Annex B (normative)

Method of manufacturing recycled aggregate

for concrete-class M

B.1 General

This Annex specifies the method of manufacturing recycled aggregate concrete M.

B.2 Facilities of manufacture

B.2.1 Storage facilities for materials

The storage facilities for materials shall be as follows.

a) At the storage facilities, cement shall be classified according to the manufacturer or classification and be stored in such a way as to prevent weathering.

b) At the storage facilities, aggregates shall be separated by a partition for each division according to classification, division of grain size or division of alkali-silica reactivity to prevent segregation of sizes.

The facility of water function for prewetting aggregates shall be prepared.

The floor of storage facilities shall be made by concrete with providing waste water treating and preventing impurity incorporation.

Moreover the storage facilities shall store the aggregates which amount is more than the maximum quantity of shipment for concrete per one day.

c) The transportation facility at the storage of aggregates or on the way from storage to batch plant shall be provided consistent quality of aggregates in such a way as to prevent segregation.

d) The storage facility for admixture shall be classified according to classification, division and designation in such a way as to prevent quality change of admixture.

B.2.2 Batching plant

The batching plant shall be as follows.

a) At the plant, the storage bin shall be stocked according to each materials.

b) The measuring device shall measure each materials precisely within errors in accordance with B.4.2. Moreover the device shall be prepared an indicator which can indicate the measuring value with precision above.

c) All indicator shall be watched by operator and the measuring device shall be easy to control by them.

d) The measuring device shall measure in succession each materials using for concrete of different mix proportion.

e) The measuring device shall provide the equipment which is easy to correct measuring value for surface water ratio of aggregates. However for coarse aggregate, the measuring value for surface water ratio may be corrected by calculation.

B.2.3 Mixer

The mixer shall be as follows.

a) The mixer shall be fixed mixer or truck-mixer.

b) The fixed mixer or truck-mixer shall conform to the requirements in clause 6 of JIS A 8603-2 (Evaluation of test results).

c) When mixing concrete of specified slump according to the amount given in B.5 b), the mixers shall mix sufficiently and discharging homogeneously.

d) When the mixer mix specified amount for specified hours and the testing value in accordance with JIS A 1119 shall not exceed the following value, the mixer shall be judged to have the capability of mixing concrete homogeneously.

— Variability by measuring bulk density for mortar in concrete 0.8 %

— Variability by measuring unit amount of coarse aggregate in concrete 5 %

For truck-mixer, concrete specimen shall be sampled in accordance with Clause 4 of JIS A 1119 (Specimen).

B.2.4 Transportation vehicle

For transportation of recycled aggregate for concrete-class M, truck-agitator or truck-mixer with following performances shall be used.

a) The truck-agitator or truck-mixer shall maintain mixing concrete homogeneously and discharge easily and completely in such a way as to prevent segregation of materials.

b) The specimen for slump test shall be taken from 1/4 and 3/4 part of concrete flow when the truck-agitator or truck-mixer discharge ready-mixed concrete on site and the difference between both slumps shall be less than 3 cm. In this case, the slump of sampling concrete shall be 8 to 18 cm.

B.3 Adjustment of aggregates

The aggregates shall be finished prewetting by previous day for using, drained water and at the time of using, the surface water ratio of aggregate shall be in stable condition.

B.4 Measuring of materials

B.4.1 Measuring method

The measuring method for materials shall be as follows.

a) The cement, aggregates, water and admixture shall be measured by each own measuring device. However the water may accumulate with chemical admixture measuring beforehand.

b) The cement, aggregates and admixture shall be measured according to mass. The admixture may be calculated by amount of bags with approval of the purchaser.

However if measuring amount is less than one bag, it shall be measured by mass.

c) The water and chemical admixture shall be measured according to mass or volume.

d) When using recycled aggregate mixed with aggregate[1)] conform to Annex A of JIS A 5308, the each types of aggregate shall be measured independently.

Note[1)] The artificial lightweight aggregate shall be excluded among the aggregate conform to Annex A of JIS A 5308 (c.f. 8.2).

B.4.2 Tolerance of measured value

The tolerance of measured value shall be as follows.

a) The tolerance of measured value of cement, aggregates, water and admixture shall be in accordance with Table B.1.

TableB.1 Tolerance of measured value of materials

(%)

Types of materials	Measuring error for one butch
Cement	±1
Aggregate	±3
Water	±1
Admixture [a)]	±2
Chemical admixture	±3
Note [a)] The tolerance of measured value of ground granulated blast-furnace slag for one batch shall be ±1 %.	

b) The measured value shall be calculated by the following formula rounding-off to integer.

$$m_0 = \frac{(m_2 - m_1)}{m_1} \times 100$$

where, m_0 : tolerance of measured value (%)

m_1 : target measured amount for one batch

m_2 : effective measured value

B.5 Mixing

The mixing shall be as follows.

a) The recycled aggregate concrete M shall be mixed homogeneously by mixer given in B.2.3.

b) The mixing amount, mixing method and mixing hours for the recycled aggregate concrete M shall be tested given in JIS A 1119 and be specified by B.2.3 d).

For truck-mixer, the rotational speed of the drum shall be specified.

B.6 Transportation

The transportation of the recycled aggregate concrete M shall be as follows.

a) The transportation of the recycled aggregate concrete M shall be operated by carrier conforming to the requirement in B.2.4.

b) The transportation hours[2)] for recycled aggregate concrete M shall be the time between the manufacturer start mixing to the transportation vehicle arrive at unloading site and the time limit shall be within one and a half hours. However the manufacturer may consult with the purchaser to change the limit of transportation hours.

Note[2)] The transportation hours can be confirmed the time difference of departure and arrival time of delivery shown in the delivery notice given in Table 7.

B.7 Treatment for mortar adhering in drum of truck-agitator or truck-mixer

The treatment of adhesive mortar shall be as follows.

a) After all the mixing concrete was discharged from truck-agitator or truck-mixer, the fresh mortar which adhering to inner wall or blade of drum may be reused with adhesive mortar stabilizer given in Annex D (Method for use of mortar adhering to truck agitator drum) of JIS A 5308.

b) The reusing adhesive mortar shall be used in accordance with Annex D of JIS A 5308, and the mixing hours of concrete and the time of manufacturing slurry by adhesive mortar shall be recorded.

B.8 Quality management

The manufacturer shall perform quality management to guarantee the quality of concrete given in Clause 5. The manufacturer shall present the test result if requested by the purchaser.

Annex C (normative)

Method of countermeasure for restraint alkali-silica reactivity of recycled aggregate for concrete-class M

C.1 General

This Annex specifies the method of countermeasure for restraint alkali-silica reactivity of recycled aggregate for concrete-class M.

C.2 Division

The division of countermeasure for restraint alkali-silica reactivity shall be as follows.

a) The countermeasure regulating total amount of alkali in concrete so as not to exceed 3.0 kg/m³.

b) The countermeasure using blended cement effective to restraint alkali-silica reactivity, and regulating total amount of alkali in concrete so as not to exceed 3.5 kg/m³.

c) The countermeasure using blended cement effective to restraint alkali-silica reactivity, and regulating total amount of alkali in concrete so as not to exceed 4.2 kg/m³.

d) The countermeasure using blended cement effective to restraint alkali-silica reactivity, and regulating upper limit value of unit cement amount.

e) The countermeasure using aggregates judged as harmless.

C.3 Method of the countermeasure regulating total amount of alkali in concrete so as not to exceed 3.0 kg/m³.

The method of the countermeasure regulating total amount of alkali in concrete so as not to exceed 3.0 kg/m³ shall be as follows.

a) Use portland cement which total amount of alkali[1)] is admittedly, and confirm the total amount of alkali in concrete (R_t) calculated by the following formula (C.1) shall not exceed 3.0 kg/m³.

$$R_t = R_c + R_a + R_{rg} + R_{rs} + R_s + R_m + R_p \quad \text{----------(C.1)}$$

where, R_t : total amount of alkali in concrete (kg/m³)

R_c : total amount of alkali[1)] in cement in concrete (kg/m³)
= unit amount of cement (kg/m³)×total amount of alkali[1)] in cement (%)/100

R_a : total amount of alkali in admixture in concrete (kg/m³)
= unit amount of admixture (kg/m³)×total amount of alkali[1)] in admixture (%)/100

R_{rg} : total amount of alkali in recycled coarse aggregate M or recycled coarse aggregate L in concrete (kg/m³)
= unit amount of coarse aggregate (kg/m³) × total amount of alkali in recycled coarse aggregate[1] (%)/100

R_{rs} : total amount of alkali in recycled fine aggregate M or recycled fine aggregate L in concrete (kg/m³)
= unit amount of fine aggregate (kg/m³) × total amount of alkali in recycled fine aggregate[1] (%)/100

R_s : total amount of alkali in normal aggregate[2] in concrete (kg/m³)
= unit amount of aggregate (kg/m³) × 0.53 × amount of NaCl in aggregate (%)/100

R_m : total amount of alkali in chemical admixture in concrete (kg/m³)
= unit amount of chemical admixture (kg/m³) × total amount of alkali in chemical admixture[1] (%)/100

R_p : total amount of alkali[3] in superplasticizer in concrete (kg/m³)
= unit amount of superplasticizer (kg/m³) × total amount of alkali in superplasticizer[1] (%)/100

However, for the value of total amount of alkali in cement, maximum value of alkali shown in the test result certificate over the last six months shall be used. The value of total amount of alkali in admixture, chemical admixture and superplasticizer and the value of NaCl in aggregate shall be used shown in the latest test result certificate.

Note[1] The value shown as convert total sum of contained Na_2O or K_2O into equivalent amount of Na_2O (Na_2Oeq) , and it shall be Na_2Oeq (%) = Na_2O (%) + 0.658 K_2O (%).

Note[2] The aggregate conform to Annex A of JIS A 5308. However the artificial lightweight aggregate shall be excluded. (c.f.8.2)

[3] The purchaser add superplasticizer for fluidization if necessary on unloading site. The purchaser who operate fluidization shall announce the value (R_p) to the manufacturer in advance.

b) The total amount of alkali in recycled coarse aggregate shall be obtained by one of the following method.

1) The total amount of alkali in recycled coarse aggregate M or recycled coarse aggregate L shall be obtained by the test given in C.8.

2) The total amount of alkali in recycled coarse aggregate M or recycled coarse aggregate L shall be calculated by the following formula to the second decimal place. However, maximum value of total amount of alkali in recycled coarse aggregate M or recycled coarse aggregate L shall be 0.20 and 0.25 %.

$$r_{rg} = 0.025 \times Q_{rg} + 0.075$$

$$Q_{rg} = {}_a Q_{rg} + 1.64\sigma$$

where, r_{rg} : total amount of alkali in recycled coarse aggregate M or recycled coarse aggregate L (%)

Q_{rg} : water absorption of recycled coarse aggregate (%)

${}_aQ_{rg}$: mean value of water absorption for recycled coarse aggregate manufactured in the past (%)

σ : standard deviation (%)

c) The total amount of alkali in recycled fine aggregate shall be obtained by one of the following method.

1) The total amount of alkali in recycled fine aggregate M or recycled fine aggregate L shall be obtained by the test given in C.8.

2) The total amount of alkali in recycled fine aggregate M and recycled fine aggregate L shall be calculated by the following formula to the second decimal place. However, maximum value of total amount of alkali in recycled fine aggregate M or recycled fine aggregate L shall be 0.30 and 0.50 %.

$$r_{rs} = 0.033 \times Q_{rs} + 0.067$$

$$Q_{rs} = {}_a Q_{rs} + 1.64\sigma$$

where, r_{rs} : total amount of alkali in recycled fine aggregate M or recycled fine aggregate L (%)

Q_{rs} : water absorption of recycled fine aggregate (%)

${}_aQ_{rs}$: mean value of water absorption for recycled fine aggregate manufacturing in the past (%)

σ : standard deviation (%)

NOTE : The total amount of alkali in recycled aggregate M shall be calculated for finding the relativeness between the ratio of cement paste containing recycled aggregate M and water absorption by linear expression when amount of alkali in adhered cement is 1 % hypothetically. The condition for the amount of water containing cement paste adhering recycled aggregate M shall be zero as a safety side. The relativeness between the water absorption of recycled aggregate M and the amount of adhering cement paste, and the amount of cement shall be calculated as a safety side by achievements value in the past.

C.4 Method of countermeasure regulating total amount of alkali so as not to exceed 3.5 kg/m³ using blended cement effective for reducing alkali-silica reactivity.

Under the condition of the total amount of alkali calculated by the formula (C.1) given in C.3 is confirmed not to exceed 3.5 kg/m³, one of the following cement or admixture shown in a) to c) shall be used.

a) The portland blast-furnace slug cement B or portland blast-furnace slag cement C conform to JIS R 5211 shall be used. However the amount of blast-furnace slag (mass fraction) for portland blast-furnace slag cement B shall be 40 % or greater.
When confirmed the amount of ground granulated blast-furnace slag according to the test result certificate of cement and added ground granulated blast-furnace slag to the amount of 40 % or greater, it may be used as the blast-furnace slag cement B.

b) The portland fly-ash cement B or portland fly-ash cement C conform to JIS R 5213 shall be used. However the amount of fly-ash (mass fraction) for portland fly-ash cement B shall be 15 % or greater.
When confirmed the amount of fly-ash according to the test result certificate of cement and added fly-ash to the amount of 15 % or greater, it may be used as the portland fly-ash cement B.

c) When using portland cement or ordinary ecocement, the ground granulated blast-furnace slag conform to JIS A 6206 or the fly-ash conform to JIS A 6201 shall be used for admixture.
However, the ground granulated blast-furnace slag shall be 40 % or greater of the total amount of portland cement, ordinary ecocement and ground granulated blast-furnace slag. The fly-ash shall be 15 % or greater of the total amount of portland cement, ordinary ecocement and fly-ash.

C.5 Method of countermeasure regulating total amount of alkali so as not to exceed 4.2 kg/m³ using blended cement effective for reducing alkali-silica reactivity.

To confirm the total amount of alkali calculated by the formula (C.1) given in C.3 is not exceed 4.2 kg/m³, any of the following cement or admixture shown in a) to c) shall be used.

a) The portland blast-furnace slug cement B or portland blast-furnace slag cement C conform to JIS R 5211 shall be used. However the amount of blast-furnace slag (mass fraction) for portland blast-furnace slag cement B shall be 50 % or greater.
When confirmed the amount of ground granulated blast-furnace slag according to the test result certificate of cement and added blast-furnace slug to the amount of 50 % or greater, it may be used as the blast-furnace slag cement B.

b) The portland fly-ash cement C conform to JIS R 5213 shall be used.
When confirmed the amount of fly-ash according to the test result certificate of cement and

added fly-ash to the amount of 20 % or greater, it may be used as the portland fly-ash cement C.

c) When using portland cement or ordinary ecocement, the ground granulated blast-furnace slag conform to JIS A 6206 or the fly-ash conform to JIS A 6201 shall be used for admixture.

However, the ground granulated blast-furnace slag shall be 50 % or greater of the total amount of portland cement, ordinary ecocement and ground granulated blast-furnace slag. The fly-ash shall be 20 % or greater of the total amount of portland cement, ordinary ecocement and fly-ash.

C.6 Method of countermeasure regulating the upper limit for amount of unit cement using blended cement effective for reducing alkali-silica reactivity.

The method shall be any of the followings shown in Table C.1.

Table C.1 Method of countermeasure for the upper limit of unit cement amount using blended cement

Classification of recycled aggregate concrete M	Classification of countermeasure for alkali-silica reactivity		Supplementary item
Recycled M1 frost damage resistance type or recycled M1 ordinary type	portland blast-furnace slug cement	amount of slug(mass fraction) is 40% or greater (cf. C.4)	upper limit of unit cement amount is 400 kg/m³ or under
	fly-ash cement	amount of fly-ash(mass fraction) is 15% or greater (cf. C.4)	
	portland blast-furnace slug cement	amount of slug(mass fraction) is 50% or greater (cf. C.5)	upper limit of unit cement amount is 500 kg/m³ or under
	fly-ash cement	amount of fly-ash(mass fraction) is 20% or greater (cf. C.5)	
Recycled M2 ordinary type	portland blast-furnace slug cement	amount of slug(mass fraction) is 50% or greater (cf. C.5)	upper limit of unit cement amount is 350 kg/m³ or under
	fly-ash cement	amount of fly-ash(mass fraction) is 20% or greater (cf. C.5)	

C.7 Method of countermeasure using aggregate judged as safety

The recycled aggregate M given in division “A” of Annex A shall be used. When using aggregate[2)] conform to Annex A of JIS A 5308, the aggregate judged as “harmless” by the result of the test in accordance with JIS A 1145 or JIS A 1146 shall be used.

C.8 Measuring method for content of alkali in recycled aggregate

C.8.1 Specimen

C.8.1.1 Conditioning of specimen

The recycled aggregate for test shall be dried more than 24 hours by 105 ℃ heat as retaining its shape to specified amount and cool it down to room temperature prior to use.

C.8.1.2 Sampling of specimen

The specimen shall be sampled in such a way as to represent the lot being tested in accordance with JIS A 1158. The amount of specimen for each test shall be 500g for recycled coarse aggregate and 100g for recycled fine aggregate.

C.8.2 Outline of test method

Measure and take a specified amount of specimen for recycled aggregate as retaining its shape, add 70 times large volume than specimens amount of hydrochloric acid (1+100) and dissolve the adhered paste by shaking apparatus continuously for 24 hours 130 times/minutes. If the dissolving is insufficiency, continue elution. By insoluble residue or the concentration of Na or K in solution, the amount of Na_2O, K_2O, Na_2Oeq, adhered paste and the amount of Na_2Oeq against adhered paste shall be calculated. The test shall be performed twice per one specimen and the mean value shall be the result of the test for specimen.

The test procedure shall be shown in Figure C.1.

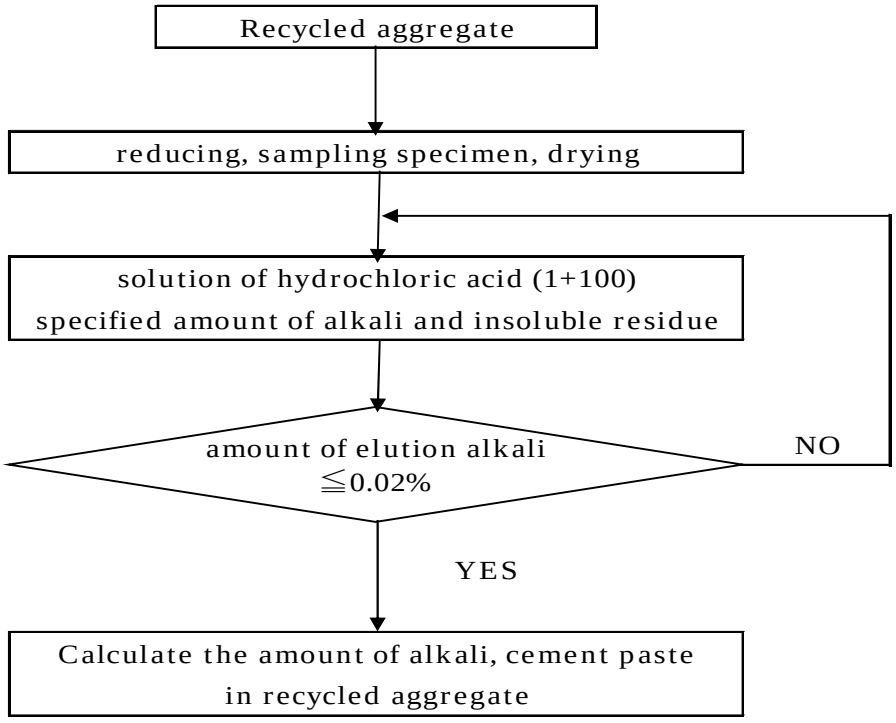

Figure C.1 Measuring procedure for content of alkali in recycled aggregate

C.8.3 Operation

The operation of measuring content of alkali in recycled aggregate shall be as follows.

a) For the specimen sampling in accordance with C.8.1.2, the volume (m_s), measure to the first decimal place, put into container made by polyethylene with specified amount of hydrochloric acid (1+100)(V_{HCl}).

The amount of additional hydrochloric acid (1+100) shall be 35 L for recycled coarse aggregate, 7 L for recycled fine aggregate.

b) By using shaking apparatus adjusting 130 times/minutes for shaking and 4 to 5 cm for shaking amplitude, the shaking of sample liquid shall be continued 24 hours.

c) After shaking, leave the sample liquid to stand for a while for sedimentation of large grains and use filter paper (5 type B regulated in JIS P 3801 or the one which has same performance) and Buchner funnel for sucking filtration. The filtrate shall be collected and stored.

d) After washing the insoluble residue on filter paper by distilled water, dry it to specified amount by 105 ℃ heat, cool it down to room temperature and measure the amount ($m_{insol.n}$). The washing liquid shall be excluded for the filtrate.

e) Take the specified amount of filtrate (v_n) collected at c), put all of them into separately each 100 ml flask, add water till marked line and shake for mixing. Using this dilute sample solution, quantify the density of Na and K by Atomic Absorption Spectrophotometry, calculate the amount of Na_2O_{ns} or K_2O_n in specimens and the amount of conversion alkali (Na_2Oeq_n) by the formula shown in C.8.4.1.

f) Put the whole amount of insoluble residue dried in d) into container made by plastic or glass, and add new hydrochloric acid (1+100) as same amount as a) and operate b) to e) again.

g) Keep continue operation b) to f) until the amount of conversion alkali (Na_2Oeq_n) at n times elution by hydrochloric acid (1+100) is 0.02 % or under of amount of specimens sampled in accordance with C.8.1.2.

h) When the amount of conversion alkali (Na_2Oeq_n) at n times elution by hydrochloric acid (1+100) becomes 0.02 % or under of amount of specimens sampled in accordance with C.8.1.2, calculate the amount of Na_2O, K_2O, Na_2Oeq, adhered paste and the amount of Na_2Oeq against adhered paste by the formula shown in C.8.4.2.

C.8.4 Calculation

C.8.4.1 Calculation of the amount of Na_2O, K_2O, Na_2Oeq, adhered paste in the specimen of n times elution.

The amount of Na_2O, K_2O, Na_2Oeq and adhered paste at n time elution by hydrochloric acid (1+100) shall be calculated by following formula.

$$Na_2O_n = \frac{CNa_n \times V_{HCl}}{V_n \times m_s} \times 100 \times 1.348$$

$$K_2O_n = \frac{CK_n \times V_{HCl}}{V_n \times m_s} \times 100 \times 1.205$$

$$Na_2Oeq_n = Na_2O_n + 0.658 \times K_2O_n$$

$$P_n = 100 - \frac{m_{INSOL.n}}{m_s} \times 100$$

where, Na_2O_n : amount of Na_2O measured at n time elution(%)

K_2O_n : amount of K_2O measured at n time elution(%)

Na_2Oeq_n : amount of conversion alkali measured at n time elution(%)

P_n : amount of adhered paste measured at n time elution(%)

CNa_n : density of Na for dilute sample solution at n time elution(g/100mL)

CK_n : density of K for dilute sample solution at n time elution(g/100mL)

$m_{insol.n}$: dried amount of insoluble residue at n time elution (g)

V_{HCl} : amount of used hydrochloric acid (1+100) (mL)

V_n : amount of separation from filtrate (mL)

m_s : amount of sampling specimen (g)

C.8.4.2 Calculation of the amount of Na_2O, K_2O, Na_2Oeq, adhered paste in the specimen and the amount of Na_2Oeq against adhered paste.

Total amount of measured value of each elution, the amount of Na_2O, K_2O, Na_2Oeq, adhered paste in the specimens and the amount of Na_2Oeq against adhered paste shall be calculated in accordance with following formula.

$$Na_2O = \sum_n Na_2O_n$$

$$K_2O = \sum_n K_2O_n$$

$$Na_2O_{eq} = Na_2O + 0.658 \times K_2O$$

$$P = 100 - \frac{m_{insol}}{m_s} \times 100$$

$$R_p = \frac{Na_2O_{eq}}{P} \times 100$$

where, Na_2O : amount of Na_2O containing in specimens(%)
(sum of Na_2O at each elution time)

K_2O : amount of K_2O containing in specimens (%)

(sum of K_2O at each elution time)

Na_2Oeq : amount of conversion alkali containing in specimens (%)

P : amount of adhered paste (%)

$m_{insol.}$: dried amount of insoluble residue at latest elution (g)

R_p : amount of Na_2Oeq against adhered paste (%)

m_s : amount of sampling specimens (g)

C.8.5 Marking of result

The test result of Na_2O, K_2O, Na_2Oeq shall be given to the second decimal place by rounding off. The test result for the amount of adhered paste and the Na_2Oeq against adhered paste shall be given to the first decimal place by rounding off.

C.9 Report

When performing the countermeasure in accordance with this Annex, the code for the method of countermeasure shown in Table C.2 shall be filled in the designing mix proportion for recycled aggregate concrete M given in Table 6.

Table C.2 Method and marks for contermeasure of alkali-silica reactivity

Method of countermeasure	marks
Regulating total amount of alkali in concrete to 3.0 kg/m³ or under	AL (kg/m³) a)
Using blended cement and regulating total amount of alklali in concrete to 3.5 kg/m³ or under	FB-AL3.5(kg/m³) a)
Using blended cement and regulating total amount of alklali in concrete to 4.2 kg/m³ or under	FB-AL4.2(kg/m³) a)
Using blended cement and regulating the upper limit of unit cement amount	FB-UC
Countermeasure used by the aggregate judged as in safe	A
Note a) In parentheses put the total amount of alkali calculated by rounding off to the first decimal place	

Annex D (normative)

Test method for freeze thaw of recycled coarse aggregate M

D.1 General

This Annex specifies the test method for evaluating freeze thaw resistance of the recycled coarse aggregate M.

D.2 Testing instrument

D.2.1 Container

The container[1)] shall be made by plastic which has enough capacity for filling specimen of recycled aggregate and water, moreover enough capability of operation given in D.5 d) or e).

Note[1)] Cylindrical container with a cap is desirable. For example, the food container made by polypropylene or polyethylene may be used.

D.2.2 Freezer

The electric freezer specified in JIS C 9607 or refrigerator - freezer with three star or four star freezing chamber specified in JIS C 9607 shall be used. The time for freezing specimens of recycled aggregates shall be different according to the amount of specimens or the power of the freezer, therefore the amount of specimens which can be tested in the freezer at one time in accordance with D.4 shall be confirmed in advance.

D.2.3 Water tank

The water tank shall be used for melting frozen container of specimens. Preventing running out the specimens of aggregates, the container shall be placed so as to the top is slightly higher than the water surface, by using stands or the like under the container in the water for adjusting.

D.2.4 Sieve

The sieve shall be wire sieve of 4.75 mm, 9.5 mm, 19 mm and 26.5 mm in nominal size specified in JIS Z 8801-1.

D.2.5 Scale

The scale shall measure 2 kg or over for weighing and 0.1 g or under for sensitizing amount.

D.2.6 Thermometer

The thermometer shall measure water temperature in the container and measuring range shall be between －30 ℃ to 25 ℃。

D.3 Preparation for specimens

This test method shall be performed for recycled coarse aggregate which grain size range is between 5 to 20 mm or 5 to 25 mm.

The test shall be operated more than three times per one lot and take about 5 kg of each

materials from more than three different part of the tested lot.

The specimen shall be in air-dried state. The recycled aggregate shall not expose to oven-dry condition or high temperature, preventing the reduction of frost damage resistance.

D.4 Setting number of containers for test at once

The freezing speed for specimens of recycled aggregate is different according to the power of freezer and the amount of specimens placed in at once. Therefore the number of the containers[2)] putting into the freezer at once shall be settled in advance according to the test condition specified in D.5 d). For finding the exact number, prepare several containers which fills aggregate (not only for recycled aggregate) and water as same method as D.5, confirm the relations between the number of containers setting into the freezer and the temperature of specimens reached in time. The number of containers tested at once shall be always same. However if the tested specimens is not enough number, another containers filled with aggregate and water but which is not provided for the test shall be prepared.

Note[2)] The 5 to 10 containers filled with 750 g of recycled aggregates and 400 ml of water per 100L of freezer shall be used as a standard.

D.5 Test method

The test procedure shall be as follows.

a) Take the recycled aggregate of enough amount for the container in accordance with JIS A 1158. The amount shall be 750 g or over for specimens of 5 to 20 mm, 1000 g or over for specimens of 5 to 25 mm. The grain size distribution of the recycled coarse aggregate shall be measured unit 0.1 g by screening using wire sieve of 4.75 mm, 9.5 mm, 19 mm and 26.5 mm. The screening shall be performed carefully, preventing crushing of the specimens of recycled aggregates by sieving. The grain sized 4.75 mm or under or 26.5 mm or over shall be removed.

b) Put the specimens into container and submerged with water completely[3)]. The amount of pouring water shall be always same for each container.

Note[3)] The specific heat of water is about 10 times greater than aggregates and increasing the amount of water in container, longer the processing time for freeze thaw. The guideline of water in container shall be 1/2 of specimens of recycled aggregates.

c) Set a thermometer in one of the container. The thermometer shall be placed to measure the temperature of the center of container.

d) Put the container into freezer and freezing until contained water is −18℃ or under. The freezing time shall be 16 ±2 hours.

e) Take out the container from freezer, put into the water tank, remain into the water until inside ice completely melt. The time of freeze thaw shall be 8±2hours.

f) Operate one cycle per one day and repeat d) and e) alternately[4].

Note[4] When test cannot be operated due to a day off, the specimens shall be kept in the freezer.

g) After finished ten cycles of the test, the specimens of recycled aggregates shall be taken out from the containers and be in air-dried condition. Confirm all amount of specimens is ±1 % or under for the amount of before the test, sieve as same method as a) and measure the amount of each grain for 19 mm or over, 9.5 to 19 mm, 4.75 to 9.5 mm and 4.75 mm or under.

D.6 Calculation

The fineness modulus (FM) shall be calculated from grain size distribution of before and after the test. However it suppose all the grains of 4.75 mm or under remain on 2.36 mm sieve and calculate FM by following formula.

$$FM = \frac{(M_{20}+M_{10}+M_5)}{100} + 5.0$$

where, M_{20},M_{10},M_5 : amount percentage (%) of specimens remaining on the sieves of 19 mm, 9.5 mm, 4.75 mm. The value shall be in relation to total amount of specimens either before or after the test due to the timing.

The FM frost damage index shall be calculated by following formula.

$$\Delta FM = FM_a - FM_b$$

where, ΔFM : FM frost damage index

FM_a : fineness modulus before the test (FM)

FM_b : fineness modulus after the test (FM)

The FM frost damage index per one lot shall be calculated as mean value of the test results performed more than three times and rounded off to two decimal places.

D.7 Report

The report shall include the following information.

a) The location of manufacturing recycled aggregate

b) The maximum size of recycled coarse aggregate

c) The tested lot (manufacturing time)

d) The date of test

e) The FM frost damage index (the value of each time or the mean value for one lot)