

# NZTA T20: 2020

Procedure for the Ethylene Glycol Accelerated Weathering Test

# 1 Preamble

This test method has been developed to assess the durability of aggregates for pavement construction. It is based on elements of NZS 4407 Test 3.10 (The Crushing Resistance of Coarse Aggregate under a Specified Load) and AS 1141.22 (Methods for sampling and testing aggregates - Wet/Dry strength variation). The method also uses laboratory equipment and methods described in other parts of NZS 4407 so users are advised to read this method in conjunction with NZS 4407.

## 2 Scope

This method specifies a procedure for determining the quantity of fines produced by the crushing of aggregate in both oven dry (unsoaked) and saturated surface dry (ethane-1, 2-diol soaked) conditions, at a specified load of 230kN. The proportional change in the percentage of fines between soaked and unsoaked test specimens is then calculated and used as an estimate of aggregate durability.

**Note:** The soaking medium is properly referred to as ethane-1, 2-diol, but more commonly known as ethylene glycol.

## 3 Related Documents

- (a) Standards New Zealand NZS 4407 Methods of Sampling and Testing Road Aggregates.
- (b) Standards Australia AS 1141.22 Methods for Sampling and Testing Aggregates, Method 22 Wet/Dry Strength Variation.
- (c) ASTM International (ASTM) D2693 Standard Specification for Ethylene Glycol.

## 4 Apparatus

The following apparatus is required:

- (a) A drying oven of appropriate size complying with the requirements of NZS 4407.
- (b) An open-ended steel cylinder, plunger, and square base plate complying with the dimensions indicated in Figure 1 for a nominal 150mm diameter cylinder. The surfaces in contact with the aggregate shall be machined and case-hardened, or otherwise treated, to resist wear.
- (c) A round straight steel rod of 16mm nominal diameter and 450mm to 600mm long with one end rounded to a hemispherical tip.
- (d) A balance, readable and accurate to 0.2% of the mass of the test sample.
- (e) An appropriate range of test sieves and receivers to cover the size fractions present in the sample.
- (f) A compression testing machine capable of applying a load of 500kN and complying with the requirements of Grade 2.0 of BS EN ISO 7500-1 for accuracy. The machine shall have a means of loading rate control which will allow the application, at uniform rate, of the specified load in  $10 \pm 1$  min.
- (g) Container with sealable lid. Container will be glass or suitable plastic, nonreactive with the reagent of sufficient size to hold the aggregate and reagent filled to 50mm above the aggregate particles.
- (h) Metal trays of sufficient size.

## 5 Reagents

- (a) Ethane-1, 2-diol (monoethylene glycol, ethylene glycol) of purity 99.5% or better complying with ASTM D2693.

**Note:** Consult material safety sheets regarding personal protective equipment requirements and establish safe responsible procedures when working, storing and disposing of ethylene glycol.

## 6 Preparation of Test Specimens

Prepare the test specimens as follows:

- (a) By quartering or by means of a sample divider obtain a test sample sufficient to produce four test specimens as required in clause 7 below.
- (b) Wash the test sample thoroughly with potable water and dry at 105°C to 110°C in the drying oven to constant mass. The sample shall be deemed to be dry when the change in mass of the sample after successive drying periods of 4 hours does not exceed 0.1% of the dry mass of the aggregate. Remove the test sample from the oven and allow it to cool to room temperature. Sieve from the test sample sufficient material passing a 13.2mm sieve and retained on a 9.50mm sieve to provide, after tamping as described in 7(a) a depth of 100mm ± 5mm in the steel cylinder. During this sieving ensure that the mass retained on each sieve does not exceed that permitted in Table 1.

## 7 Test Procedure

### 7.1 Preparation of Test Specimens

Use the following procedure:

- (a) Place the steel cylinder of the test apparatus centrally on the baseplate. Add the first test specimen in three approximately equal portions, each third being subjected to 25 strokes from the tamping rod to a final depth of 100mm ± 5mm in the cylinder.
- (b) Remove the aggregate from the mould, determine its mass to the nearest 1g and record as  $M_A$ .
- (c) Prepare an additional three test specimens of aggregate of mass  $M_A \pm 10g$  as determined in (b) above. Where there is no significant breakdown during the preparation, obtain the test specimens by quartering or riffing. Where there is significant breakdown, obtain the test specimens by quartering only. Two of the test specimens will be tested dry as in 7.2 below and the other two test specimens will be tested after soaking as in 7.3 below.
- (d) Place all test specimens in sealed and labelled containers and store until ready for testing.

### 7.2 Crushing of Control Specimens (Dry Condition)

Two test specimens shall be tested in accordance with the following procedure:

- (a) Charge the test cylinder as in 7.1(a) above and then carefully level the surface of the aggregate. Insert the plunger so that it rests horizontally on the surface.
- (b) Place the apparatus, with the specimen and plunger in position, between the platens of the testing machine. Apply load at a uniform rate so that the 230kN (or otherwise specified) load is reached in  $10 \pm 1$  minutes.
- (c) After the specified loading has been reached return the machine to zero and remove the cylinder.
- (d) Extract the whole of the test specimen from the cylinder by tapping the outside of the cylinder with the tamping rod, collecting the specimen in a metal tray. Take care to ensure there is no loss of material during this extraction process. A brush can be used to ensure all remaining particles attached to the walls of the metal mould are transferred into the tray.
- (e) Weigh the total specimen to 1g ( $M_B$ ) and then sieve it over the 2.36mm sieve until not more than 0.2% of the mass of the residue passes in 1 minute. Weigh the fraction passing the 2.36mm sieve to 1g and record this as  $M_C$ .
- (f) Repeat the process described above for the second sample.

## 7.3 Crushing of Soaked Specimens (Saturated Surface Dry)

Two test specimens shall be tested in accordance with the following procedure:

- (a) Immerse the test specimen in ethylene glycol such that there is at least 30mm of the ethylene glycol above the test specimen. Place a lid on the soaking container and maintain it room temperature for 21 days.
- (b) During the 21 day soaking process, periodically carefully agitate the container with the test specimen in it to release any trapped air bubbles.
- (c) Remove the test specimen from the container after 21 days of soaking and drain the specimen over a 0.075mm sieve protected by a 4.75mm sieve.
- (d) Transfer all material retained on the 0.075mm and 2.36mm sieves into a large flat tray for drying purposes. The flat tray can be placed at a slight angle to assist with the initial draining of any excess ethylene glycol. Potable water can be used to wash any fines on the 0.075mm sieve on to the tray.

**Note:** The ethylene glycol will only be used for a single test and not re-used.

- (e) Air dry the sample back to a saturated surface dry condition and test within 48 hours after draining. The individual particles of the test specimen should be well spread out not to overlap and can be moved around to hasten the drying process. A fan may be used to assist drying.

**Note:** The saturated surface dry aggregate will have a damp appearance from the ethylene glycol evaporation but no free ethylene glycol will be present.

- (f) Repeat step 7.1(a) above and then carefully level the surface of the aggregate and insert the plunger so that it rests horizontally on the surface. Care should be taken to ensure all particles that may have broken down during the soaking and drying process are placed into the steel cylinder. A brush may be used to transfer all remaining particles in the drying flat tray to the steel cylinder.
- (g) Repeat step 7.2(b).
- (h) Repeat step 7.2(c).
- (i) Repeat step 7.2(d).
- (j) Place the test specimen in an oven in a well-ventilated place at a temperature not exceeding 90°C for a period of approximately 24 hours so that the majority of remaining ethylene glycol is evaporated from the specimen.

**Note:** Ethylene glycol has a flash point of 110°C.

- (k) Increase the temperature of the oven so that final drying of the sample will be completed at 105°C to 110°C. The test specimen shall be deemed to be dry when the change in mass of the sample after successive drying periods of 4 hours does not exceed 0.1% of the dry mass of the aggregate.
- (l) Weigh the total specimen to 1g ( $M_D$ ) and then sieve it over the 2.36mm sieve until not more than 0.2% of the mass of the residue passes in 1 minute. Weigh the fraction passing the 2.36mm sieve to 1g and record this as ( $M_E$ )
- (m) Repeat the process described above for the second sample.

## 8 Calculations

- (a) For each of the dry condition specimens calculate the percentage by mass passing the 2.36mm sieve using the equation below:

$$A_n = \frac{M_C}{M_B} \times 100 \quad (\%)$$

- (b) Calculate the mean percentage passing the 2.36mm sieve for the two dry condition specimens using the equation below:

$$A_{mean} = \frac{A_1 + A_2}{2} \quad (\%)$$

- (c) For each of the soaked specimens calculate the percentage by mass passing the 2.36mm sieve using the equation below:

$$B_n = \frac{M_E}{M_D} \times 100 \quad (\%)$$

- (d) Calculate the mean percentage passing the 2.36mm sieve for the two soaked specimens using the equation below:

$$B_{mean} = \frac{B_1 + B_2}{2} \quad (\%)$$

- (e) Calculate the proportional change in the mean percentage fines from the soaked and mean percentage fines for the dry samples from the following equation, reported to 0.1 %.

$$C = \frac{B_{mean} - A_{mean}}{A_{mean}} \times 100 \quad (\%)$$

**Note:** A negative value for C shall be reported as zero.

## 9 Reporting of Results

The following shall be reported:

- The specified load.
- The aggregate size fraction tested.
- The number of days the saturated surface dry test specimens were soaked.
- The percentage fines for each test sample and the mean percentage fines achieved for the dry and saturated surface dry test specimens at the specified load to 0.1%.
- The proportional change to 0.1%.

State the following:

- The date of the test.
- The source and description of the field sample.
- The sampling method used, including the clause number and description, if known. For example, "NZS 4407, method 2.4.7 Sampling From Freshly Spread Layers".
- The condition of the field sample as received for testing.
- That the result was obtained in accordance with this test method.

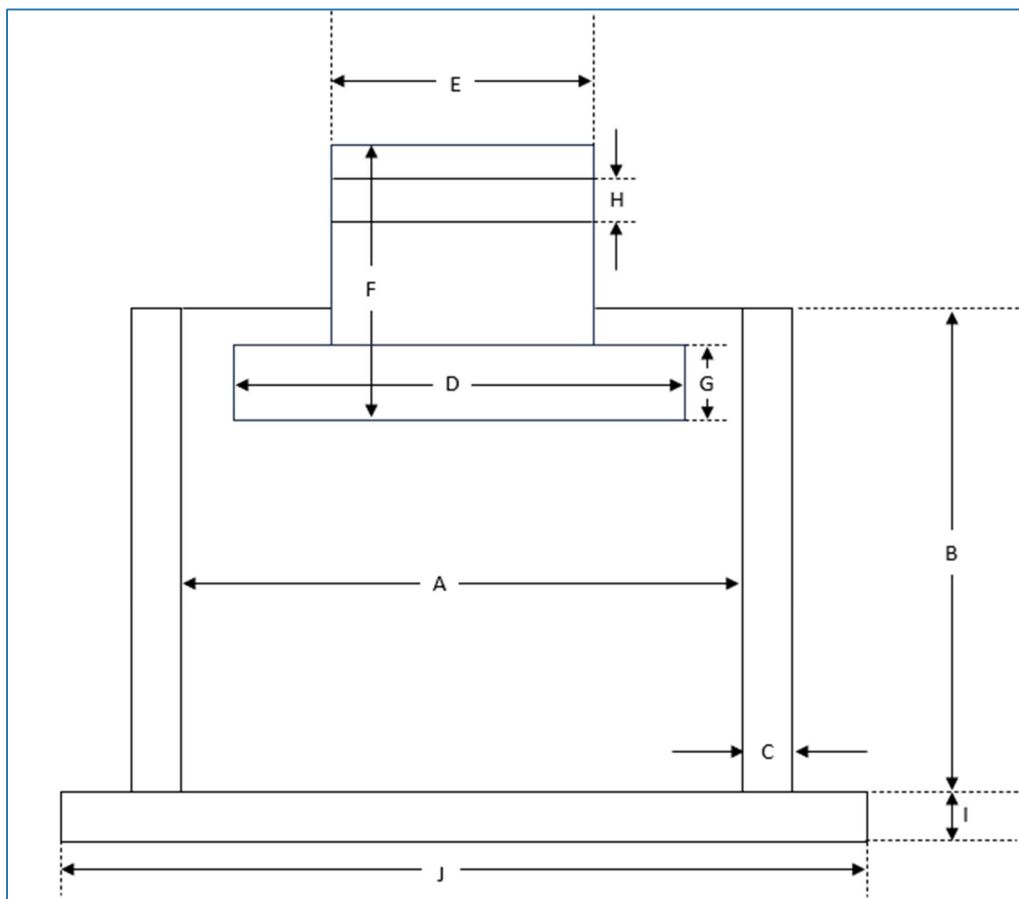
**Table 1 Maximum mass of material to be retained on each test sieve at completion of sieving**

Test sieve aperture size (mm)	Maximum mass of material to be retained on sieves of diameter shown		
	450 mm diameter	300 mm diameter	200 mm diameter
106	15kg	--	--
63.0	12kg	--	--
53.0	10kg	4.5kg	--
37.5	8kg	3.5kg	--
26.5	6kg	2.5kg	--
19.0	4kg	2.0kg	1000g
13.2	3kg	1.5kg	600g
9.50	2kg	1.0kg	450g
6.70	1.5kg	0.7kg	300g
4.75	1.0kg	0.5kg	250g
2.36	0.5kg	0.3kg	150g

Table 2 Test conditions for aggregate size

Nominal size of aggregate		Nominal diameter of cylinder to be used (mm)	Depth of test portion in cylinder after tamping (mm)	Aperture size sieve for separating fines (mm)
Passing (mm)	Retained (mm)			
13.2	9.50	150	100 ± 5	2.36

Figure 1 – Apparatus for determining crushing resistance of coarse aggregate



Identification	Dimension for	Nominal cylinder diameter (mm)
		150
<b>Cylinder</b>		
A	Internal diameter *	153, +1.5, -0
B	Internal depth	120 - 140
C	Wall thickness	16 minimum
<b>Plunger</b>		
D	Diameter of piston *	151, +1.5, -0
E	Diameter of stem	95 - 120
F	Overall length of piston plus stem	95 - 115
G	Depth of piston	20 minimum
H	Diameter of hole	16 - 19
<b>Baseplate</b>		
I	Thickness	12 minimum
J	Length of each side	210 - 230

\* The difference between A and D shall be between 1mm and 3mm