SEMINAR ON CEMENT AND CONCRETE APPLICATIONS – ROADS
1 – 2 AUGUST 2018
JKR CREATE, MELAKA

COLD IN PLACE RECYCLING (CIPR)
CONTENTS:

- GENERAL
- DEFINATION
- WHERE TO USE
- PROCESS OF CIPR
  - Pavement Investigation
  - Laboratory Testing
- CONSTRUCTION SEQUENCES
- PLANT & MACHINERY
- COST COMPARISON
- POST CONSTRUCTION TESTING
Pavement rehabilitation is work undertaken to extend the service life of an existing road. This includes resurfacing, restoring and rehabilitation (3R).
Stabilisation is the improvement of a soil or pavement material, through the addition of a small amount of binder additive.

Few Additives Used for Stabilization

1. Granular
2. Cementitious
   - Ordinary Portland Cement
   - Cementitious Blend
3. Lime
4. Bitumen
   - Foamed Bitumen
   - Bitumen Emulsion
5. Chemicals
Austroads Classification Chart  
(Stabilisation Agent vs. PI)

<table>
<thead>
<tr>
<th>Plasticity Index</th>
<th>MORE THAN 25% PASSING 75μm</th>
<th>LESS THAN 25% PASSING 75μm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PI ≤ 10</td>
<td>10 &lt; PI &lt; 20</td>
</tr>
</tbody>
</table>

Key:  
- Usually suitable:  
- Doubtful:  
- Usually not Suitable:  

Cement products cover wider range of property.
Some Examples of Stabilised Process:

- **Asphalt Mix** - such as ACWC, ACBC, DBM
- **WMM** - Wet Mix Macadam
- **CBM** - Cement Bound Material
- **CIPR** - Cold-In Place-Recycle Material
- **HIPR** - Hot-In-Place-Recycling
- **Foam Bitumen**

*Additive used to improve engineering properties
Local material to be improved*
COLD IN PLACE RECYCLING (CIPR)

What is Cold in Place Recycling?

Cold In-Place Recycling (CIPR) is a pavement rehabilitation technique that reuse the existing asphalt pavement. This process “generally” uses 100% Reclaimed Asphalt Pavement (RAP) mixed with a new binder either emulsion, foamed bitumen or cement. The cold nature of the process reduces the impact on the environment and preserves environment.

How it Works...

... the recycling machine scarifies the existing pavement layers (to maximum depth of 250mm) then adds either cement or bituminous material or both as stabilizing additives before laying it back to the same pavement area in a single process.
This technology is not new and has been used successfully in Malaysia since 1980’s.

Engineering design ensure the outcome matches the expectation of the end user.

Value for money with long term performance.

Most failures in the past was due to poor execution not because the treatment was wrong.

EXPERIENCE IS IMPORTANT!
Advantages

✓ Minimises the usage of quarries products
✓ Minimises disposal
✓ Reduced Construction Cost / Cost Saving
✓ Less Construction Time
✓ Reduces energy use / Green technology
✓ Less trucks / machinery at work site which means less fuel & pollution
Where to use??
Where to use CIPR..?

- Severe Crocodile Cracks
- Rutting or Deformation
COLD IN PLACE RECYCLING (CIPR)

Pavement Investigation & Testings
Investigation & Testings for CIPR

Coring
Investigation & Testings for CIPR

Material Sampling
Investigation & Testings for CIPR

Laboratory Test – Granular Material

1. Moisture Content
2. Grading Analysis
3. Material Properties
4. Mix Design
Material Properties

1. Plasticity Index
2. Aggregate Crushing Value (ACV)
3. Flakiness Index
4. Compaction Test
5. Unconfined Compression Strength (UCS)
6. Indirect Tensile Strength (ITS)
Investigation & Testings for CIPR

Testing during Construction

Moisture Content
Cube Preparation
Field Density Test
# Requirements Test

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirements</th>
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</thead>
<tbody>
<tr>
<td>Unconfined Compression Strength Test (UCS)</td>
<td>Minimum 97% of Modified AASTHO density</td>
</tr>
<tr>
<td>Indirect Tensil Stress (ITS)</td>
<td>Minimum 97% of Modified AASTHO density</td>
</tr>
<tr>
<td>Maximum cement content by weight</td>
<td>5%</td>
</tr>
</tbody>
</table>
Method of CIPR Works

Construction Steps

1. Milling asphalt layer (if required)
2. Spreading of Stabilizing Agent (cement)
3. Recycle using CR2200 or equivalent
4. Curing (before open to traffic)
5. Laying of premix as a finished layer
Method of CIPR Works

Recycling in Progress

Milling of asphalt layers

Spreading the cement

Distribution of cement

Recycling in Progress

Compaction

Placement of premix as Finished Layer
COLD IN PLACE RECYCLING (CIPR)

Plant and Machinery
Plant & Machinery for CIPR Works

Common Equipment

- **Specialized Machines**
  1. Stabiliser/Reclaimer/Milling
  2. Mechanical Spreader

- **Supporting Machines**
  1. Water Tanker
  2. Motor Grader**
  3. Vibratory Roller

Type of Machines
Plant & Machinery for CIPR Works

Typical Machines on Site
The Process
The granulated material is mixed with the pre-spread cement and injected water, thus creating a new homogenous mix in an in-situ process.

The recycled mix is deposited between the rear track units via a material guide plate system.

The spreading auger spreads the material evenly enabling the integrated Vogele paving screed to precisely pave and pre-compact it true line and level.

Final compaction by pneumatic-tyred rollers, the recycled layer serves as a high quality base for the new road.
The Recycling Process
Comparison
Design Comparison

Between Deep Lifting Upgrading and CIPR

EXISTING ROAD REHABILITATION
Common Design (ATJ 5/85)

**Typical Design**
- **50mm ACWC**
- **60mm ACWB**
  - 300mm Base Course
  - 100mm Sub Base
  - **Min. CBR 5%**

**CIPR – Proposed**
- **50mm ACWC**
- **60mm ACWB**
  - 250mm Base Course with cement
  - 100mm Sub Base
  - **Min. CBR 5%**

**Milling Level**

**Recycle Level**

*Remove & Replace*
## Design Comparison

<table>
<thead>
<tr>
<th>Conventional Design</th>
<th>$SL_c$</th>
<th>$T_A$</th>
<th>Alternative Design</th>
<th>$SL_c$</th>
<th>$T_A$</th>
</tr>
</thead>
<tbody>
<tr>
<td>50mm ACWC</td>
<td>1.0</td>
<td>50</td>
<td>50mm ACWC</td>
<td>1.0</td>
<td>50</td>
</tr>
<tr>
<td>60mm ACBC</td>
<td>1.0</td>
<td>60</td>
<td>60mm ACBC</td>
<td>1.0</td>
<td>60</td>
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<tr>
<td>300mm C. Run</td>
<td>0.32</td>
<td>96</td>
<td>250mm CTB</td>
<td>0.45</td>
<td>113</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>50mm C. Run</td>
<td>0.32</td>
<td>16</td>
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<tr>
<td><strong>SUM</strong></td>
<td><strong>206</strong></td>
<td></td>
<td><strong>SUM</strong></td>
<td></td>
<td><strong>239</strong></td>
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</table>

Ref: Arahan Teknik (Jalan) 5/85

Alternative Design slightly exceeds original Design Life
## Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th></th>
<th>CIPR</th>
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<th></th>
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<tbody>
<tr>
<td></td>
<td>Unit Cost</td>
<td>Cost</td>
<td>Unit Cost</td>
<td>Cost</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RM</td>
<td>RM/m²</td>
<td>RM</td>
<td>RM/m²</td>
<td></td>
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<tr>
<td>50mm ACWC</td>
<td>500/m³</td>
<td>25.00</td>
<td>50mm ACWC</td>
<td>500/m³</td>
<td>25.00</td>
</tr>
<tr>
<td>60mm ACBC</td>
<td>450/m³</td>
<td>27.00</td>
<td>60mm ACBC</td>
<td>450/m³</td>
<td>27.00</td>
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<tr>
<td>300mm Crusher Run</td>
<td>80/m³</td>
<td>24.00</td>
<td>110mm Milling &amp; Disposal</td>
<td>80/m³</td>
<td>9.00</td>
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<tr>
<td>410mm Milling &amp; Disposal</td>
<td>80/m³</td>
<td>33.00</td>
<td>250mm CIPR</td>
<td></td>
<td>25.00</td>
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<tr>
<td><strong>SUM (RM)</strong></td>
<td></td>
<td><strong>109.00/m²</strong></td>
<td></td>
<td></td>
<td><strong>86.00/m²</strong></td>
</tr>
</tbody>
</table>

21% Saving
Best Practices for CIPR Works

• Allowance of 24 hours lane closure
• Curing period of 1 day (rapid setting emulsion to be applied for early opening to traffic)
• Mixing & pulverize twice (dry & wet)
• Complete full lane every section of works
• Curing with water after compaction (if still not covered with asphalt)
• Provision of trench to prevent water ponding (if any).
Best Practices & Challenges

Challenges for CIPR Works

- Reclaimer/Stabiliser Machinery not easy to locate
- Working without proper mechanical spreader
- Not easy to get Skill & Experience workers
- Testing not included in contract
- Site Investigation not properly done
- Design mix was not done base on existing material
- Road need to open to traffic, as soon as possible
- OPC set in 2 hours, but working still on progress
COLD IN PLACE RECYCLING (CIPR)