Appendix U.2.3 AS/NZS 4456.9

Generic Name of Test	*Impacting* Steel Balls : Abrasion Test
Principle of Test	Steel balls tumbling in a rotating box over concrete pavers.
Historic Development of Test	This test was developed from the South Sydney City Council (SCC) test which was initially derived from the British Standard BS 5395 : 1977. The current test was issued as a draft in 1995 and issued as a standard in 1997 by Standards New Zealand and Standards Australia i.e. *AS/NZS 4456.9:1997 Masonry units and segmental pavers-Methods of test. Method 9: Determining abrasion resistance*. This test method replaced the MA20 test as well as the SCC test.
Apparatus and Abrasives	Concrete specimens are secured, with their wearing faces inwards, over openings provided in a rectangular container, which rotates on a steel shaft about its longitudinal axis. 600 15.9mm diameter steel balls are used as an abrasive charge. (See figure U.2.3.1) [AS/NZS 4456.9 (1997)]

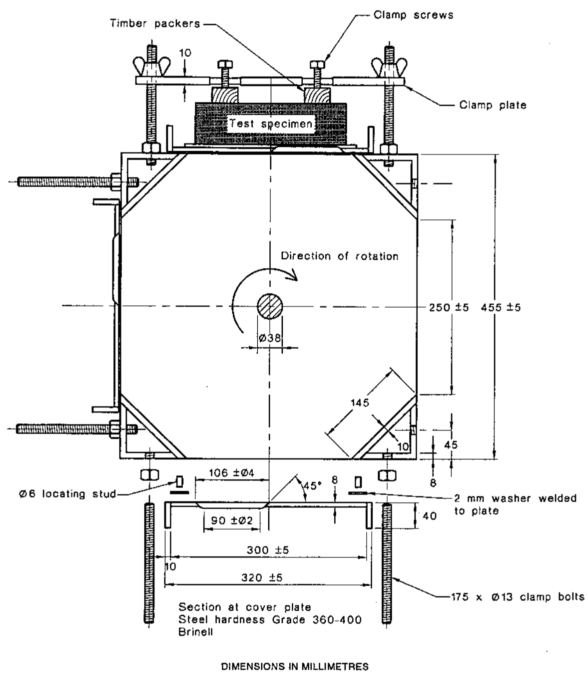

Figure U.2.3.1 Section through tumbler [AS/NZS 4456.9:1997]

Test Method	The concrete specimens are oven dried and then secured to the inside of the abrasion testing machine with their wearing faces inwards and centrally located over the cover plate. 600 steel ball bearings of 15.9mm diameter are placed inside the tumbler, which is then run at 60rpm for 3600 revolutions. [AS/NZS 4456.9 (1997)]
Abrasion Wear	The mass loss of each specimen is determined by weighing before and after, and converting to an 'abrasion index' by dividing by the bulk density of the specimen. [AS/NZS 4456.9 (1997)]
References	<u>Author</u> / <u>Comment</u> AS/NZS 4456.9 (1997) / Source document

APPENDIX U.2.3

Wear Mechanisms according to Author

(i) AS/NZS 4456.9 (1997): The specimens are subjected to the impact and rolling action of the steel balls.
(ii) Visual Effects: None given in AS/NZS 4456.9

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 result 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:

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

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

Where $Q_{Crushing}$ and $Q_{Shearing}$ represent the loss of material owing to crushing and shearing (see figure U.2.3.2) 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.

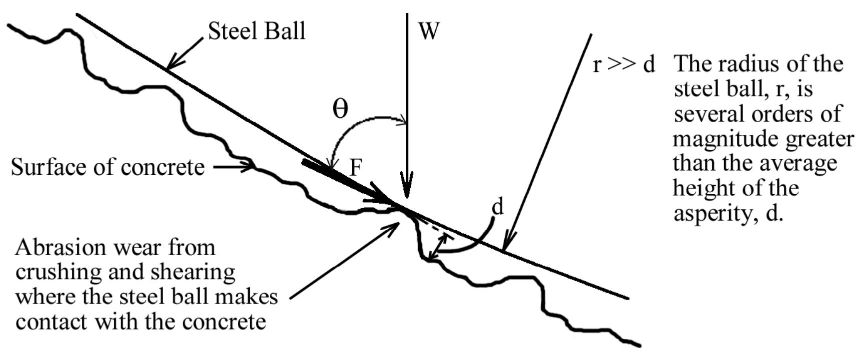

Figure U.2.3.2 Microscopic wear mechanism for rolling and sliding

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 (discussed in detail in chapter 3.) Axial cracking is less likely given the relatively small mass of the balls (corresponding to 15,9mm diameter), and the limited freefall.

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