PREDICTING THE WEAR CHARACTERISTICS OF IRISH LIMESTONE AC MIXES

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ABSTRACT
This paper summarises a laboratory investigation into predicting the polishing characteristics of Irish Carboniferous limestone. Aggregate was sampled from 10 quarry sources located throughout Ireland. The polished stone value (PSV) was determined for each source. 20mm AC slabs were manufactured using a Cooper roller compactor and subjected to accelerated wear testing using the Road Test Machine located at the University of Ulster. The change in wet skid resistance and texture depth was determined at regular intervals during testing.

KEY WORDS: limestone, skid resistance, texture depth, simulated wear.
1. INTRODUCTION

Due to the nature of road surfacing materials and the need to provide a safe road surface for the road user to travel over, a minimum standard of aggregate quality is required in order to ensure acceptable properties of the asphalt surface mixture throughout their life span, such as the provision of an adequate level of skid resistance and texture depth. This sets the context of the research reported in this paper i.e. to better understand the wear characteristics associated with using local Irish limestone as a highway construction material subjected to trafficking.

Ireland has an abundance of hard Carboniferous limestone. Kandhal et al. suggested that medium to high category limestone aggregates have the potential to provide adequate skid resistance levels [1]. Masad et. al. found that limestone aggregate may polish to unacceptable levels [2]. The rate at which limestone aggregates will polish is dependent on the nature and age of the limestone formation, with softer limestone aggregates polishing faster than harder limestone aggregates [3].

However, no such comparable study has been carried out to assess the hard Carboniferous limestone’s available throughout Ireland. This is particularly relevant given the need to make greater use of local materials, to re-cycle and re-use within the construction industry.

Awareness of sustainability issues, global climate change, increasing energy costs, transport issues, scarcity of natural resources, reduced budgets and the introduction of long-term maintenance contracts has promoted considerable interest in properly understanding the materials being used and developed. The over-riding issue of understanding material performance has highlighted that much greater knowledge is required of the materials being used both in the structural layers and at the tyre / asphalt surface.

2. MATERIALS USED IN THE STUDY

Ireland is composed of many different rock formations formed over millions of years by different geological processes. Of the many different types, Carboniferous limestone is the most abundant. The aggregates assessed in the testing programme were sampled from ten different quarry locations throughout Ireland. Quarry selection was based on geographic and geological formation and resulted in a representative range of available limestone sources throughout the island of Ireland being used in the investigation.

Samples of 10/6.3mm aggregate from each source were prepared for PSV testing. Aggregate blends were prepared from each source to manufacture asphalt slabs. As one of the aims of the study was to assess the polishing of the coarse aggregate component in an asphalt mix, the <6.3mm component of each mix was kept constant i.e. from the same quarry.
Figure 1 shows the 20mm AC grading used. The bitumen used was a 70/100 pen grade typically used in Irish AC mixes. Test slabs 305 x 305 x 50mm were prepared using a Cooper roller compactor.

3. TEST METHODOLOGY

3.1 Polished Stone Value

The Polished Stone Value Test (PSV) was first introduced in British Standard BS 812 in 1960 in order to provide a means of establishing an aggregate’s resistance to polishing under the action of trafficking by vehicle tyres. Since then the test method has undergone some refinement and has now been introduced into the recently adopted European Standards [9].

The test consisted of preparing 10mm aggregate, ensuring all flakey particles had been discarded, before arranging 40-60 of the aggregate particles into a standard mould and holding them together with a resin binder. The PSV samples were photographed in order to analyse the range and change in colour characteristics before and after the polishing cycles.

The samples were then subjected to simulated trafficking using the accelerated polishing machine, using a standard rubber tyre, corn emery and emery flour to abrade and polish the aggregate particles respectively. The amount of polish was assessed using the portable skid tester.
3.2 The RTM Test Methodology

The Road Test Machine (RTM) was built by what is now known as the Transport Research Laboratory (TRL) in the 1930’s to research the properties of asphalt road materials. The equipment was relocated from the TRL to the University of Ulster in 2004 and undertook significant upgrading.

The RTM is used to assess the wear characteristics of High Friction Surfacing systems for BBA accreditation for use in the United Kingdom in accordance with Appendix H of TRL Report 176 [4, 10]. The RTM is also used at the University of Ulster to investigate the wear characteristics of asphalt materials [5, 6, 7, 8]. The same methodology as used for high friction surfacings was used in this laboratory investigation i.e. a 100,000 wheel pass test.

The RTM is shown in Figure 2. The machine consists of a 2.1m diameter table that rotates at 10 rpm. Up to ten 305mm x 305mm x 50mm test specimens can be mounted on this table. Two vertically mounted tyres run freely on the table applying a load of approximately 5kN. New tyres are fitted prior to testing a new set of test specimens. During testing the tyres track back and forth across the width of the test slab. The RTM is enclosed in a temperature controlled room where testing is typically carried out at 10±2°C. Both the number of rotations and temperature are recorded automatically. The RTM can be programmed to stop after a specified number of rotations.

When testing High Friction Surfacing materials, the specified 100,000 wheel pass test is judged to simulate 5 to 10 years trafficking. However, like most types of laboratory testing, the test conditions are idealised and do not exactly simulate actual in-situ conditions.

The asphalt test slabs were mounted on the RTM table and subjected to accelerated wear. After initial determination of skid and texture properties,
testing was stopped after 50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, 40000, 75000 and 100000 wheel passes. The slabs were removed and tested for skid resistance using the British pendulum tester (PTV) and texture depth using the sand patch method.

Figure 3 PSV moulds showing range in colour of limestone aggregates used

4. ANALYSIS OF POLISHED STONE VALUE TEST DATA

Figure 3 shows the PSV moulds used for testing and illustrates the range in colour of the different limestone aggregates used in this research investigation.
The two columns of moulds to the far right of the figure are the control specimens used for the PSV test. Figure 4 plots the found PSV for the 10 limestone sources. This shows the values to range from 54 to 35.

5. ANALYSIS OF RTM TEST DATA

The aim of the investigation was to determine how a 20mm AC mix responded to simulated trafficking under controlled laboratory conditions. This was assessed using pendulum tester and sand patch texture data collected with increasing number of wheel passes i.e. increasing simulated trafficking. The referencing system used for the AC slabs is equivalent to the referencing system for the PSV testing i.e. Slab 1 is made with aggregate from Q1; Slab 2 is made with aggregate from Q2 etc.

Figure 5 plots the development of wet skid resistance (PTV) with increasing number of wheel passes for the 20mm AC mixes. This shows a general overall trend i.e. an initial loss of skid resistance in early life followed by a stabilising of wet skid resistance up to 20,000 wheel passes, before a further decrease in wet skid resistance between 20,000 and 40,000 wheel passes. Thereafter, the skid resistance remains constant i.e. equilibrium conditions.

Figure 6 plots all of the texture depth data measured during the 100,000 wheel pass test. Similar to skid resistance, it shows a general trend in terms of texture depth development during testing i.e. an early life decrease followed by stabilisation. Although all the test specimens show very slight increases or
decreases in texture depth between initial decrease and 20,000 wheel passes, there is a noticeable trend of increasing texture depths for all the AC test slabs after 20,000 wheel passes.

In terms of texture depth, this increase in the later stages of testing relates to the onset of surface ravelling and stone loss i.e. the surface of the test slab is starting to disintegrate under the action of simulated trafficking. This suggests that the testing method is a simple means of putting a time-scale against the relative performance of an asphalt surfacing material, not only in skidding resistance and texture depth but also in its structural integrity.

It should also be pointed out that all of the RTM testing reported in this paper is carried out dry. It would be expected that should the test slabs be pre-conditioned by soaking in water or salt solutions that more rapid change in surfacing properties may occur.

![Figure 6 Change in texture depth for 100,000 wheel passes](image)

### 6. RELATIONSHIP BETWEEN PSV AND WET SKID RESISTANCE

The PSV test is a measure of the resistance to polishing of 10/6.3mm single sized aggregate, whereas wet skid resistance is a technical term used to quantify the amount of friction available from a surfacing mixture in-service i.e. the mixture of aggregate, filler and bitumen. Figure 7 shows a ranking of wet skid resistance (PTV) for each slab compared to PSV for the >6.3mm aggregate used to manufacture each slab. The wet PTV values reported are the values obtained after 100,000 wheel passes. With the exception of Q4 and Q1, there is very good agreement between PSV values and PTV.
Conclusions

Ten Carboniferous limestone aggregate sources were sampled from quarries located throughout Ireland. The 10/6.3mm aggregate size was tested using the PSV test. 20mm AC slabs were prepared using the >6.3mm limestone from each source with the <6.3mm kept constant. This paper has summarised the initial findings of a laboratory investigation to assess their skid resistance characteristics based on PSV and by the accelerated testing of asphalt slabs using simulated trafficking. By stopping the simulated trafficking periodically it was possible to assess how skid resistance and texture properties changed with time. The following conclusions are made:

- There was a comparable ranking of limestone sources based on PSV and PTV measurements. For two of the sources, the PSV is markedly higher than the PTV value recorded for the AC slab i.e. PSV may be over-predicting the skid resistance qualities of the aggregate when used in this type of asphalt mix.
- The wet skid resistance of each slab dropped by approximately 20 points during the first 1000 wheel passes of simulated trafficking. There followed 2 periods of skid resistance loss separated by periods of equilibrium. These periods of equilibrium may be due to the interaction of the tyres with bitumen removal, exposure and polishing of fines, to polishing of the main coarse aggregate component in the mix.
- Texture depths remained relatively constant up to 20,000 wheel passes. Thereafter, a gradual increase in texture relates to the onset of minor surface ravelling.
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REFERENCES


