

## **Use of Recycled Aggregates in Concrete for Minor Structures and Non-structural Works**

### **Introduction**

To reduce the pressure on the demand for public filling and landfill capacity, one of the means of resource conservation and waste minimisation is to recycle hard and inert construction and demolition materials, such as broken rock, recycled glass cullet and concrete, into aggregates and put them into good use. This practice note sets out the technical guidelines for using recycled aggregates in concrete of strength grade C20 to C35.

### **Technical Guidelines**

2. The technical guidelines for concrete strength grade C20 with 100% recycled aggregate is given in Appendix A, and that for concrete strength grade C25 to C35 with 20% recycled aggregate is given in Appendix B.
3. The above technical guidelines have made reference to the technical specifications developed by the Standing Committee on Concrete Technology (SCCT) and Highways Department (HyD) which were based on internationally recognised standards and results of laboratory tests done locally. They have been promulgated via Works Bureau Technical Circular No. 12/2002 (Technical Circular) for use amongst works departments.
4. Concrete producers in Hong Kong are also well aware of the Technical Circular through their Concrete Producers Association's meetings with SCCT when developing the specifications.

### **Applications**

5. Concrete of strength grade C20 with 100% recycled aggregate should only be used for minor structures or non-structural works. They may include, for example, on-grade slabs, blinding layer, U-channels/stepped channels, bedding and haunching for pipe works, concrete footings for posts and fences, and mass concrete fill which does not sustain appreciable loading.
6. Concrete of strength grade C25 to C35 with a maximum of 20% recycled aggregates may be used for the following applications that do not have major structural concern:
  - (a) concrete or reinforced concrete landscape features such as planters and planter walls, fence walls, mass concrete walls and footings for supporting landscape features;

- (b) storm water manholes and sand traps; and
- (c) footways, cycle tracks, reinforced concrete infill walls and mass concrete under footings or rafts.

7. Where recycled aggregates are used in precast concrete paving units for surfacing of pedestrian ways, service lanes and footpaths, the requirements of HyD including the guidance and particular specifications contained in the “Guidance Notes on Design and Construction of Pavements with Paving Units” published by HyD<sup>1</sup> should be followed.

8. Concrete with recycled aggregates should **not** be used in liquid-retaining structures, pre-stressed concrete structures, transfer structures or hanger structures.

9. Where concrete with recycled aggregates is used in building works, it should be clearly stated on the plan that contains general structural specifications and in the Part I structural calculations. Reference should be made to PNAP ADM-8 in this respect. A statement should also be made on the plan that the proposed use of concrete with recycled aggregates should strictly comply with the technical guidelines given in Appendices A and/or B to this practice note. The scope of the works involving the use of recycled aggregates should also be indicated on the relevant structural plans.

10. Other requirements governing the use of concrete in structures are also applicable to concrete with recycled aggregates.

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<sup>1</sup> [https://www.hyd.gov.hk/en/technical\\_references/technical\\_document/guidance\\_notes/pdf/gn044b.pdf](https://www.hyd.gov.hk/en/technical_references/technical_document/guidance_notes/pdf/gn044b.pdf)

## **Technical Guidelines for Concrete with 100% Recycled Coarse Aggregates**

### **Scope**

This set of technical guidelines is only applicable to concrete strength grade C20.

### **Applications**

2. Concrete with 100% recycled coarse aggregates should only be used for minor structural or non-structural works.

### **General requirements**

3. The design, construction and quality control of concrete should comply with the relevant provisions of the Code of Practice for Structural Use of Concrete 2013.

### **Recycled coarse aggregates**

4. Recycled coarse aggregates should be produced by crushing old concrete and should meet the requirements in Table 1 below.

### **Fine aggregates**

5. Fine aggregates should be within the limits of grading M specified in the Construction Standard CS3:2013 (CS3). Fine aggregate derived from recycled concrete should not be used.

### **Grading**

6. The grading of the coarse aggregates should comply with the limits in CS3 for single-sized 20 mm and 10 mm aggregates.

### **Mix proportions**

7. Concrete should be mixed in the following proportions:

- (a) Ordinary portlandcement: 100 kg;
- (b) Fine aggregates: 180 kg;
- (c) 20 mm coarse aggregates: 180 kg; and
- (d) 10 mm coarse aggregates: 90 kg.

/Workability...

## Workability

8. Recycled coarse aggregates should be thoroughly wetted before being used. The concrete should have a slump of 75 mm when it is ready to be compacted to its final position.

## Test cubes

9. The sampling rate, making, curing and testing of concrete should comply with Construction Standard CS1:2010 (CS1).

## Minimum strength

10. The minimum concrete cube strength should be 14 MPa and 20 MPa at 7 and 28 days respectively.

## Trials

11. Laboratory trials should be conducted to confirm that the strength requirement can be met before the mix is used in the works. The 28-day strength of each of the 3 cubes in the trial should not be less than 26 MPa.

<b>Mandatory Requirements</b>	<b>Limits</b>	<b>Testing Method</b>
Minimum dry particle density (kg/m <sup>3</sup> )	2000	Section 17 of CS3
Maximum water absorption	10%	Section 17 of CS3
Maximum content of wood and other material less dense than water	0.5%	Manual sorting in accordance with BRE Digest 433
Maximum content of other foreign materials (e.g. metals, plastics, clay lumps, asphalt and tar, and glass)	1%	
Maximum fines	4%	Section 10 of CS3
Maximum content of sand (<4mm) (% m/m)	5%	Section 10 of CS3
Maximum content of sulphate (% m/m)	1%	Section 21 of CS3
Flakiness index	40%	Section 11 of CS3
10% fines test	100 kN	Section 16 of CS3
Grading	Table 3.1 of CS3	
Maximum Chloride content	Clause 5.2.3 of CS3 – 0.05% by mass of chloride ion of combined aggregate	

**Table 1: Requirements on recycled coarse aggregates**

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## **Technical Guidelines for Concrete with 20% Recycled Coarse Aggregates**

### **Scope**

This set of technical guidelines is only applicable to concrete strength grade C25 to C35.

### **Applications**

2. Concrete with 20% recycled coarse aggregates may be used for applications specified in this practice note. This type of concrete should not be used in liquid-retaining structures, pre-stressed concrete structures, transfer structures or hanger structures.

### **General requirements**

3. The design, construction and quality control of concrete should comply with the relevant provisions of the Code of Practice for Structural Use of Concrete 2013.

### **Cementitious material**

4. Only ordinary portland cement to BS EN 197-1 should be used.

### **Coarse aggregates**

5. Coarse aggregates should consist of 80% natural mineral aggregates as defined in CS3. Recycled coarse aggregates should be produced by crushing old concrete and should meet the requirements in Table 1 below. Tests on recycled aggregates from a particular source should be carried out at weekly intervals to check compliance with Table 1 below.

### **Fine aggregates**

6. Fine aggregate should comply with CS3. Fine aggregate recycled from old concrete should not be used.

### **Grading**

7. The grading of the coarse aggregates should comply with the limits in CS3 for single-sized 20 mm and 10 mm aggregates.

/Workability...

## Workability

8. Recycled coarse aggregates should be thoroughly wetted before use. The concrete should have a minimum slump of 75mm when it is ready to be compacted to its final position.

## Laboratory mix trials and plant trials

9. Before any concrete is produced for use in the works, laboratory trials and plant trials should be performed to meet the compliance criteria as specified in the Annex.

## Concrete batching

10. Recycled coarse aggregates should be stored in separate stockpiles or silos to prevent inadvertent mixing with natural aggregates. A separate compartment should be provided for recycled coarse aggregates in the batching plant.

## Acceptance criteria for compressive strength

11. Concrete should be tested in accordance with CS1 for compliance with the specified grade strength in accordance with the Code of Practice for Structural Use of Concrete 2013.

<b>Mandatory Requirements</b>	<b>Limits</b>	<b>Testing Method</b>
Minimum dry particle density (kg/m <sup>3</sup> )	2000	Section 17 of CS3
Maximum water absorption	10%	Section 17 of CS3
Maximum content of wood and other material less dense than water	0.5%	Manual sorting in accordance with BRE Digest 433
Maximum content of other foreign materials (e.g. metals, plastics, clay lumps, asphalt and tar, and glass)	1%	
Maximum fines	4%	Section 10 of CS3
Maximum content of sand (<4mm) (% m/m)	5%	Section 10 of CS3
Maximum content of sulphate (% m/m)	1%	Section 21 of CS3
Flakiness index	40%	Section 11 of CS3
10% fines test	100 kN	Section 16 of CS3
Grading	Table 3.1 of CS3	
Maximum Chloride Content	Clause 5.2.3 of CS3 – 0.05% by mass of chloride ion of combined aggregate	

**Table 1: Requirements on recycled coarse aggregates**

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**Laboratory Mix Trials and Plant Trials for Concrete  
with 20% Recycled Coarse Aggregates**

**Laboratory mix trials**

Laboratory mix trials should be made in the laboratory using the proposed mix designs and constituents.

2. Laboratory mix trials should be carried out in accordance with Section 11 of CS1. Three separate batches should be made, each of sufficient size to provide samples for two slump tests and to make six 100 mm or 150 mm test cubes.
3. Two slump tests in accordance with CS1 should be performed on separate specimens from each batch of laboratory trial mix concrete.
4. Six 100 mm or 150mm test cubes should be made from each batch of concrete, stored, cured and tested for compressive strength at 28 days in accordance with CS1.

*Compliance criteria*

5. When test data relating to the proposed plant or plants show that the plant standard deviation exceeds 5.5 MPa for 100 mm test cubes or 5 MPa for 150 mm test cubes, or in the absence of acceptable data, the results of tests on laboratory mix trial concrete should comply with the following requirements:
  - (a) The average of the six slump values should be within 20 mm or 25%, whichever is the greater, of the design slump value; and
  - (b) The average compressive strength at 28 days of the 18 test cubes should exceed the grade strength by at least 14 MPa for 100 mm test cubes or 12 MPa for 150 mm test cubes, and the compressive strength of each individual test cube should exceed the grade strength by at least 7 MPa for 100 mm test cubes or 6 MPa for 150 mm test cubes.
6. When test data relating to the proposed plant or plants show that the plant standard deviation does not exceed 5.5 MPa for 100 mm test cubes or 5 MPa for 150 mm test cubes and the data are considered acceptable, the results of tests on laboratory mix trial concrete should comply with the following requirements:
  - (a) The average of the six slump values should be within 20 mm or 25%, whichever is the greater, of the design slump value; and

/(b) ...

- (b) The average compressive strength at 28 days of the 18 test cubes should exceed the grade strength by at least 10 MPa for 100 mm test cubes or 8 MPa for 150 mm test cubes, and the compressive strength of each individual test cube should exceed the grade strength by at least 3 MPa for 100 mm test cubes or 2 MPa for 150 mm test cubes.

### **Plant trials**

7. Plant trials should be made using the proposed plants and the proposed mix designs and constituents.

8. One batch of concrete of the proposed mix design should be made on each of three days in each proposed plant. The batch should be at least 60% of the mixer's nominal capacity. If the concrete is batched in a central plant and mixed in a truck mixer, three different truck mixers should be used.

9. Three samples of concrete should be provided from each batch at approximately 1/6, 1/2 and 5/6 of the discharge from the mixer. Each sample should be of sufficient size to perform a slump test and two 100 mm or 150 mm test cubes. The method of sampling should be as stated as in CS1.

10. Each sample taken in accordance with paragraph 9 above should be tested to determine its slump value in accordance with CS1.

11. Two 100 mm or 150 mm test cubes should be made from each sample taken in accordance with paragraph 9 above and stored, cured and tested to determine the compressive strength at 28 days in accordance with CS1.

#### *Compliance criteria*

12. The results of tests on concrete taken from plant trials should comply with the following requirements:

- (a) The average of the nine slump values should be within 20 mm or 25%, whichever is the greater, of the designed slump value;
- (b) The range of the three slump values for each batch of concrete should not exceed 20% of the average of the three slump values for that batch;
- (c) The average compressive strength at 28 days of the 18 test cubes should exceed the grade strength by at least 12 MPa for 100 mm test cubes or 10 MPa for 150 mm test cubes, and the compressive strength of each individual test cube should exceed the grade strength by at least 5 MPa for 100 mm test cubes or 4 MPa for 150 mm test cubes; and

/(d)...



- (d) The range of the compressive strength of the six test cubes from each batch of concrete should not exceed 20% of the average compressive strength of the six test cubes from that batch.

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