Test method T373

Determination of the toughness of a fibre reinforced shotcrete mix

OCTOBER 2012

Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		New issue (Greg Forster)	D.Dash	May 1999
	5 & 6	Method of normalising peak load and energy absorption amended. (Greg Forster)	D.Dash	Feb 2001
Ed 2/ Rev 0	All	Reformatted RMS template	J. Friedrich	October 2012

Note that Roads and Maritime Services is hereafter referred to as 'RMS'.

The most recent revision to Test method T373 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T373

Determination of the toughness of a fibre reinforced shotcrete mix

1. Scope

The purpose of this test method is to determine the toughness of a particular fibre reinforced shotcrete mix. It shall be assessed by measuring the amount of energy that can be absorbed by a determinate round panel when centrally loaded.

2. Apparatus

Round panels shall be supported on three freely rotating pivots to achieve determinate support. These pivots shall be arranged at 120° to each other and all points shall lie on a diameter of 750 mm. The pivots shall be prevented from moving laterally. The centre of the specimen shall be concentric with the centre of the support points during a test. The space under the centre of the panel, and between the supports, shall be free of obstructions to prevent contact between segments of the failing panel and any potential additional points of support.

A suggested design for the test rig is shown in Fig. 1. The test rig shall provide support to a panel in accordance with the arrangement depicted in Fig. 2.

A suggested design for a supporting apparatus that may be placed within a universal testing machine is given in Fig. 3.

A suggested design for the pivot points is given in Fig. 4. These shall be made of steel and be capable of rotating freely in response to rotation of failed portions of a panel during a test.

The loading fixture shall consist of a circular steel piston of 100 mm diameter and 100 mm spherical radius (see Fig. 5). The objective in using a spherical surface to contact the specimen is to induce failure near the centre of the panel regardless of irregularities in the surface. A blunt-ended loading ram has been found to result in irregular failure patterns.

Tests shall be conducted in a machine that incorporates automatic servo-control of the rate of displacement. A test shall be executed without intervention or disturbance from operators.

Displacement of the loading piston shall be taken to represent the deflection of the centre of the panel. As this can lead to an under-estimate of energy absorption when significant elastic deformation occurs in the load frame during a test, the load frame and supporting fixtures for the panel shall sufficiently stiff to minimise this error.

Note:
For both electro-mechanical and hydraulic test systems in which deflection is measured using a transducer inside the actuator or cross-head, system stiffness can be determined by measuring the central deflection of the panel relative to the supports, and comparing this to the indicated deflection of the actuator. The deflection of the supporting fixtures shall not be deducted from the indicated deflection of the loading mechanism to arrive at a 'corrected' panel deflection.

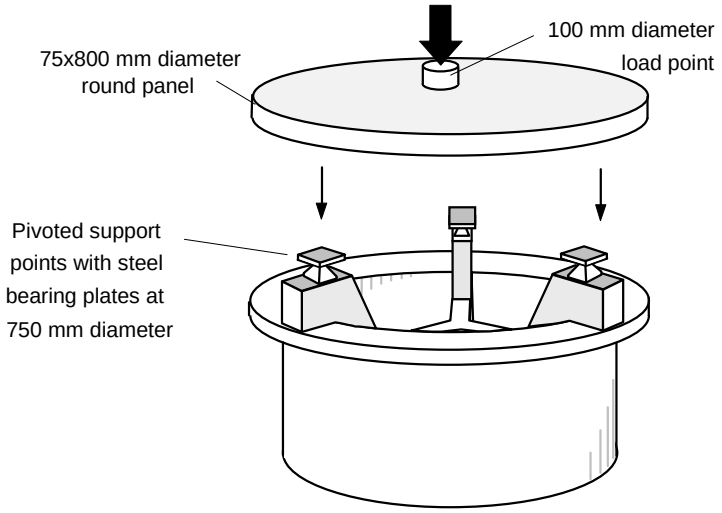

Fig. 1 - Typical Test Fixture for Round Determinate Panel Test.

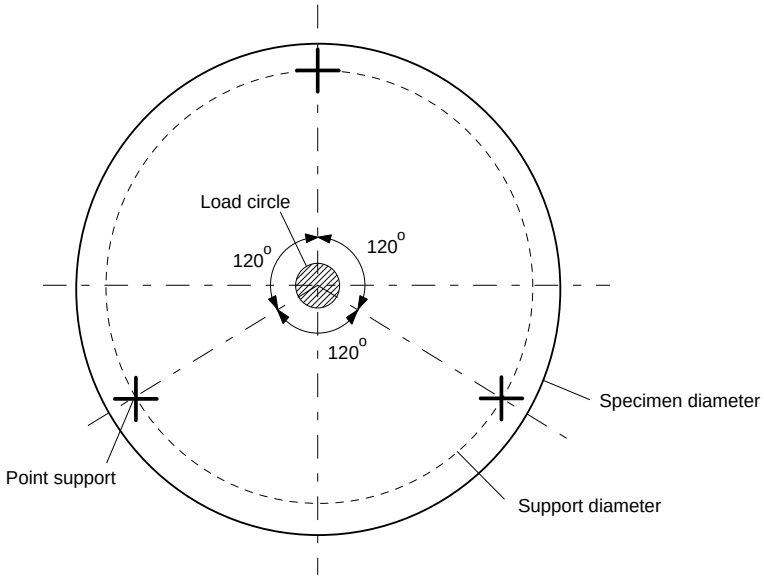

Fig. 2 - Arrangement of Pivots for Support Of Panels.

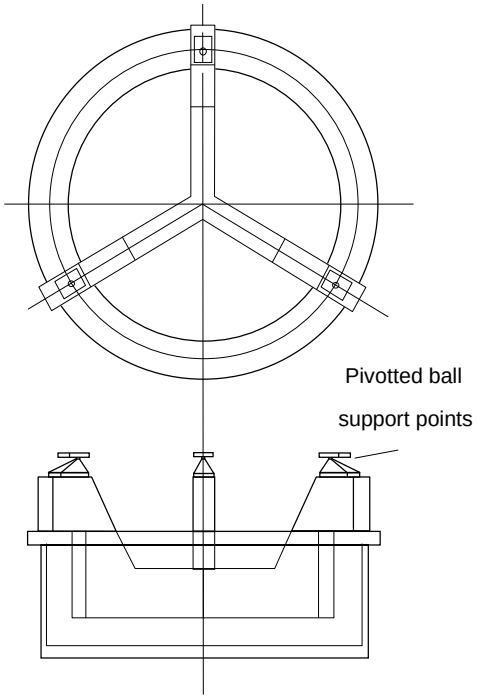

Fig. 3 - Plan and elevation of a welded steel support rig for round determinate panels

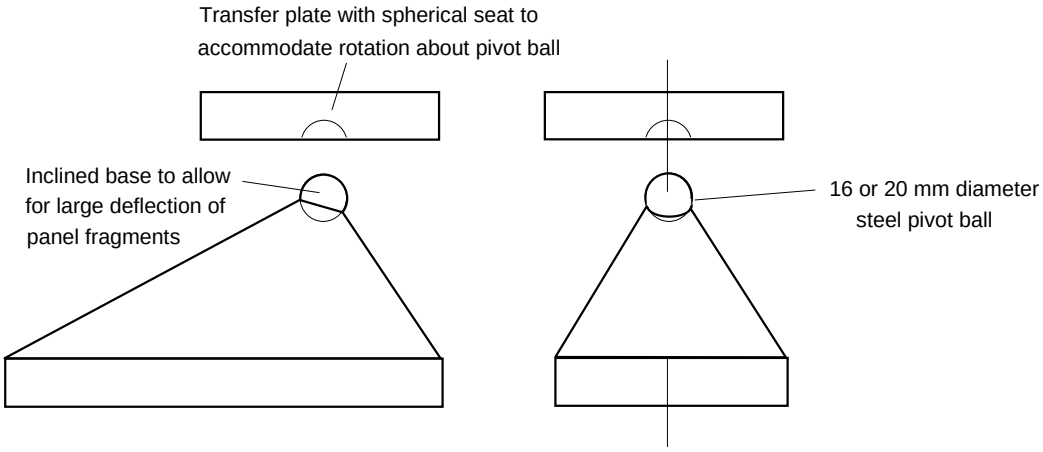

Fig. 4 - Suggested Configuration For Pivoted Panel Support Units.

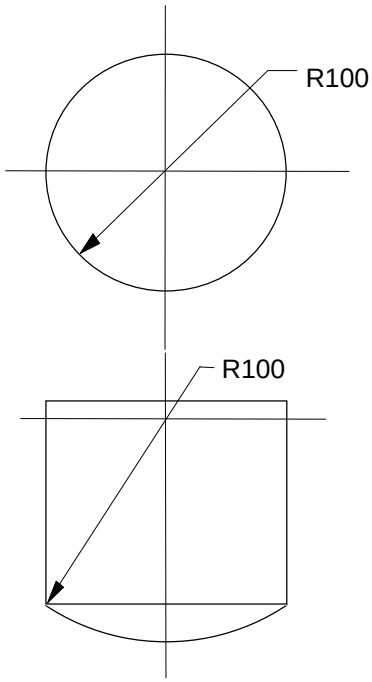

Fig. 5 - Loading piston with spherical contact surface.

3. Preparation of Test Specimens

(a) **Moulding**

Forms shall consist of 800 ± 5 mm diameter round melamine-coated formply screwed to wooden stiffeners arranged in a square. Strip metal sheeting of appropriate width shall be wrapped around the form and securely fastened to form the sides of the sprayed panel (see Fig. 6). The sheeting shall be uncoated steel strip of 0.6 mm thickness.

The formply shall be at least 17 mm thick. The stiffeners shall consist of rectangular members at least 70 x 35 mm in section, free from twist, bow, or warping. The stiffeners shall be screwed firmly together and to the underside of the ply to form a level square measuring approximately 600 x 600 mm.

The width of the steel strip shall be selected and fastened to the ply so that the completed inside depth of the form is 75 mm. Silicone sealant shall be used at the joints. Form surfaces shall be coated with release agent prior to spraying. Forms that are damaged or produce panels with a rough or distorted underside shall not be used since production of uneven surfaces can reduce the apparent toughness of a panel.

The mean thickness of the specimen after stripping shall be 75 ± 5 mm.

The mean diameter of the specimen after stripping, obtained from three measurements taken at 60^{o} angles, shall not exceed 810 mm.

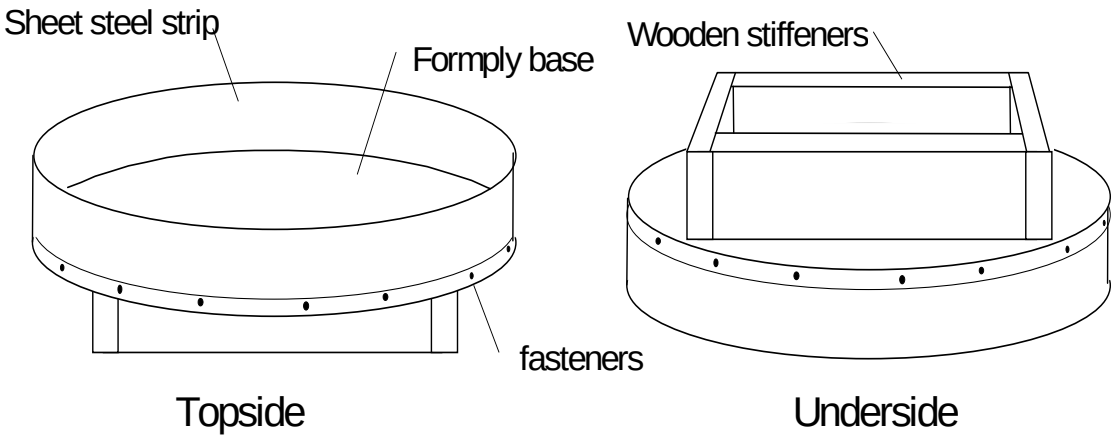

Fig. 6 - Round Forms for Production of Panels, Made of Formply, Sheet Steel, and Wooden Stiffeners.

(b) **Spraying and Curing**

Shotcrete shall be sprayed horizontally onto vertical panels or onto inclined panels. Panels shall be sprayed by the same nozzle operator that carries out the spraying of the member under construction, using the same mix and spraying procedure.

Panels shall be cured using the same curing proposed for the structure. Only after initial curing is completed shall the panel be stripped and moved for testing. The minimum required period for initial curing shall be 3 days.

4. Test Procedure

1. Place the test panel symmetrically on the three pivot points.
2. Apply a central point load to the test panel at a displacement rate of 10.0 ± 0.5 mm/min.
3. Continue loading until the total displacement equals 40 mm, recording the load and displacement at intervals of not greater than 0.1 mm displacement.
4. Discard the test if:
   (a) any part of a failing panel comes into contact with any part of the testing machine before a central displacement of 40 mm is achieved, or
   (b) the panel cracks in any mode other than by three radial cracks, or
5. From the load (kN) / displacement (mm) record determine :
   (a) the maximum load reached during the test (measured in kN)
   (b) the energy absorbed by the failing specimen (measured in J)

5. Calculations

(a) Peak Load (kilo Newtons)

This is the highest point in the load / displacement graph.

(b) Energy Absorbed (Joules)

This is calculated by integration of the area under the load / displacement graph from the Start of Loading to the points representing 5 mm and 40 mm central displacement.

The point representing the Start of Loading can be found from the intercept of the elastic portion of the loading curve and the displacement axis as shown in Figure 7.

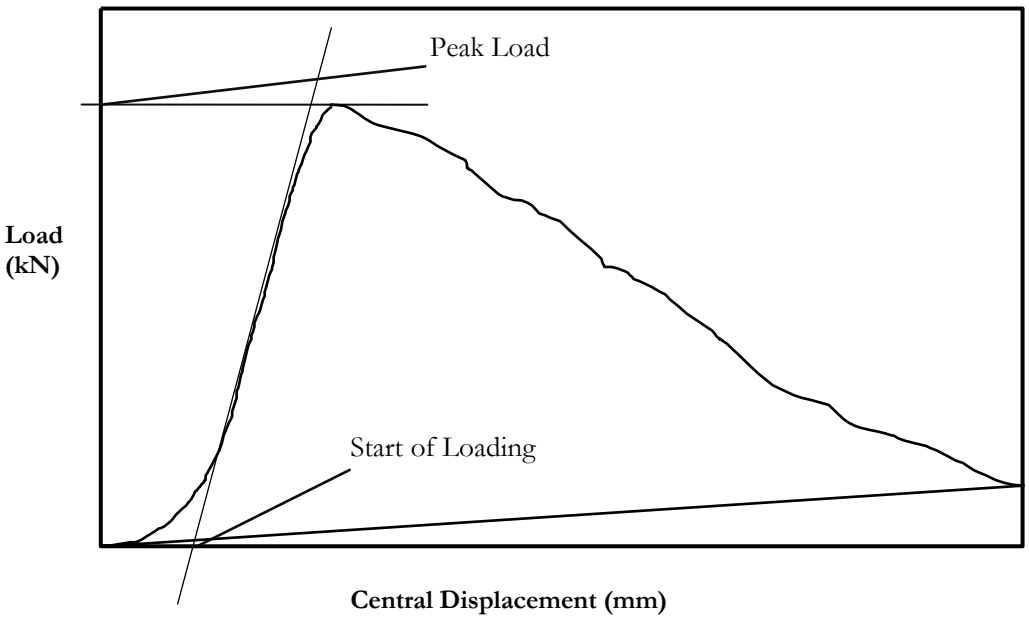

Fig. 7 - Determination of Start of Loading From Load-Displacement Record

The Peak Load achieved shall be normalised to a panel depth of 75 mm and diameter of 800 mm as follows:

$$P = P' \left(\frac{t_o}{t} \right)^{\alpha} \left(\frac{d_o}{d} \right)$$

Where: P is the normalised peak load achieved by the test specimen

P' is the peak load of the test specimen of non-standard dimensions

t and d are the mean thickness and mean diameter of the non-standard specimen

t_o and d_o are the thickness and diameter of the standard specimen (ie 75 mm and 800 mm)

$\alpha = 2.0 - \delta/40$ where δ is the central deflection of the specimen in mm

The Energy Absorbed shall be normalised to a panel depth of 75 mm and diameter of 800 mm as follows:

$$W = W' \left(\frac{t_o}{t} \right)^{\beta} \left(\frac{d_o}{d} \right)$$

Where: W is the normalised energy absorption of the test specimen

W' is the energy absorption of the test specimen of non-standard dimensions

t and d are the mean thickness and mean diameter of the non-standard specimen

t_o and d_o are the thickness and diameter of the standard specimen (ie 75 mm and 800 mm)

$\beta = 2.0 - \delta/80$ where δ is the central deflection of the specimen in mm

6. Reporting

The following results for a round panel test shall be reported:

(a) Specimen identification.

(b) Location, time, and date of spraying, and name of nozzle operator.

(c) Curing conditions, and age at testing.

(d) Identification of testing laboratory.

(e) Six (6) measured thicknesses, three at the edge and three near the centre after failure (in mm), and the mean of the six (6) measurements (in mm).

(f) Three (3) measured diameters (in mm), and the mean of the three (3) measurements (in mm).

(g) Load-displacement curve as recorded during test (optional).

(h) Normalised peak load achieved (in kilo Newtons).

(i) Energy absorption at 5 mm and up to 40 mm central specimen deflection (in Joules) normalised to a thickness of 75 mm and diameter of 800 mm.

(j) Number of radial cracks formed during test