BituForce

Reinforced bitumen-emulsion

STABILIZATION AND FULL DEPTH RECLAMATION OF SURFACED ROADS

An Ecobond Reinforced Bitumen product

According to AEMA,

Full Depth Reclamation using bitumen emulsion is a cost-effective technique for correcting deficiencies, reclaiming distressed pavements and providing structurally sound bases for existing roads.

BENEFITS OF BITUMEN EMULSION STABILIZATION (SABITA'S TG2 2009)

- High strength – can be used in place of asphalt base & crushed stone base.
- Improved durability and less moisture sensitivity compared to granular base.
- Can use lower quality aggregates (e.g. sands.)
- Permanent deformation failure mode is easier to repair.
- Not temperature sensitive.
- Not overly sensitive to changes in material and binder content.
- Minimization of traffic disruptions.

BENEFITS OF RECLAMATION

- Using materials in-place minimizes hauling and use of virgin materials.
- Drainage and crowns can be re-established.
- The existing road material is reused and recycled.
- The process builds structure down into pavement, minimizing needs for road re-alignment.
- Reclamation can be used as a first step in stage construction, adding more structure as needed to meet increasing traffic.
- Reclamation is a low cost process for improving road structure and widening roads.

Ecobond
Reinforced Bitumen

Over the past 60 years,

Bitumen stabilization of particulate materials has shown it can be a durable method of improving the engineering properties of road construction materials. As crushed stone and good quality gravels are non-renewable resources it is important to use them optimally. In situ stabilization of existing pavements with bitumen has been shown to be a cost effective and reliable method of optimizing these resources.

There are three kinds of stabilization that have been successful historically, namely cement, lime and bitumen. These three products have known test methods and failure mechanisms, these three products also significantly increase the wet strength and stability of stabilized aggregates. Cement stabilization provides good stiffness but brittleness means it is best used as a subbase.

There have been over 40 alternative products for stabilization (polymers, enzymes, ionic exchangers, etc.) on the market that do not improve the wet strength of the aggregates and as such cannot be tested or classified according to established engineering methods. The South African National Roads Agency Limited's South African Pavement Engineering Manual (2013 edition) goes as far as to say:

"It must be clearly stated that, other than those products based on and including traditional stabilisers (cement, bitumen, and lime), none of the proprietary chemical stabilisers currently marketed produce strengths equivalent, or even close to, those produced by the conventional soil stabilisers."
- SANRAL South African Pavement Engineering Manual 2013, Chapter 4, Section 6.2.

BituForce is a cold applied modified bitumen emulsion that has been specially formulated by expert scientists and engineers for stabilization of road pavement layers. The resin modification is designed to evenly improve the stiffness as it cures as well as improving the bond to the aggregate. The bitumen is chemically broken out of its emulsion at a controlled rate, resulting in an even dispersal of fine water impervious bitumen droplets in between the aggregate particles. These effects improve the strength, water resistance and durability of an aggregate.

A BituForce stabilized pavement layer functions as a significantly improved granular pavement layer, due to the non-continuously bound nature of the material. The failure mechanism for the layer is permanent deformation due to localised shear failure. When correct design principles are followed and strength requirements are exceeded the rate of deformation can be slowed significantly.

As recommended by SANRALs SAPEM 2013 manual, the mix design guidelines set out in SABITA Manual TG2 (2009) should be used when designing with BituForce.

BituForce applied through road recycler.

Benefits

The major benefits of Ecobond BituForce over normal bitumen stabilized materials are:

- Increased adhesion between binder and aggregate
- More even dispersal of binder, due to a a liquid binder and controlled chemical breaking.
- The right balance between stiffness and flexibility. A homogenous increase in stiffness of binder as a specially designed liquid resin modification is used. Other binders and additives increase stiffness but are brittle and were not designed for this use.

This is illustrated practically by:

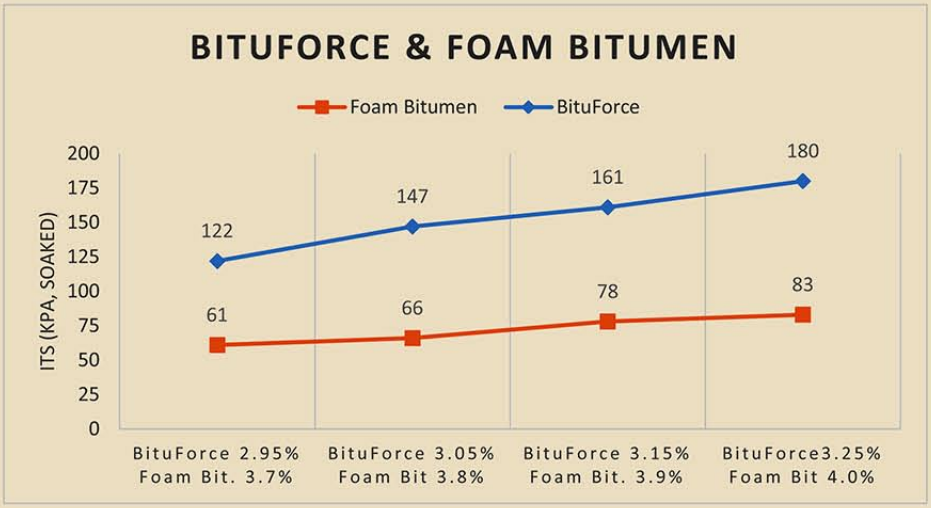
- Increased Cohesion in Triaxial testing.

BSM Laboratories Level 3 Triaxial (see complete results)

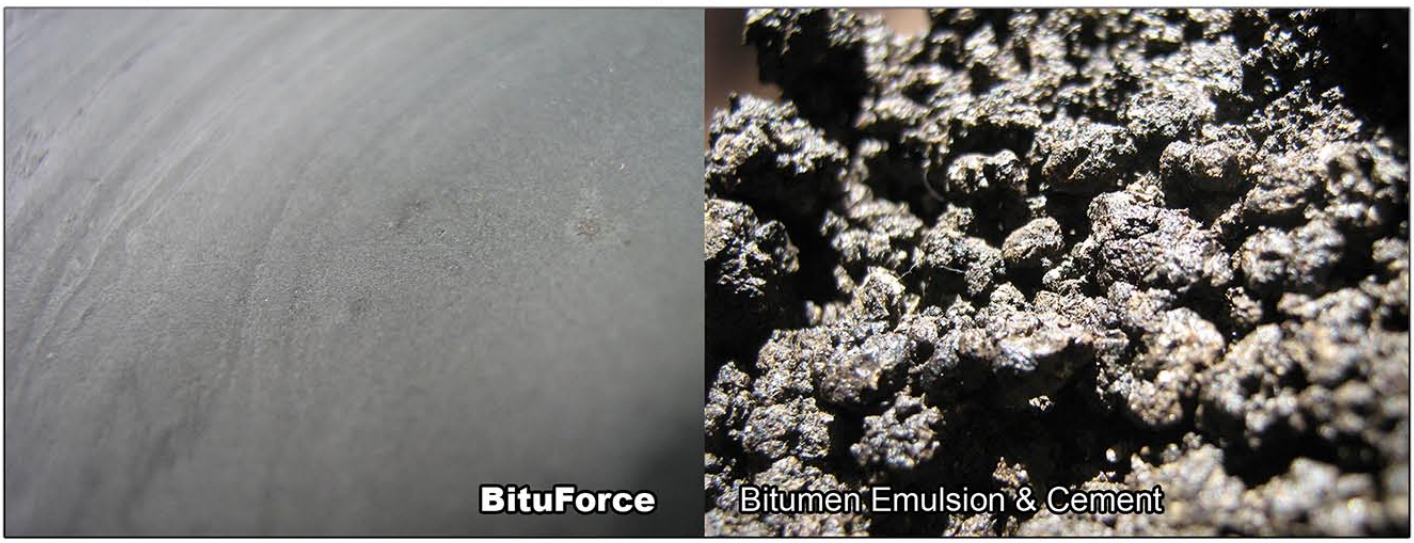
Ecobond				
Residual Bitumen Added (%)	2.0			
Ecobond BituForce Resin added (%)	0.75			
Applied failure stress (kPa)	1935	2409	2829	3099
	σ_3:0	σ_3:50	σ_3:100	σ_3:200
Major principle stress at failure ($\sigma_{1,f}$) (kPa)	1938	2412	2832	3099
Cohesion (c) (kPa)	435			
Internal angle of friction (φ)	44.5			

Foamed Bitumen				
Foam Bitumen added (%)	3.0			
Lime filler added (%)	1.0			
Applied failure stress (kPa)	1496.8	1936.0	2282.6	2929.6
	σ_3:0	σ_3:50	σ_3:100	σ_3:200
Major principle stress at failure ($\sigma_{1,f}$) (kPa)	1500	1939	2285	2930
Cohesion (c) (kPa)	287			
Internal angle of friction (φ)	48.7			

- Increased 24-hour-soaked strength in TG2 ITS tests (as well as TRH UCS tests), sometimes double at the same price.



- Homogenous binder composition, BituForce (left), Bitumen Emulsion and cement (right).



Suitable and useable:

SANRAL SAPEM 2013 on the use of new products based on existing materials

"these materials should be tested as the equivalent cement or bitumen emulsion treated material would be, and comply with the same UCS or ITS required for an equivalent conventionally treated material"

"If there is a significant benefit/cost ratio and the risk is deemed to be acceptable, there is no reason why the product should not be used." - Chapter 3 Section 6

COMPOSITION

The BituForce resin component replaces the use of cement or lime as 'active filler' in a bitumen stabilized material (BSM). It forms a bond to the substrate and bitumen micro-particles at a controlled rate when cross linking takes place. The BSM is also more water resistant due to a more even dispersal of binder as all the product is suspended in water initially.

An Ecobond Bitumen Stabilized Material (BSM) improves the shear strength by increasing the cohesion of aggregates without significant change to the angle of internal friction.

It is important to understand the mix design method. The following guidelines are used depending on project:

THE CLASSIFICATION OF BSMS INCLUDES THREE MATERIAL CLASSES

- BSM1: This material has a high shear strength, and is typically used as a base layer for design traffic applications of more than 6 million equivalent standard axles (MESA). For this class of material, the source material is typically a well graded crushed stone or reclaimed asphalt.
- BSM2: This material has a moderately high shear strength, and would typically be used as a base layer for design traffic applications of less than 6 MESA. For this class of material, the source material is typically a graded natural gravel or reclaimed asphalt.
- BSM3: This material is typically a soil-gravel and/or sand, sometimes requiring higher bitumen contents. As a base layer, the material is only suitable for design traffic applications of up to 1 MESA. It could also be utilized as a sub base or selected layer.

The mix design of BSMs involves three levels of testing, which depend on the design traffic level. ITS testing in dry and wet (24 hour soak) states is used for Level 1 (up to 3m ESAs) and level 2 testing involves ITS testing of sample at equilibrium moisture content (+-50% of moulding moisture content) and after 24 hour soak (typically used for pavements up to 6m ESAs).

Example of suitable materials for BituForce stabilization:

Suitable materials are generally crushed stone, natural gravels and sandy material. Generally the factor making a material unsuitable for use is a high clay content, with clay materials the surface area becomes very large and the material itself is unworkable and difficult to mix with the binder and compact. The TG2 confidence factor method can be used to determine stabilized material class.

Test or indicator	Material	Design Equivalent Material Class			Not Suitable for
		EBSM1	EBSM2	EBSM3	EBSM
Soaked CBR (%)	CS (98%)	>80	>25	>10	<10
	NG (95%)		>25	>10	<10
P0.075 (%)	CS (98%)	2 to 15			>15
	NG (95%)		5 to 25	25 to 40	>40
	GS		5 to 20	15 to 30	>30
	SSSC			0 to 20	>20
Plasticity Index	CS (98%)	<10	<10		
	NG (95%)	<6	<12	<15	>15
	GS		<11	<15	>15
	SSSC			<15	>15
Grading Modulus	NG	2.0 to 3.0	1.2 to 2.7		
	GS		1.2 to 2.5	0.75 to 2.7	< 0.75

Design and Product Storage

Test	Specimen diameter	BSM1	BSM2	BSM3
ITS_{dry}	100 mm	> 225	175 to 225	125 to 175
ITS_{wet}	100 mm	> 100	75 to 100	50 to 75
ITS_{equil}	150 mm	> 175	135 to 175	95 to 135
ITS_{soaked}	150 mm	> 150	100 to 150	60 to 100

Acceptance control testing is done according to the industry norms for bitumen stabilized materials (e.g. SAPEM 2013 and TG2 2009).

Ecobond staff work together with the contractor and project engineers to ensure the correct procedures and process are being followed.

The structural design of BSMs often is done using the Pavement Number (PN) design method. The PN method is recommended for design traffic between 1 and 30 MESA and for Category A and B roads. For design traffic less than 1 MESA, a catalogue of typical designs is available.

Product Storage

The product is stored on site in liquid form at ambient temperatures and mixed with water to be dispensed into the tankers which feed water and product into a road stabilizer/ reclaimer machine (Below.)

Ecobond staff work together with the contractor and project engineers to ensure the correct procedures and process are being followed.

	Pavement Class and Design Bearing Capacity		Foundation (CBR)
Road Category	ES0.3 ≤ 300 000	ES1 300 000 to 1 000 000	
B (95% Reliability)		S 125 BSM2	> 15
		S 125 BSM2 150 G6	7 to 15
		S 125 BSM2 150 G5 150 G7 150 G9 40 AC 300 BSM2	3 to 7
C (80 % Reliability)	S 100 BSM3 125 G6 S 125 BSM3	S 125 BSM3 150 G6 S 150 BSM3	> 15
	S 125 BSM3 125 G6 125 G7 S 300 BSM3	S 125 BSM3 150 G5 150 G7 40 AC 200 BSM3	7 to 15
	S 100 BSM3 125 G6 125 G7 125 G9 40 AC 200 BSM3	S 150 BSM3 150 G5 150 G7 150 G9 40 AC 200 BSM3	3 to 7
D (50% Reliability)	S 100 BSM3	S 100 BSM3	> 15
	S 100 BSM3 125 G6 S 250 BSM3	S 100 BSM3 125 G6 30 AC 150 BSM3	7 to 15
	S 125 BSM3 125 G6 S 300 BSM3	S 125 BSM3 150 G6 30 AC 175 BSM3	3 to 7

Figure 5.1 Catalogue of Designs for BSM Pavements Carrying up to 1 MESA

Catalogue of pavement designs for < 1 MESA traffic loads.

Summary:

- Cold process.
- More strength per binder content.
- Increase strength without Reflective cracking, stabilization cracking and shrinkage cracking.
- Can be sealed and trafficked soon after construction.
- Increase the durability of the stone in the aggregate.
- No reversal of stabilization or carbonation.
- 1 year storage life.
- Can be constructed using conventional equipment, reclaimers/stabilizers or in plan mixes.
- No curing with water.
- Less importation of aggregates.

Techneco (Pty) Ltd (sole Ecobond manufacturer) is a materials supplier and does not construct roads or apply dust inhibition. Choose your preferred construction team, one of our distributors or contact us so that we can recommend a suitable applicator in your area.

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