Emulsion Treated Aggregate (ETA)
Emulsion Treated Aggregate (ETA)

Introduction

Whatever I am going to present here is based on my field experience. There may be gaps in whatever I have learnt from field and there may be further scope for improvement with due guidance of people like you.

When we talk about Pavement Design, the questions that come to our mind are:-

- Whether our design is safe?
- Whether it is economical?
- Whether it will last long?

There can be multiple answers and ways to overcome these queries. One of the ways, out of many, is to improve the strength and durability of material being used in different layers of pavement. The easiest way is to improve the strength of the weakest layer like subgrade, sub-base and base by improving the modulus of pavement layer. It will result in less thickness of pavement and thereby making it economical and environment friendly.
Emulsion Treated Aggregate (ETA)

Stabilisation

- Process of mixing a stabilizer to produce a material whose strength is greater than that of the original unbounded material.
- Used to improve the properties of a material.
- Increases strength and load spreading ability of materials used.

Need of Stabilisation

- Lack of good quality materials.
- Less quarrying and transport there by less emission of CO₂
- Consume less energy & saving the natural resources.
Emulsion Treated Aggregate (ETA)

Stabilisation of Aggregate

Cement Treated Base (CTB)
- High Modulus
- More Cost Effective
- Less Quarrying
- Difficult Construction
- Fatigue Failure Prominent
- Not Suitable for Rehabilitation
- Traffic Opening Delayed

Emulsion Treated Aggregate (ETA)
- Good for Rehabilitation
- Less Saving in Aggregate
- Medium Modulus
- Less Cost Effective
- Easy Construction
- No Scrapping of Existing Bituminous Layer
- Early Traffic Opening
Emulsion Treated Aggregate (ETA)

Cement Treated Aggregate (CTB)

- To improve the performance of material.
- To increase strength, stiffness and durability of material.
- To use less quantity of material.
- To protect environment.
- Less quarrying and transport.
- Reduction in cost.
Emulsion Treated Aggregate (ETA)

Caution for CTB

- Shrinkage cracks
- Grading of aggregates.
- Curing of mix.
- Due to fatigue modulus reduces to 1500 - 2000 MPa.
- Subsequently layer broken down into blocks of 1- 5 times the layer thickness.
- Effective elastic modulus further reduced to 200 - 500 MPa, material broken down into particle sizes less than the thickness of the layer.
- Effective modulus values further decrease to 50 - 200 MPa when moisture enters layer.
- Rapid deterioration of pavement during equivalent granular phase on water entering pavement with pumping and deformation.
Emulsion Treated Aggregate (ETA)

Aggregate treated with bitumen emulsion with small quantity of cement (required for dispersion of bitumen emulsion in the mix) to improve the properties of material like increase strength, load spreading ability is named as ETA.

Advantage of ETA over CTB

- Stabilization of ETA is much easier as compared to CTB.
- Traffic can be allowed after few hours while in case of CTB it is only after 7 days.
- Execution and quality control of ETA is easier than CTB.
- ETA base does not reflect shrinkage cracks.
- Curing period of ETA is far less.
- Crack Relief layer not require.
Emulsion Treated Aggregate (ETA)

Economic Consideration

• In rehabilitation, the addition of emulsion eliminates the need for the removal of the present material and its replacement by new material.
• Savings would be generated in terms of material costs, transportation of material handling costs.
• Reduces road user delay costs.
• Reduces the costs for the construction.

Salient Features of ETA (Mix Design)

• Materials Characteristics.
• Optimum Moisture Content (OMC)
• Preparation of samples
• Compaction.
• Curing of samples.
• Determination of optimum residual bitumen and optimum fluid contents.
• Determination of Indirect Tensile Strength (ITS) > 225 KPa after 96 hours.
Emulsion Treated Aggregate (ETA)

Construction of ETA

- Material Preparation
- Application of Emulsion
  - Mixing & Shaping
  - Compaction
- Opening for Traffic
Emulsion Treated Aggregate (ETA)

Material Preparation

- Material use for ETA should fulfill any one of the following grading:
  1. WMM grading

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Percent by weight passing the IS Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>53.00 mm</td>
<td>100</td>
</tr>
<tr>
<td>45.00 mm</td>
<td>95-100</td>
</tr>
<tr>
<td>26.50 mm</td>
<td>-</td>
</tr>
<tr>
<td>22.40 mm</td>
<td>60-80</td>
</tr>
<tr>
<td>11.20 mm</td>
<td>40-60</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>25-40</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>15-30</td>
</tr>
<tr>
<td>600.00 micron</td>
<td>8-22</td>
</tr>
<tr>
<td>75.00 micron</td>
<td>0-5</td>
</tr>
</tbody>
</table>

- Proposed WBM grading

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Percent by weight passing the IS Sieve (Combined Grading)</th>
</tr>
</thead>
<tbody>
<tr>
<td>53.00</td>
<td>100.00</td>
</tr>
<tr>
<td>45.00</td>
<td>90-100</td>
</tr>
<tr>
<td>26.50</td>
<td>25-55</td>
</tr>
<tr>
<td>22.40</td>
<td>23-40</td>
</tr>
<tr>
<td>13.20</td>
<td>15-30</td>
</tr>
<tr>
<td>11.20</td>
<td>13-27</td>
</tr>
<tr>
<td>9.50</td>
<td>12-25</td>
</tr>
<tr>
<td>5.60</td>
<td>10-20</td>
</tr>
<tr>
<td>0.18</td>
<td>0-5</td>
</tr>
</tbody>
</table>
Emulsion Treated Aggregate (ETA)

(iii) RAP grading

<table>
<thead>
<tr>
<th>Sieve Size mm</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>37.5</td>
<td>87-100</td>
</tr>
<tr>
<td>26.6</td>
<td>77-100</td>
</tr>
<tr>
<td>19</td>
<td>96-99</td>
</tr>
<tr>
<td>13.2</td>
<td>61-87</td>
</tr>
<tr>
<td>4.74</td>
<td>33-50</td>
</tr>
<tr>
<td>2.36</td>
<td>25-47</td>
</tr>
<tr>
<td>0.60</td>
<td>12-27</td>
</tr>
<tr>
<td>0.30</td>
<td>8-21</td>
</tr>
<tr>
<td>0.75</td>
<td>2-9</td>
</tr>
</tbody>
</table>

- RAP contaminated with clay, lime to be used to modify the clay and make it suitable.

- The designed/desired moisture to be maintained.

- While preparing the mix, Marshal Moulds to be prepared for testing of ITS (Indirect Tensile Strength).
Emulsion Treated Aggregate (ETA)

Application of Emulsion

• Emulsion diluted with design optimum water content is mixed with aggregate.

• Degree of dilution of the emulsion should be adjusted according to weather conditions.

• Higher fluid content may result in deformation of the surface under final compaction.

• 10% of emulsion and corresponding fine aggregate quantity be held back for enrichment of upper 25 - 30 mm layer.

• Water not to be applied directly to the mix once bitumen emulsion has been added to the aggregate.
Emulsion Treated Aggregate (ETA)

Mixing and shaping

- Obtain homogeneous mix having uniform appearance throughout.

- Obtaining substantial preliminary compaction (by grid rolling or other suitable means).

- Bringing layer to final level and cross-section.

- Achieving reasonably uniform surface texture, free from segregation.

- Top of the layer should then be enriched by even application of diluted emulsion and fine aggregate.

- Mixing may be done by rotavator, disc harrow, rotary mixer or similar equipment.

- Laying should be done by paver or grader.
Emulsion Treated Aggregate (ETA)

Compaction

- Slushing, using additional quantity of diluted emulsion to improve rough spots, but not in excess.

- Brooming, blading to redistribute fine material to surface.

- Final rolling - best performed by means of heaviest available soil compactor (normally 28 tonnes) followed by a 10 - 12 tonne steel wheel roller.

- Avoid excessive rolling to prevent deformation of surface.

- Final surface should be smooth, tightly knit and free of undulations, corrugations, holes, bumps or loose material.

Laying ETA Link  Strength Checking Link
Opening to traffic

Light traffic like two wheels, Cars, Jeeps, etc can be allowed after 3-4 hours of final compaction. Heavy Vehicles should be allowed after 24 hours of final compaction.
Emulsion Treated Aggregate (ETA)

Evaluation of ETA

Pavement constructed with ETA layer can be evaluated by FWD. Module of different layers are evaluated by back calculation using KGP Back and there after remaining life of pavement is calculated with use of IIT Pave. Pavement evaluation of newly constructed road in district Moradabad was carried out in the month of May 2019.
Emulsion Treated Aggregate (ETA)

Case Study
Biliary-Jargaon-Chandausi Road
District - Moradabad

CBR = 5.20 %
MSA = 5.01
Design Life = 10 Years

Crust Composition
Granular = 250 mm
ETA = 130 mm
Bituminous = 75 mm

Road Before

Road After ETA
Emulsion Treated Aggregate (ETA)

Deflection Data

Deflection were obtained by FWD at three places. First reach of road was selected where BC has been laid. Second stretch were DBM was laid and one stretch where only ETA layer was laid over existing granular layer.

Modulus of different layers were obtained using KGP Back Software.
Emulsion Treated Aggregate (ETA)

**Obtained Modulus**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Modulus (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-grade</td>
<td>77.1</td>
</tr>
<tr>
<td>Sub-base &amp; ETA*</td>
<td>422.6</td>
</tr>
<tr>
<td>Bituminous</td>
<td>3458.9</td>
</tr>
</tbody>
</table>

**Note:**
* Deflection obtained over ETA & with back calculation, Modulus of ETA obtained is 1190 MPa.
Emulsion Treated Aggregate (ETA)

**Strain**

Permissible Strain

Fatigue \( (E_t) = 425.33 \times 10^{-6} \)

Rutting \( (E_v) = 784.03 \times 10^{-6} \)

Strain as obtained using IIT Pave

\[
E_t = 193.2 \times 10^{-6}
\]

\[
E_v = 365.4 \times 10^{-6}
\]

Remaining life of pavement can be evaluated from the above strain obtained from IIT Pave. For present traffic pavement will last for 40 Years.
Conclusion

ETA is very useful for rehabilitation. For strengthening of existing roads like MDR/ODR where we cannot provide bypass, ETA is very effective as traffic can be allowed in short time. Strengthening of existing road where existing bituminous surface is to be scraped for further granular layer as required for strengthening is a hazard for traffic. ETA can be overlayed on existing bituminous surfacing like Premix Carpet or badly damaged bituminous layer. ETA can be used in wet condition also. In Year 2018-19 UP PWD sanctioned 736 km roads (MDR/ODR) amounting Rs 327.32 crores using ETA.
Thanks to CRRI and specially lot of thanks to Director CRRI for giving me an opportunity to interact with you all. You people have great academic knowledge and are masters in your respective fields. Your knowledge can not be compared with the knowledge of a man like me. Being in an organization like state PWD we do not have adequate facilities to experiment with new things. At the same time, we do not have enough time to refresh our knowledge with new advancements.

Stabilization of subgrade and sub-base with different type of additives is being commonly used now a days. Similarly stabilization of base with cement has also been suggested in IRC 37:2012.

In my today's presentation, I will discuss “Emulsion Treated Base”. We started stabilization of aggregates with emulsion in UPPWD nearly 4 years back and I am happy that now IRC 37:2018 has incorporated stabilization of virgin aggregate with emulsion and for that catalogue has been provided in IRC 37:2018.