# Appendix U.2.12 – ASTM C779 Proc. C

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| **Generic Name of Test** | *Rolling* Steel Balls : Abrasion Test |
| **Principle of Test** | Loaded orbiting steel balls |
| **Historic Development of Test** | This test was developed from 1964 though to 1971 to measure the average depth of wear for horizontal concrete surfaces, i.e. *ASTM C779 Proc. C Test Method for Abrasion Resistance of Horizontal Concrete Surfaces* [Liu (1991), Alexander (1984)] It seems that this is the successor to the earlier Davis tests (see U.2.10 & U.2.11). |
| **Apparatus and Abrasives** | Figure U.2.12.1 shows 8 ball bearings, diameter 15.8mm are located in a brass disc. The balls run in a raceway attached to a motorised shaft. Water is used to flush out loose particles. A dial gauge is mounted to provide a direct reading of the abraded depth. [ASTM C779] |

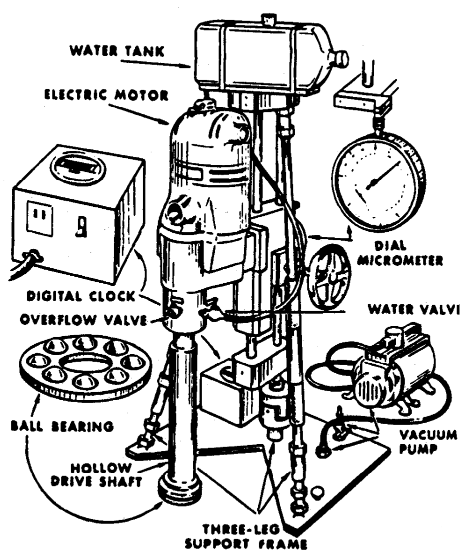


**Figure U.2.12.1** Diagram showing test apparatus

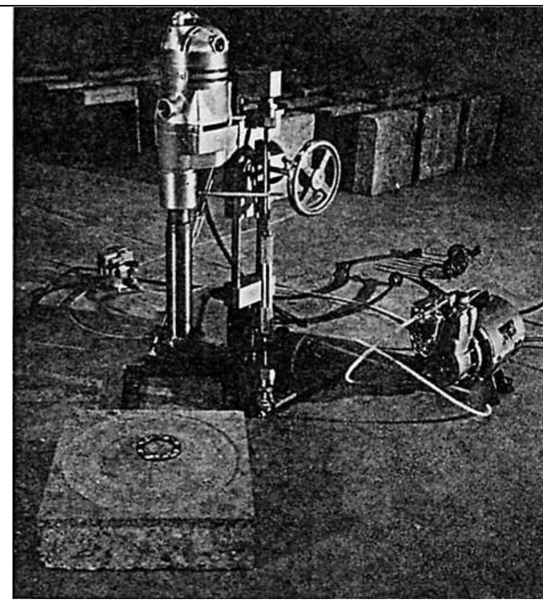

**Figure U.2.12.2** Test apparatus with specimen in foreground [Lane (1973)]

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| **Test Method** | The ball race is rotated on the concrete specimen at a speed of 1000 rpm. Water is used to flush loose particles from the test path. Abrasion readings are taken every 50 seconds with a dial micrometer. Readings are continued for a total of 1200 seconds or until a maximum depth of 3 mm is reached. [Liu (1991)] |
| **Abrasion Wear** | This is expressed as the average depth of abrasion wear. Wear-time curves may be plotted. |
| **References** | <u>Author</u> — <u>Comment</u><br>ASTM C779 — Source document<br>Liu (1991) — Source document<br>Hutchings (1992) — Source document<br>Ghafoori (1995) — Source document<br>Lane (1973) — Source document |

## Wear Mechanisms according to Authors

(i) Liu (1991): Abrasion is caused by impact as well as sliding friction.

(ii) Visual Effects:

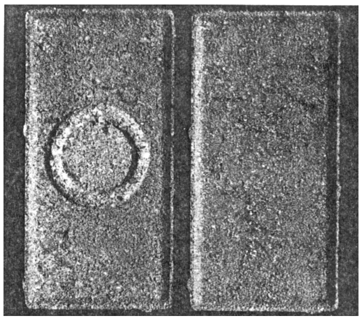

**Figure U.2.12.3** Abrasion wear of concrete paving block [Ghafoori (1995)]

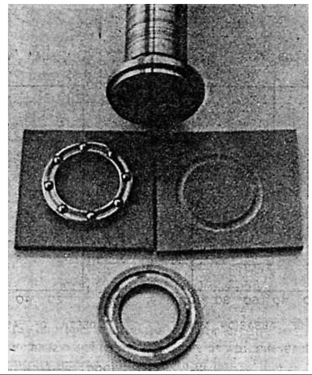

**Figure U.2.12.4** Characteristic abrasion groove on concrete specimens. Note also the brass cage that houses the balls. The raceway is shown below it. [Lane (1973)]

## 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 ‘axial’ and ‘lateral’ cracks will also develop, as indicated in figure U.2.12.6.

(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 eight balls in the raceway. 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

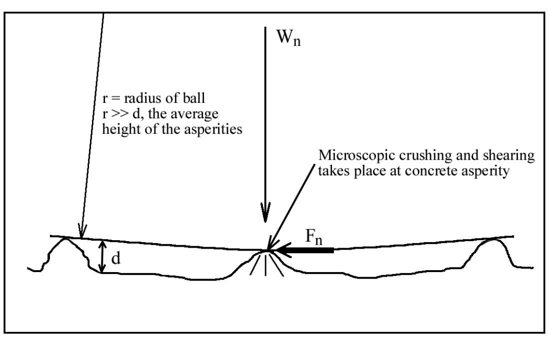


**Figure U.2.12.5** Rolling and slewing wear mechanism

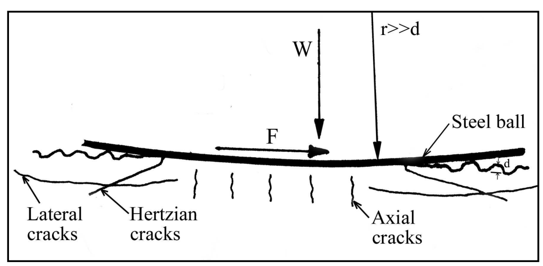


**Figure U.2.12.6** The geometry of a Hertzian cone crack formed by a sphere loaded normally on the plane surface. Note also ‘lateral’ and ‘axial’ crack formations.

in circumferential contact depending on the sectional position of the ball in the groove [see Hutchings (1992)]. Finally there is also a degree of frictional resistance between balls and ball-race that translates into friction at the concrete/ball interface. These concepts are more fully explained in chapter 3 but the net effect is frictional forces (see Fn and F in above figures) and sliding leading to shearing effects.

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