Appendix U.3.2 Chained Tyres

<table>
<tr><td>Generic Name of Test</td><td>Rolling Chained Tyres : Abrasion Test</td></tr>
<tr><td>Principle of Test</td><td>Loaded large chain fitted tyres.</td></tr>
<tr><td>Historic Development of Test</td><td>This test was developed in order to determine the abrasion wear of traffic on concrete surfaces. The test was conducted over a period of 18 months and the results were reported in 1924 by Jackson.</td></tr>
<tr><td>Apparatus and Abrasives</td><td>A circular concrete track (191m circumference, 60.6m diameter) was built which consisted of 62 concrete test sections each 1.2m wide by 3m long (see figure U.3.2.1). A 2-wheeled rubber tyred (or tyre chained) test vehicle was guided around the track to provide abrasion (see figure U.3.2.2). [Jackson (1924)]</td></tr>
<tr><td colspan="2">

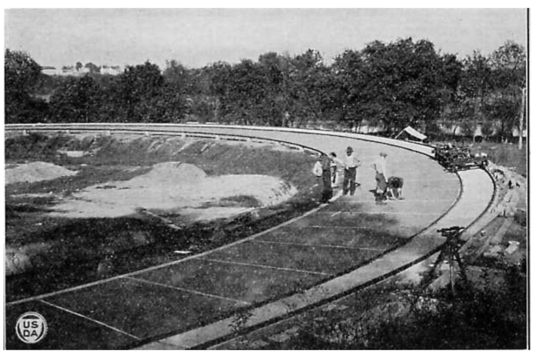

Figure U.3.2.1 General view of circular pavement showing the test panels under construction [Jackson (1924)]

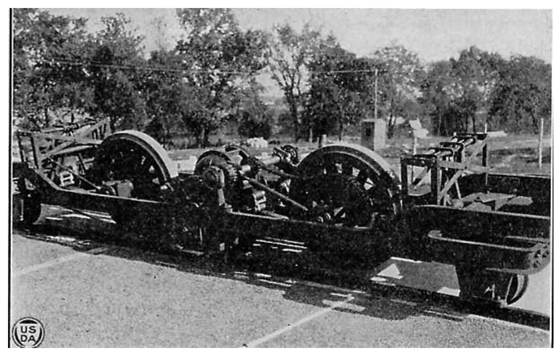

Figure U.3.2.2 The testing machine, notice the guide rails. [Jackson (1924)]

</td></tr>
<tr><td>Test Method</td><td>The test vehicle was loaded such that each wheel carried a load of 1360kg. The vehicle was run at 35kph approximately 300 000 times around the track, firstly on rubber wheels and then later on tyres fitted with chains. Chains were required since after 55 000 revolutions less than 0.5 mm of wear was detected from the rubber tyres. After chains were fitted only 1000 revolutions were needed to wear away the thin mortar top and after 25000 revolutions abrasion wear was as high as 25mm on certain sections. [Jackson (1924)]</td></tr>
<tr><td>Abrasion Wear</td><td>Plaster cast profiles were made which then allowed the average depth of abrasion wear to be calculated. [Jackson (1924)]</td></tr>
<tr><td>References</td><td><u>Author</u>   <u>Comment</u>
Jackson (1924)   Source document</td></tr>
</table>

APPENDIX U.3.2

Wear Mechanisms according to Author

(i) Jackson (1924): The abrasion machine was constructed so as to have the same effect as truck traffic. Whereas the rubber tyres produced ‘no wear’, the chains produced a ‘noticeable effect’ ranging from 5 to 25 mm depending on the abrasion resistance of the concrete.

(ii) Visual Effects: See figure U.3.2.3

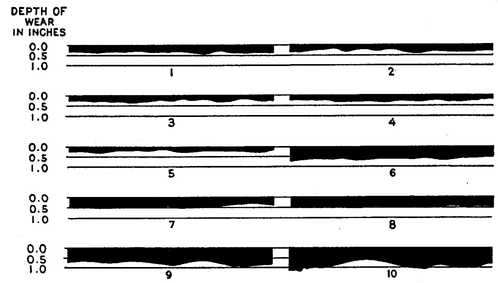

Figure U.3.2.3 Reproduction of plaster cast profiles showing wear of various concrete pavements under chain traffic [Jackson (1924)]

Wear Mechanisms according to writer [R3 S3 I3]

As the chain wheel rotates it will roll, slide and bounce. (Bouncing will be accentuated as the concrete’s surface becomes rougher). Rolling will result in crushing effects (or even cracking), sliding will result in shearing, while the impact from bouncing will result in either crushing or cracking. These mechanisms are considered in more detail below.

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

$$Q_{Crushing} \propto W = m.g \text{ (for rolling) and } Q_{Shearing} \propto F = \mu W \text{ (for sliding)}$$

Where $Q_{Crushing}$ and $Q_{Shearing}$ represent the loss of material owing to crushing and shearing (see figure U.3.2.4) at the microscopic asperities where contact is made. W and F are respectively the weight on the steel link and the frictional drag from the link sliding, where μ is the coefficient of friction between concrete and steel. That the abrasion wear was as deep as 25mm strongly suggests that the mechanism of abrasion wear went beyond that shown in figure U.3.2.4. The various cracking mechanisms of figure U.3.2.5 allow for deeper sub-asperity abrasion, beginning with Hertzian cone cracks, and followed by lateral cracks and finally axial cracks (for very severe loads).

(ii) Impact: The abrasion wear Q arising out of the impact of a steel chain link against the concrete may be quantified by the expression $Q \propto \frac{m.U^2}{H}.f(\theta)$ (mm^3) [Hutchings (1992)] , where m is the mass of machine per wheel, H is the hardness of the concrete and $f(\theta)$ is a factor associated with the angle of impact. Clearly, the velocity U is the most dominant factor in this expression. However since for normal rolling U = 0 in the radial direction at the point directly beneath the axle, it may be postulated that impact abrasion wear from the normal course of the wheel’s rotation is virtually zero and therefore only the downward velocity associated with bouncing contributes to impact. Depending on the severity of the impact, abrasion wear may take the form of figure U.3.2.4 or U.3.2.5

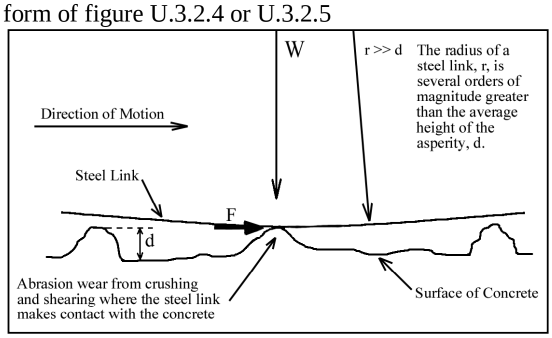

Figure U.3.2.4 Wear mechanism for mild abrasion

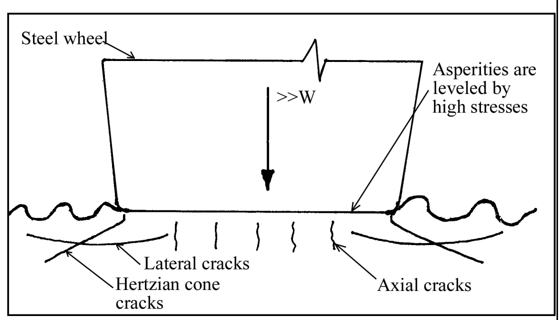

Figure U.3.2.5 Cracking wear mechanisms from large loads *and* high contact pressures.

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