New technology road surfacing constructability trials in Ethiopia: planning and setting up phase

Gurmel Ghataora - May 2022

A road pavement comprises layers of various materials designed to prevent failure of the subgrade. Each layer in a road pavement system has a specific function for all types of roads. In the case of a sealed road, the surface layer has the function of preventing ingress of water into the sublayers; it must be smooth but provide adequate friction to resist skidding; it must be abrasion resistant and durable as it is subjected to both traffic loading and impact of weather.

The impact of global warming is likely to result in an increased rate of deterioration of roads built using conventional surfacing techniques as the upper-most layer is likely to be the most impacted by predicted increases in temperature and precipitation events. Thus, roads will require more maintenance and surfacings may have to be replaced more frequently than the typical replacement interval of eight to twelve years. This will impact both Road Authorities budgets and road user costs.

There is thus the need to improve the longevity of surfacings and reduce whole life costs using newer technologies, particularly for low-income countries with limited budgets. Three technologies investigated during this project include fibre mastic asphalt (FMA), modified epoxy asphalt surfacing (MEAS) and modified epoxy chip seal (MECS). This reading pack introduces literature that underpins constructability trials in Ethiopia (planning and set up phase). It highlights the importance of rigorous trialling of the application of new technologies to ensure peak performance and the future proofing of investments. Finally, the reading pack highlights the need for location specific trialling of new technologies and the development of context specific guidance.

FMA is based on cellulose fibres extracted from oil palm fibre, which was developed in Malaysia, where it has been used successfully in several road trials. It has been shown to be a cost-effective way of reducing cracking, rutting and stripping.

Over the last few decades epoxy asphalts surfacings have been used on steel bridge decks. Their success has led researchers to investigate their application as surfacing for asphalt roads. The epoxy asphalts have required lesser maintenance and been shown to extend life by three to five times compared to that of conventional asphalt. The widespread application of epoxy asphalt has been developed in New Zealand and are now being considered for applications in Europe.

Studies have shown that whilst there is increased initial construction cost the whole life cost is favourable, with increased benefit for the road users as the need for maintenance and the impact of road works for renewals is reduced. This project is the first to demonstrate that both FMA and epoxy asphalt can be used to LIC country.

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Gurmel has over 50 years of experience in Civil Engineering. He specialises in Geotechnical Engineering, with focus on sustainable and climate resilient materials for roads and railways. He has worked on numerous research projects, supervised 60 research students and published widely with over 200 papers and reports. In 2021 he was awarded the Les Nichol award by the Midland Geotechnical Society for exemplary commitment to the profession of Ground Engineering, including geotechnical, geological and geoenvironmental perspectives.

Key Readings

Reading 1: Muniandy, R. and Huat, B. B. K. (2006). *Laboratory Diameteral Fatigue Performance of Stone Matrix Asphalt with Cellulose Oil Palm Fibre*, American Journal of Applied Sciences. **https://doi.org/10.3844/ajassp.2006.2005.2010**

Compared to other modes of road failures in Malaysia, fatigue cracking along the wheel paths is the most common issue. Several additives have been investigated, but these tend to be very expensive. Various types of cellulose fibres have been used in a range of applications, but little work had been done on fatigue behaviour of stone mastic asphalt which included cellulose fibre from oil palm. This was particularly relevant to Malaysia as it is one of the largest producers of palm oil and current practice is to either use the waste for mulch or to burn it as fuel.

Stone mastic asphalt (SMA) is essentially gap graded angular aggregate that is held together in a matrix of bitumen. SMA has been shown to be a strong material, but little is known about its resistance to fatigue loading. Cellulose oil palm fibres in proportions of 0.2, 0.4, 0.6, 0.8 and 1.0% by weight of aggregates and 100 mm diameter prisms were subjected to fatigue loading of 1000N and 1500N at 30, 40 and 50°C.

Results showed that there was improvement in performance of SMA with inclusion of fibre. Maximum initial modulus and lowest initial strain were achieved with 0.4 to 0.6%, and 0.6% fibre content respectively. There was an improvement in fatigue life at all temperatures.

Reading 2: Muniandy, R. (2021) *Fibre Mastic Asphalt - A Novel Material for More Resilient Roads.* CRISPS Presentation. **https://bit.ly/37p926C**

This presentation summarizes the research and practical studies on the use of cellulose palm fibres in fibre mastic asphalt in Malaysia. It shows that cellulose palm fibres exhibit improved binder retention compared to other fibres and gives FMA design parameters used in Malaysia together with performance requirements. It then shows case studies of application of FMA on roads in Malaysia.

Reading 3: International Transport Forum (2008) *Long Life Surfaces for Busy Roads*, OECD. **https://www.oecd-ilibrary.org/transport/long-life-surfaces-for-busy-roads_9789282101209-en**

This report was prepared by a Working Group with representatives from eighteen countries who researched and tested Epoxy Asphalt and High-Performance Cementitious Materials as roads surfaces. The summary below relates only to the Epoxy Asphalt surfaces only.

Epoxy asphalt is a two-part material which comprises a curing agent and bitumen/resinous compound. The characteristics (mixing temperature, curing rate, etc.) of the materials can vary depending on the supplier. Epoxy asphalt tests were conducted in seven countries to evaluate curing behaviour, rheological properties oxidation susceptibility, air voids content, rut depth, modulus of epoxy asphalt from various suppliers using different mix compositions tested at a range of temperatures. In addition to these, raft of tests that included assessment of susceptibility to moisture damage, fatigue resistance and thermal crack resistance were also conducted. The behaviour of epoxy asphalt overlay on beds of dense base macadam and concrete was also examined. Based on these tests it was concluded that cured epoxy asphalt compared favourably with conventional asphalts on the following basis.

- stiffer (higher modulus) at service temperatures, with greater load spreading ability;
- more resistant to rutting;
- more resistant to low temperature crack initiation and propagation;
- more resistant to surface abrasion from tyre action, even after oxidation;
- more resistant to fatigue cracking (although the benefits are less marked at higher strain levels);
- less susceptible to water induced damage; and
- more resistant to oxidative degradation at ambient temperatures.

Epoxy asphalt surfaces have larger initial cost compared to conventional asphalt pavements. It was also shown that over a thirty-year period, benefits of reduced maintenance, increased durability and savings in user costs, exceed the high initial cost.

The report also includes areas that needed future consideration. Some of the key recommendations include:

- Careful consideration needs to be given to type of aggregate used. Since epoxy asphalt may last 3 to four times longer than conventional surfacing, the effect of traffic polishing the aggregate should be considered.
- Epoxy asphalt is a thermosetting material. Therefore, timing and temperatures should be carefully controlled during the manufacture and construction stages.
- Consideration should be given to health and safety issues, particularly in the uncured state of epoxy asphalt.

Questions to guide readings

1. Trials of SMA with inclusion of fibre have shown improvement in performance, what content of fibre was considered optimal?
2. Trials have concluded that cured epoxy asphalt compared favourably with conventional asphalts in several ways, what are some of these?
3. Why is careful consideration needed when utilising new road surfacing technologies?

References

International Transport Forum (2008) *Long Life Surfaces for Busy Roads*, OECD.

Muniandy, R. and Huat, B. B. K. (2006). *Laboratory Diameteral Fatigue Performance of Stone Matrix Asphalt with Cellulose Oil Palm Fibre*, American Journal of Applied Sciences.

Muniandy, R. (2021) *Fibre Mastic Asphalt - A Novel Material for More Resilient Roads.* CRISPS Presentation.