Australian Standard®

# Methods of test for supplementary cementitious materials

# Method 6: Determination of relative water requirement and strength index



## PREFACE

This Standard was prepared by the Standards Australia Committee BD-031, Supplementary Cementitious Materials to supersede AS 3583.6—1995, *Methods of test for supplementary cementitious materials for use with portland cement*, Method 6: *Determination of relative water requirement and relative strength.*

## METHOD

### 1 SCOPE

This Standard sets out the reference method for determining the relative water requirement and two methods, one the standard test and the other an accelerated test, for determining the strength index of fly ash and slag only. Both properties are determined by comparing results for a test sample mortar with results for a General Purpose cement mortar. The methods do not provide a basis for comparison between different types of supplementary cementitious materials because of the differing total binder volumes used with each. Also, since the performance of these materials is affected by interaction with the cement, the test results for a given sample are dependent upon the properties of the cement used. The results for relative water requirement and strength index should not be used to infer potential concrete performance.

Relative water requirement and strength index for amorphous silica should be performed according to the appropriate method given in ASTM C1240 Standard Specification for Silica Fume Used in Cementitious Mixtures.

### 2 REFERENCED DOCUMENTS

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

AS

2350 Methods of testing portland, blended and masonry cements

2350.12 Method 12: Preparation of a standard mortar and moulding of specimens

2701 Methods of sampling and testing mortar for masonry construction

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AS

3582 Supplementary cementitious materials
3582.1 Part 1: Fly Ash
3582.2 Part 2: Slag—Ground granulated blast-furnace

3972 General purpose and blended cements

AS/NZS
2350 Methods of testing portland, blended and masonry cements
2350.11 Method 11: Compressive strength

ASTM
C1240 Standard Specification for Silica Fume Used in Cementitious Mixtures

## 3 DEFINITIONS

For the purpose of this Standard the definitions given below apply.

### 3.1 Control mortar

A mortar prepared using a selected General Purpose cement without addition of supplementary cementitious material.

### 3.2 Test mortar

A mortar prepared using a mixture of the test material and the General Purpose cement used for the control mortar.

## 4 PRINCIPLE

### 4.1 Relative water requirement

A control mortar is prepared using the amount of water required to give a specified flow. A test mortar having the same flow is prepared and the relative water requirement is calculated from the ratio of the water additions for the respective mixes.

### 4.2 Strength index

Compressive strength determinations are performed on prismatic specimens made from control and test mortars prepared in the same manner as for the determination of the relative water requirement.

The strength index of the test sample is calculated by expressing the test mortar strength as a percentage (%) of the control mortar strength.

## 5 APPARATUS

The following apparatus is required:

(a) All apparatus as specified in AS/NZS 2350.11 and AS 2350.12.

(b) Flow table, callipers and tamping rod, as specified in AS 2701.

(c) Water bath for accelerated test. A water bath capable of being maintained at 50 ±1°C for a minimum time period of 46 ±0.5 h.

## 6 MATERIALS

Standard sand and water as specified in AS 2350.12. The cement used shall be General Purpose (Type GP) cement conforming with AS 3972. The same sample of cement shall be used for control and test mortars.

## 7 PREPARATION

### 7.1 General

In the determination of relative water requirement and strength index, results for the test mortar are related to results for the control mortar. It is therefore necessary to prepare a control mortar on each day that one or more test mortars are prepared.

### 7.2 Control mortar

A batch of control mortar shall consist of 450 ±2 g of cement, 1350 ±2 g of sand and sufficient water to achieve a flow of 110 ±5% when determined in accordance with AS 2701 (nominally 210 g water).

### 7.3 Test mortar

Slag and fly ash shall be prepared in accordance with Table 1.

A batch of test mortar shall consist of the quantities of Type GP cement and a test sample of slag or fly ash as shown in Table 1, 1350 ±2 g of standard sand, and sufficient water to achieve a flow within ±3 units of the flow recorded for the control mix.

**TABLE 1**

**PROPORTIONS OF TEST MORTARS**

| | Slag sample<br>g | Fly ash sample<br>g |
|---|---|---|
| General Purpose cement (Type GP) | 225 ±1 | 360 ±1 |
| Test sample (see Note 1) | 77 × relative density of the slag | 65 × relative density of the fly ash (see Note 2) |

NOTES:

1 The test sample calculations shown here incorporate the multipliers previously used for slag and fly ash. This results in test samples of different supplementary cementitious material types having different total binder volumes.

2 The proportions of Type GP cement and fly ash are designed to produce a mortar having the same absolute volume of dry materials as for a control mortar but with partial sand replacement. Material quantities have been increased to avoid the need to split a standard 1350 g bag of sand.

### 7.4 Strength index test specimens

Two sets of test specimens shall be prepared, one from a control mortar batch and the other from a test mortar batch. Fresh batches of mortar shall be prepared containing the quantities of water used to achieve the required flow as recorded in the procedure clauses of this Standard.

## 8 PROCEDURE

### 8.1 General

Materials and apparatus for preparing mortars shall be at laboratory temperature as specified in AS 2350.12.

### 8.2 Control mortar

The procedure shall be as follows:

(a) Mix the batch of mortar as described in AS 2350.12.

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(b) Measure the flow of the mortar as described in AS 2701. If the flow is not within the range 110 ±5%, the mortar shall be discarded and a new batch prepared with an adjusted water content.

(c) Provided the flow is in the range 110 ±5%, record the mass of water used and the flow.

(d) Discard the mortar batch used to determine the flow.

### 8.3 Test mortar

The procedure shall be as follows:

(a) Mix the batch of mortar as described in AS 2350.12.

(b) Measure the flow of the mortar as described in AS 2701. If the flow is not within three units of the flow recorded for the control mortar, the mortar shall be discarded and a new batch prepared with an adjusted water content.

(c) Provided the flow is within three units of the figure recorded for the control mortar, record the mass of water used and the flow.

(d) Discard the mortar batch used to determine the flow.

### 8.4 Strength index specimens

The procedure shall be as follows:

(a) Prepare, mix and cure each set of three specimens as described in AS/NZ 2350.11 and AS 2350.12, using the water contents determined in Clauses 8.2 and 8.3 above.

(b) Demould each set of specimens as described in AS/NZ 2350.11.

(c) For a standard test, cure the specimens in lime saturated water at 23 ±2°C, as described in AS/NZ 2350.11, before testing at an age of 28 days (see Note 1).

(d) For an accelerated test, after initial 24 h curing in the humidity cabinet, cure the specimens in lime saturated water at 23 ±2°C, as described in AS/NZS 2350.11 for 4 days ±1 h. Remove and immerse the specimens in a water bath at 50 ±1°C for 46 h ±0.5 h. Remove and condition the specimen in water at 23 ±2°C for 2 h ±0.25 h before testing at age seven days (see Note 2).

NOTES:

1 Caution should be exercised when attempting to correlate results between 28 day and 7 day (accelerated) results. Where possible, 28 day results should be used — they are more reliable.

2 Specimens from both the control mortar and the test mortar should be subjected to the same curing regime.

### 8.5 Compressive strength testing

The procedure shall be as follows:

(a) Determine the compressive strength of a set of specimens as described in AS/NZS 2350.11.

(b) Record the mean compressive strength for each set of specimens.

## 9 CALCULATION

### 9.1 Relative water requirement

The following calculations shall be made:

(a) *Slag samples* The relative water requirement is calculated as follows:

$$\text{Relative water requirement} = \frac{m_t}{m_c} \times 100 \qquad \ldots 9.1(1)$$

where

$m_t$ = mass of water used in test mortar, in grams

$m_c$ = mass of water used in control mortar, in grams

(b) *Fly ash samples* The relative water requirement is calculated as follows:

$$\text{Relative water requirement} = \frac{m_t}{m_c} \times 0.95 \times 100 \text{ (see Note)} \quad \ldots 9.1(2)$$

where

$m_t$ = mass of water used in test mortar, in grams

$m_c$ = mass of water used in control mortar, in grams

NOTE: The factor 0.95 is needed because the quantities of Type GP cement, fly ash, and water for fly ash test mortar are increased to account for the partial sand replacement. See Note 2 to Table 1.

### 9.2 Strength index

The following calculations shall be made:

(a) *Standard cured test* The strength index at 28 days ($R_{28}$) is calculated as follows:

$$\text{Strength index}\left(R_{28}\right) = \frac{T_{28}}{C_{28}} \times 100 \quad \ldots 9.2(1)$$

where

$T_{28}$ = mean compressive strength of test mortar at 28 days, in MPa

$C_{28}$ = mean compressive strength of control mortar at 28 days, in MPa

(b) *Accelerated test* The strength index at 7 days ($R_{7A}$) is calculated as follows:

$$\text{Strength index}\left(R_{7A}\right) = \frac{T_{7A}}{C_{7A}} \times 100 \quad \ldots 9.2(2)$$

where

$T_{7A}$ = mean compressive strength of the accelerated test mortar at 7 days, in MPa

$C_{7A}$ = mean compressive strength of control mortar at 7 days, in MPa

## 10 REPORT

The report shall include the following details:

(a) Identification of sample, in accordance with AS 3582.1 or AS 3582.2 as appropriate, including its origin.

(b) Source of General Purpose (Type GP) cement used in control mortar.

(c) Test method used, i.e. this Method (AS 3583.6).

(d) Result of the calculation expressed as a percentage to the nearest whole number.

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NOTES

NOTES

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