HYDRATED LIME AND LIMESTONE FILLER IN HOT MIX ASPHALT: A DURABLE COMBINATION

ASPHALT EXPERT RUSSELL CRABB WRITES ABOUT THE BENEFITS OF USING HYDRATED LIME AND GROUND LIMESTONE IN HOT MIX ASPHALT PRODUCTION, IN THIS ARTICLE SPONSORED BY GRAYMONT AUSTRALIA.

Hydrated lime has been used by most State Road Authorities in Australia in various hot mix asphalt products.

Both hydrated lime and ground limestone dust are used as filler components in hot mix asphalt (HMA), but they have very different functions. Filler is defined as material that is less than 75 micrometre in size. The filler forms an important component of the asphalt mixture design in terms of volumetric properties and pavement performance.

HYDRATED LIME

Hydrated lime has been used for some time by most state road authorities in Australia in various HMA products to reduce the potential for loss of adhesion between aggregates and bitumen binders – usually referred to as stripping. Its addition to HMA at ratios between one to 1.5 per cent has been proven to be an excellent anti-stripping agent over many years in products such as dense graded asphalt (DGA), open graded Asphalt (OGA) and stone mastic asphalt (SMA). It is now mandated in state road authority specifications for heavy duty asphalt, open graded asphalt and stone mastic asphalt applications in New South Wales, Queensland, Victoria (granite only), South Australia and Western Australia (Perth).

Hydrated lime was introduced to the industry in Australia some 20 years ago after significant stripping issues, mainly in NSW, which impacted the performance of DGA on several highway projects. Since its introduction, along with mix design and field compaction improvements, there has been a substantial reduction in the incidents of stripping and a significant improvement in the service life of asphalt pavements.

No single theory seems to completely explain this loss of adhesion between aggregate and bitumen. Rather it is most likely that two or more mechanisms may occur simultaneously in any one mixture, thus leading to loss of adhesion. The main factors appearing to affect adhesion are surface tension of the bitumen and aggregate and/or chemical composition of the bitumen and aggregate mineralogy.

Hydrated lime is a multi-functional product and it interacts with bitumen to perform several functions when added to HMA. These include:

1. **Improving the aggregate/bitumen bond by:**
   - The action of calcium (Ca) coating on the aggregate and the acid content of the bitumen;
   - The conversion of carboxylic acids in the bitumen to insoluble salts which reduces the absorption of water;
   - Modification or stabilisation of deleterious matter such as clay.
2. **Improving the properties of bitumen when added at 20 per cent of the bitumen content:**
   - Significant increase in viscosity;
   - Improved recovered viscosity (RTFO);
   - Improved ductility;
   - 100 per cent increase in fracture toughness.
3. **Improving the performance of HMA by:**

- Reducing the effects of oxidisation through chemical bonding;
- Toughening the HMA.

Regardless of the aggregate type used, it has been demonstrated that hydrated lime is the most effective and consistent long term stripping agent in most cases.

The improvement in pavement performance and increased service life of HMA due to the use of hydrated lime over the past 20 years has also been confirmed through reduction in observable incidents of pavement failure directly attributed to stripping. In particular, the Hume Highway in NSW is a good example of this improvement with reduced maintenance intervention and longer lasting pavements.

Also, hydrated lime was used in the Sydney Airport HMA project, where stripping was considered as a risk due to the proximity of the water table in the pavement structure. Again, its use has proven to reduce the incidence of stripping in the asphalt pavement layers.

GROUND LIMESTONE

Ground Limestone (Calcium Carbonate) is a high-performance lime often used as a filler in HMA where other fillers are unavailable or where there is a high quantity required in an asphalt mix such as SMA. Modern asphalt production plants have systems that separate and retain filler dust that is generated from the drying and heating of coarse and fine aggregates. This material is usually referred to as baghouse filler. The amount of 75 micrometre material in these aggregates will determine the quantity of baghouse filler that is produced. Where the amount produced is small, or if there is an excessive demand of the baghouse filler, there may be a need to supplement the baghouse filler with another external supply. This applies particularly to older asphalt plants that may have small baghouse filler storage capacity.

Although there are other filler materials that may be suitable, such as fly ash sourced from coal fired power stations, it should be acknowledged that as these power stations are replaced by renewable energy sources over the coming years, fly ash will become increasingly difficult to obtain with preference being given to its use in the concrete industry.

There are some real benefits in using ground limestone in HMA compared to baghouse filler or fly ash and these include:

- Greater Increase in the softening point of the binder resulting in improved asphalt stiffness;
- Improved water resistance due to its neutralisation of acid interaction between aggregate and bitumen;
- Having a stabilising effect due to its uniform particle grading and well-shaped grains.

Because there are different grades of ground limestone available, it is important that the correct grade is selected by the mix designer.

If the material is too fine, it will have an adverse impact on the volumetric properties of the asphalt mixture by effectively extending the binder in the asphalt mix and reducing the voids in mineral aggregate (VMA) which can result in flushing or bleeding of the asphalt.

Because there may be a higher amount of ground limestone filler required in the asphalt mixture – particularly SMA – it is desirable to use a filler that has Rigden voids (voids in dry compacted filler) of less that 40 per cent. Therefore, a limestone classified as less than 250 micrometre or 150 micrometre is recommended as this will not impact on the design requirements or mechanistic performance characteristics of the asphalt.

Ground limestone is an excellent supplementary filler for HMA production. It is a readily available, cost-effective and generally lower in cost than fly ash (depending on the location of the asphalt plant). It is also less bulky when air is blown into a storage silo, which makes transfer from bulk road tanker to a plant silo more efficient.

There are many examples of successful use of ground limestone as a filler in the production of SMA for major projects on the Pacific Highway in northern NSW, particularly on the Coffs Harbour to Ballina section of the highway duplication. Some of the asphalt used has now been in place for several years and the excellent performance of the pavement here is clearly evident.

SUMMARY

The ability of lime to improve the resistance of HMA mixtures to moisture damage, reduce oxidative aging, improve mechanical properties, and improve resistance to fatigue and rutting has led to observed improvements in performance of lime treated HMA pavements.

Life cycle cost analyses have shown that using lime in asphalt results in improved field performance and showed an increase of two to 10 years (20 to 50 per cent more durable) in the expected pavement life (Hicks, NLA, 2003).

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