Erodability of Stabilised Pavements Using the Wheel Tracking Test

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Synopsis: An estimated total of $1.5billion dollars is spent on road rehabilitation in Australia per annum. This invokes a sustainable urgency to ensure reasonable service life is achieved for pavements. Cement treated basecourse provides a strong support to the pavement and is deemed as an alternate solution to reduce maintenance requirements of unsealed roads whilst minimising the generation of dust. When cemented basecourses are used for unsealed roads, Its primary purpose is often to maintain serviceability in lieu of sustaining heavy traffic loads, thus the vulnerability to erosion dictates its service life. In Australia, the study of erosion due to tyre loading on cemented pavements and its testing methodology thereof are very limited. The Cooper Wheel Tracking Test typically used for asphalt rutting testing is carried out to determine the Erodibility Index of cement treated crushed rocks. Results indicate that the increase in cement content increases the Erodibility Index. A proposed testing methodology for stabilised basecourse is ultimately derived from the investigation.

Keywords: unsealed pavements, stabilisation, dust control, erodibility, wheel tracking test.

1. Introduction to Unsealed Roads

Due to the geographical vastness of Australia and marginally low population densities in rural locations, unsealed roads form approximately 500,000 km, which represents 65% of roads in Australia [1]. Furthermore, the development of the Australian commodity sector also extends the requirements of unsealed road networks to be developed to access remote areas.

The network of unsealed roads comprise of built up gravel roads, graded tracks or unformed roads on natural surface. Due to nature of these roads, more than $1 billion each year is spent on the construction and maintenance of unsealed roads [1], invoking a sustainable urgency to ensure reasonable service life is achieved for these pavements.

Defects requiring maintenance works of unsealed roads are generally categorised as either surface or structural. Structural defects involve failure of subgrades which result in permanent deformation of the road. On the other hand, surface defects include corrugations, potholes, slippery surface, rutting, ice formations, scouring, loose material and loss of surface material [1], which are generally localised on the surface of pavements and typically treated with re-grading works.

Furthermore, a critical issue with unsealed roads is the generation of dust. The generation of dust is a critical environmental issue, severely reduces visibility of trailing vehicles, increases wear and tear of vehicles and is detrimental to health.

2. Stabilisation of Unsealed Pavements with Cement

With the issues highlighted above, treatment of unsealed pavements in the form of stabilisation techniques is used typically to improve their serviceability. However, the stabilisation philosophy of unsealed pavement in the past had generally been to avoid the use of cement binders as it is not compatible with the maintenance regime typically applied for unsealed pavements. Cement stabilisation results in stiff bound surfaces which disallows routine grading and periodic shaping to be undertaken [1].

However in recent times, the use of cement and slag blend as a stabilisation option in rural Australia is gaining momentum due to its ability to minimise dust generation, reduce development of material sources and considerably decrease maintenance frequency on unsealed low traffic roads [2], potentially reducing their whole of life cost. In New South Wales, 5 unsealed pavement trial sections of various stabilising agents were constructed with promising results [2] as summarised in Table 1 below.

Table 1. AustStab Unsealed Pavement Trial

Road Name	Town	Reference Density (t/m^3)	Stabilisation Agent Tested
Barber	Griffith	2.2	Quicklime
Woodlands	Wombat	2.2	Cement/slag blend (70:30) and polymer based binder
Old Corowa	Jerilderie	2.05	Cement/slag (80:20)
Four Corners	Jerilderie	-	Quicklime
Back Mimosa	Temora	2.09	Quicklime

All stabilised unsealed pavements trialled showed adequate performance in wet weather conditions except the polymer based binder which became too slippery when wet. The cost per kilometre of stabilisation worked out to be $22,500 to $39,000 [2].

Since the issues associated to use of bound pavements for low volume roads, i.e. fatigue cracking is avoided, the performance criteria of stabilised unsealed pavements are therefore its durability and its propensity to generate dust, both manifested as the erodibility of the pavement.

3. Erodibility Index and the Wheel Tracking Test

De Beer [3] undertook a comprehensive review of testing methods available at the time to assess pavement erodibility and durability [4]. In his study it was recommended that the use of South African Wheel Tracking Test (SAWTET) was deemed to be a more representative testing method for lightly cemented basecourse materials due to its ability to model in situ distress mechanisms experienced by thin sealed pavements [5] and more specifically unsealed pavements in the context of this paper. It was proposed that an Erodibility Index was to be used as an empirical quantification of the propensity of particulates of a surface to erode and is expressed as a depth of erosion caused by the SAWTET apparatus after 5000 passes [3].

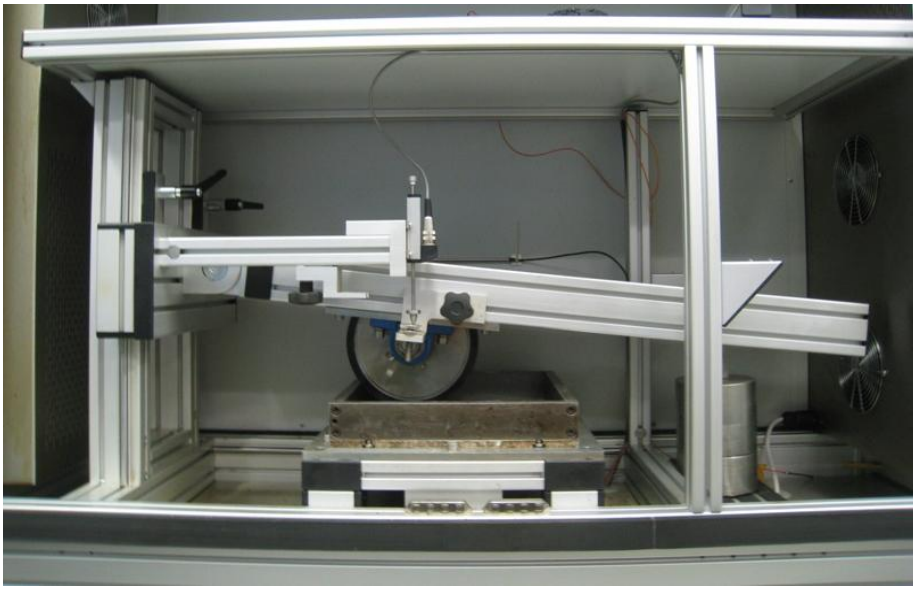

Figure 1. Cooper Wheel Tracking Test Device

Similar test setups emulating the concept of SAWTET also exist for asphalt testing to measure the rutting resistance of asphaltic seals. The Cooper Wheel Tracking Device is the most widely accepted asphalt tester in Australia [6] and is part of the repertoire of testing apparatus available at Curtin University's Pavement Research Group. The Wheel Tracker Test uses a reciprocating table which travels 230mm on linear bearings at a specified speed. The tests specimen is then placed on the bed with a rubber tyre wheel connected to a transducer resting onto the specimen. The typical setup is shown in Figure 1 above.

The Wheel Tracking Device is used to assess Erodibility Index of cement treated crushed rock available in Western Australia.

4. Sample Preparation and Testing Procedure

Crushed rocks sourced from Western Australia which meets Main Roads Western Australia Specifications 501 for aggregates are used for this experiment. The crushed rocks sourced are widely used in Western Australia as basecourse material. Cement Type General Purpose (GP) conforming to Australian Standard AS3697 is used for stabilisation.

The Cooper Compactor as shown in Figure 2 was utilised to create slab specimens measuring 305mm wide x 305mm long x 50mm deep. First the volume required to create the slabs were ascertained. The cement and aggregates were first dry mixed before water is added.

Specimens are compacted to a target modified dry density 2.35 t/m^3 at optimum moisture content.

The specimens were than spreaded evenly onto the mould and loaded onto the compactor which applied roller compacting actions at 3 pressure settings of 7 kPa, 12 kPa and 15 kPa for 10 times respectively. The specimens are weighed before and after compaction to ensure the target density is reached.

Figure 2. Cooper Compactor used to prepare slab specimens

The specimens are then wrapped cured for 7 days with a damp cloth in a sealed bag to promote the hydration of the specimen throughout the curing process. The specimen was then soaked for 12 hours prior to testing.

The Wheel Tracking Test was allowed to run up to 5000 passes with an applied total load of 700N comprising of a surcharge load of 180N and the wheel load of 520N. The average depth erosion at the centre 50mm span of the specimen is used to determine Erodibility Index.

5. Results and Analyses

A typical profile of the eroded surface at completion of 5000 passes for a 6% cement content slab is shown in Figure 3 below.

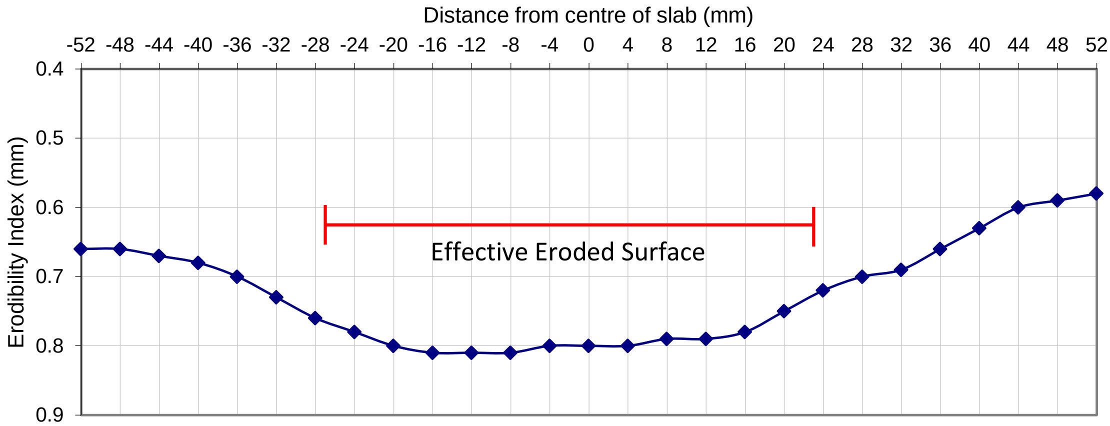

Figure 3. Typical profile of cement treated crushed rock slab after 5000 runs

As shown from the profile of the slab surface in Figure 3 above, where 0 mm represents the centre of the slab, the most severe erosion is experienced on the centre of the slab. This supports the methodology applied in this study whereby the Erodibility Index is determined from the centre 50mm of the slab.

The diminished erosion experienced towards the edge of the slabs is perceived to be caused by the deceleration of the wheel tracker. Surface inspections after each test were also undertaken to ensure that the readings are not distorted due to any deposits of large aggregates on the surface.

By taking the average of erodibility against number of runs for all specimens, Figure 4 showing the development of erosion can be created as shown below in Figure 4.

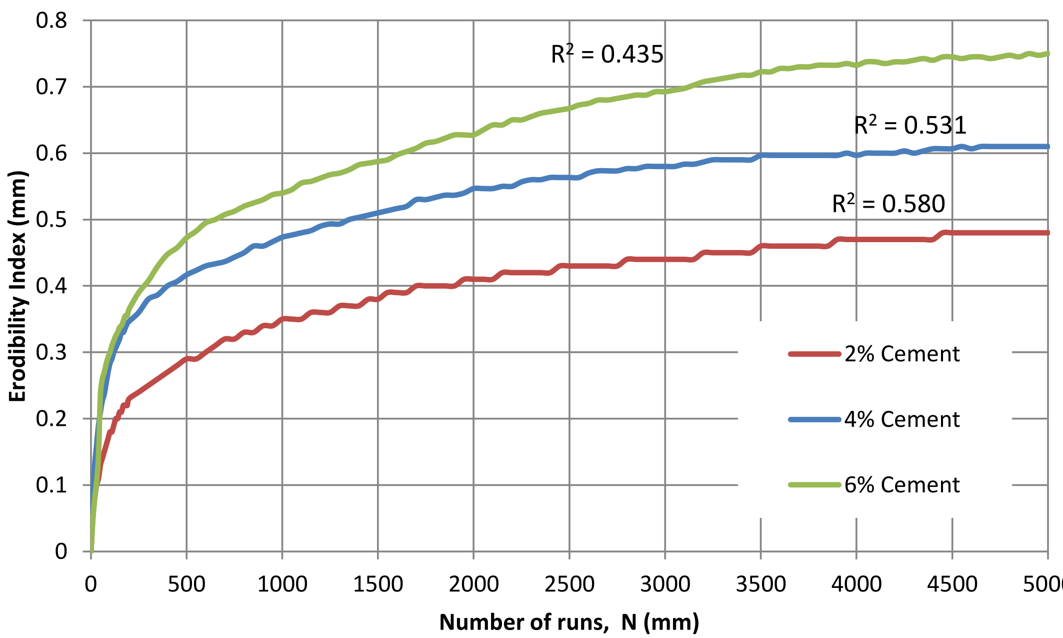

Figure 4. Erodibility Index vs. number of runs for various cement content

The Erodibility Index of the specimens, taken as the maximum eroded depth after 5000 passes, obeys the power law which is characterised with a sharp initial increase before achieving a resilient state with minor addition of erosion.

The Erodibility Index also shows a positive linear relationship with cement content. The Erodibility Index increases by approximately 0.1mm for an increase of 2% cement content. This suggests that the increase in cement content would result in faster surface deterioration of unsealed roads. An explanation of this observation can be traced to the change in water cement ratio. The water cement ratio from 2% cement content to 6% cement content decreases from 3 to 1.17, which potentially mean that the cement paste develops a higher propensity to migrate to the base of the slab during curing periods. As this occurs, less cement paste are being exposed on the surface. This is supported with visual observed of specimens prepared during the tests. The increased cement content showed a more pronounced concentration of cement paste on the surface of the slab. Figure 5 below shows a typical finished surfaced of a 6% cement content slab.

Figure 5. Typical Surface Depression After 5000 Runs

6. Limitations of the Erodibility Test

A cause for concern for the analysis undertaken is the relatively low least square regression achieved from the analysis, i.e. $R^2 \approx 0.5$. This clearly indicates that there is some variability with the results.

This is likely to be caused by the limitations of using the Cooper Wheel Tracking Test. The machine does not provide control measures to maintain the moisture of the specimens throughout the test unlike the South African Wheel Tracking Test used by De Beer [3]. Also, the temperature control system blew directly onto the specimens which caused expedited drying of specimens. As a result, specimens undergo significant fluctuations in moisture content, especially on the surface, throughout the test.

Furthermore, due to delays between testing and handling of specimens, the soaking period was varied ± 2 hours which resulted in a trend with Erodibility Index. Preliminary observations showed that the moisture condition at test significantly impacts the Erodibility Index. These observations however are still premature and will not be reported in this text.

7. Conclusions

The Cooper Wheel Tracking Test is capable of providing an indicative measurement of Erodibility Index for Cement Treated Basecourse. The Erodibility Index should be measured from the centre 100mm of the slab where the erosion is most critical. The Erodibility Index can be used as a design criteria for unsealed pavements or pavements with thin seals.

The Erodibility Index increases linearly with cement content and the development of erosion. This suggests that by reducing cement content a reduction of erosion and the generation of dust can potentially be realised.

However, there are limitations to the tests and modifications for the Cooper Wheel Tracking Test Device can be investigated to maintain moisture content throughout the test.

8. References

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