MANUFACTURING FOAM BITUMEN IN A STANDARD DRUM MIXING ASPHALT PLANT

DC Engelbrecht

Director
National Asphalt (Pty.) Ltd.
PO Box 1657
Hillcrest
3650

Tel: 0325 – 62146 or 082 333 3515
Cell: 083 255 7105

1. INTRODUCTION

The foaming of bitumen for the manufacture of base or surfacing material from granular, crushed or reclaimed materials has become increasingly popular in certain regions of South Africa. This is mainly due to economical and practical considerations.

The technology to manufacture foamed bitumen has existed for quite some time, but it was only recently applied in South Africa by importing very sophisticated and expensive equipment.

Material mixed with foam bitumen has a particular application in the construction field but until it becomes widely accepted and regularly used, the economic viability of purchasing the necessary equipment will remain beyond the means of most contractors.

This paper covers the approach that led to the design and manufacture of an inexpensive and simple foaming chamber that can be used in a standard drum mix asphalt plant, without major disruption of mainstream production. It also discusses mix design considerations and results obtained from mixed product.

2. TECHNOLOGY

2.1 Method

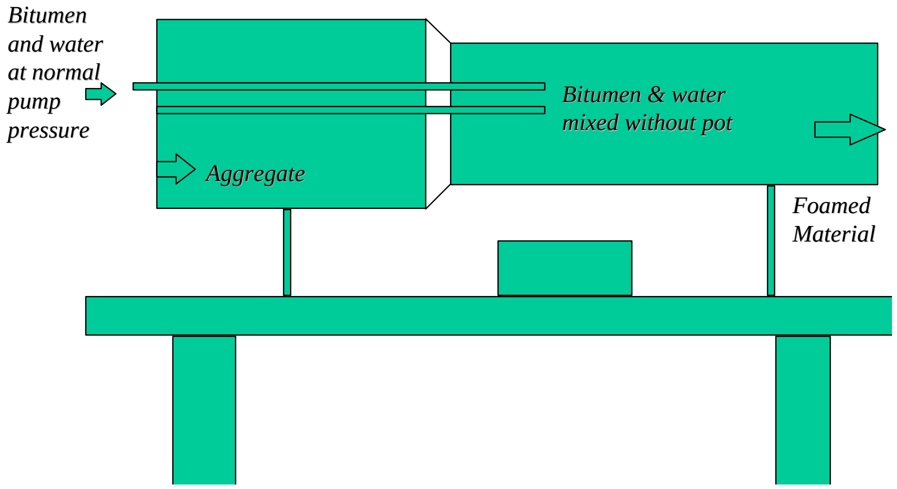
Foam bitumen is a mixture of air, water and bitumen. It is typically 98% bitumen, 1% water and 1% additive (anti-stripping agent). It is produced by injecting the cold water onto the hot (180 degrees C) bitumen in a foaming chamber. The bitumen expands to about 15 times its original volume and forms a fine mist of foam, which is highly efficient in wetting and coating the surface of fine particles. As the foam collapses most of the water is lost in the form of steam, leaving residual bitumen with properties similar to the original bitumen. The time that the expanded bitumen takes to settle to half its expanded volume is called the half-life. A desirable design value is 60 seconds.

2.2 Initial development

For the first trial a standard, locally produced 120 tons per hour drum mix asphalt plant was modified, by simply running a 19 mm galvanized pipe parallel to the bitumen injection pipe to spray water onto the bitumen before it reached the aggregate.

Diagram 1:

Initial Asphalt drum layout for foaming purposes



Although the process was occasionally successful, the water cooled the bitumen to such an extent that inconsistent mixing took place. The two substances separated and balled into a mass.

2.3 Development of foaming chamber

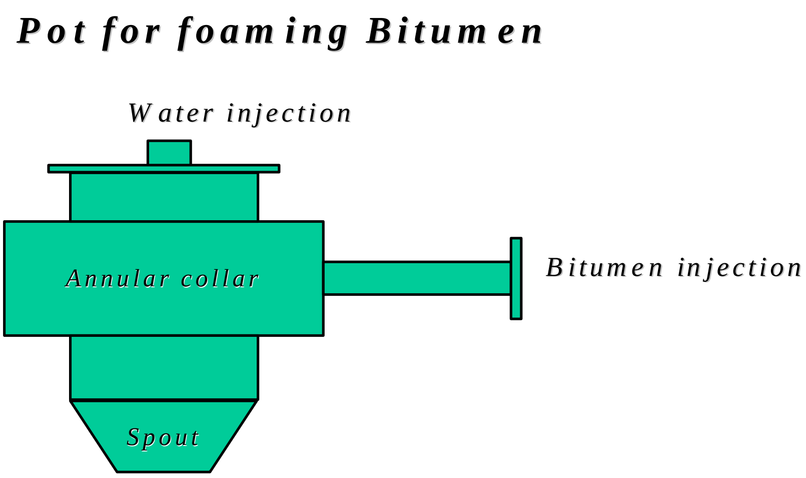
A vessel of simple but effective proportions had to be designed in order to manipulate the bitumen expansion and half-life requirements of the foam.

This was based on a mix production rate of 100 tons per hour and a binder content of 3.5%. It was calculated that at these parameters 59.84 litres of bitumen and 0.61litres of water per minute would be required to produce the correct amount of foam.

Foam can be compressed the same as air. This factor made it possible to design and manufacture a cylindrical steel vessel small enough (90 l) to fit inside an asphalt plant drum yet capable of handling an expanded volume of 906.75 litres (at an expansion rate of fifteen times the original volume).

The vessel was fitted with an annular collar that kept the bitumen at a constant pressure of 4 bar and released the fluid in a mist form into the main cylinder through 4 nozzles at a predetermined flow rate. A water pump capable of maintaining a pressure of 2 bar sprayed water onto the bitumen through a conical nozzle in the top lid. The foam was expelled onto the aggregate through a spout in the conical section of the pot.

Diagram 2:



The pot as a unit could be bolted onto a separate bitumen injection line that is left in the plant during the manufacture of normal hot asphalt mixes.

3. PROCESS

Combining the water and additive, which are at ambient temperature, with the bitumen, which is at 180 degrees Celsius, results in a violent reaction.

During this foaming and expansion phase the whole vessel is placed under tremendous pressure which facilitates the foam dropping out onto the aggregate. Compressed air is added to the system to further assist the foaming process.

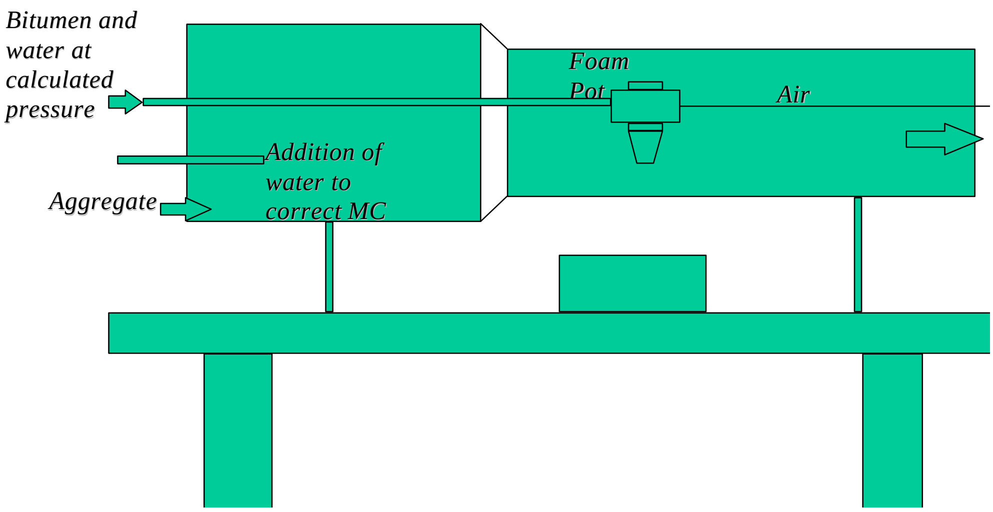
It is important to consider the following when manufacturing foamed bitumen successfully in a drum mixing plant:

1. The type (penetration) and temperature of the binder. (150/200-penetration grade bitumen at 180 degrees Celsius produces the best results.)
2. Lime should be added to the aggregate to facilitate mixing.
3. A water pump with flow control is essential to add the correct amount of water.
4. The foam injection point in the drum should be long enough to provide for adequate mixing.
5. It is necessary to fit a pressure gauge onto the injection line to ensure that the correct pressure is maintained during the manufacturing process.
6. The bitumen injection must be controlled accurately.
7. The moisture content in the material must be checked and adjusted to approximately 1% above optimum. This is done to compensate for loss of moisture during stockpiling.

Mixing takes place at ambient temperature and NO MODIFICATION TO THE MIXING PLANT other than bolting the pot to the end of the existing injection line and fitting a pressure gauge is necessary.

Diagram 3:

Typical Asphalt drum layout for foaming purposes



4. MIX DESIGN

An indicator test should be carried out on the aggregate to determine its gradation and plasticity.
Do a moisture /density relationship using Mod AASHTO effort.

In the case of reclaimed asphalt, determine the binder content of the proposed material.

Normal Marshall compaction equipment, moulds and procedure should be used to manufacture briquettes.
Specimens should be left in their moulds for 24 hours at ambient temperature prior to being extracted and then cured in an oven for a further 72 hours at 60-degree Celsius before testing commences.

Bulk relative density, indirect tensile strength and soaked indirect tensile strength should then be determined.

The mix is prepared and applied at ambient temperature.

A shelf life of not more than 90 days is recommended.

5. SPECIFICATION

5.1 Bitumen Content:
Bitumen content should be controlled to within the specified limit plus or minus 0,5%

5.2 Moisture Content:
Moisture content of the newly mixed material should not be lower than the optimum moisture content (OMC) nor should it exceed OMC plus 3.0%.

The following tests should be carried out in addition to the above tests to confirm the results:

1. Indirect Tensile Strength (Dry)	min. 200 kPa
2. Indirect Tensile Strength (Wet)	min. 80 kPa
3. Resilient Modulus	min.1500 MPa
4. Dynamic Creep	min 15 MPa

6. RESULTS OBTAINED

6.1 Results on material before foaming
A decomposed granite was used for all the initial foam trials and subsequently, as the material proved successful, on larger more elaborate contracts.

The material was primarily used as base course and surfaced with a continuously graded asphalt. The foamed material was paved by mechanical paver and both steel drum and pneumatic tyred rollers were used for compacting the layer. Results obtained were derived from plant and field samples and depicted as such.

Table 1: Indicator information on the material used before it was foamed.

Sieve Analysis

Sieve Size	**% Passing**
37.5	100
26.5	93
19.0	89
13.2	82
4.75	54
2.00	35
0.425	17
0.075	9
Grading Modulus	2.38
Soil Constants	
Liquid Limit	31
Plasticity Index	15
Linear Shrinkage	7.0
Classification (TRH 14)	G7
California Bearing Ratio	
OMC	5.2
Maximum Dry Density	2097
CBR at: 100%	54
98%	39
95%	23
93%	16
90%	9

6.2 RESULTS OBTAINED FROM FOAMED GRANITE

The results depicted in this section of the brief were all obtained from material supplied to a shopping complex contact. The work was done during the rainy and the contract ran behind schedule. This resulted in foam granite being placed during or just shortly after rainstorms as no time loss could be allowed

Table 2. Average results obtained from Drum mix foamed granite - Fields Center.

Sieve Analysis

Sieve Size	**% Passing**	
37.5	100	
26.5	93	
19.0	89	
13.2	82	
4.75	54	
2.00	35	
0.425	17	
0.075	9	
Binder content	3.5	
Bulk Relative density	2055	
Average Field Density	98%	(sand displacement)
ITS (dry)	240.0	
ITS (soaked)	155	
Dynamic Creep	37	
Resilient Modulus	1855	
Moisture Content	6.50%	

7. CONCLUSIONS

This inexpensive yet highly effective method of foaming bitumen and mixing base or surfacing mixes works very well. It makes the whole process cost effective, easy to apply and within reach of all asphalt manufacturers whom have access to a drum mixing plant. With the fluctuating work situation, especially in the construction field, it makes economical sense to have multi-purpose equipment rather than highly specialised plant that becomes idle for extended periods due to lack of demand in mixes that has a specific application.

8. ACKNOWLEGEMENTS

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