



A STUDY ON THE MANUFACTURE AND USE OF BITUMEN EMULSION IN GRAVEL ROADS

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ABSTRACT : Soil is considered to be most basic construction material that has good shear strength due to the cohesion and internal friction among the soil solid particles. But due to much heavy loads coming from bridges, buildings etc. even soils having good shear strength can fail resulting in subsequent failure of the structures due to differential settlement. Many attempts have been made by numerous scholars in the history to increase the strength of soil by different methods including addition of lime, cement etc. Recent research is being carried to use non-traditional materials like Bitumen Emulsions etc. for improving the properties of soil. Bitumen Emulsions are usually dispersions of minute droplets of bitumen in water i.e. oil in water emulsions and are used to improve the cohesive strength of granular, low cohesion, low plasticity materials. They can also improve the integrity of road base, sub-base or sub-grade materials by resisting the damage caused by water. The final strength of roadway is developed as the mixture cools. Alternatively, the bitumen is diluted with petroleum solvents like kerosene until fluid and the final strength of the material only develops when the solvent evaporates. Bitumen emulsions provide an alternative approach in which the bitumen is liquefied by dispersing in water. Emulsions can be used with cold and wet aggregates, the final strength of the road material develops as the emulsions 'sets' – reverts to a continuous bitumen phase – and water is lost.

Keywords: Gravel soil, Bitumen Stabilization, bitumen emulsion

INTRODUCTION

Soil is a standout amongst the most abundant construction materials of nature. Just about all kind of construction is based with or upon the soil. Long term performance of pavement structures is altogether affected by the strength and durability of the subgrade soils. In-situ sub-grades frequently don't provide the support required to achieve acceptable performance under the traffic loading with increasing environmental demands. Despite the fact that stabilization is a well-known option for improving soil engineering properties yet the properties determined from stabilization shift broadly because of heterogeneity in soil creation, contrasts in micro and macro structure among soils, heterogeneity of geologic stores, and because of chemical contrasts in concoction interactions between the soil and utilized stabilizers. These properties require the thought of site-specific treatment alternatives which must be accepted through testing of soil-stabilizer mixtures.

Whether the pavement is flexible or rigid, it rests on a soil foundation on an embankment or cutting, normally that is known as subgrade. It may be defined as a compacted layer, generally occurring local soil just beneath the pavement crust, providing a suitable foundation for the pavement. The soil in subgrade is normally stressed to certain minimum level of stresses due to the traffic loads. Subgrade soil should be of good quality and appropriately compacted so as to utilize its full strength to withstand the stresses due to traffic loads for a particular pavement. This leads the economic condition for overall pavement thickness. On the other hand the subgrade soil is characterized for its strength for the purpose of design of any pavement. Improvement of soil engineering properties is referred to soil stabilization. There are two primary methods of soil stabilization. One is mechanical method and the other one is chemical or additive methods. Soil is a gathering or store of earth material, determined regularly from the breakdown of rocks or rot of undergrowth that could be uncovered promptly with force supplies in the field or disintegrated by delicate reflex means in the lab. The supporting soil beneath pavement and its exceptional under course is called sub grade soil. Without interruption soil underneath the pavement is called regular sub grade. Compacted sub grade is the soil compacted by inhibited development of distinctive sorts of substantial compactors.

WHAT IS AN EMULSION?

An emulsion is a dispersion of small droplets of one liquid in another liquid. Oil-in-water (O/W) emulsions are those in which the continuous phase is water and the disperse (droplet) phase is a water-insoluble 'oily' liquid. Water-in-oil (W/O) emulsions are those in which the continuous phase is oil and the disperse phase water. W/O emulsions are sometimes called 'inverted emulsions'. Multiple phase emulsions can be formed in which the dispersed droplets themselves contain smaller droplets of a third phase, usually the same liquid as the continuous phase.

Bitumen emulsions are normally of the O/W type although inverted emulsions based on cut-back bitumen's have special applications. There is evidence that bitumen can form multiple W/O/W emulsions. Emulsions containing from

40 to 80 % bitumen are brown liquids with consistencies ranging from that of milk to heavy cream. The droplets normally range from 0.1 to 20 microns in diameter.

MANUFACTURE OF BITUMEN EMULSIONS

Bitumen emulsion can be produced either in a batch or an in-line process plant. The batch process involves at least two process steps water phase (soap) preparation and the actual emulsion production. The water phase is prepared in a tank into which heated water, emulsifier and other emulsion chemicals are metered and the solution properly mixed. In the emulsion production process the bitumen and the pre-made water phase are dosed to the colloid mill. If solvent is to be added to the bitumen, then a batch tank is needed for bitumen as well, or the solvent must be dosed in-line.

In the batch plant the emulsion production itself involves only a few material flows, which allows manual process control. However, proper metering of the various components are decisive for the quality of the emulsion and automatic or semi-automatic control will make the manufacturing more efficient and reduce human error. Furthermore, the chemicals used may be hazardous as well as corrosive, which means closed dosage systems rather than open tanks and portable pumps are preferable in order to ensure safe work and environmental conditions. In the in-line process the water heating and all material dosage are done continuously using individual dosage pumps for each material. No batch tanks are used. Instead, the water phase system must further be designed to provide sufficient reaction time for the chemicals so that adequate neutralization and solution take place before the water phase meets the bitumen. The process needs to be automatically controlled using flow meters for all material dosage except acid, which should be controlled by the pH in the water phase.

Various special additives such as latex, SBS or bitumen dope may be used and will then require special components and technical solutions. Latex for example is shear sensitive and may coagulate in pumps and lines. SBS modified bitumen's usually require the emulsion to be produced above the boiling point of water, which requires production under pressure and cooling before release to atmospheric pressure in the storage tank.

THE EMULSIFICATION PROCESS

Emulsification involves the break-up of the bitumen into droplets. This process is opposed by the internal cohesion and viscosity of the bitumen and the surface tension which resists the creation of new interface.

Droplets also have a tendency to coalesce (rejoin). To achieve a small particle size in the emulsion, it is necessary not only to apply mechanical energy in the right way in order to create small drops, but also to prevent their coalescence once formed. The particle size of the resulting emulsion can be related to the design of the mill head, mill rotor speed, the gap between rotor and stator, the dwell time in the mill, the concentration and type of emulsifier and the emulsification temperature.

Normally the highest practical temperature is used to prepare the emulsion in order to reduce the bitumen viscosity. Bitumen is heated to 110–160° C until it has a viscosity of 500cSt or less for pumping into the mill. The water phase is also heated to 30–70° C to dissolve the emulsifiers and to achieve the required emulsification temperature after mixing with the bitumen.

In colloid mills, which are not pressurized, this temperature is limited to 100° C, but in modern pressurized equipment may reach 120° C or higher. For good emulsion quality the bitumen phase should have a viscosity less than 10,000cSt at the emulsification temperature, which means pressurized systems are preferred for hard or highly polymer modified bitumen's

APPLICATIONS OF EMULSIONS

Depending on the choice of emulsifier, the system may provide quick-setting slurry which can be trafficked within 60 minutes, or slower setting materials suitable for handwork. Slurry Surfacing in thick layers with quick-setting polymer-modified slurries is called *micro surfacing*. For best results the emulsion reactivity should be matched to that of the aggregate, but additional chemicals may be added on the paver to adjust the setting rate. Following are the various applications of emulsions

- **Plant Mixes**

Structural materials can be from emulsion and crushed aggregates or reclaimed asphalt pavement which meet the same demands as hot mix. Depending on the aggregate gradation, medium or slow-setting emulsions can be used. Cold mixes which combine bitumen emulsion with cement can give much improved bearing capacities.

- **Cold In-place Recycling**

Surface courses or even the full depth of the roadway can be recycled in place either by a specially built mobile plant or by simple equipment. Cold recycling uses bitumen emulsions either alone or in combination with cement or lime. Typically, a cationic slow-setting emulsion is used.

- **Soil Stabilization**

Cationic slow-setting emulsions can be used for stabilization of uncrushed naturally occurring gravels and sandy soils. Generally, soils with a sand equivalence value of more than 25 (measure of clay content) can be treated with some degree of success for use as a base material for hot overlay or for minor roads where a seal coat may be

sufficient. Materials of even lower sand equivalence can in some cases be treated with a combination of emulsion and a hydraulic binder such as lime or cement.

- **Prime Coats**

Emulsion prime coats are applied to unbound sub-bases in order to seal the surface before the application of the asphalt layers. The primer seal prevents the ingress of water into the layer, loss of fines from wind or water erosion and ideally allows construction vehicles to drive over the surface without pick up on tyres. A few centimeters of penetration is readily achievable if the compacted material is not too dense but may be very difficult in practice with fine graded and highly compacted bases. Penetration can be achieved using very slow set cationic or anionic emulsions containing solvent but in some cases deep penetration can be very difficult. However, current thinking says that deep penetration may be unnecessary as dense and highly compacted bases are already very robust and merely need to be sealed from water intrusion. A very thin primer application with minimal penetration is then sufficient. It is still important that the binder should not be picked up on the tyres of construction vehicles and this can be achieved by using a very hard grade bitumen with a rapid setting emulsion formulation.

- **Tack Coats**

Tack coats are light application of bitumen between layers of hot mix to prevent slippage. There is considerable variation in the type of emulsion used for tack coats worldwide. In many countries slow-setting anionic or cationic emulsions are used which may be diluted with water, but Europe uses rapid-setting cationic emulsions. It is necessary for the tack coat to wet out any dust on the surface of the lower layer and this favours emulsions of small particle size and some solvent content. New developments are for tack coats based on very hard binders which cure rapidly and avoid sticking to the tires of traffic or construction equipment.

- **Fog Seal**

A light application of diluted emulsion restores bitumen to weathered surfaces and extends roadway life at low cost.

- **Penetration Macadam**

A rapid or medium setting cationic emulsion is applied to a compacted open-graded layer. It soaks in, binding the roadway.

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