Paving the Way for Nanotechnology
Road to Progress

Nanotechnology for Asphalt Roads

- Improved Strength
- Improved Flexibility
- Waterproofed Asphalt Concrete
Introduction

Rains, Seasonal changes coupled with increasing traffic volumes, vehicle loads and tyre pressures cause accelerated degradation of pavements.

The principle of sustainability in the 21st century dictates the need of conserving resources such as stones, asphalt and cement. Durability is the key parameter at acceptable serviceability index (2-4).

Nanotechnology

Zycosoil nanotechnology is a patented breakthrough to address these issues at an economic cost. It reacts with the aggregates and acts as a bonding agent to asphalt binder. The technology offers 35-45% compressive higher strength and increased flexibility in asphaltic pavements at similar binder content.

Zycosoil Benefits

Antistripping

The reactive chemistry of Zycosoil improves antistripping performance by an order of magnitude.

The polar surface of aggregates gets converted to nonpolar surface by Zycosoil reactive modification. These nonpolar aggregates can bond with 95% of the nonpolar asphalt composition, contrary to 5% of the polar asphalt composition bonding to polar aggregates. This results into 15-20 fold improved antistripping performance and will lead to improved service life of the road.

Zycosoil is directly added to hot asphalt binder, mixed and then used.

Aggregates Susceptible To Stripping

Aggregates that are very susceptible to stripping like Quartzite's, can give excellent antistripping performance by using 0.2 - 0.4 % Zycosoil on the weight of asphalt binder as an antistripping agent. Tests were carried as per AASHTO T182 at 60°C.

Ecology

Soil dust and stone dust do not affect the performance of asphalt concrete composition when Zycosoil is used in Asphalt. Zycosoil nanotechnology can convert soil dust and stone dust hydrophobic (asphalt loving) and resolve the reverse emulsification of asphalt binder due to clay particles.

World over poor quality aggregates are used due to local availability and cost considerations.
Zycosoil Features

Zycosoil is a water soluble reactive organo-silicon compound. It forms Si-OH silanol groups upon hydrolysis. These silanols are reactive and can form Si-O-Si siloxane bonds with surface silanol groups of inorganic substrates. Zycosoil nanotechnology offers:

- Permanent water repellent nano layer on all types of soil, aggregates & other inorganic road construction materials
- Reaction leads to permanent nano siliconization of the surfaces by converting the water loving silanol groups to water repellent siloxane bonds
- The Si-O-Si Siloxane bond is Mother Nature’s strongest bond which survives for centuries
- Substantial reduction in soil water infiltration and erosion
- Has ultraviolet and thermal stability for 20 plus years
- Is non leachable as it chemically binds to surfaces permanently

Zycosoil’s reactive bonding with the aggregates and asphalt helps to reduce incompatibility with aggregates:

- Minimum loss of compressive strength and flexibility of asphalt concrete under wet conditions
- Stripping and hydraulic scouring due to bond failure of asphalt binder with aggregates under wet conditions

Zycosoil Reaction With Silicate Containing Surfaces

Silanol groups make surface very hydrophilic (water loving)

Typical Soil and Aggregates surface structure

Zycosoil molecules create molecular level hydrophobic zone (water repellent)

Soil and Aggregates surface structure after Zycosoil reaction
Anti Stripping Performance
ASTM 1664 / AASHTO T182 at 60°C
Basalt Aggregate (DBM) : 45% 20 mm, 10% 10 mm, 45% less than 6 mm with stone dust
Asphalt Grade : AC-20 (VG-30, 60-70 penetration grade)

<table>
<thead>
<tr>
<th>Test Sample By weight of mix</th>
<th>24 hr %</th>
<th>48 hr %</th>
<th>120 hr %</th>
<th>360 hr %</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5% asphalt binder</td>
<td>95</td>
<td>85*</td>
<td>25*</td>
<td>20*</td>
</tr>
<tr>
<td>4.5% asphalt binder with 2% hydrated lime</td>
<td>98</td>
<td>90*</td>
<td>55*</td>
<td>30*</td>
</tr>
<tr>
<td>4.5 asphalt binder containing 0.5% amine</td>
<td>96</td>
<td>88*</td>
<td>50*</td>
<td>25*</td>
</tr>
<tr>
<td>4.5% asphalt binder containing 0.1% Zycosoil</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td>97</td>
</tr>
</tbody>
</table>

* Less than 95% → Fail, (as per specified standards)

ASTM 3625 Boiling Test
Basalt Aggregate (DBM) : 45% 20 mm, 10% 10 mm, 45% less than 6 mm with stone dust
Asphalt Grade : AC-20 (VG-30, 60-70 penetration grade)

<table>
<thead>
<tr>
<th>Test Sample By weight of mix</th>
<th>10 min %</th>
<th>30 min %</th>
<th>1 hour %</th>
<th>6 hours %</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5% asphalt binder</td>
<td>40</td>
<td>Total Failure</td>
<td>Total Failure</td>
<td>Total Failure</td>
</tr>
<tr>
<td>4.5% asphalt binder with 2% hydrated lime</td>
<td>82</td>
<td>45*</td>
<td>Total Failure</td>
<td>Total Failure</td>
</tr>
<tr>
<td>4.5 asphalt binder containing 0.5% amine</td>
<td>80</td>
<td>42*</td>
<td>Total Failure</td>
<td>Total Failure</td>
</tr>
<tr>
<td>4.5% asphalt binder containing 0.1% Zycosoil</td>
<td>98</td>
<td>98</td>
<td>96</td>
<td>95</td>
</tr>
</tbody>
</table>

* Less than 75% → Fail, (as per specified standards)

All control samples showed significant amount of stripped asphalt binder floating in water. Asphalt binder containing Zycosoil samples showed, if any, very little amount floating in water during boiling. Control samples were completely stripped in the boiling water test, while Zycosoil containing asphalt binder remained adhered to the aggregate surface even after six hours in boiling water.
MARSHALL STABILITY & FLOW VALUE
ASTM D 1075 / AASHTO T165 at 60°C, 24 hrs.

Basalt Aggregate (DBM) : 45% 20 mm, 10% 10 mm, 45% less than 6 mm with stone dust

<table>
<thead>
<tr>
<th>Asphalt Grade</th>
<th>Strength Kg</th>
<th>Flow Value mm</th>
<th>Strength Kg</th>
<th>Flow Value mm</th>
<th>Strength Kg</th>
<th>Flow Value mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-10 (VG-10, 60-100)</td>
<td>1208</td>
<td>2.71</td>
<td>1465</td>
<td>2.85</td>
<td>2980</td>
<td>2.7</td>
</tr>
<tr>
<td>AC-20 (VG-30, 60-70)</td>
<td>1350</td>
<td>2.78</td>
<td>1665</td>
<td>2.95</td>
<td>2461</td>
<td>3.0</td>
</tr>
<tr>
<td>CRMB-60*</td>
<td>1599</td>
<td>3.18</td>
<td>1794</td>
<td>3.14</td>
<td>2988</td>
<td>3.1</td>
</tr>
<tr>
<td>PMB-40**</td>
<td>1846</td>
<td>3.05</td>
<td>2346</td>
<td>3.09</td>
<td>2333</td>
<td>3.02</td>
</tr>
</tbody>
</table>

* CRMB-60 : Crumb Rubber Modified Bitumen  ** PMB-40 : Polymer Modified Bitumen

Zycosol containing asphalt concrete has a significant increase of 35 - 45 % in stability strength along with flow properties. This is expected to improve the load bearing strength of the asphalt pavement in wet condition.

Zycosol addition of 0.04 - 0.1 % on weight of asphalt binder is recommended. Higher dosage of 0.2-0.4 % for aggregates susceptible to stripping should be used.

MARSHALL STABILITY STRENGTH
ASTM D 1075 / AASHTO T165 at 60°C, 24 hrs.

Basalt Aggregate (DBM) : 45% 20 mm, 10% 10 mm, 45% less than 6 mm with stone dust

<table>
<thead>
<tr>
<th>Asphalt Grade</th>
<th>Test Sample</th>
<th>Stability Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-20 (VG-30, 60-70)</td>
<td>Hydrated Lime (2%)</td>
<td>Dry 2059 Wet 1721 Ratio 83.7</td>
</tr>
<tr>
<td>AC-20 (VG-30, 60-70)</td>
<td>Zycosol (0.1%)</td>
<td>Dry 2512 Wet 2451 Ratio 98.0</td>
</tr>
<tr>
<td>CRMB-60*</td>
<td>CRMB</td>
<td>Dry 2152 Wet 1794 Ratio 83.4</td>
</tr>
<tr>
<td>PMB-40**</td>
<td>PMB-40</td>
<td>Dry 2442 Wet 2346 Ratio 95.1</td>
</tr>
</tbody>
</table>

* CRMB-60 : Crumb Rubber Modified Bitumen  ** PMB-40 : Polymer Modified Bitumen

The performance of Zycosol is equal or slightly better than the polymer modified asphalt binder.
MARSHALL STABILITY - VARYING BINDER CONTENT
ASTM D 1075 / AASHTO T165 at 60°C, 24 hrs. Immersion

Basalt Aggregate : 33% 20mm, 24% 10mm, 41% less than 6mm with stone dust

<table>
<thead>
<tr>
<th>Asphalt Binder Content in %</th>
<th>Strength KG</th>
<th>Flow Value mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Modified</td>
</tr>
<tr>
<td>5.1</td>
<td>1140</td>
<td>1025</td>
</tr>
<tr>
<td>4.5</td>
<td>1407</td>
<td>1575</td>
</tr>
<tr>
<td>4.0</td>
<td>1120</td>
<td>1230</td>
</tr>
<tr>
<td>3.5</td>
<td>938</td>
<td>1085</td>
</tr>
</tbody>
</table>

Zycosoil can enable a reduction in asphalt binder for maintaining same stability strength without compromising flow values.

Addition of 0.1% Zycosoil in asphalt binder resulted in approx. 40% increase in compressive strength of asphalt concrete mixture with 5.1% asphalt binder.

Results indicated that 0.1% Zycosoil addition at 4% asphalt binder content matched the compressive strength of the controlled with 5.1% asphalt binder content concrete mix.

Technical Specifications
Color : Clear to pale yellow
Solid content : 41 +/- 2%
Solvent : Ethylene glycol
Flash Point : 80°C
Viscosity (25°C) : 200-800 cps
Solubility : Soluble in asphalt

Application Process
- 1 Kg Zycosoil is mixed with 1 MT of Asphalt (0.1%)
- The Hot Molten asphalt is mixed with circulating pump for 20-30 min.
- The modified hot molten asphalt binder is mixed with aggregates by a spray technique as needed.