Gilsonite Emulsion - Sunscreen for our Pavements

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ABSTRACT

Christchurch Airport has 820,000sqm of airside pavement surfacing, 66% of which is asphaltic surfacing which never receives any aircraft traffic loadings. This pavement deteriorates only by environmental factors and is replaced approximately every 12-15 years due to moisture penetration and oxidation of the bitumen binder, resulting in embrittlement and the creation of Foreign Object Debris (FOD) which is a serious problem for the airport operations.

Gilsonite is a natural resinous hydrocarbon high in nitrogen particles with a resistance to free radical oxidation. When included into a bitumen emulsion, it can be used as a preservation agent for deteriorating pavements and has recently successfully been applied to the airside pavement at the Christchurch International Airport.

A drawback becomes apparent when friction characteristics are investigated. Upon application, the pavement will lose approximately 0.3 grip numbers before undergoing a curing process, which allows the friction values to steadily return to status quo. With careful planning and management through the use of trials, weather predictions and friction testing, the effects of friction loss can be mitigated.

With its successful use on the airside pavements of Christchurch International Airport, is there scope to broaden the horizons into our road network?

INTRODUCTION

Asphalt pavements have a limited life span dueto the effects of traffic loading and environmental factors such as sun and rain. Christchurch International Airport has 820,000sqm of airside pavement surfacing, 66% of which is asphaltic surfacing which never receives any aircraft traffic loadings. This pavement deteriorates only by environmental factors and is replaced approximately every 12-15 years due to moisture penetration and oxidation of the bitumen binder causing embrittlement and cracking, resulting in the creation of Foreign Object Debris (FOD) which is a serious problem for the airport operations.

Continual replacement of asphalt pavement surfacing is costly and time consuming, but there are ways to extend the life of the pavement surfacing. One such way is by the application of bituminous emulsions, also known as Surface Enrichment Spray Treatments (SEST).

This paper aims to highlight the existence of Gilsonite and how it is used in SEST products to aid in the longevity of asphalt surfacings, with a brief case study on the SEST used at Christchurch International Airport.

WHAT IS GILSONITE?

Gilsonite, or North American Asphaltum is a natural, resinous hydrocarbon found in the Uintah Basin in north-eastern Utah. This natural asphalt is similar to a hard petroleum asphalt and is often called Asphaltite, Uintaite, or Asphaltum. (Ziegler Chemical & Mineral Corp., 2014).

Gilsonite is found below the earth's surface in nearly parallel, vertical veins or seams. They extend many kilometres in length and as deep as 450 metres. Visibly, Gilsonite is a shiny, black substance similar in appearance to the mineral Obsidian. It is brittle and can be easily crushed into a dark brown powder. (Ziegler Chemical & Mineral Corp., 2014).

Figure 1: A Sample of Gilsonite

Whilst first discovered in the early 1860's, Gilsonite gets its name from Samuel H. Gilson, who began promoting the product in the mid 1880's. (Ziegler Chemical & Mineral Corp., 2014).

A Particularly Useful Property of Gilsonite

Bitumen slowly oxidises when in contact with air; a characteristic considered to be the main cause of bitumen ageing. The Asphaltene content of the bitumen increases continuously due to oxidation of the resins. Chemical processes cause the bitumen to become more viscous, which is presented as brittleness in the asphalt surfacing.

Petro Tar Co (2014) stated a unique feature of Gilsonite is its high nitrogen content, which is present mainly as Pyrrole, Pyridine, and Amide functional groups. The low oxygen content relative to nitrogen suggests that Gilsonite is more resistant to free radical oxidation.

BRINGING GILSONITE DOWN UNDER

Christchurch International Airport has an established Annual Pavement Maintenance Works (APMW) programme which is driven by their collaborative asset management team consisting of the Airport Asset Owners - Propel, Engineering Consultants - AECOM, and Works Contractors - Fulton Hogan.

The Airport has 820,000sqm of airside pavement surfacing, 66% of which is asphaltic surfacing which never receives any aircraft traffic loadings. This pavement deteriorates only by environmental factors and is replaced approximately every 12-15 years due to moisture penetration and oxidation of the bitumen binder, resulting in embrittlement and the creation of Foreign Object Debris (FOD).

It was clear to the APMW team that the oxidation resistant properties of Gilsonite would provide significant benefits to pavement preservation at Christchurch Airport. The selected solution for achieving this was via application of a Gilsonite based SEST product to the pavement surface similar to a coating of sunscreen.

Undertaking Due Diligence

Before committing to the application of Gilsonite, AECOM's New Zealand based engineers undertook extensive research into the performance of Gilsonite as an emulsion product, including attendance at the American Society of Civil Engineers (ASCE) conference in May 2013 which included presentations on Gilsonite by Federal Aviation Authority (FAA).

The FAA paper authored by Gregory (2010) reported a notable trend in the enhancement of surfacing life where preservation and rejuvenation techniques were used. A Gilsonite SEST product was recognised as the most effective product in achieving this, with rates of deterioration typically reducing by 2 to 3 times.

Note this data is site specific to locations in the USA. As a new product to New Zealand, performance data is yet to be collected.

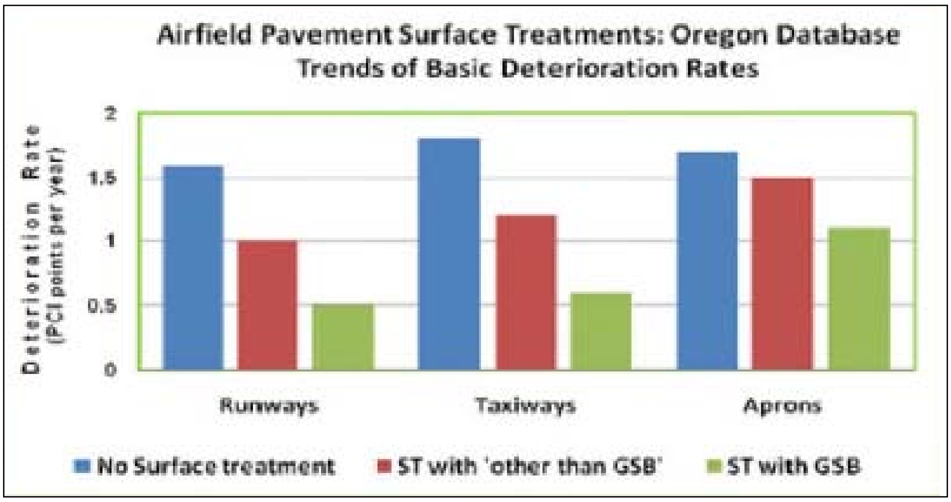

Figure 2: Pavement Deterioration Rates – Gilsonite SEST Products (Gregory, 2010)

There is significant mounting evidence from the USA to suggest that bituminous treatments early in the surfacing's life cycle (within the first 5 years) significantly improves longevity, especially in low usage zones which are not subject to accumulated flexural distress from loads and where the primary mode of deterioration is environmental weathering. These early life treatments fall under the "preservation" category whereas late in life treatments fall under the "rejuvenation" category.

The potential benefits of early service treatments are show Figure 3 below. These treatments are very low cost when compared to resurfacing overlays.

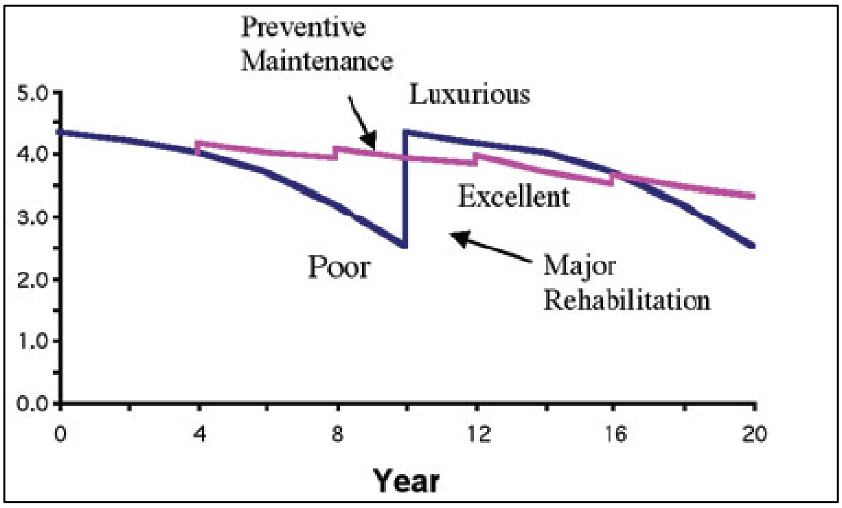

Figure 3: Typical Performance of Pavements Subjected to Preventative Maintenance

Sustainability

Prolonged pavement life results in reduced maintenance cycles, reduction in raw material usage, enhancement in the qualities of existing surfacing materials, reduction in maintenance costs and the improvement in liveability of our end users, in this case, airline passengers.

The SEST product used at Christchurch Airport is the first known application of a bitumen emulsion with a full life cycle assessment (LCA) and Green Circle accreditation in New Zealand. Figure 4 shows the Road Life Cycle Environmental Impact per Square Metre over a 3 month period. As can be seen, the SEST product performs well against the traditional asphalt replacement.

Indicator	Gilsonite SEST	Asphalt Cement
Global Warming (kg CO_2 equiv.)	20,000	40,000
Ozone Depletion (kg CFC-11 equiv.)	0	0
Acidification (kg SO_2 equiv.)	100	300
Eutrophication (kg PO_4 equiv.)	0.007	0.02
Photochemical Smog (kg O_3 equiv.)	40	80
Cancer (kg benzene equiv.)	0.08	0.2
NonCancer (kg toluene equiv.)	2	5
Ecotoxicity (dimensionless)	1000	2000
Fossil (tons oil equivalent)	40,000	90,000

Figure 4: Results of the Life Cycle Assessment (Asphalt Systems Inc, 2014)

With such promising results coming out of the USA and with the economic and environmental considerations in mind, the application of a Gilsonite based SEST at Christchurch International Airport was approved.

APPLICATION OF GILSONITE AT CHRISTCHURCH AIRPORT

Over the past year, Gilsonite based SEST has been applied to almost 400,000m^2 of Christchurch Airport pavement surfacing, providing protection to the outer thirds of the main runway, all of the secondary cross-runway, the large majority of the taxiways and the Antarctic and Post Aprons. High use areas such as the main runway centre third and around the terminal gates have not received application due to the logistics surrounding operations and the likely dominant pavement surfacing deterioration mode of traffic loadings.

A typical emulsion spray tanker can be used to apply the product (refer Figure 5: GSB-88 Application below), making application very rapid. The product goes down a dark brown and depending on weather conditions, was found to “break” in approximately 15 to 45 minutes, forming a dry black surface, as shown in Figure 7.

With a 1 to 1 product to water ratio, the emulsion is also very thin, allowing the product to percolate into any voids within the surfacing, as shown in Figure 6 below. The surface does retain a tackiness once broken, however it was discovered that a light dousing of water, similar to a light drizzle of rain, three to four times after it has broken, is effective in removing this initial tackiness.

Figure 5: GSB-88 Application

Figure 6: GSB-88 Percolating Into Voids

Figure 7: Birds Eye View of Broken GSB-88

Friction Characteristics

The main drawback for the use of the Gilsonite based SEST is the initial reduction in friction levels after application. However, with a managed approach, the effects of this can be mitigated.

Trial investigations found that 0.3 grip numbers are lost with the initial application of 0.5 litres/m^2 of the SEST (from original friction levels) and an increase of approximately 0.1 grip number is achieved after 24hrs of application on an un-grooved surface.

Figure 8 shows the results for the friction testing prior to the SEST application, the results the day after application and the improvement in results daily thereafter. The application of a fine, angular sand is often used to help minimise the initial reduction in friction.

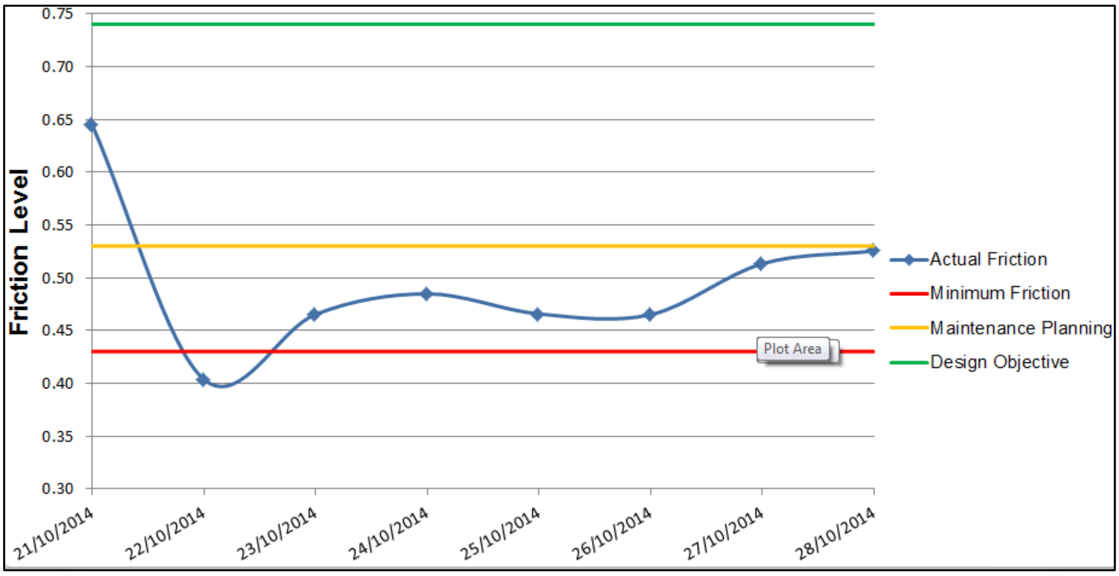

Figure 8: Summary of Friction Testing Results

Success

Whilst the physical effectiveness of the product is yet to be determined, the application of Gilsonite at Christchurch Airport can so far be classed as a success.

Extending pavement surfacing life will result in reduced interruptions to aircraft operations and hence ensure increased safety and reliability for airline passengers and airport construction workers.

A PARTING THOUGHT

With the success of Gilsonite based emulsion application in the Airport environment, is there scope to broaden the horizons? Could Gilsonite be a viable option to extend the life of pavement surfacing within New Zealand's road network?

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