

ASPHALT ADHESION PROMOTERS
GUIDANCE NOTE SERIES IM/900 NG 2



PREPARED FOR INFRASTRUCTURE MALTA

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ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
g	Gram
ITSR	Indirect Tensile Strength ratio
UK	United Kingdom

1 INTRODUCTION

The adhesion between aggregate and bitumen is crucial in asphalt pavements and has a strong influence on the service time of the road. Thus, the addition of adhesion promoters is gaining importance, particularly with regards to enhancing the utilisation of more sustainable aggregate sources and therefore removing the amalgamation of multiple aggregate sources. The following report offers an overview on physical and chemical properties of most common types of adhesion promoters currently used in asphalt industry in the UK.

2 ASPHALT PAVEMENTS

All asphalt pavements basically consist of bitumen and aggregate. The function of bitumen which typically represents 4-7% of the pavement is to act as a binder in-between the aggregate skeleton thereby providing the cohesion to the asphalt. Therefore, it is essential for the bitumen to have a strong bond to the aggregate used in the asphalt.

The fact that roads can suffer from water damage is well established and visible through fretting / ravelling but also through rutting and deformation. This leads to rough surfaces and eventually potholes, loss of structural strength.

The underlying problem on a micro scale is loss of adhesion between the bitumen and the aggregate surface. Water would penetrate between the bitumen-aggregate interface and strip the material. Experience has shown that there are few aggregate/bitumen combinations provide a good bond, these being mainly limestone aggregates. Other aggregates such as granite are known to have poor adhesion whereas aggregates like basalt and sandstones are dependant on the bitumen. Different chemistry in different bitumen has different implications on these intermediate aggregates.

3 ASPHALT DURABILITY

Traffic volume and the number of heavy trucks on roads is increasing in Malta and the asset is under more pressure than ever. This is also happening in many other countries around the World.

In order to get best value for money by extending the lifetime of pavements, some countries have, therefore, implemented national requirements of mandatory addition of adhesion promoters in asphalt mixes, to secure and maintain the adhesion and durability of asphalt pavements over time.

In the UK, the national specification, requires an Indirect Tensile Strength Ratio (ITSR) in accordance with BS EN 12697-26 of >70%. ITSR is a measure of durability and it is a very good discriminatory test and easily identifies mixtures that are not durable. Therefore, manufacturers, have introduced adhesion promoters as these enable mixtures to pass ITSR and enhances their durability.

Another advantage of using adhesion promoters is that locally available raw materials can be used to a greater extent leading to less transportation demand and reduced impact on the environment. In the case

of Malta, it would make Basalt fine aggregate better suited and usable and would assist in replicating the benefits of limestone fines.

Note 1: Imported aggregates - namely basalt from the Catania (Lentini) region in Sicily - were first introduced in Malta for the Italian Protocol Roads in 2004 for the wearing course in substitution of locally-sourced limestone but without adhesion agents.

Note 2: Dolomitic limestone is imported from various regions in Europe namely, Albania, Montenegro and Greece and from the Maghreb (North Africa, Tunisia).

4 ADHESION BETWEEN AGGREGATE AND BITUMEN

It is the presence of water at the interface of bitumen and the aggregate which is the primary cause of moisture-induced damage and the premature failure of road pavements.

Whilst it is easy to visualise how the stripping of large aggregate results in fretting and ravelling, it is important to the fine aggregates. This can lead to serious issues in the mastic element of the asphalt.

In basic terms bitumen is an oily material and therefore very hydrophobic. This means it is a waterproof material and rejects water readily, but it also means it struggles to adhere to hydrophilic surfaces. This means it is not very good at coating aggregate as all aggregate is hydrophilic.

This means that bitumen cannot adhere to a wet surface and can be replaced by water over time.

In practice the adhesion between bitumen and aggregate depends on the chemical nature of the components and therefore the source of the bitumen and type of aggregate. Other aggregate properties such as surface texture, porosity, shape and absorption will also influence the aggregate/bitumen adhesion.

4.1 Polarity

Due to its chemical composition, bitumen has quite a low polarity whereas water is extremely polar. Aggregates may be of an “acidic” type, with surfaces that tend to be negatively charged, or “basic” with surfaces that tend to be positively charged.

Acidic aggregates include those with high silica contents, while basic aggregates include carbonates. Bitumen, especially those with high acid value, have a tendency to be slightly negatively charged and thus adhesion problems occur particularly, but not exclusively, with acidic (negatively charged) aggregates.

It is the function of the adhesion promoter to alter the relative surface properties and polarity of incompatible materials, thus facilitating a strong bond between the bitumen and the aggregate which resists the water displacing effect for the service life of the pavement.

Therefore, by definition, light coloured granites which are very high in silica tend to have low adhesion whereas marble which is very low in silica will adhere to bitumen better. In the case of Basalt, this varies dependant on the amount of iron and magnesium and mafic minerals.

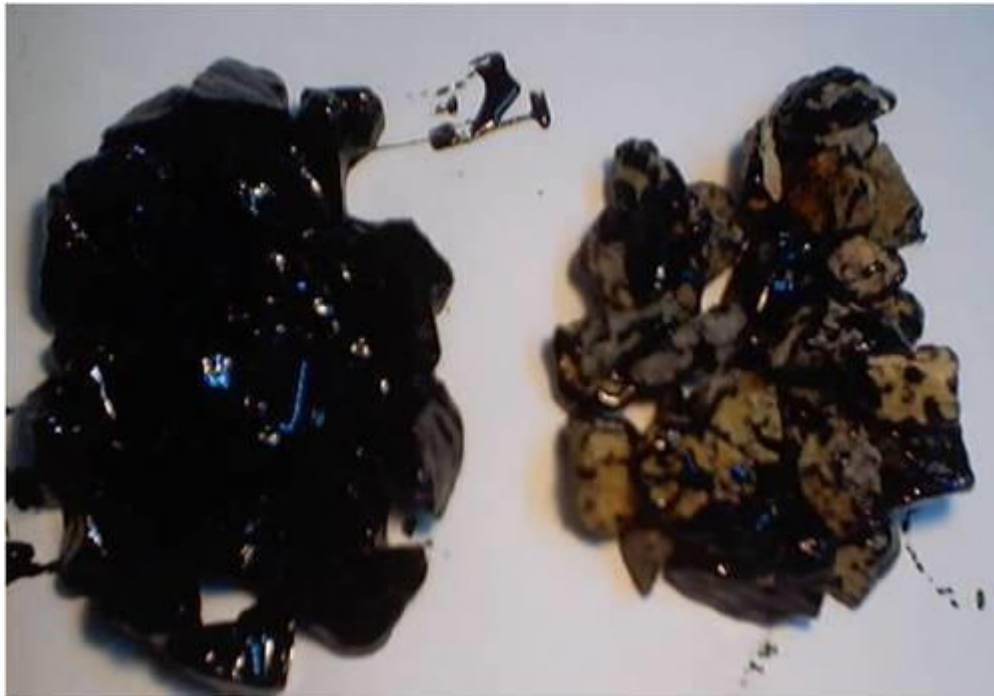


Figure 1: Aggregate / Bitumen Adhesion

5 PASSIVE ADHESION IN ASPHALT PRODUCTION

Passive adhesion is the ability of a binder to maintain the integrity of the adhesive bond with aggregate to prevent stripping under wet conditions. Therefore, this helps the asphalt retain its durability over its life in service.

Passive adhesion can be ensured by the addition of an adhesion promoter to the binder. Typically, 0.2-0.5% calculated on bitumen (0.3% corresponds to 150-200 g/tonne of hot mix) is sufficient to impart water resistance. This modifies the wetting of bitumen by reducing its viscosity and modifies the chemical affinity of the bitumen and aggregate.

The addition of fillers in dense asphalts has the effect of increasing the viscosity of the bitumen and reducing its wetting ability. A liquid adhesion promoter on the other hand improves the wetting.

The type of liquid adhesion promoter to be used depends on the nature of the aggregate, type of bitumen and production temperature. The choice of adhesion promoter is also dependent on the chemical nature of the aggregate (alkaline or acidic).

Bitumen treated with an adhesion promoter coats the aggregate and reinforces the adhesive bond between the aggregate and the bitumen thereby improving long – term resistance to bitumen detachment by ingress of water.

6 HOW DOES IT WORK?

Adhesion promoters are cationic surface-active molecules which concentrate at the bitumen – aggregate interface. The adhesion promoter has a hydrophobic end and a hydrophilic end, where the former embeds into the bitumen and the latter embeds into the aggregate thus acting as a bridge or adhesive between the two asphalt elements.

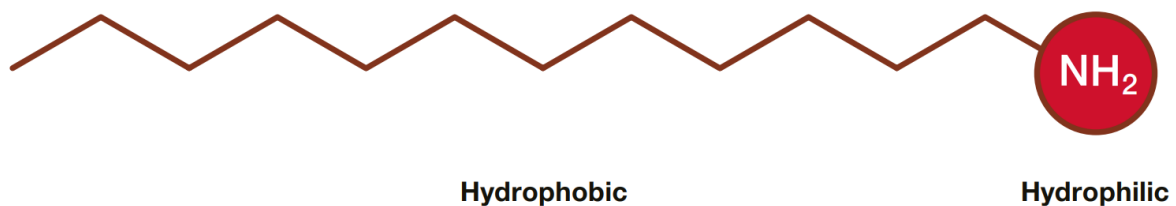


Figure 2: Hydrophobic and Hydrophilic Ends of Adhesion Promoter

7 APPLICATIONS

7.1 Hot Mix Asphalts

In Malta, asphalt mixes are made hot with dry aggregate. The use of adhesion promoters ensures complete coating of aggregates that are difficult to coat and also improves the adhesion and durability of the final asphalt pavement. Typical use levels range from 0.2-0.5 % in the bitumen. Tests on asphalt specimens show that mixes containing treated bitumen maintain their load bearing capacity (stiffness modulus) even after being immersed in water.

7.2 Hot Recycling

As Malta enters its asset management phase, post completion of all capital investment, recycling of asphalt pavements will grow rapidly due to the environmental benefits and the cost savings in re-using existing assets. The material arising from asphalt planings can be variable in quality and in general if partly coated surfaces are obvious in the reclaimed asphalt, adhesion promoters should be used.

7.3 Low temperature Hot Mix (Warm Mixes)

In the UK there is a growing interest within the road industry to reduce the temperature when producing hot mixes. Energy savings, reduction of CO₂ emissions (carbon footprint) and improved working conditions for all workers are at the forefront of advancements in the industry. In warm mixtures, the aggregates are heated to a lower temperature than normal hot mix production, and therefore water may not be completely removed. Therefore, it is essential to use an adhesion promoter in those cases.

8 RECOMMENDATION

Due to the variability and lack of stable sources of aggregates in Malta, it is recommended that adhesion promoters are further explored for use and that Water Sensitivity (BS EN 12697-12) and Affinity between Aggregate and Bitumen (BS EN 12697-11) tests are carried out and specified as asphalt requirements.

In the UK, Highways England have set Water Sensitivity for surface courses at a minimum of 70. Other urban UK authorities have set even higher requirements. In order to achieve high specification, asphalt producers tend to introduce adhesion promoters in the mixtures, and this can only lead to more durable asphalt mixtures.