transition temperature[*1]	Value specified by structural adhesive manufacturer
(d)	Durometer hardness[*1]	Value specified by structural adhesive manufacturer
(e)	Cure shrinkage[*1]	Value specified by structural adhesive manufacturer
(f)	Tensile shear strength[*2]	Standard test: *FRP* laminate specimens: · In cases where the ratio of adherent failure is not less than 40%, the total ratio of adherent failure and cohesion failure is to be not less than 80%. · In cases where the ratio of adherent failure is less than 40%, the total ratio of adherent failure and cohesion failure is to be not less than 80% and not less than 6.9*MPa*. Aluminium specimens: not less than 6.9*MPa* High humidity and high temperature exposure test: *FRP* laminate specimens: · In cases where the ratio of adherent failure is not less than 25%, the total ratio of adherent failure and cohesion failure is to be not less than 50%. · In cases where the ratio of adherent failure is less than 25%, the total ratio of adherent failure and cohesion failure is to be not less than 50% and not less than 3.5*MPa*. Aluminium specimens: not less than 6.9*MPa*
(g)	Tensile shear fatigue strength[*2]	*FRP* laminate specimens: not to be fractured for less than 10^6 cycles or the failure is a adherent failure. Aluminium specimens : Not to be fractured for less than 10^6 cycles
(h)	Peel strength[*3]	Not less than 98*N*/25*mm*

Notes:

*1: Used to verify uniform quality

*2: Used to verify stress assessments and moulding procedures, etc. of joints moulded by structural adhesives.

*3: Used to verify that structural adhesives have a uniform peel strength.

EFFECTIVE DATE AND APPLICATION

1. The effective date of the amendments is 15 November 2012.