Appendix U.2.15 – MA20SA

Generic Name of Test	*Rolling* Steel Balls : Abrasion Test
Principle of Test	Loaded orbiting steel balls
Historic Development of Test	In an attempt to avert some of the problems inherent in the Australian MA20-1986 test, it was modified in South Africa in 1987 and subsequently designated the MA20SA procedure. These modifications included testing pavers that had been soaked for 24 hours, a local bearing consisting of 13 rather than 12 balls, an improved guiding system and a more secure method of fastening test samples. [Doulgeris (1995)]
Apparatus and Abrasives	A vertically mounted electric drill drives a raceway which in turn bears on 13 balls running on the paver surface. Water is run through the bearing whilst the equipment is running. The total mass of the balls is 17 kg. A dial gauge provides an abrasion depth reading. See figures U.2.15.1- U.2.15.3.

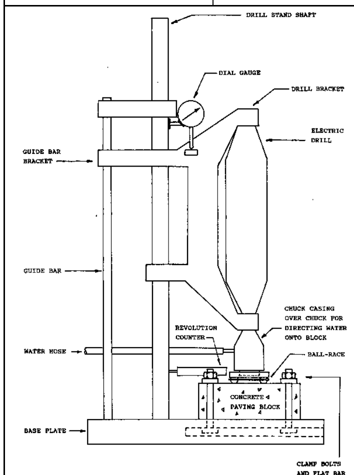

Figure U.2.15.1 and U.2.15.2 Diagram and photograph illustrating MA20SA apparatus

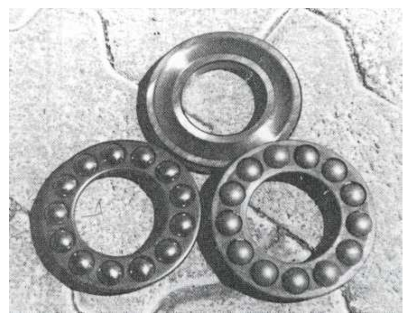

Figure U.2.15.3 Bearing and raceway used in MA20SA test

Test Method	The concrete specimen being tested is clamped to the horizontal surface. A sufficient flow of water should be present to clear grinding debris. The drill is run at a speed of 1000-1050 rpm. The test specifies 5000 revolutions of the ball race after which the final depth of penetration is read off the dial gauge. [Papenfus (1994)]
Abrasion Wear	This is measured in terms of the average depth of abrasive wear from which an abrasion index I_a is calculated, where $I_a = \frac{\sqrt{5000\,\text{revs}/1000}}{\text{depth}\,(\text{mm})}$ [MA20 (1986)]
References	<u>Author</u> — <u>Comment</u> Papenfus (1994) — Source document Doulgeris (1995) — Source document Rocha (1994) — Source document Mazo (1986) — Source document MA20 (1986) — Source document

APPENDIX U.2.15

Wear Mechanisms according to Author

(i) Doulgeris (1995): The abrasive action is believed to be one of micro crushing occurring under high compressive and perhaps some impact stresses exerted by the steel balls.

(ii) Rocha (1994): The ball bearings cause impact as well as sliding friction.

(iii) Visual Effects:

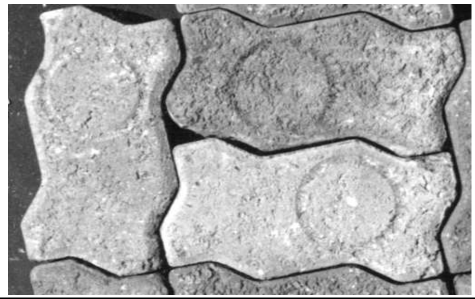

Figure U.2.15.4 Abrasion wear pattern on concrete paving block [Holland (1991)]

Wear Mechanisms according to writer [R3 S1 I2]

(i) <u>Rolling</u>: As the ball race rotates under the action of the drill, the individual balls roll over the surface resulting in crushing effects. In the initial phase of the test the contact area between ball and concrete surface is very small, resulting in high compressive stresses, particularly at the asperities, leading to rapid abrasion. If the load W is sufficiently high relative to the tensile strength of he concrete, then sub-asperity cracking will develop in the form of Hertzian cone cracks, and quite likely 'lateral' and 'axial' cracks will also develop as indicated in figure U.2.15.6.

(ii) <u>Impact:</u> There is a degree of vibration inherent in the drill machine, which results in some bouncing and consequent impact. Bouncing may increase as the balls penetrate deeper into the surface, owing to a roller-coaster-like profile developing, given that the harder aggregate particles in the wear path abrade at a slower rate relative to the mortar matrix. However, this undulation will be relatively shallow owing to the levelling effect of having 13 balls all at the same level. Impact will accentuate the compressive stresses described in (i), thus increasing abrasion-wear.

(iii) <u>Sliding:</u> Spheres rolling on a surface experience 'Reynolds' slip due to the progressive stretching of the surface within the contact region. As the groove deepens 'Heathcote' slip also occurs, as a result of variations in circumferential contact depending on sectional position of the ball in the groove. These concepts are more fully explained in chapter 3 but the net effect is frictional forces (see Fn and F below) and frictional slip leading to shearing effects.

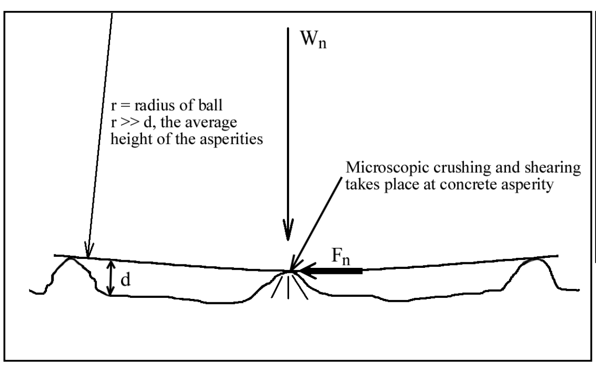

Figure U.2.15.5 Microscopic rolling and sliding wear mechanisms

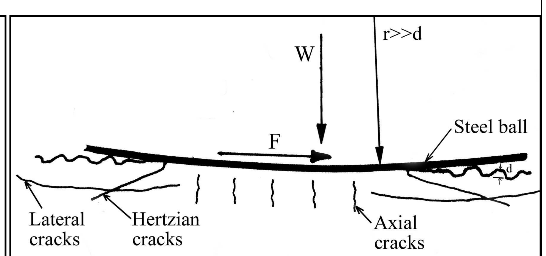

Figure U.2.15.6 The geometry of a Hertzian cone crack formed by a sphere loaded normally on the plane surface. Note also 'lateral' and 'axial' crack formations

(iv) <u>Adhesion and deformation:</u> See note 1 in introduction to appendix U