

Appendix U.2.4 – SABS 541

Generic Name of Test	<i>Impacting Steel Balls : Abrasion Test</i>						
Principle of Test	Steel balls tumbling in a rotating box lined with concrete specimens.						
Historic Development of Test	The test appears to have been developed in 1971 i.e. <i>SABS 541:1971 "Standard specification for precast paving slabs"</i>						
Apparatus and Abrasives	The apparatus shown in figure U.2.4.1 consists of a rectangular box tumbler with removable openings in each side. The tumbler is rotated about its longitudinal axis. 500 steel balls with a diameter of 13.2mm are used as the abrasive medium. [Rocha (1994)]						
<div style="display: flex; justify-content: space-between; align-items: center;"> <div data-bbox="256 659 941 1449"> </div> <div data-bbox="971 919 1234 1092"> <p>Figure U.2.4.1 Cross section through a box tumbler (AS/NZS 4456.9) which is similar in operation to the SABS 541 test apparatus.</p> </div> </div>							
Test Method	Four test specimens 300 x 300mm are mounted so that they cover the openings in the side of the container and the 500 steel balls are placed inside. The tumbler is rotated at 60 rpm for 24 hours and then for a further 24 hours in the opposite direction. [Rocha (1994)]						
Abrasion Wear	This is measured as the loss of mass, which should not exceed 450g. [Rocha (1994)] Converted to volume this equates to an average depth of wear of 0.5 mm for concrete of density 2300 kg/m ³						
References	<table border="0" style="width: 100%;"> <thead> <tr> <th style="text-align: left; border-bottom: 1px solid black;">Author</th> <th style="text-align: left; border-bottom: 1px solid black;">Comment</th> </tr> </thead> <tbody> <tr> <td>Rocha (1994)</td> <td>Source document</td> </tr> <tr> <td>Doulgeris (1996)</td> <td>Source document</td> </tr> </tbody> </table>	Author	Comment	Rocha (1994)	Source document	Doulgeris (1996)	Source document
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Doulgeris (1996)	Source document						

Wear Mechanisms according to Author

- (i) Rocha (1994): No comment on the wear mechanism.
- (ii) Doulgeris (1996): ‘Abrasive forces of impact’ are induced by the enclosed steel balls. However, he considered the 13.2mm steel balls of this test too light and yielding too mild an abrasive action to simulate the abrasive effects in ore passes, and increased the size of the balls in a modified version of this test (described in U.2.2).
- (iii) Visual effects: None shown in specification.

Wear Mechanisms according to writer [R2 S2 I2]

As the drum rotates the balls will roll, slide bounce and fall. Collectively this may be referred to as tumbling. (Bouncing will be accentuated as the concrete’s surface becomes rougher). Rolling will result in crushing effects, sliding in shearing, while bouncing and falling results in impact. These mechanisms are considered in more detail below.

(i) **Impact:** The abrasion wear Q arising out of the initial impact of the ball against the concrete may be quantified by the expression $Q \propto \frac{m.U^2}{H}.f(\theta)$ (mm^3) [Hutchings (1992)]. Clearly the velocity at impact, U , is the most dominant factor, while the mass of the ball, m , the hardness of the concrete, H , and a factor $f(\theta)$ based on the angle of impact θ are also important.

(ii) **Rolling and sliding:** The abrasion wear corresponding to rolling and sliding may respectively be quantified by the expressions:

$$Q_{\text{Crushing}} \propto W \text{ (for rolling)}$$

$$Q_{\text{Shearing}} \propto F = \mu W \text{ (for sliding)}$$

Where Q_{Crushing} and Q_{Shearing} represent the loss of material owing to crushing and shearing (See figure U.2.4.2) at the microscopic asperities where contact is made. W and F are respectively the weight of the ball and the frictional drag from sliding, and μ is the coefficient of friction between concrete and steel.

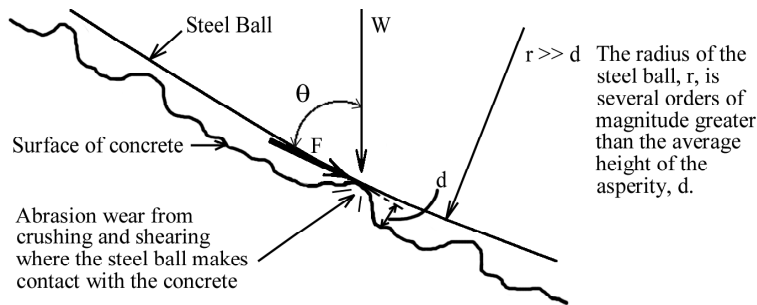


Figure U.2.4.2
Microscopic wear Mechanism for Rolling and Sliding

Relative severity: Impact from bouncing and falling will result in substantially more severe crushing and shearing than rolling and sliding, but because the balls are relatively small (13.2mm) with minimal freefall, given the size of the apparatus, the worst cracking that is likely is a degree of sub-asperity Hertzian cone cracking. (discussed in detail in chapter 3.)

(iii) **Adhesion and deformation:** See note 1 in introduction to appendix U