Appendix U.2.2 PCI TM 7.8

Generic Name of Test	*Impacting* Steel Balls : Abrasion Test
Principle of Test	Steel ball tumbling in a rotating box lined with concrete test specimens.
Historic Development of Test	This test '*Impact abrasion test. PCI test method 7.8*' was developed in 1983 to test the impact abrasion resistance of concrete to be used in ore-pass linings. The test is modelled on the apparatus used in SABS 541:1971 but appears to use two 300mm x 300mm test specimens per side rather than one 300mm x 300mm specimen as per SABS spec. [Doulgeris (1996)]
Apparatus and Abrasives	The apparatus consists of a rectangular box tumbler with removable openings in each side. The tumbler is rotated about its longitudinal axis. 25 kg of 25mm diameter manganese-steel balls are used as an abrasive (see figure U.2.2.1). [Doulgeris (1996)]

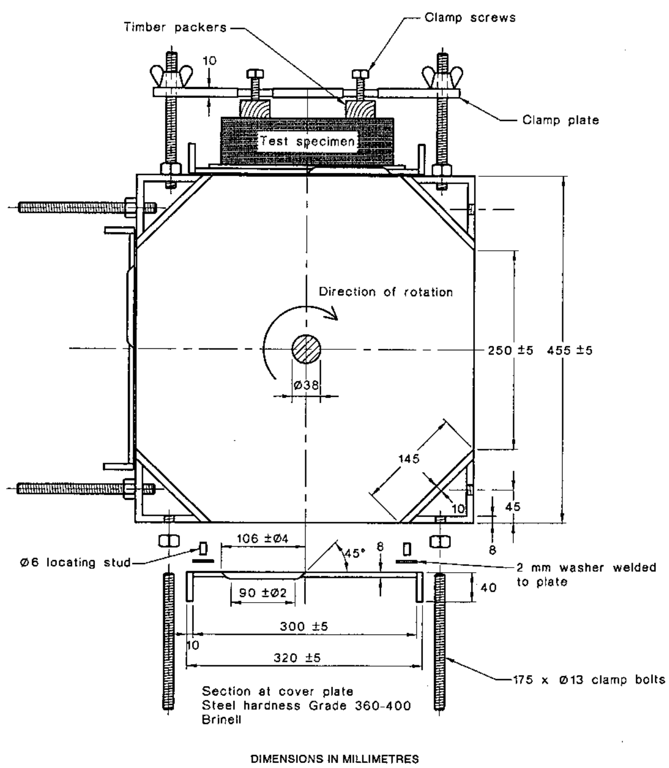

Figure U.2.2.1 Cross section through the AS/NZS 4456.9 tumbler apparatus which is similar in principle to that described in the PCI TM 7.8 test.

Test Method	The concrete specimens are secured such that they cover the openings in the container and the manganese-steel balls are added. The test duration is 40 hours in ten periods of 4 hours, each at a speed of 60 rpm with the direction of rotation reversed each time. [Doulgeris (1996)]
Abrasion Wear	This is measured as the volume of abraded material. [Doulgeris (1996)]
References	<u>Author</u> <u>Comment</u> Doulgeris (1996) Source document

APPENDIX U.2.2

Wear Mechanisms according to Author

(i) Doulgeris (1996): Doulgeris used this test as he considered that it simulated the impact / abrasion effects in ore passes. 'The majority of wear that takes place in an ore-pass is believed to take place by attrition …"pluck out" and shattering of smaller particles is likely to occur.'

(ii) Visual effects: None shown by author.

Wear Mechanisms according to writer [R2 S2 I3]

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 result in impact. These mechanisms are considered in more detail below.

(i) Impact: The abrasion wear Q arising out of the 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:

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

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

Where $Q_{Crushing}$ and $Q_{Shearing}$ represent the loss of material owing to crushing and shearing (see figure U.2.2.2) 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.

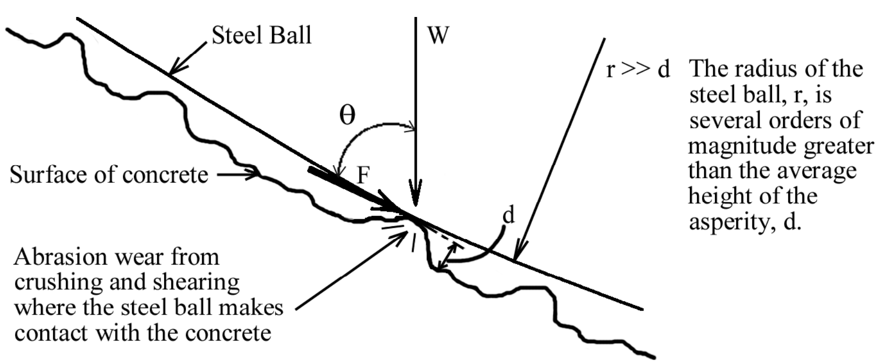

Figure U.2.2.2 Microscopic wear mechanism for rolling and sliding

Relative severity: Impact from bouncing and falling will result in substantially more severe crushing and shearing than rolling and sliding, as well as various types of sub-asperity cracking, such as Hertzian cone cracks and lateral cracks. It is doubtful that the impact induced compression of this test is severe enough for the occurrence of axial cracking (discussed in detail in chapter 3) since the balls have limited mass and impact velocity U.

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