

Annex A (normative)

Recycled aggregate M for concrete

A1. General

This Annex specifies the recycled aggregate M for concrete (hereafter referred to as “recycled aggregate M”) manufactured by treatment such as crushing, grinding and classification to the concrete lumps¹⁾ generated as a result, for example, of pulling down a building.

Moreover the original concrete shall include the product of which manufactured by crushing hardening lumps of returned ready mixed concrete. However the product which added water when it was fresh or crushed into gravel within a few days after discharged by carrier²⁾ shall be excluded.

Note ¹⁾ Concrete lumps are generated not only by pulling down buildings but also by hardening the concrete which returned from concrete products and ready mixed concrete.

²⁾ Due to not to handle significantly unhardened ones

A.2 Classification, division and designation

A.2.1 Classification

The classification of recycled aggregate M shall be in accordance with Table A.1.

Class	Symbol	Remarks
Recycled coarse aggregate M	RMG	Coarse aggregate prepared by giving the original concrete a high level treatment such as crushing and grinding, and performing grading as necessary.
Recycled fine aggregate M	RMS	Fine aggregate prepared by giving the original concrete a high level treatment such as crushing and grinding, and performing grading as necessary.

A.2.2 Division according to grain size

The division according to the grain size for recycled aggregate M shall be in accordance with table A.2.

Table A.2 Division according to grain size

Division	Grain size range	Symbol
	mm	
Recycled coarse aggregate M 4005 a)	40 to 5	RMG4005
Recycled coarse aggregate M 2505	25 to 5	RMG2505
Recycled coarse aggregate M 2005	20 to 5	RMG2005
Recycled coarse aggregate M 1505	15 to 5	RMG1505
Recycled coarse aggregate M 1305	13 to 5	RMG1305
Recycled coarse aggregate M 1005	10 to 5	RMG1005
Recycled coarse aggregate M 4020 a)	40 to 20	RMG4020
Recycled coarse aggregate M 2515	25 to 15	RMG2515
Recycled coarse aggregate M 2015	20 to 15	RMG2015
Recycled coarse aggregate M 2513	25 to 13	RMG2513
Recycled coarse aggregate M 2013	20 to 13	RMG2013
Recycled coarse aggregate M 2510	25 to 10	RMG2510
Recycled coarse aggregate M 2010	20 to 10	RMG2010
Recycled fine aggregate M	5 max.	RMS

Note a) To be restricted to the recycled aggregate which manufactured by original concrete using aggregates of which maximum size is 40 mm or over.

A.2.3 Division according to alkali-silica reactivity

The division according to the alkali-silica reactivity for recycled aggregate M shall be in accordance with table A.3.

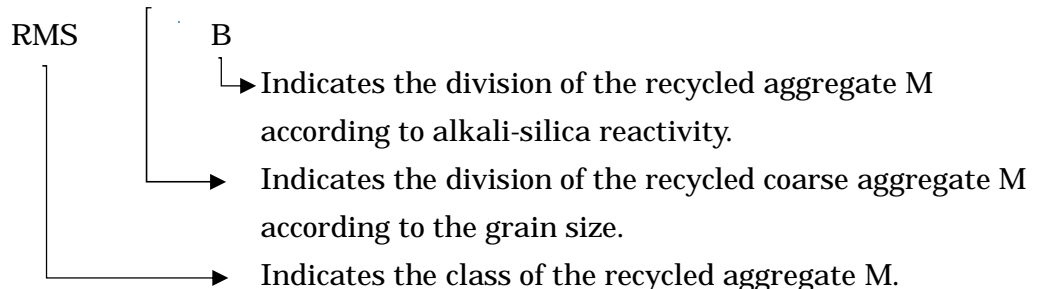
Table A.3 Division according to alkali-silica reactivity

Division	Remarks
A	The recycled aggregate judged as "harmless" in alkali-silica reactivity.
B	Other recycled aggregates than those judged as "harmless" in alkali-silica reactivity.

A.2.4 Designation

The designation of recycled aggregate M shall be as follows.

Example RMG 2005 A



A.3 Quality

A.3.1 Amount of impurities

The recycled aggregate M shall not contain harmful amount of impurities that may have an adverse effect on the quality of concrete. The amount of impurities shall satisfy the requirements in table A.4 when tested in accordance with A.5.2. The amount of aluminium pieces and zinc pieces shall be tested in accordance with A.5.3 and shall not exceed 5 mL in the amount of gas generation.

Table A.4 Upper limit of the amount of impurities

Classification	Contents of impurities	Upper limit a)
		%
A	Tiles, bricks, pottery and asphalt concrete lumps	1.0
B	Glass pieces	0.5
C	Gypsum and gypsum board pieces	0.1
D	Other inorganic board pieces than C	0.5
E	Plastics pieces	0.2 b)
F	Wooden pieces, bamboo pieces, cloth pieces, paper scraps and asphalt lumps	0.1
G	Metal pieces other than aluminium or zinc	1.0
	Total amount of impurities (total amount of impurities of A to G)	2.0
Notes a)	The upper limit is the value, expressed in mass ratio, of amount of impurity of each classification relative to the total amount of impurities.	
b)	Some types of plastic have a lower softening point and at elevated temperatures, they can adversely affect the quality of concrete. Therefore, when concrete is to be steam cured or autoclave cured, the upper limit for plastics piece should be set to 0.1 %.	

A.3.2 Physical properties

The recycled coarse aggregate M and recycled fine aggregate M shall conform to the requirements in Table A.5 when tested in accordance with A.5.4 and A.5.5. The tolerance on the density in oven-dry condition shall be $\pm 0.1 \text{ g/cm}^3$ for the value agreed between the manufacturer and the purchaser.

Table A.5 Physical properties

Test items		Recycled coarse	Recycled fine
		aggregate M	aggregate M
Density in oven-dry condition a)	g/cm^3	2.3 min.	2.2 min.
Water absorption	%	5.0 max.	7.0 max.
Content of material finer than 75 μm seive	%	2.0 max.	8.0 max.
Note a) Even in one of the test carried out in accordance with A.5.4, the result shall conform to the requirements in this table.			

A.3.3 Alkali-silica reactivity

A.3.3.1 Alkali-silica reactivity of recycled coarse aggregate M

When being in compliance with all of the following requirements, the alkali-silica reactivity of recycled coarse aggregate M shall be judged as harmless.

- a) All the original coarse and fine aggregates shall be identified.

“Identification of original aggregate” shall be given in Annex A of JIS A 5021.

- b) All the original coarse and fine aggregates or recycled coarse aggregate M shall be judged as harmless by the alkali-silica reactivity test given in A.5.7.

Alkali-silica reactivity test for original aggregate shall be carried out for every original aggregate specified at a).

A.3.3.2 Alkali-silica reactivity of recycled fine aggregate M

When being in compliance with all of the following requirements, the alkali-silica reactivity of recycled fine aggregate M shall be judged as harmless.

- a) All the original coarse and fine aggregates shall be identified. “Identification of original aggregate” shall be given in Annex A of JIS A 5021.

- b) All the original coarse and fine aggregates or recycled fine aggregate M shall be judged as harmless by the alkali-silica reactivity test given in A.5.7.

Alkali-silica reactivity test for original aggregate shall be carried out for every original aggregate specified at a).

A.3.4 Freeze thaw resistance of recycled coarse aggregate M

The freeze thaw resistance of recycled coarse aggregate M shall be evaluated as Table A.6 by the FM frost damage index in accordance with the test of A.5.6.

Class	FM frost damage index	Remarks
	Recycled coarse aggregate M	
	0.08 min.	available to use for frost damage resistance
		not available to use for frost damage resistance

A.3.5 Grain size

A.3.5.1 Grain size

The grain size of the recycled aggregate M shall be tested in accordance with A.5.8 and shall be within the range given in Table A.7. The manufacturer may consult with the purchaser to change the range of the mass fraction of those which pass the sieve for each division according to the grain size.

The specified range in Table A.7 is applicable to those retained on the sieve of nominal size

75 μm .

When the recycled coarse aggregate M shall be mixed with the coarse aggregate³⁾ conform to Annex A of JIS A 5308, the grain size of the mixed recycled coarse aggregate M shall be satisfied the designation given in recycled coarse aggregate M4005, recycled coarse aggregate M2505 or recycled coarse aggregate M2005.

When the recycled fine aggregate M shall be mixed with the fine aggregate³⁾ conform to Annex A of JIS A 5308, the grain size of the mixed recycled fine aggregate M shall be satisfied the designation given in recycled fine aggregate M.

Note ³⁾ The artificial lightweight aggregate shall be excluded among the aggregate conform to Annex A of JIS A 5308 (c.f. 8.2)

Table A.7 Grain size

Division	Mass fraction of those passing through sieve %												
	Nominal sieve size a) mm												
	50	40	25	20	15	13	10	5	2.5	1.2	0.6	0.3	0.15
Recycled coarse aggregate M4005	100	95 to 100		35 to 70			10 to 30	0 to 5					
Recycled coarse aggregate M2505		100	95 to 100		30 to 70			0 to 10	0 to 5				
Recycled coarse aggregate M2005			100	90 to 100			20 to 55	0 to 10	0 to 5				
Recycled coarse aggregate M1505				100	90 to 100		40 to 70	0 to 15	0 to 5				
Recycled coarse aggregate M1305					100	85 to 100		0 to 15	0 to 5				
Recycled coarse aggregate M1005						100	90 to 100	0 to 15	0 to 5				
Recycled coarse aggregate M4020	100	90 to 100	20 to 55	0 to 15			0 to 5						
Recycled coarse aggregate M2515		100	95 to 100		0 to 15		0 to 5						
Recycled coarse aggregate M2015			100	90 to 100	0 to 15		0 to 5						
Recycled coarse aggregate M2513		100	95 to 100			0 to 15	0 to 5						
Recycled coarse aggregate M2013			100	85 to 100		0 to 15	0 to 5						
Recycled coarse aggregate M2510		100	95 to 100				0 to 10	0 to 5					
Recycled coarse aggregate M2010			100	90 to 100			0 to 10	0 to 5					
Recycled fine aggregate M							100	90 to 100	80 to 100	50 to 90	25 to 65	10 to 35	2 to 15

Note a) The nominal sieve sizes in the table correspond to the nominal sieve apertures specified in JIS Z 8801-1, namely, 53mm, 3705 mm, 26.5 mm, 19 mm, 16 mm, 9.5 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 μm , 300 μm , and 150 μm , respectively.

A.3.5.2 Fineness modulus

The tolerance on the fineness modulus in the recycled aggregate M shall be ± 0.20 of the fineness modulus specified by the agreement between the manufacturer and the purchaser. Where the recycled coarse aggregate M shall be used by mixing with gravel, crushed stone, etc. or the recycled fine aggregate M shall be used by mixing with sand and crushed sand, etc., the manufacturer may relax the tolerance on the fineness modulus upon consultation with the purchaser.

A.3.5.3 Quantity which remains on continuous sieves

The recycled fine aggregate M shall be such that, in any of the sieves given in Table A.7, the difference from the volume which remains on the continuous sieve is not over 45 %.

A.3.6 Grain shape

The grain shape shall be as follows.

- a) The solid volume percentage for shape determination of the recycled coarse aggregate M shall be tested in accordance with A.5.9 and the result, including the tolerance, shall be at least 55 %. The tolerance to be applied shall be ± 1.5 % of the value specified by agreement between the manufacturer and the purchaser. When the recycled coarse aggregate M is used by mixing with gravel, crushed stone, etc., the manufacturer may relax the tolerance on solid volume percentage for shape determination upon consultation with the purchaser.
- b) The solid volume percentage for shape determination of the recycled fine aggregate M shall be tested in accordance with A.5.9 and the result, including the tolerance, shall be at least 53 %. The tolerance to be applied shall be ± 1.5 % of the value specified by agreement between the manufacturer and the purchaser. When the recycled fine aggregate M is used by mixing with sand, crushed sand, etc., the manufacturer may relax the tolerance on solid volume percentage for shape determination upon consultation with the purchaser.

A.3.7 Chloride content

The chloride content⁴⁾ in recycled aggregate M shall not exceed 0.04 % when tested in accordance with A.5.10. However, this maximum limit may be set at under 0.1 % if approved by the purchaser.

Note⁴⁾ Indicated as a value converted to NaCl.

A.4 Manufacture

A.4.1 Storage of original concrete

The original concrete shall be stored exactly classified in such a way as to prevent impurity incorporation and mixture with other materials.

A.4.2 Manufacture recycled aggregate M

The manufacture of recycled aggregate M shall be as follows.

- a) The original concrete showing evident signs of abnormalities that can be attributed to the aggregate, such as alkali-silica reactivity, shall not be used.

- b) The original concrete containing a lot of chloride shall not be used.
- c) The original concrete containing a number of impurities shall not be used.
- d) The original concrete not fully hardened shall not be used.
- e) The original concrete that is chemically contaminated shall not be used.
- f) For the original concrete, the light-weight aggregate concrete shall not be used.
- g) For the original concrete of recycled coarse aggregate using for the frost damage resistance of recycled aggregate concrete M, concrete which damaged by frost shall not be used.
- h) Sea water shall not be used for cleaning water.
- i) When any product other than the recycled aggregate M is manufactured at the same manufacturing facility, the recycled aggregate M shall be handled in such a way as to prevent impurity incorporation. The recycled aggregate M mixed with contamination shall not be handled as the recycled aggregate M.
- j) The recycled aggregate M of division A in alkali-silica reactivity shall be handled so as not to be mixed with the recycled aggregate M of division B during storage of the original concrete and at each stage of manufacture, storage and shipment of the recycled aggregate M.

A.4.3 Storage of recycled aggregate M

The recycled aggregate M shall be stored appropriately by division in such a way as to prevent segregation and mixture with other materials according to classification, division of grain size or division of alkali-silica reactivity.

A.5 Test method

A.5.1 Sampling of specimen

The specimen to be taken shall be a representative part of the recycled aggregate M and shall be reduced by a method given in JIS A 1158.

A.5.2 Test of amount of impurities

The test shall be in accordance with Annex B (Test method for impurities of recycled aggregate H by means of boundary sample) of JIS A 5021.

A.5.3 Test of aluminium pieces and zinc pieces

The test shall be in accordance with Annex C (Testing method of judgement for harmful amount of aluminium pieces and zinc pieces contained in recycled aggregate for concrete-class H) of JIS A 5021.

A.5.4 Test of density in oven-dry condition and percentage of water absorption

The test shall be performed in accordance with JIS A 1109 or JIS A 1110. The difference from the mean value of two tests may be $0.03\text{g}/\text{cm}^3$ or under for the density in oven-dry condition and 0.2 % or under for percentage of water absorption. At the test of density in oven-dry condition and water absorption for fine aggregate, the amount of specimen in one test may be 450g.

A.5.5 Test of content of materials finer than 75 μm sieve

The test shall be performed in accordance with JIS A 1103.

A.5.6 Test of freeze thaw for recycled coarse aggregate M

The method of freeze thaw test evaluating freeze thaw resistance of recycled coarse aggregate M shall be performed in accordance with Annex D.

A.5.7 Test of alkali-silica reactivity

The test shall be performed in accordance with JIS A 1145, JIS A 1146 or Annex D (Test method for alkali-silica reactivity of recycled aggregate for concrete class H) of JIS A 5021.

A.5.7.1 In test performed according to JIS A 1145

- a) The cement paste adhered to the original aggregate or recycled aggregate M shall be removed by dissolving with hydrochloric acid or the like and then washing with water prior to testing.
- b) The judgement shall be made based on the average of the determined values of the measurement items. In the range where the amount of dissolved silica (Sc) is 10mmol/L or over and the amount of alkali concentration decrease (Rc) is under 700mmol/L, and if the amount of dissolved silica (Sc) is less than the amount of alkali concentration decrease (Rc), the aggregate shall be judged as "harmless". However if the amount of dissolved silica (Sc) is equal to or greater than the amount of alkali concentration decrease (Rc) in the same range, the aggregate shall be judged as "not harmless". When the amount of dissolved silica (Sc) is under 10mmol/L and the amount of alkali concentration decrease (Rc) is under 700mmol/L, the aggregate shall be judged as "harmless". When the amount of alkali concentration decrease (Rc) is 700mmol/L or over, the aggregate shall not be judged.

A.5.7.2 In test performed according to JIS A 1146

- a) The cement paste adhered to the original aggregate or recycled aggregate M shall be remained for testing.
- b) When the average expansion coefficient of three specimens in 26 weeks is under 0.100 %, the aggregate shall be judged as "harmless" and when it is 0.100 % or greater, it shall be judged as "not harmless". When the aggregate shows expansion of 0.050 % or greater at the material age of 13 weeks, it shall be judged as "not harmless" at that point, and measurement at the material age of 26 weeks may be omitted.

A.5.7.3 In test performed according to Annex D of JIS A 5021

- a) The cement paste adhered to the original aggregate or recycled aggregate M shall be remained for testing.
- b) When the water absorption of recycled aggregate M is high and the mixing of mortar or the preparation of specimen is difficult, the preparation of test specimen may be supplied for the test in the surface dried state or in similar condition⁵⁾.
- c) When the specimen is in oven-dry condition or in air-dried condition, the water may be added into mixing of mortar for producing the surface dry condition of recycled aggregate M.

d) The mix proportion number and mix proportion of mortar shall be in accordance with one of the follows.

- 1) For measurement of ultrasonic propagation velocity or dynamic modulus of elasticity, the mix proportion number of mortar shall be one and the constitution ratio of fine aggregate shall be in accordance with the constitution condition 1 indicated in Table A.8. The mix proportion of mortar shall be in accordance with a) 2) of D.5.1 (mix proportion of mortar) of JIS A 5021
- 2) For measurement of change of length, the mix proportion number of mortar shall be four, with the constitution ratio of fine aggregate changed. The test shall be carried out with constitution condition 1 in Table A.8, and depending on the result, additional tests shall be carried out with the constitution conditions 2 to 4 as necessary. The mix proportion of mortar shall be in accordance with a) 2) of D.5.1 of JIS A 5021.

Table A.8		Constitution ratio and mass of fine aggregate (standard sand, test specimen)			
Constitution condition of fine aggregate	Constitution ratio of fine aggregate (mass ratio)		Mass of fine aggregate		
	Standard sand	Test specimen	Standard sand	Test specimen	Total
1	25	75	300	900	1,200
2	0	100	0	1,200	1,200
3	50	50	600	600	1,200
4	75	25	900	300	1,200

e) The judgement shall be as follows.

- 1) For measurement of ultrasonic propagation velocity or dynamic modulus of elasticity, the judgement shall be made on the rate of ultrasonic propagation velocity or the coefficient of relative dynamic modulus of elasticity which is the mean value of test results of three specimens of fine aggregate constitution condition 1 rounded off to an integer. When the conditions which the rate of ultrasonic propagation velocity is not less than 95 % and the coefficient of relative dynamic modulus of elasticity is not less than 85 % are satisfied, judgement shall be “harmless” and when not satisfied, judgement shall be “not harmless”.
- 2) For measurement of change rate of length, when the test results of three specimens of fine aggregate constitution condition 1 rounded off to two decimal places, is 0.07 % or less, judgement shall be “harmless” and when the value is exceeding 0.07 %, judgement shall be “not harmless”. However, when the change rate of length is exceeding 0.07 % but less than 0.10 %, additional tests shall be carried out with fine aggregate constitution

conditions 2 to 4 indicated in Table A.8, and if all the results of the fine aggregate constitution conditions 1 to 4 turn out to be under 0.10 %, judgement shall be “harmless”.

Note⁵⁾ The similar condition of surface dried state means the conditions of which removing most of surface water of specimen in infiltrating state by means of a centrifugal machine or so or adding the water into the testing specimens in oven-dry condition of which amount is as same as water absorption in the recycled aggregate M before crushing.

A.5.8 Test of sieve analysis

The test shall be performed in accordance with JIS A 1102.

A.5.9 Test of solid volume percentage for shape determination

The test shall be performed as follows.

- a) The specimens of the recycled coarse aggregate M shall be used recycled coarse aggregate M4005, recycled coarse aggregate M2505 and recycled coarse aggregate M2005, meanwhile the specimens of recycled coarse aggregate M in the other division shall be used the mixture which conform to the grain size of recycled coarse aggregate M2505 or recycled coarse aggregate M2505.

Well dry these specimens to an oven-dry condition.

Sieve 24 kg of 20 mm to 10 mm grains and 16 kg of 10 mm to 5 mm grains and mix them well and use as specimen for test.

The specimens of the recycled fine aggregate M shall be washed well and sieve nominal size 2.5 mm to 1.2 mm and dry them to an oven-dry condition.

- b) The bulk density of the specimens shall be obtained by the method specified in JIS A 1104.
- c) For the density in oven-dry condition of the specimen, the value obtained in A.5.4 shall be used.
- d) The solid volume percentage for shape determination shall be calculated by the following formula :

$$G = \frac{T}{d_D} \times 100$$

where, G : solid volume percentage for shape determination (%)

T : bulk density of the specimen (kg/L)

d_D : density in oven-dry condition (g/cm³)

A.5.10 Test of chloride content

The test shall be performed as either the followings.

- a) The test shall be in accordance with 5.5 of JIS A 5002. However the analysis of chloride content (chloride ion concentration) in the specimen shall be in accordance with Clause 4 (analyzing method) in JIS A 1144.

The quantity of the specimen shall be 1,000 g and the chloride content shall be four times

value of the test result.

- b) The test shall be in accordance with JIS A 1154.

A.6 Inspection

A.6.1 Inspection method

The inspection of recycled aggregate M shall be as follows.

- a) For inspection, the lot size shall be determined for each class by agreement between the manufacturer and the purchaser, the specimen shall be taken in accordance with a reasonable sampling plan, the test shall be carried out as specified in A.5 and those which conform to the requirements in A.3 shall be accepted.
- b) The maximum value of a lot shall be the less either 1,500 t or the amount which can be manufactured in two weeks.
- c) The density in oven-dry condition of the specimen shall be calculated in accordance with A.5.4.
- d) Alkali-silica reactivity for all types of original aggregate or recycled aggregate M shall be confirmed by the test given in A.5.7. However the maximum value of a lot in alkali-silica reactivity test or the target may be changed as shown in 1) to 3) blow depending on the condition.
 - 1) For recycled aggregate M which has been judged as harmless in three consecutive alkali-silica reactivity test, the maximum lot for the test after that may be set as of which can be manufactured in 1 month.
 - 2) For recycled aggregate M which shall be judged as harmless in alkali-silica reactivity of all classes of original coarse and fine aggregate by means of test certification, the maximum value of a lot in the alkali-silica reactivity test may be set as of which can be manufactured in 3 months.
 - 3) When all the original coarse and fine aggregates taken by original concrete has been judged harmless in the alkali-silica reactivity test in A.5.7, the alkali-silica reactivity test for recycled aggregate M can be omitted.
- e) The maximum value of a lot for freeze thaw test for recycled coarse aggregate M shall be the less either 500t or the amount that can be manufactured in one week. However if being in compliance with all of the following requirements, the maximum value of a lot may be the amount that can be manufactured in 3 months.
 - 1) All the original concrete shall be identified⁶⁾.
 - 2) All the original concrete shall be AE concrete.

Note ⁶⁾ If the class of original concrete, nominal strength, air content and the class of original aggregate can be identified by such as the work record of the demolished construction, the mix proportion report of the original concrete, the

test result certificate of the original aggregate, etc., the original aggregate is regarded as identified.

A.6.2 Preservation of inspection data

The manufacturer shall store the records of the test results obtained in the inspection for a specified period.

A.7 Marking

The marking shall be as follows.

- a) In the invoice of recycled aggregate M, the following information shall be given.
 - 1) Class and division (according to the designation in A.2.4)
 - 2) Name of manufacturer, name of manufacturing factory and its address
 - 3) Time of manufacture and date of shipment
 - 4) Mass or volume
 - 5) Name of the company and factory of consignee
- b) Address where the original concrete was produced. However if the original aggregate can be identified and also if necessary.

A.8 Report

The manufacturer shall present the test result certificate if requested by the purchaser. The standard format of the test result certificate shall be in accordance with Table A.9 or Table A.10.