SARF COURSE

PRACTICAL ROAD PAVEMENT ENGINEERING

10. LATEST FLEXIBLE PAVEMENT TECHNOLOGIES

LATEST TECHNOLOGIES

INTRODUCTION

Over the last two decades a number of new developments have taken place largely driven by rehabilitation requirements. In the first world material sources are very scarce and therefore much emphasis has been placed on using materials that are already in place. In contrast the third world is driven by limited finances and vital networks which are rapidly deteriorating past the point of maintenance. Thus possibly for differing reasons worldwide the road industry has been looking at innovative ways of dealing with existing pavements and materials.

Particularly in South Africa due to limited finance and strong political direction of funds into other (also essential) areas of education and health it has become clear that apart from certain major toll roads there will over the next decade be very little money spent on new construction. If those tasked with managing our road networks are responsible, a significant portion of the meager funds will go to maintenance (protecting the investment) and what remains will be used as efficiently as possible on rehabilitation works. It is therefore vitally important for us to continually be looking at new ways to rework/modify existing materials to save both precious resources and to work economically.

The two major areas of interest have been recycling processes and methods of treating materials (including bituminous binders to enhance their performance). In Southern Africa recycling has been carried out using conventional plant, milling machines, milling and processing machines and for asphalt preheating, planning, milling and remixing machines. The most common treatment agents for recycled materials are cement, bituminous emulsion, foamed bitumen (to a lesser extent) and for asphalts bitumen/rejuvenator oils. For surfacing seals binder modifiers (SBR, SBS and rubber crumb) have been widely used to enhance seal properties particularly over flexible (high deflections) and cracked surfaces. In asphalts modified binders, cellulose fibers and gilsonite have been used for special situations.

LATEST TECHNOLOGIES

MODIFIED BINDERS

Two major forms of modifiers in the form of elastomers and plastomers are used:

Non-homogeneous = Rubber crumbs

Homogeneous = SBR, SBS, & EVA

Latex = SBR polymer in emulsion form

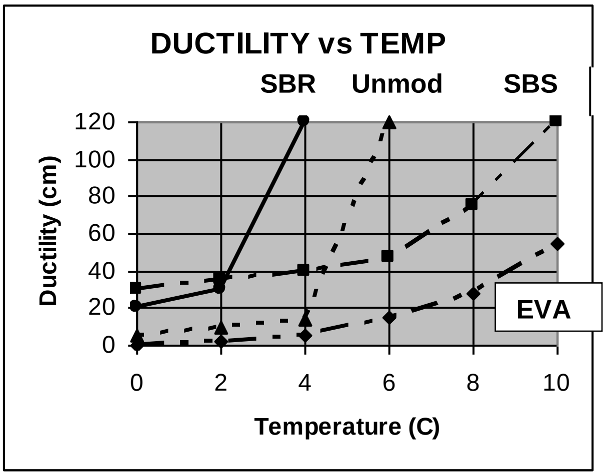
They alter the performance of standard bitumens as follows:

- Increased viscosity and hence able to accommodate increased deformation
- Improved adhesion and resistance to raveling
- There is a large difference in the properties between the various modifiers

Match performance requirements to the modifier properties: high and low temperature and ageing

Chemical make-up

Bitumen-rubber: not clearly understood but properties appear to be long lasting and with 20% rubber crumb effective.



Ordinary penetration bitumens have strongly related properties: pen, viscosity, stiffness, etc. For modified binders one cannot use the standard predictive models.

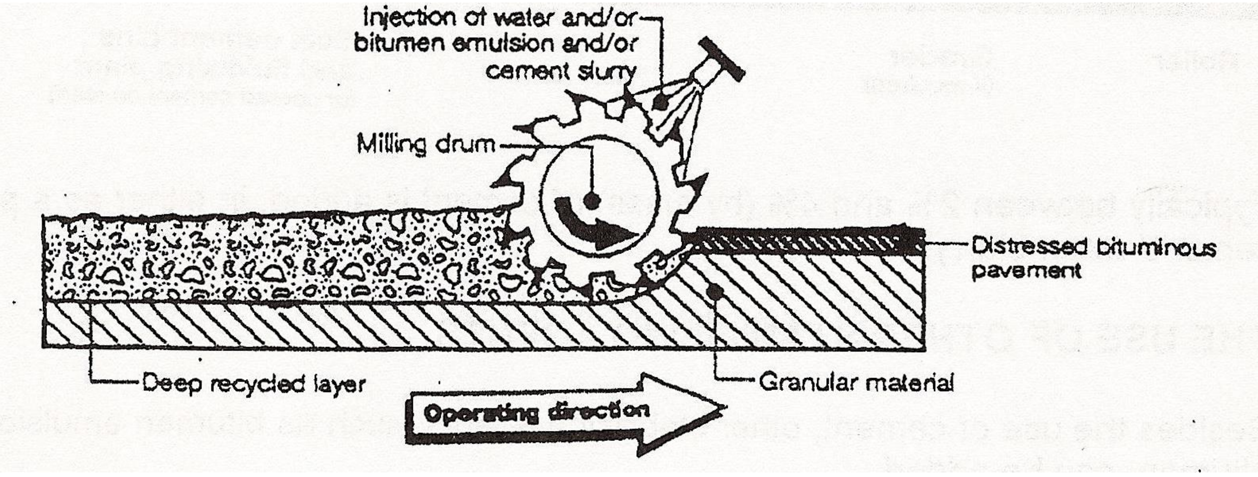
SBR: Non-networking polymer, modest improvement of properties, not as durable, limit on amount that can be added – pen bitumen about 3% and emulsion 5%.

SBS & EVA: Networking polymer (reforms networking when it cools down), improves toughness and tenacity, more durable than SBR, significantly improves ductility characteristics. Typical amount used is 4% and one can increase polymer content but it is relatively expensive.

Construction: Increased polymer content affects spraying ability (blocked nozzles). Important to chip closely behind the distributor. Overseas in colder conditions preheated chips are being uses.

THE COLD IN PLACE RECYCLING PROCESS

Cold deep in place recycling is carried out using specialized recycling machines, the heart of which is a milling drum equipped with a large number of hardened steel picks. The drum rotates, milling the material in the existing road, as shown diagrammatically below.



As the milling process is taking place water from a water tanker that is pushed ahead of the recycler is delivered through a flexible hose and is sprayed into the mixing chamber. The water, which is metered accurately by the microprocessor controlled pumping system, is mixed thoroughly together with the milled material to bring it up to its optimum compaction moisture content.

COLD IN PLACE RECYCLING WITH CEMENT

Cement may be added during the recycling process in three different ways.

It can be:

- spread onto the surface of the road ahead of the recycler. The recycler passes over it and mixes it together with the underlying material in a single operation

LATEST TECHNOLOGIES

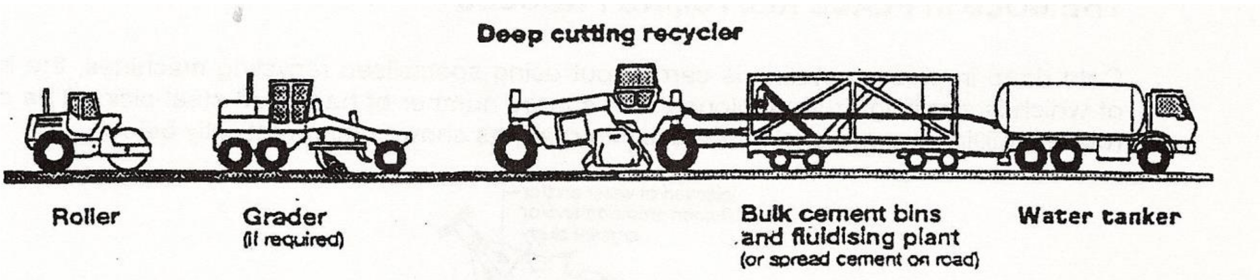
- mixed together as a slurry in a specially designed slurry mixer. In this case the cement/water slurry is introduced directly into the mixing chamber. This ensures accurate application rates and eliminates the wastage of cement, as it cannot be blown away during windy conditions

- applied using a specialized cement spreader, that can be incorporated in the recycler

Behind the recycling machine the recycled layer of material is profiled with a motor grader before being compacted using a vibratory roller. Finally, a rubber tyred roller is normally used to obtain a well-knitted surface finish.

Once compaction of the recycled layer has been completed, the road should be surfaced with a bituminous layer. This may vary, depending upon the traffic loading, from a thin surface treatment in the case of lightly trafficked roads, to one or more layers of hot-mixed asphalt when the pavement carries heavy traffic.

The recycling train is depicted in the diagram below.



Typically between 2% and 4% (by mass) of cement is added, either as a powder or as a cement/water slurry.

THE USE OF OTHER STABILISING AGENTS

Besides the use of cement, other stabilizing agents, such as bitumen emulsion and foam bitumen, can be added.

<u>Using bitumen emulsion</u>

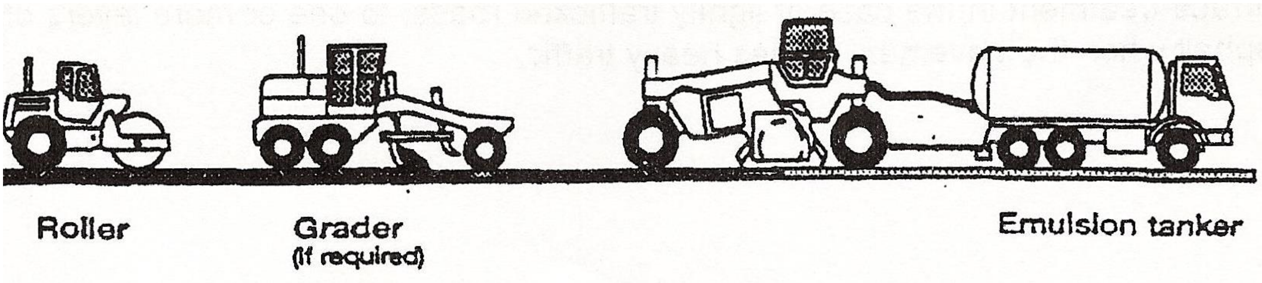
Bitumen emulsion is manufactured by emulsifying bitumen and water, using emulsifying agents. Usually the emulsion contains approximately 60% of bitumen and 40% of water. The advantage of bitumen emulsion is that it is a liquid at ambient temperatures and can be mixed with road building aggregates without the need to heat the stone and the bitumen, as is the case with hot-mixed asphalt.

When bitumen emulsion is used in the cold in place recycling process, it is transported in a tanker that is pushed ahead of the recycling machine, as shown in the diagram below. The emulsion is delivered to the recycling machine via a flexible hose and sprayed into the mixing chamber of the recycler as it moves forward. The milled material and the bitumen emulsion are thoroughly mixed together in the recycler's mixing chamber and the mixture is then discharged from the rear of the recycler.

The recycled layer is profiled using a motor grader and is then compacted in the same way as the cement treated layer.

Typically around 3% (by mass) of bitumen emulsion is added to granular road building materials. However, if the existing pavement consists of a thick layer of asphalt, the amount of emulsion that has to be added can usually be reduced to between 1% and 2 %, depending upon the proportion of asphalt in the mix.

A typical recycling train where bitumen emulsion is being used is shown below.



ADVANTAGES OF COLD DEEP IN PLACE RECYCLING

The main advantages of cold in place recycling are:

- ***Consistent mixing*** Excellent mixing of in situ materials with new aggregate and/or stabilizing agents is assured. Addition of water and fluid stabilizing agents is electronically controlled and sprayed across the full width of the milling drum through a series of nozzles.

- ***Precise control of layer thickness.*** Once set, the depth of cut of the milling drum is controlled electronically to within 5mm, ensuring accurate control of layer thickness.

- ***Shorter construction period.*** This is due to the high production rate of modern recycling machines.

- ***Less reliance on fine weather conditions.*** The process offers the distinct advantage of being able to continue working during periods of uncertain weather. When rain threatens the work can be temporarily stopped and then restarted again as soon as the rain has passed.

- ***Greatly reduced traffic disruption and improved safety.*** The entire process can be carried out on one half of the road with, while the other half is left open to traffic.

LATEST TECHNOLOGIES

APPLICATIONS OF COLD IN PLACE RECYCLING

A wide variety of applications of the cold in place recycling process is possible. In broad terms, road pavements can be recycled to depths of as little as 100 mm, up to depths in excess of 300 mm. Three typical variations are given below, but the process is by no means limited to these specific applications.

Upgrading of unsurfaced roads

Unsurfaced roads cause problems during the dry season when vehicles moving along them cause clods of dust during the dry season, while in the wet season they become unpleasantly muddy, and dangerously slippery. Maintenance of the gravel wearing course is on-going, with regular grading being required to maintain the roads' riding quality.

From time to time it is necessary to replenish the gravel wearing course, using borrow pits located along the routes. Besides the cost of the excavating, loading, hauling and placing the gravel on a regular basis, there is an adverse impact on the environment, as with time the borrow pits grow bigger and bigger, becoming eyesores and causing soil erosion.

The cold in place recycling process offers an economical means of upgrading these roads. By strengthening them using this process, and providing them with a durable blacktopped surface, the dust and mud problems are eliminated. Besides this, studies carried out in many countries show that economic benefits can be expected in the longer term, due to a substantial reduction in maintenance costs.

The upgrading of unsurfaced, lightly trafficked rural and village roads can be carried out very cost-effectively by recycling 100 mm to 120 mm of the existing gravel wearing course with either bitumen emulsion or foamed bitumen, and then applying a thin surface treatment such as a chip seal or bituminous slurry seal.

Recycling thin asphalt pavement layers

Pavements where the distress is caused by aging of the asphalt layers can be effectively rehabilitated by recycling a relatively thin layer. This type of distress can be identified by cracking and potholing that occurs without severe rutting.

The minimum depth of this type of recycling is usually around 100 mm and the recycling is carried out with the addition of either bitumen emulsion or foamed bitumen followed by the application of a bituminous surfacing. In order to improve the gradation of the milled asphalt, so as to ensure good compaction, it is sometimes necessary to spread a layer of crusher sand onto the surface of the existing pavement prior to recycling so that it mixes with the asphalt during the recycling process.

LATEST TECHNOLOGIES

Rehabilitation of thick asphalt pavements

Modern recycling machines are capable of recycling tough pavements consisting of thick layers of hot-mixed asphalt. The complete process is normally carried out in a single pass, significantly cutting construction time and reducing traffic congestion.
Very little new material, if any, has to be brought in, the process recycles and strengthens the material in the pavement of the existing road in a single operation.
The thick layer that can be recycled using modern recycling machines means that it is possible not only to rectify superficial asphalt aging problems described above, but is also to be able to address weaknesses that occur deeper in the pavement. These can normally be identified by the presence of severe deformation and rutting, which occur together with cracking and potholing.

Recycled layer thicknesses of up to 300 mm, using cement alone, or combinations of cement and bitumen emulsion or foamed bitumen are commonplace. Obviously the use of heavy duty vibratory rollers is essential to ensure proper compaction of thick recycled layers.

In the case of very heavily trafficked roads it is normally necessary to strength the pavement further by paving one or more layers of hot-mixed asphalt on top of the recycled layer.

CONCLUSIONS

The development of powerful, efficient, recycling machines enables a variety of pavement recycling applications to be carried out, ranging from unsurfaced, lightly trafficked rural roads to busy highways and city streets.

The process allows a wide selection of stabilizing against to be employed to strengthen the pavement without having to import additional material to thicken it, as well as to enhance durability and improve its resistance to moisture.

Cost savings of at least 20% have are normally achieved, compared to the use of softer conventional methods for rehabilitating and upgrading roads and there is now doubt that the rapid growth of cold in place recycling throughout the world is evidence of the cost-effective growth of cold in place recycling throughout the world is evidence of the cost-effectiveness of this process.

LATEST TECHNOLOGIES

FULL-SCALE TREATMENT OF ROAD-BUILDING MATERIALS WITH FOAMED BITUMEN

INTRODUCTION

Foamed bitumen is rapidly gaining popularity around the world as a cost-effective means of treating road building materials. This is by no means a new process, having been invented by Prof. Ladis Csanyi of Iowa State University, who, in 1957, demonstrated the addition of foamed bitumen to marginal quality aggregates. His process used steam, which was injected under pressure into hot bitumen. This method was not, however, found to be impractical due to the complexity of the equipment and difficulties in accurately metering the steam.

In the late ‘sixties and early ‘seventies the process was modified by Mobil, who replaced the steam with between 1.5% and 2.5% of cold, atomized water. The water was injected into the hot bitumen in a specially designed expansion chamber, the foamed bitumen exiting through nozzles to be mixed with cold, damp aggregate.

This paper provides a brief introduction into the characteristics of foamed bitumen and the properties of aggregates treated with this product. It then goes on to describe the two most commonly used processes that are used to treat road building materials with foamed bitumen.

CHARACTERISTICS OF FOAMED BITUMEN

When a carefully metered quantity of cold water is introduced into hot bitumen, a foam is formed, greatly increasing the bitumen’s volume and surface energy. In the foaming process the viscosity of the bitumen is greatly reduced, enabling it to be properly dispersed through the aggregate.

The foaming process enables stiff, penetration-grade bitumen to be mixed together with cold, moist aggregate without having to resort to the added cost of heating the stone, or emulsifying the bitumen.

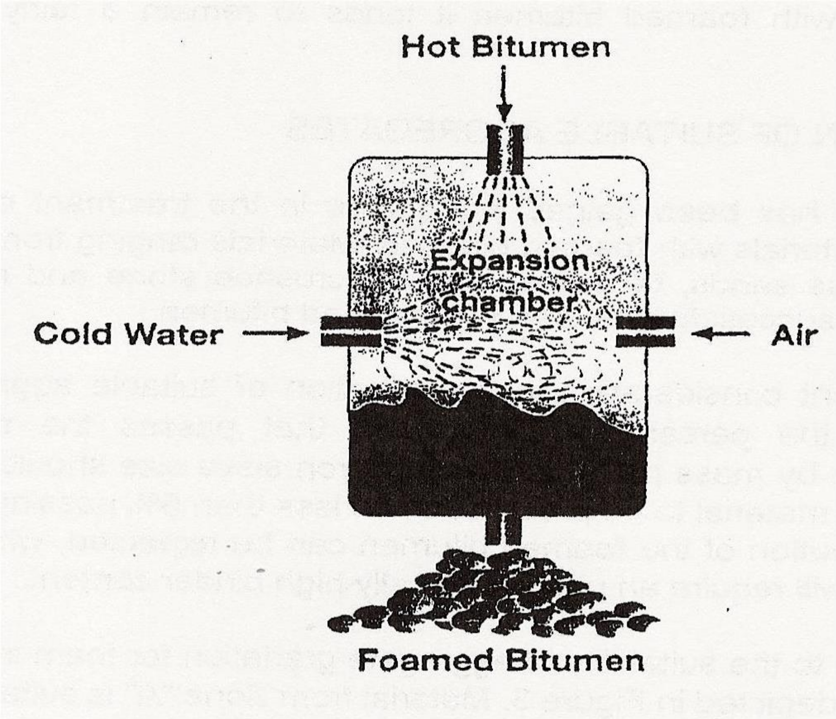
The foaming process is carried out in a specially designed expansion chamber. In order to ensure that the water that produces the foam is fully atomized, low pressure air is also injected into the expansion chamber, improving the properties of the foamed bitumen. This is shown diagrammatically in Figure 1.

Two parameters have been developed that assist in characterizing foamed bitumen. “Expansion Ratio” is defined as the ratio of the maximum foam volume to the volume of bitumen once the foam has completely subsided, while “Half Life” is described as the time in seconds that the foam takes to settle to one-half of the maximum volume that it attained.

LATEST TECHNOLOGIES

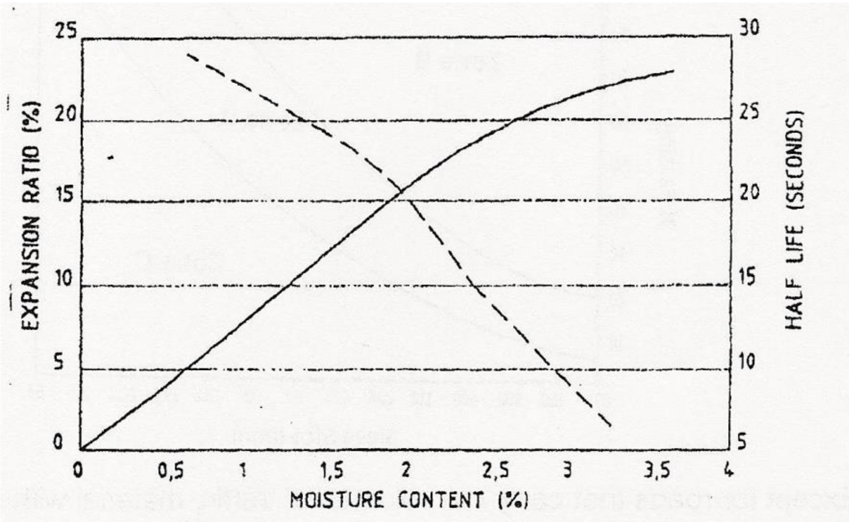
In designing foamed bitumen the aim is to produce foam with an expansion ratio as great as possible, and with the longest possible half-life.

Figure 1. Showing the method for producing foamed bitumen in an expansion chamber.



Both expansion ratio and half-life are influenced by the grade and type of bitumen used, as well as by the quantity of water injected into the hot bitumen during the foaming process. As can be seen in Figure 2, the expansion ratio increases with increasing additions of water. However, increases in the addition of water cause a decrease in the foam's half-life. In practice a compromise has to be reached regarding the foaming process.

Figure 2 The Effect of water on the Expansion Ratio and Half-Life of Foamed Bitumen.



LATEST TECHNOLOGIES

A distinct difference between mixtures produced using foamed bitumen and hot mixed asphalt, or mixes using emulsified bitumen, is the way in which the bitumen is dispersed through the aggregate. In the case of hot and emulsion mixes the bitumen tends to coat all the particles, while in foamed bitumen mixes the large particles are not fully coated. Close examination will show small specks of bitumen in the mixture, the foamed bitumen seeks and disperses itself among the fine particles of aggregate, forming a mortar that effectively bonds the mixture together.

This partial coating accounts for the small change in the color of aggregates treated with foamed bitumen compared to similar materials when they are either mixed hot (as in the case of hot-mixed asphalt), or cold with bitumen emulsion, when they assume a much darker or even black color. For instance, when a light-colored aggregate is processed with foamed bitumen it tends to remain a fairly lightly colored or grey product.

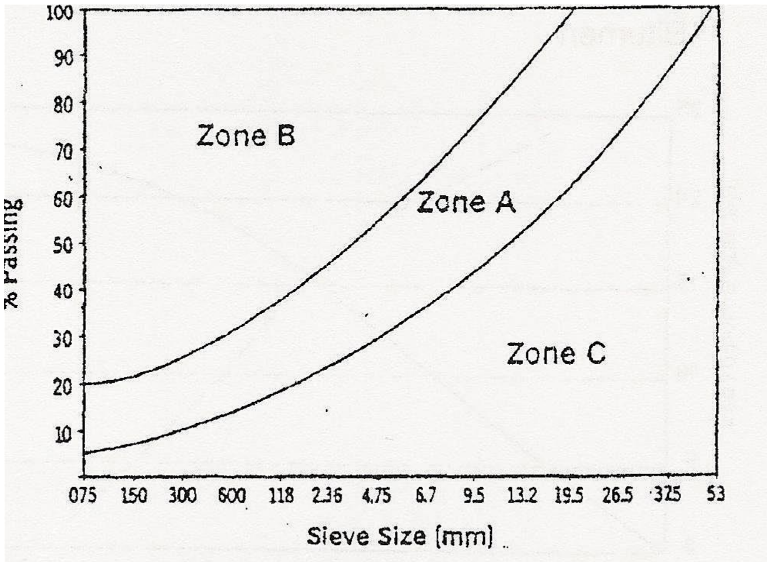
SELECTION OF SUITABLE AGGREGATES

Experience has been gained world wide in the treatment of a wide variety of road building materials with foamed bitumen. Materials ranging from weak pedogenic “marls”, cohesion less sands, to natural gravels, crushed stone and reclaimed asphalt millings have been successfully treated with foamed bitumen.

An important consideration in the selection of suitable aggregates is their gradation, especially the percentage of material that passes the smaller sieve sizes. The percentage by mass passing the 75 micron sieve size should be in the range of 5% to 20%. If the material to be processed has less than 5% passing the 75 micron sieve size, poor distribution of the foamed bitumen can be expected, while a filler content of more than 20% will require an uneconomically high binder content

As a guide to the suitability of aggregate gradation for foam treatment three zones, A, B and C are depicted in Figure 3. Material from Zone “A” is suitable without modification.

Figure 3 Guide for selection of a suitable aggregate gradation



LATEST TECHNOLOGIES

Except for roads that carry low volumes of traffic, material with gradations that fall within Zone “B” tend to be too fine, and require blending with a coarser material for effective foam treatment. Conversely, a proportion of finely graded material should be added to aggregate where its gradation falls into Zone “C”.

In many cases either hydrated lime or Portland cement is added in the range of 1% to 2%, to enhance the adhesion properties of the bitumen.

MIX DESIGN PROCEDURES

In order to carry out laboratory mix designs it is necessary to produce foamed bitumen in a laboratory foam plant that closely simulates full-scale production.

This equipment essentially consists of a kettle to heat the bitumen, and calibrated systems, for bitumen, water and air. The equipment enables predetermined volumes of bitumen, water and air to be injected into the expansion chamber where the foam is formed and is then discharged through a nozzle. The expansion ratio and half-life of the foam can be manipulated by altering the proportio0n of water that is added to the bitumen, or by the addition of additives that enhance the properties of the foam.

Once the design of the foam has been completed, the requirement volume of foamed bitumen is discharged directly into a sample of the aggregate, while it is being agitated in a laboratory mixer. Normally five samples are produced in this way, with varying bitumen contents. Prior to mixing in the foamed bitumen, moisture is added to bring the material to its optimum moisture content for compaction. If required road lime or cement is also added to the aggregate before it is mixed with the foamed bitumen.

Laboratory tests are then carried out on briquettes manufactured from the foamed bitumen treated samples. Before testing, the samples are cured to simulate the gain of strength that occurs in the road as the material dries out and gains in strength. Indirect tensile strength tests are commonly used, with the optimum bitumen content being that which produces the higher strength.

Further testing may be carried out to determine the moisture susceptibility of the treated material by carrying out indirect tensile strength tests on soaked briquettes, while resilient modulus tests may be undertaken to determine the stiffness of the mixture.

TREATING MATERIALS FULL-SCALE WITH FOAMED BITUMEN IN A STATIC MIXING PLANT.

Two distinctly different methods for the full-scale treatment of materials with foamed bitumen are being carried out world-wide; in place treatment using recycling machines, and treatment using static mixing plants. The latter method of treatment is covered below.

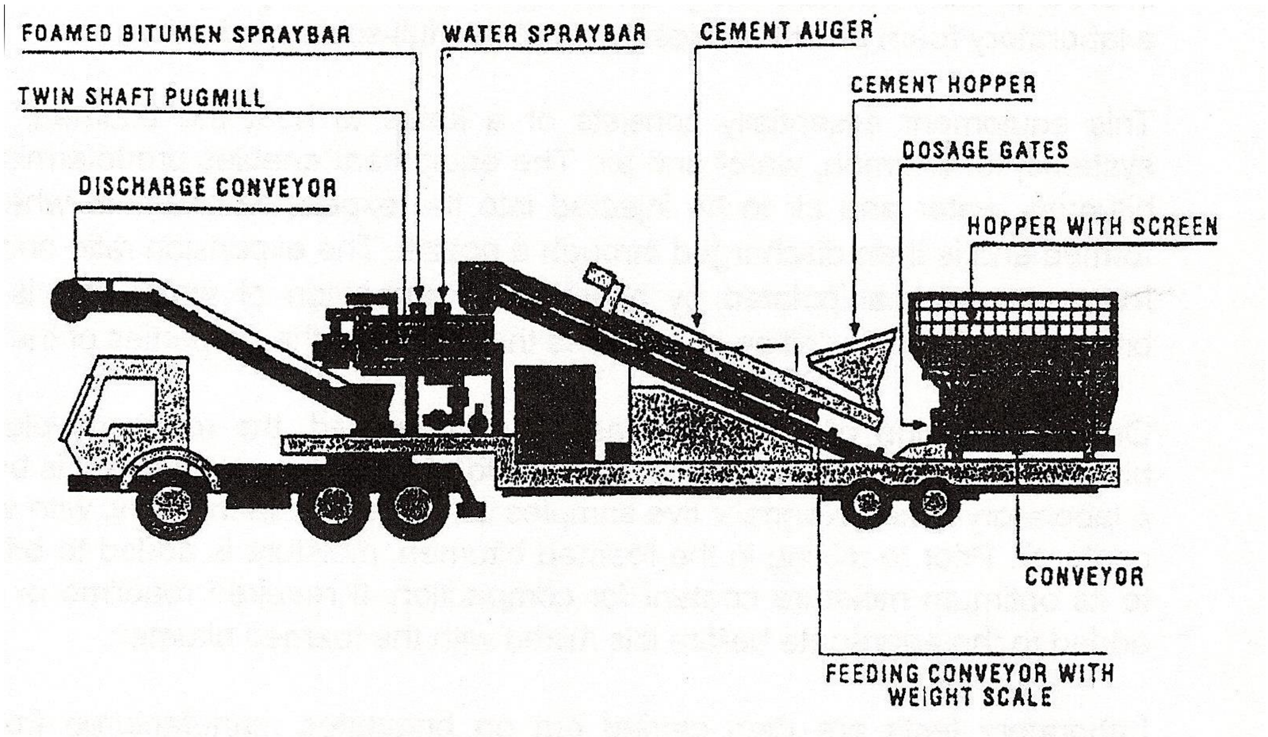
LATEST TECHNOLOGIES

The process commences with material being loaded into the plant's double compartment aggregate hopper. Each compartment has its own adjustable flow gate, which enables two different aggregates and variable proportions to be used. The aggregate is transported by conveyor into the twin shaft continuous feed pugmill where mixing takes place. As the material enters the pugmill moisture is added, followed by the foamed bitumen. The treated material discharges from the pugmill onto a stacker, which places it into stockpile. A belt weighing system on the primary conveyor is used in conjunction with a microprocessor to accurately proportion aggregate, bitumen and water.

There are distinct advantages in constructing these plants to be as mobile as possible, so that they can be brought close to the jobsite and quickly established. Once they have completed treatment of the desired volume of aggregate, they can be moved to another site quickly and efficiently.

The mixing plant is shown diagrammatically in Figure 4. The plant is transported to the mixing site using a mechanical "horse" rig.

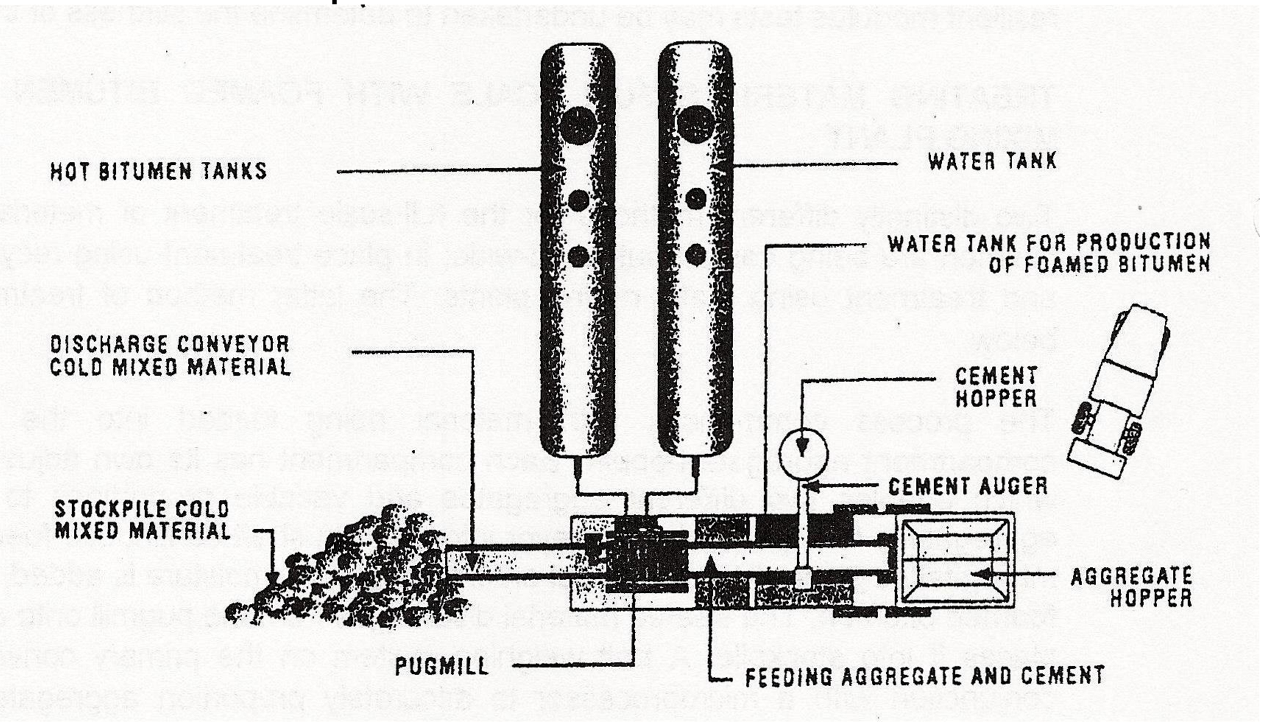
Figure 4 Showing the mobile plant being drawn by a "horse" rig, which is Disengaged once the plant is in position.



Two tanks, one for bitumen and the other for water, are positioned close to the mixing plant and are connected to the plant by separate hoses, as depicted in Figure 5.

LATEST TECHNOLOGIES

Figure 5. Showing a plan view of the plant, bitumen and water tanks, as well as the stockpile of treated material.



Features of the mobile mixing plant.

An important feature of these plants is their mobility, they can be moved easily from site to site, where establishment is quick and simple. No concrete foundations are required. When using natural gravels the usual strategy is to position the plant close to, or even in, a suitable borrow pit near to the road works, and to transport in supplies of bitumen and water. Gravel haulage costs can therefore be substantially reduced.

These mixing plants are capable of high rates of production compared to equivalent sized hot-mix asphalt plants, with production rates in excess of 100 tons per hour being commonplace.

Other advantages of using mobile foamed bitumen treatment plants include:

- ***Significantly reduced environmental pollution compared to hot-mixed plants***
  There are no gas or dust emissions, and very little noise is generated in the cold-mix process.

- ***The aggregate does not have to be dried or heated in the process***
  The cost of heating and drying the aggregate, as is required when using a hot process is therefore eliminated

LATEST TECHNOLOGIES

- ***These plants are versatile and can handle a variety of different aggregate types***
  A wide range of aggregate types can be processed, including crushed stone, natural gravel, and milled recycled asphalt (RA). The divided cold feed hopper enables two different types of material to be accurately blended together, as is sometimes necessary to correct gradation deficiencies.

Methods of placing the foamed bitumen treated aggregate

The advantage of the foamed bitumen treated material compared to a hot-mixed product is apparent. There are no problems with the mix cooling down before it can be placed, as can happen with hot-mixed asphalt.

The material may be stockpiled for several weeks before it is used, enhancing flexibility in the programming of the work.

Three methods are commonly used for placing foamed bitumen treated aggregate:

<u>By means of a finisher paver</u>

The most productive means of placing foamed bitumen treated aggregate is to use a paver. A normal asphalt paver can be used without any modifications being necessary, although a high compaction screed is advisable, particularly when paving a thick layer. The operation is carried out in the same way as for hot-mixed asphalt. The mix is produced at optimum fluid content that enables the paved layer to be compacted easily.

<u>Using a motor grades</u>

In this case the treated aggregate is dumped at the correct spacing's to achieve the required layer thickness and is the spread using a motor graded.

<u>Hand placement</u>

In developing countries where there is an abundance of labor and a policy to construct roads by labor-intensive means, foamed bitumen treated material can be placed as a road pavement layer by hand. The material is tipped onto the prepared underlying layer and then spread by hand. Layer thickness and shape are controlled by string line and straightedge from reference pegs located along the edges of the road. On minor roads compaction of the foamed bitumen can be achieved using pedestrian type vibratory rollers, but on larger roads it is advisable to use full sized vibratory rollers with a static mass of about 9 tons.

A distinct advantage of foamed bitumen treated material is that it is a cold product, and therefore lends itself to the relatively slow process of being placed by hand.

LATEST TECHNOLOGIES

On more lightly trafficked roads, the labor component can be further enhanced using a Bituminous slurry surfacing over the foamed bitumen treated layer. The ingredients of the slurry, consisting of bitumen emulsion, sand and cement, can be mixed using a high labour input, and the slurry mixture can then be spread by hand to form the wearing course.

CONCLUSIONS

Mobile mixing plants can be easily transported between sources of materials and quickly set up at convenient locations to produce foamed bitumen treated materials. The long stockpile life of foamed bitumen treated material means that a flexible approach can be adopted with regard to placing the material; there are no temperature restraints as with hot-mixed asphalt.

Another significant advantage is that, as this is a cold mix process, there are no smoke or gas emissions, and the plants produce very little noise. This makes it possible to use them in heavily built up areas, where it is not possible to operate hot-mix asphalt plants. The fact that reclaimed milled asphalt can be effectively recycled with only approximately 2% of new bitumen can also be regarded as a significant cost benefit.

HOT MIX ASPHALT RECYCLING

The first draft of TRH 21 "*Hot Mix Recycling*" was produced in 1996, and the latest document is SABITA Manual 36 / TRH 21 "*Use of Reclaimed Asphalt in the Production of Asphalt* " and is based on information gathered from around the world on best practise in this field.

These guidelines cover all the main aspects of hot mix asphalt recycling, a process in which reclaimed asphalt is combined with new aggregate and new binder in a mixing plant to produce recycled hot mixed asphalt. Experience gathered in South Africa, as well as international experience, has been utilised wherever possible.

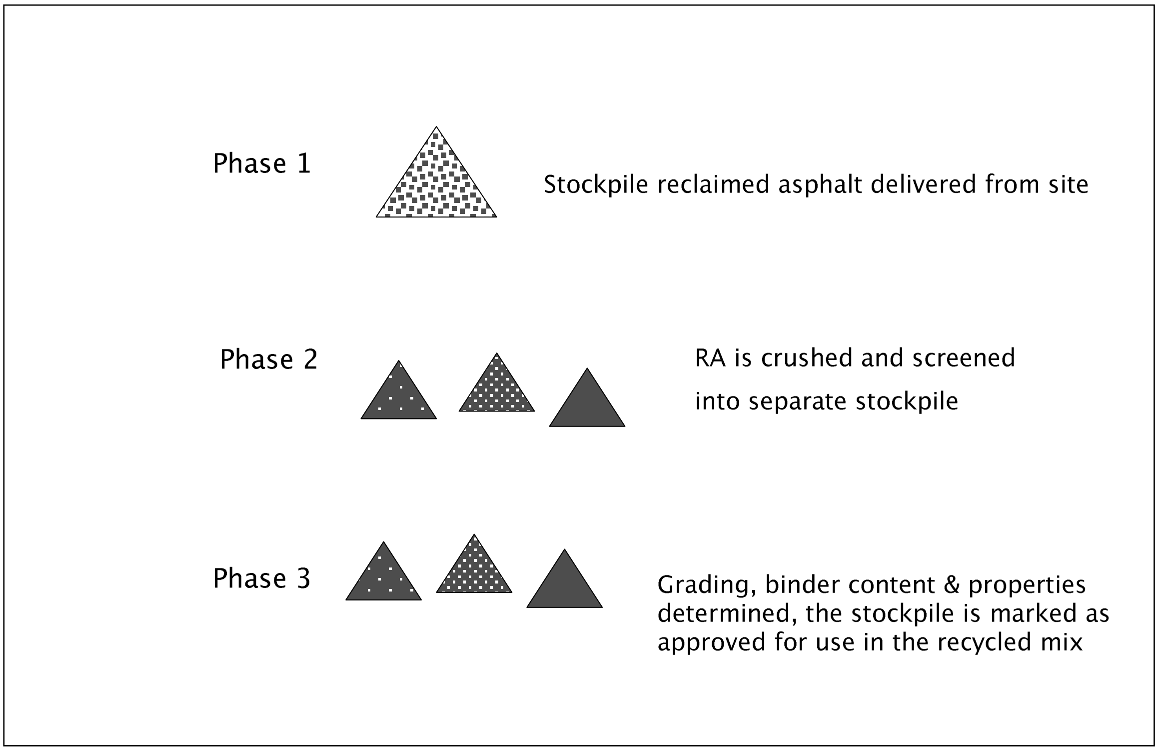
In the past, people have tended to associate the term “recycling” with a product that is “not as good as new”, or that is “second-hand” and not of the same quality as a product manufactured from virgin raw materials. Due to this misconception there has been a tendency for reclaimed asphalt to be treated sub-optimally, or even as a waste product. This is certainly not the case, and recycled hot mixed asphalt mixes containing reclaimed asphalt are subject to the same quality and performance requirements as mixes using all new materials.

Recycling asphalt pavements makes good sense from both economic and environmental points of view; the process enables petroleum and aggregate resources to be conserved, and saves landfill space that would otherwise have been taken up with the discarded asphalt. With the increasingly strong worldwide trend towards environmental issues, such as lifecycle inventories and carbon credits, the whole process of hot mix asphalt recycling makes good sense.

LATEST TECHNOLOGIES

Reclaimed asphalt, which is very often the product produced by milling an existing asphalt layer is known as RA. RA contains roughly 95% of high quality aggregate and 5% of aged bitumen, both valuable non-renewable resources. After many years of service the aged asphalt has most likely deformed or cracked as the aging process causes the binder to harden, making the asphalt brittle. However the aggregate quality will not have altered and the RA should be treated as a valuable asset.

In order to obtain a product with a known, uniform grading, the RA is processed in a crushing and screening plant, and stockpiled separately as shown in the diagram below.



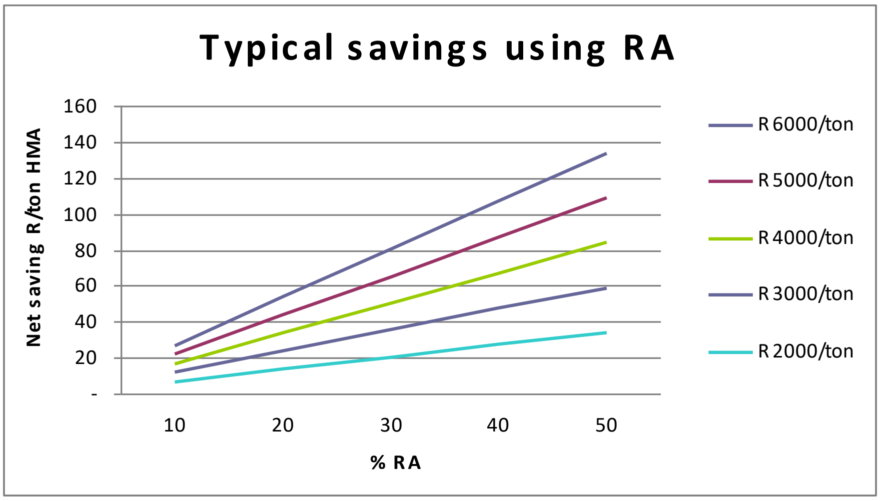
Laboratory mix design work is carried out, the extent of which is governed by the percentage RA that it is intended to include in the mix, as indicated in the table below.

RA content in mix	Additional binder grades	RA Aggregate quality
< 15%	No change in binder grade	Check intrinsic aggregate properties
> 15%	Determine recovered binder properties of the RA. Use blending chart to decide on appropriate binder grade or if rejuvenator agent required	Check coarse aggregate for strength (ACV, 10% FACT), check fine aggregate quality (sand equivalent)

The laboratory mix design will indicate the proportion of each fraction of new aggregate, as well as the various RA fractions to use in a particular mix. The mix design will also recommend the grade of bitumen that should be used in the recycled mix; mixes containing high RA contents with aged binder properties require “softer” grades of bitumen so as to meet the specified properties.

Asphalt mixing plants are modified so that the RA can be introduced into the mix. Both batch type and continuous type drum mixers are adapted to produce recycled mixes.

As can be seen in the plot below, significant financial savings can be made be by including reclaimed asphalt in hot asphalt mixes.



WARM MIX ASPHALT

Warm mix asphalt is gaining popularity worldwide and the global asphalt industry predicts that most of the world’s asphalt will consist of “WMA” within the next ten years.

WMA is a process where asphalt is manufactured and paved at temperatures at least 20^{o}C below those of conventional hot mixed asphalt (HMA). WMA’s properties and performance are at least the same, or better, than those of HMA.

The main benefits of WMA are:

- reduced fumes and emissions
- reduced energy consumption
- larger compaction window

LATEST TECHNOLOGIES

Several technologies are available to enable the reduced manufacturing temperatures to be achieved. These include inorganic and organic substances that are either blended together with the bitumen or are introduced into the pugmill during the mixing cycle. Foamed bitumen technology is also used in WMA.

Extensive WMA trials have already been undertaken in South Africa, with very positive results. Guidelines as well as a detailed specification for WMA, using experience gained from the local trials as well as information gathered overseas, are given in SABITA Manual 32.

Warm Mix Asphalt and hot mix asphalt recycling go hand in hand, and multiply benefits to the environment.

The drive towards sustainable and more environmentally friendly roads is growing momentum and the reuse of materials from our old, distressed road pavements cannot be neglected.

REFERENCES

1 The Asphalt Institute's research report No 84.2, manual series No 20 and No. 4.

2 Technical Methods for Highways.

3 SABITA Manuals

SARF COURSE

PRACTICAL ROAD PAVEMENT ENGINEERING

11. TREATMENT OF EXISTING PAVEMENTS