

Hume City Council closes the loop with TonerPave™

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ABSTRACT: In this paper the development of a new type of asphalt paving called TonerPave™ is discussed with particular emphasis on the enhanced physical and environmental properties compared to a comparable, standard mix design commonly used for suburban roads, carparks, driveways and pathways. TonerPave is an asphalt with a polymer modified binder, however unlike expensive virgin polymers commonly used in high performance asphalt, TonerPave utilises a patented blend of post-consumer recycled polymers derived from one or more of the following :- waste toner powder, waste acrylic paint, rubber crumb from recycled car and truck tyres, and recycled engine oil. The result of this Australian innovation is a high performance asphalt with strong environmental benefits at a price comparable to standard grade asphalt. The target market for this new product range is local governments across Australia. Hume City Council, in Melbourne's north, have been recycling toner cartridges for years, 170 tonnes of toner cartridges and bottles over a 10 year period, and have recently closed the loop by laying over 2000 tonne of TonerPave, which includes approx. 40 tonne of MTP additive, made from approx. 36.8 tonnes of waste toner powder. Residual toner powder is approx. 13% by weight of all empty cartridges, so Hume's 170 tonnes equates to 22 tonnes of toner powder. Hume for one has reused all its waste toner powder in its own roads – for now.

KEYWORDS: Asphalt, bitumen, polymer modified binder (PMB), toner, modified toner polymer (MTP), Close the Loop, Downer, Hume City Council.

1 Introduction

TonerPave™ is a new asphalt with enhanced performance properties due to the use of recycled polymers and other additives. The polymers used are post-consumer recycled polymers sourced from the recycling of toner cartridges, waste acrylic paint and/or rubber crumb from recycled car and truck tyres.

This paper explains the story of the Tonerpave product range from original concept, R&D, product development, testing and commercialisation.

Bitumen is a sticky, black and highly viscous liquid or semi-solid form of thermoplastic material derived from the carefully refined residue of the distillation process of selected crude oils. It is mainly used as the glue or binder mixed with aggregate particles to create asphalt for road construction.

Toner is predominantly plastic. Very small pieces of highly engineered polymers, the main types of plastic are styrene acrylate, styrene butadiene, and polyester. Other ingredients in toner include small amounts of wax, minerals, and pigments, and some include iron oxide, silica, and other flow and charge control agents.

Asphalt is widely used in road pavement due to its good viscoelastic properties. Unfortunately asphalt becomes brittle at low temperature and is liquid at high temperature which can result in cracking at low temperature and rutting at high temperature. In order to enhance the performance of asphalt, and extend the life of the road, it is a widely accepted practice to add modifiers such as rubber, polymers, minerals and chemicals. In spite of the small proportion of these additives needed to improve the properties of asphalt, their high cost makes their use prohibitive

Close the Loop® (CtL) is an innovative Australian materials recovery company with divisions in Melbourne Australia and Kentucky USA. The core business of CtL is collection, data capture, and recycling of toner and inkjet cartridges on behalf of printer and copier companies.

Downer is one of Australia's largest infrastructure companies with a significant asphalt division

CtL and Downer have formed an exclusive partnership to commercialise this technology and both businesses have a presence in the City of Hume (HCC), in Melbourne's north. HCC has been actively engaged in the project

from the start via their BEN (Business Efficiency Network).

2 Background

CtL has been working persistently for almost 14 years to find a high volume value added reuse application for the thousands of tonnes of used toner powder it produces. Prior to this project, CtL has been supplying toner to the masterbatch industry, as an additive to a low cost black masterbatch made in Indonesia, and will continue doing so.

A small amount of R&D has been done related to the use of waste toner powder in asphalt cement in the USA dating back to pre-1997 [1], and despite laying 4 or 5 test sections of road in Texas at that time, the product has never been commercialised. After significant research by the author, it has become clear why the project was not commercially successful. Firstly, different types of toner from different sources were used in the trials, giving slightly varying results. Secondly, the toner used was in powder form which is very messy and potentially dangerous given its small particle size.

The one thing that is clear from this early work in the US, was that toner powder did improve the performance of asphalt [2], and this was further proven by CtL when they commissioned a survey of 4 of those sites some 10 years on comparing the condition of the toner modified sections to control sections [3].

CtL's first work on the subject was in 2003 when initial enquiries made to CSR Emolium marked the start of a lengthy and sporadic R&D project. The focussed push to develop and commercialise Tonerpave began in 2011. Downer were introduced to MTP in early 2013 and a 3 year exclusive partnership agreement between CtL and Downer to commercialise TonerPave signed in September 2013.

3 Materials and methods

Many types of polymers, both plastomers and elastomers are used to modify the performance and increase the longevity of asphalt [4].

3.1 From toner powder to MTP

The core product behind TonerPave is MTP (Modified Toner Polymer) which is made from post consumer recycled toner powder.

Mixed 'waste' toner powder has a mean particle size of 8 – 10 micron, comes in black, cyan, yellow and magenta, and has numerous different chemical formulations, all based on either styrene, butadiene, or polyester polymers.

Close the Loop has collected and recycled over 22,000 tonnes [5] of toner and inkjet cartridges since early 2001. Approx. 80% by weight is toner cartridges and bottles, and given that approx. 30% are returned to the brand owner for reuse and /or remanufacturing, the remaining 12,320 odd tonnes are processed for recovery of raw materials, and approx. 13% by weight, (approx. 1600 tonnes) is residual toner powder.

3.2 Preparation of asphalt modifying agent

MTP is an asphalt modifying agent, or additive. The toner powder is homogenised to minimise variability between batches, and then agglomerated to produce a finished particle of 1-3mm in diameter. During the agglomeration process one or more other materials such as recycled engine oil may be added. The finished product is called MTP, and is delivered to Downer as a polymer based additive.

3.3 Preparation of modified asphalt

MTP is added to the bitumen and aggregate at the asphalt plant and trucked to site as with any standard asphalt. Tonerpave is applied with the same equipment, with the same processes as standard bitumen.

3.4 Measurements

During development, a wide range of tests have been conducted both in the Downer NATA certified national laboratories and in third party asphalt testing facilities. The main benefits include:-

1. Approx. 11% reduction in modulus as per AS 2891.13.1
2. Approx. 30% increase in fatigue life as per AG:PT/T233
3. Approx. 50% reduction in total cracking compared to control sections after 10 years [3]

4 Carbon footprint

Downer Infrastructure has indicated that adding 0.5% MTP (Modified Toner Powder) to an asphalt mixture (TonerPave) reduces bitumen content by 0.3% and filler by 0.2%. Energetics [6] has analysed the net impact of the addition of MTP under this scenario. Our analysis takes into account:

- Production of 1 tonne of MTP
- Replacement of 600 kg of bitumen
- Replacement of 400 kg of filler
- Additional natural gas usage at Somerton associated with the above change in mix composition.

As shown in Figure 4, the key benefit from adding MTP to asphalt is found in the substitution of bitumen. The overall net benefit is 0.27 t CO₂e per tonne of MTP that is added. This result is heavily influenced by the data for MTP1 and the data for bitumen (Australian data from SimaPro database).

Due to the very low embodied emissions associated with filler production and delivery, the benefits from substitution of filler are almost negligible. The additional gas usage at the Somerton plant from substituting bitumen and filler for MTP is minimal.

5 Results and discussions

TonerPave shows improved performance over control asphalt of similar mix design in physical, mechanical, and environmental aspects. The test results show increased stiffness, which would reasonably suggest reduced rutting and cracking leading to reduced whole of life costs.

TonerPave has a lower carbon footprint to comparable mix designs due to the replacement of bitumen with post consumer recycled polymers derived from waste toner powder. This innovative asphalt alternative is the result of a partnership between Close the Loop and Downer, and when matched to local government procurement is a world class example of industrial ecology in practice.

References

1. Use of waste toner in asphaltic concrete - Solaimanian et al 1997.
2. The toner modified asphalt demonstration projects - Yildirim et al 2003
3. Report_ Modified Toner Polymer Mixtures_18April2013 – Harold Von Quintos
4. Polymer Modified Asphalt – Yvonne Becker et al 2001.
5. www.closestheLoop.com.au
6. Downer Infrastructure – Asphalt carbon footprint update 2014 V2.0 – Energetix Pty Ltd