Use of Fuel Resistant Asphalt for Aircraft Pavement surfaces in Australia

Greg White

Abstract

Many regional and smaller airport aprons in Australia are provided with an asphalt surface course. In areas where fuel spills from venting aircraft tanks and refueling operations are unavoidable, the surface is exposed to hydrocarbons on a regular basis. Bitumen binders are softened by these hydrocarbons and the surface can be damaged. Such damage can lead to increased maintenance effort being required and increased loose material on the apron surface which, can be ingested and damage aircraft engines.

Traditionally in Australia aircraft parking aprons were treated with a fuel resistant membrane. These membranes are sprayed onto the surface some weeks after asphalt finishing. Such membranes, generally tar-based products, result in top-down cracking of the asphalt and require re-treatment every two to three years.

Shell Bitumen has developed a fuel resistant asphalt binder, Mexphalte Fuelsafe. This material is a proprietary product which blends a mix of polymer products into conventional bitumen. This fuel resistant binder offers the advantages of not resulting in top down cracking and being more economical than fuel resistant membrane treatments. The resulting asphalt has a stiffness that exceeds that from conventional binders and is easily manufactured.

A field trial at an Australian Defence airfield demonstrated that the fuel resistant asphalt was manufactured, placed, compacted and finished like conventional asphalt. The only noticeable difference being that the asphalt had a slightly sticky feel which caused some adhesion to the screed at the rear of the asphalt paver. Twelve months after construction and following significant fuel exposure, the apron surface is performing well.

Otherwise identical cores of asphalt containing conventional and fuel resistant binders were taken from the trial and assessed. Based on surface exposure and submersion in diesel fuel for 10 days, it was concluded that the fuel resistant binder resisted hydrocarbons for a few days. However, after prolonged exposure the hydrocarbons were absorbed by the asphalt. Once hydrocarbons were absorbed, the fuel resistant binder softened in a similar manner to the conventional bitumen. It was concluded that the fuel resistant binder was therefore effective in resisting short term fuel spills but would be less effective under prolonged or continuous spills in an isolated area.

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Introduction

Fuel spills of a minor nature are generally considered to be inevitable on aircraft pavements where parking and refueling occurs. Many nozzles used for refueling retain some fuel at the completing of refueling and this is often spilt on removal of the nozzle. Other aircraft frequently vent fuel on engine start-up or shut-down.

Some airports have adopted concrete pavements or segmental concrete block surfaced pavements for refueling areas. However, this is not always feasible or economical. Where refueling is performed on asphalt surfaced pavements, a fuel resistance coating has commonly been applied to retard the rate of erosion and degradation of the asphalt as a result of hydrocarbon damage.

Use of fuel resistant asphalt binder as an alternate to traditional asphalt binder and a fuel resistant membrane is presented. A number of field trials are described as well as the results of preliminary testing of asphalt manufactured with traditional and fuel resistant binders.

Traditional Approach

Prior to tar based products becoming recognized as carcinogenic at elevated temperatures, tar binders were used in asphalt subject to fuel spills. While many of these pavements have now been reconstructed or overlaid with conventional asphalt, some remain in service and remain very resistant to fuel damage. When tar asphalts are overlaid, the texturing of their surface by profiling machine can be hazardous. The profiling machine heats the asphalt surface and is suspected to create potentially carcinogenic fumes.

Without the ability to use tar based binder for fuel resistant asphalt, efforts turned to the development of fuel resistant membranes that were applied to the surface of conventional asphalt layers. These membranes are generally coal tar based or acrylic products, and are applied cold as emulsions. A number of proprietary products are available and these include:

- Jetseal. By Boral Asphalt.
- Pavron. By Swepdi International.
- Superseal. By Australian Pavement Maintenance Systems.
- Bitulastic Roadseal. By Bituminous Products.
- Viroseal AB. By Slip Resistant Surfaces.
- Sealmaster Coal Tar Concentrate. By Sealmaster.

One of the advantages of these materials is that they can be applied to small and irregular areas without the need to treat an entire apron. However, significant limitations have been observed with these materials in recent times, as described below.
Softening of asphalt

Where a new asphalt surface pavement is constructed or an existing apron is provided with an asphalt overlay, fuel exposure will commence on returning the area to active service. If application of the fuel resistant membrane is significantly delayed, the new asphalt surface can be damaged by fuel exposure. However, if the fuel resistant membrane is applied within the first six weeks after asphalt resurfacing, the hydrocarbon based emulsifier can also soften the asphalt surface, leading to scuffing under aircraft traffic. Figure 1 shows scuffing of asphalt softened by the early application of a coal tar based fuel resistant membrane at Newcastle Airport.

![Figure 1 Scuffing of asphalt at Newcastle Airport](image)

Cracking of asphalt

Due to the nature of the tar-based products, they shrink after application. The fuel resistant membrane’s integrity is then lost and any spilt fuel can enter the cracks and affect the asphalt below the surface. A typical cracked membrane is shown in Figure 2. Commonly, these membranes will be replaced every two to three years and the cumulative effect of the shrinkage and cracking can crack the underlying asphalt. In some circumstances, cracks have been observed to extend through the full depth a of 50 mm asphalt surfacing as was the case at RAAF East Sale in 2006. In such circumstances, the asphalt surface generally requires full depth replacement.
Figure 2  Cracked fuel resistant membrane at Cairns Airport

**Slippery surface**

Some products have been found to be slippery under foot after application. When wet, they have been reported to be an OHS hazard to aircraft ground staff. Figure 3 shows a very slick and slippery surface after treatment with Viroseal AB at RAAF Edinburgh.

Figure 3  Slick and slippery surface at RAAF Edinburgh
Fuel Resistant Binder

In an attempt to alleviate some of the problems associated with fuel resistant membranes, a fuel resistant binder was considered as a replacement for the historically popular tar asphalt.

Kuala Lumpur International Airport was the first airport known to have specified fuel resistant asphalt for their flexible pavements. Ooms Avenhorn Holding from The Netherlands developed a Polymer Modified Binder (PMB) to be resistant to softening under fuel exposure for this project (Rooijen, et al, 2004). When compared to conventional Superpave binders, the Ooms Avenhorn Holding product demonstrated:

- Reduced increase in deformation under load following 24 hours fuel immersion.
- Reduced increase in penetration following 24 hours fuel immersion.
- Reduced loss of mass by wire brushing after 24 hour and 72 hour fuel immersion.

Since the Kuala Lumpur project, the Ooms Avenhorn Holdings product has been used at other international airports including Cairo (Egypt) and La Guardia (New York) (Corun, et al, 2006).

Nyguard is a equivalent product available in the United Kingdom, developed by Nynas Bitumen (Materials World, 2004). This product was used for the resurfacing of two runways at Bristol International Airport in 2004 and was the first reported use of such a product in the UK. This product is also a bituminous binder containing a blend of polymer additives.

In Australia, a comparable product has been developed by Shell Bitumen. Shell’s Mexphalte Fuelsafe (Shell, 2006) is also a PMB. The combination of polymers has been designed and selected to maximise the product’s ability to resist fuel damage whilst maintaining workability and other performance characteristics similar to conventional and common PMB products.

Table 1 summarizes the results of laboratory testing of dense graded asphalt sampled manufactured with Mexphalte Fuelsafe and conventional C320 bitumen.
Table 1  Comparison of Mexphalte Fuelsafe and C320 binder

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>Mexphalte Fuelsafe</th>
<th>Conventional C320</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight loss after immersion in diesel</td>
<td>% loss by mass</td>
<td>After 1 day &lt;1</td>
<td>After 1 day 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After 7 days 2</td>
<td>After 7 days 18</td>
</tr>
<tr>
<td>Weight loss after abrasion testing</td>
<td>grams</td>
<td>No immersion 10</td>
<td>No immersion 25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After 1 day 35</td>
<td>After 1 day 55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After 7 days 55</td>
<td>After 7 days 305</td>
</tr>
<tr>
<td>Deformation at 40 C</td>
<td>% deformation</td>
<td>1.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Allowable initial strain for fatigue at 1,000,000 cycles</td>
<td>µm/m</td>
<td>170</td>
<td>111</td>
</tr>
</tbody>
</table>

Based on the results presented in Table 1 it was considered that Mexphalte Fuelsafe would provide increased resistance to fuel exposure when compared to C320 binders. It was also concluded that even in non-fuel exposed areas, Mexphalte Fuelsafe can offer increased resistance to deformation and increased resistance to fatigue compared to C320 binder.

Discussion with Shell Bitumen technical staff determined that the Mexphalte Fuelsafe could be utilised as a direct substitute for conventional binder in asphalt. Shell Bitumen staff also advised that the asphalt mix would have similar workability characteristics to the same asphalt mix containing a conventional binder.

Field Trials

Based on the success of similar materials in other countries, a number of projects were selected as trials of Mexphalte Fuelsafe in Australia. The first known use of this material was on an aircraft parking apron at RAAF Amberley, near Brisbane. No formal monitoring of the resulting surface was located. SKM specified Mexphalte Fuelsafe, as a direct replacement for C320 conventional binder, on apron resurfacing projects at RAAF East Sale (west a Melbourne) and RAAF Williamtown (near Newcastle). Both projects were constructed from May to July in 2006. Table 2 presents a summary of known Mexphalte Fuelsafe use in Australia.

Table 2  Mexphalte Fuelsafe use on Australian Airports

<table>
<thead>
<tr>
<th>Airfield</th>
<th>Area</th>
<th>Dates</th>
<th>Quantity of asphalt</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAAF Amberley</td>
<td>Air Movements Apron</td>
<td>April 2005</td>
<td>600 tonne</td>
</tr>
<tr>
<td>RAAF East Sale</td>
<td>King Air Apron</td>
<td>May 2006</td>
<td>1600 tonne</td>
</tr>
<tr>
<td>RAAF Williamtown</td>
<td>Air Movements Apron</td>
<td>June 2006</td>
<td>2400 tonne</td>
</tr>
</tbody>
</table>

Constructability

No significant constructability issues were identified with the Mexphalte Fuelsafe binder. The asphalt was, however, observed as being stickier than asphalt with conventional binder. This stickiness resulted in occasional
dragging of asphalt mat when it passed the screed at the back of the paver. This dragging was minor and did not significantly affect the resulting asphalt surface. The stickiness also added minor inconvenience to hand work where the asphalt frequently stuck to shovels and lutes. Densities achieved with the Mexphalte Fuelsafe were equal to or better than those achieved for the C320 binder (Emoleum, 2006).

**Field Performance**

The work at RAAF East Sale included asphalt with Mexphalte Fuelsafe as well as C320 binders in adjacent areas. Apart from the binder used, the asphalt mixes were identical in their design. This allowed a direct comparison of the two products in the same aggregate matrix, manufactured from the same plant and constructed at the same airfield, in virtually identical locations and environments.

The most heavily fuel exposed area of the RAAF East Sale apron is the King Air parking positions. The refueling nozzles eject excess fuel at the completion of the refueling operation so regular small fuel spills are expected. The asphalt in these parking positions was re-inspected one, three and six months after construction. Despite significant evidence that fuel had been spilt in these areas, the asphalt was essentially unaffected as shown in Figure 4.

![Figure 4](image)

**Figure 4** Fuel exposed Mexphalte Fuelsafe asphalt

**Material Testing**

A number of cores were taken from the Mexphalte Fuelsafe as well as from C320 asphalt during the RAAF East Sale work. The asphalts were otherwise identical in design. Four cores were subjected to fuel exposure and monitoring over a period of 10 days at SKM’s Canberra office. Diesel was
used as a proxy to aviation fuel and two samples (one of each binder) was semi submerged in fuel to a depth 2/3 the height of the sample, whilst the other two (one of each binder) were provided with a ring of silicone sealant to retain the fuel and fuel was added to the surface only, at a rate of 0.1 mm of fuel every day for 9 days. The samples are shown in Figure 5. The samples were monitored on a daily basis and intermittently the surface exposed samples were brushed in isolated areas to determine the extent of surface softening. A summary of the observations from this experiment follows:

- The relative performance of Mexphalate Fuelsafe and C320 was essentially the same for both the semi submersed and surface exposed samples.
- During the first few days of exposure, the Mexphalate Fuelsafe sample resisted penetration of the diesel and the fuel pooled on the surface on application. The C320 sample absorbed the fuel almost instantly.
- After five days of exposure, the Mexphalte Fuelsafe absorbed newly applied fuel as quickly as C320.
- Both Mexphalte Fuelsafe and C320 samples were easily eroded by abrasion with a toothbrush at the completion of exposure. The C320 samples were more eroded and the semi submerged sample failed under its own weight when removed from the fuel bath. Figures 6 and 7 show samples following fuel exposure.

**Figure 5  Fuel exposure samples before testing**
(a) Fuelsafe sample after seven days immersion.

(b) C320 sample after seven days immersion.

Figure 6    Samples following seven days immersion in diesel.
Based on the testing performed and monitoring of the samples over time, it was concluded that during the early stages of fuel exposure, the Mexphalte Fuelsafe demonstrated significantly improved fuel resistance properties when compared to C320 samples. However, the difference in performance narrowed as fuel exposure become prolonged. Additional laboratory testing is recommended to determine the true comparative fuel resistant of Mexphalte Fuelsafe and other binders.
Cost-Benefit Analysis

Based on the 1 September 2007 price list from Shell (Shell, 2007) the price of one tonne of bitumen in Brisbane is $665 for C320 and $979 for Mexphalte fuelsafe. Given that airport asphalt typically contains 5.5 to 6.0% binder, this would result in around $18/tonne difference in the cost of asphalt. Based on a density of 2,400 kg/m$^3$ and a thickness of 60 mm, this converts to a cost difference of around $3/m^2$.

A cost benefit analysis of Mexphalte Fuelsafe versus a conventional C320 binder with a fuel resistant membrane was performed. The analysis was performed based only on capital cost as the comparative long term performance is currently not known due to the short period of time that the Mexphalte Fuelsafe binder has been available for. The cost benefit analysis is presented in Table 3 and is based on typical asphalt surfacing cost for 60 mm of 14 mm mixed asphalt. Based on capital cost alone, Mexphalte Fuelsafe has significant economic advantage over C320 binders where a fuel resistant membrane would be required. Further assessment of the whole of life cost of various binder options in fuel exposed areas is recommended once the life cycle of Mexphalte Fuelsafe asphalt is determined.

Table 3  Cost benefit of Mexphalte Fuelsafe and C320 binder ($/m$^2$)

<table>
<thead>
<tr>
<th>Assumed life</th>
<th>Mexphalte Fuelsafe</th>
<th>Conventional C320</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt cost</td>
<td>$25</td>
<td>$25</td>
</tr>
<tr>
<td>Additional cost for binder</td>
<td>$3</td>
<td>-</td>
</tr>
<tr>
<td>Fuel Resistant Membrane</td>
<td>-</td>
<td>$8</td>
</tr>
<tr>
<td>Total</td>
<td>$28</td>
<td>$33</td>
</tr>
</tbody>
</table>

Conclusions

Since the phasing out of tar binders in asphalt, the application of a fuel resistant membrane to asphalts containing C320 binder has become the norm for asphalt exposed to fuels on airport aprons. With the introduction of Mexphalte Fuelsafe by Shell Bitumen, a new option is available for these areas.

Based on literature and the limited test data available, Mexphalte Fuelsafe is concluded as being suitable for direct replacement of C320 or other conventional binder in airport asphalt mixes. The stiffness and deformation resistant of this polymer modified binder exceeds that of conventional binders.

From the experience of three asphalt overlays, including RAAF East Sale where both Mexphalte Fuelsafe and C320 were used in the same asphalt mix on adjoining pavement areas, the Mexphalte Fuelsafe appears to present no significant construction issues. The only minor issue being its tendency to stick to the paver screed and hand tools. Field performance also appears to be satisfactory for the three trials performed to date, where exposure to fuel is not severe. It is recommended that these trials be monitored over the life of the asphalt to confirm the field performance of the binder. It is considered,
however, that Mexphalte Fuelsafe will not perform as well under severe fuel exposure as tar asphalts did in the past.

From limited testing, Mexphalte Fuelsafe appears to have significantly improved fuel resistant properties under limited of short term fuel exposure. This improved performance appears to narrow after longer term or repeated exposure. It is recommended that a more formal laboratory testing regime be undertaken to further determine the short and long term benefits of this material over C320 and other binders.

The capital cost of Mexphalte Fuelsafe is greater than for conventional binders. However, when the cost of applying a fuel resistant membrane to the conventional binder is taken into account, the capital cost of Mexphalte Fuelsafe becomes very favorable. It is recommended that the comparison of capital cost be extended to consider whole of life cost once the life cycle of Mexphalte Fuelsafe asphalt is determined from observation of the field trials.

References


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