

ISAP WG2 Regional Asian Workshop On (Cold) Recycling



INTRODUCTION

- CIPR technique was first introduced in Malaysia in mid 1980's.
 - 1985: FT02 Kuala Lumpur - Kuantan (Temerloh)
 - 1988: FT08 Pagar Sasak - Merapoh, Pahang
- Approximately 10% of Federal Roads* in Malaysia have been treated using CIPR.
- Involves all the asphalt layers and part of underlying pavement layers with addition of stabilizing agents to produce stabilized base course.

* Total length = 18,580.73 km

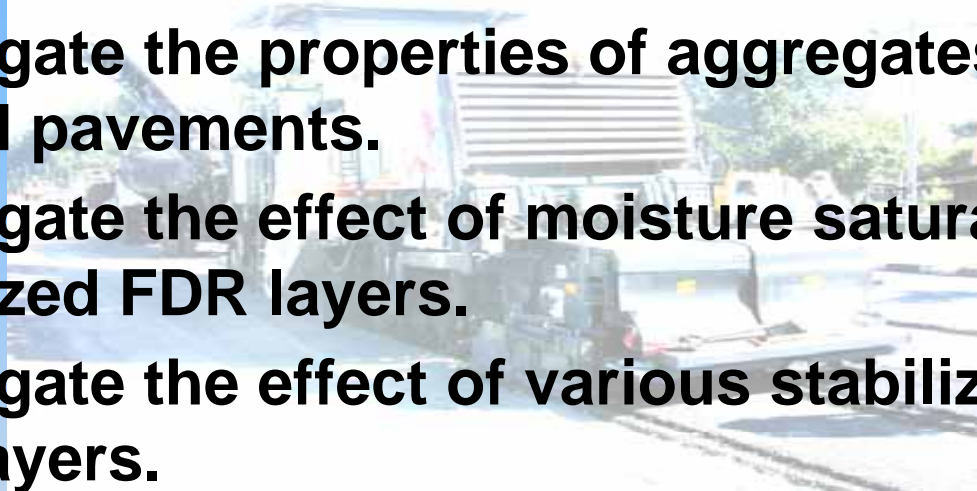
COLLABORATIVE RESEARCH

- Collaborative research between the Government (PWD) and private sector (IKRAM & Roadcare).
- Title: “Research on Fundamental Characteristics of Stabilised Full Depth Reclaimed Pavement Layers in Malaysia”
- Sites: Nine (9)
- Period: 2004 – 2009 (extended to 2012)
- Cost: RM13.2m (US\$3.8m)

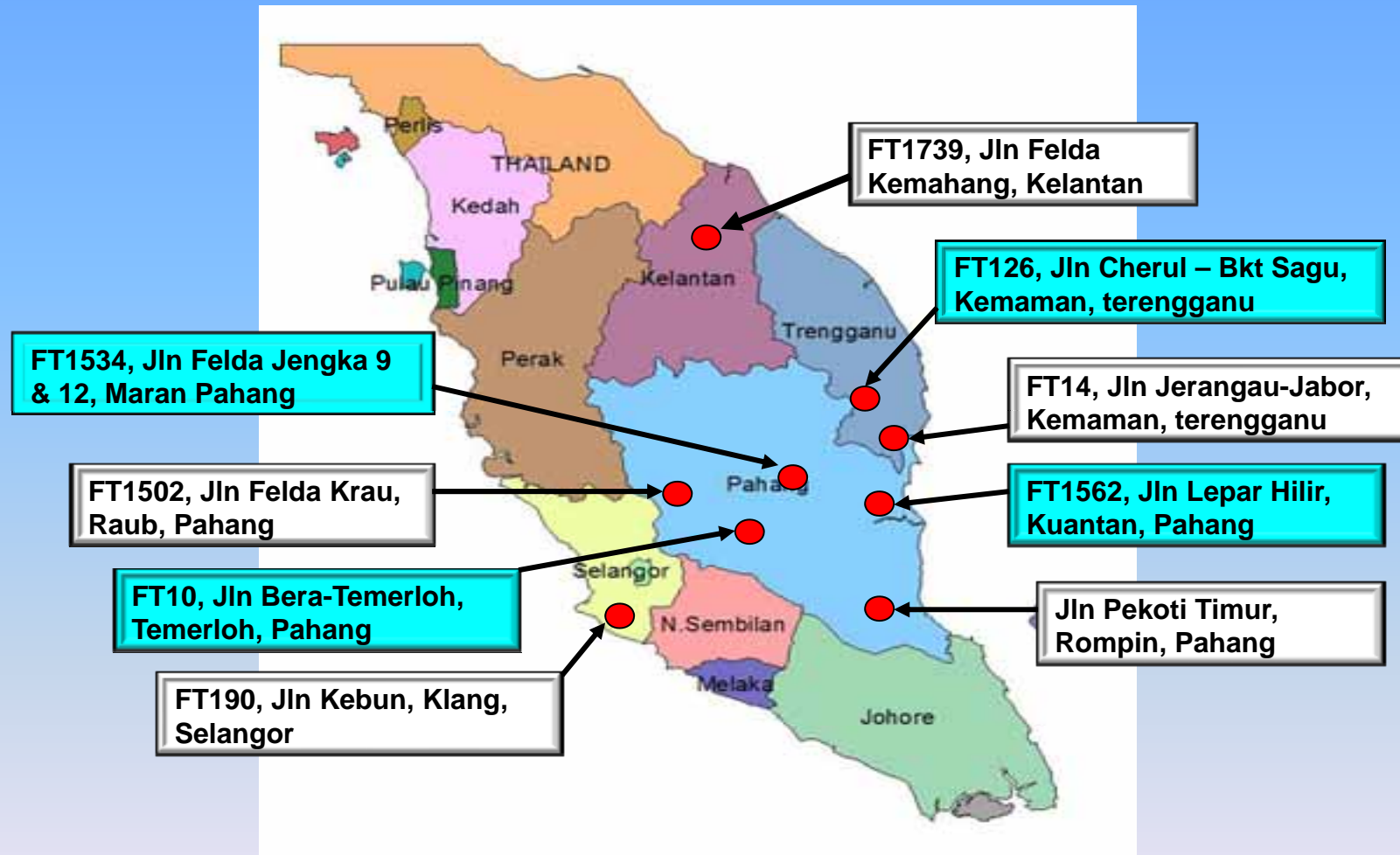


OBJECTIVES OF RESEARCH

- To study the fundamental engineering parameters of stabilized FDR layers.
- To investigate the properties of aggregates from reclaimed pavements.
- To investigate the effect of moisture saturation levels on stabilized FDR layers.
- To investigate the effect of various stabilizing agents on FDR layers.
- To study the performance of FDR pavements in Malaysia.
- To provide design & construction manual on FDR for Malaysia.



RESEARCH SITES



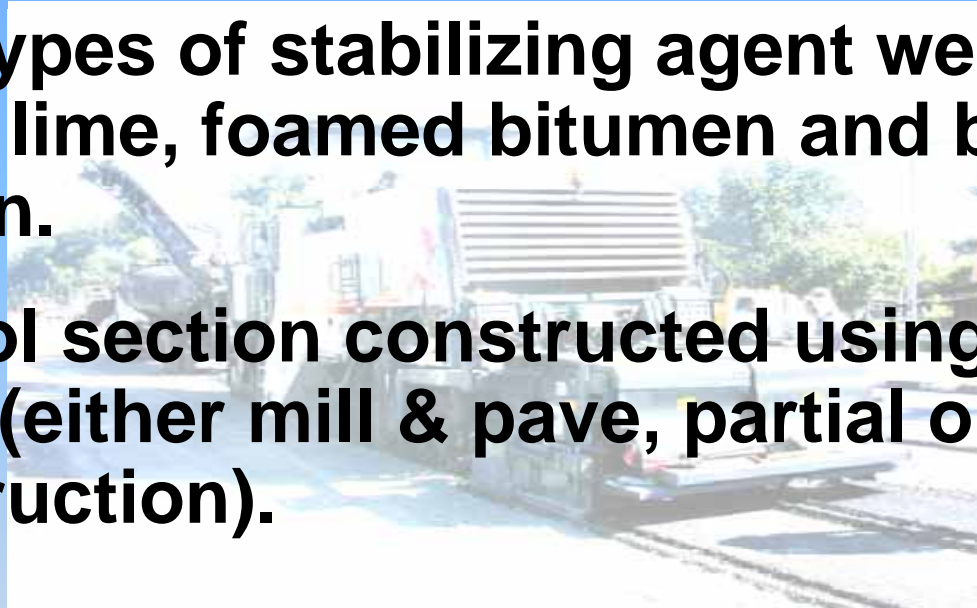
RESEARCH SITES

- Length 1 km, uniform in terrain, geometric, level of traffic, pavement type and surface condition.
- Each site divided to five 200m sections for four different types of stabilizing agent and a control section.



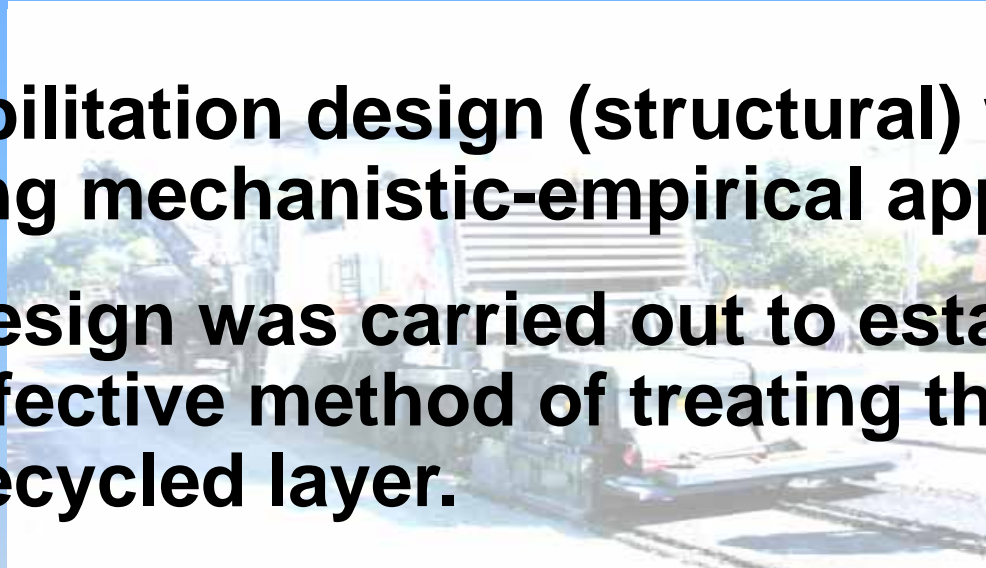
TYPES OF STABILIZING AGENT

- Four types of stabilizing agent were used – cement, lime, foamed bitumen and bitumen emulsion.
- Control section constructed using conventional method (either mill & pave, partial or full reconstruction).



DESIGN & MONITORING OF RESEARCH SITES

- Rehabilitation design (structural) was carried out using mechanistic-empirical approach.
- Mix design was carried out to establish the most effective method of treating the materials in the recycled layer.
- Each test site is monitored for 5 years after construction.



DEPTH OF RECYCLING

- Existing pavement layers were recycled from 200mm to maximum depth of 350mm with addition of stabilizing agents.



FIELD TESTING

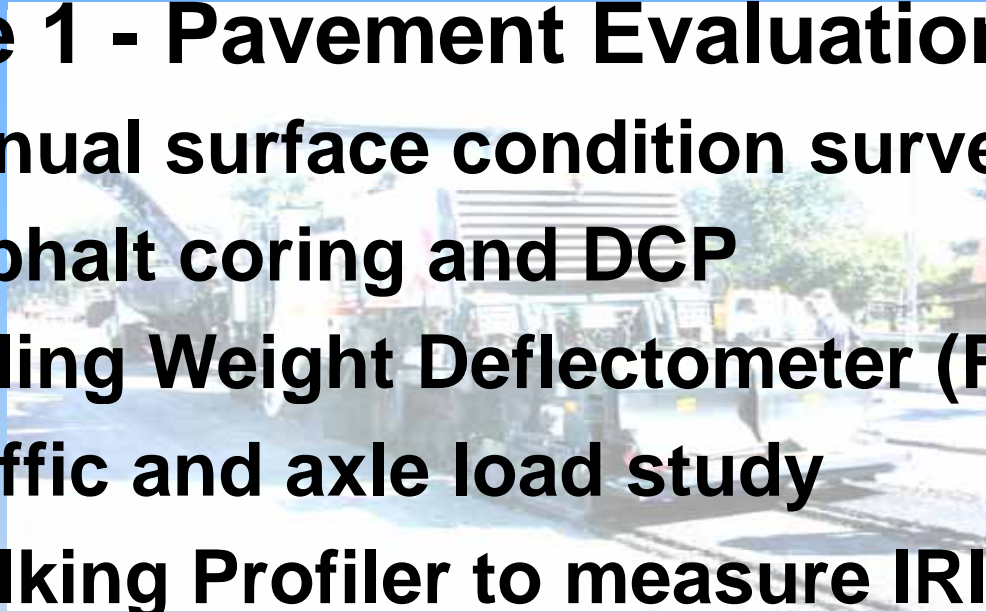
Field testing involves 2 stages:

- 1. Stage 1: Pre-Construction – carry out pavement evaluation and laboratory test to identify the existing condition and for rehabilitation design.**
- 2. Stage 2: Post Construction – monitoring the performance during the study period.**



FIELD TESTING

- **Stage 1 - Pavement Evaluation**
 - Manual surface condition survey
 - Asphalt coring and DCP
 - Falling Weight Deflectometer (FWD)
 - Traffic and axle load study
 - Walking Profiler to measure IRI
 - Test pit and sampling of existing materials



FIELD TESTING



Surface condition survey



FIELD TESTING



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FIELD TESTING



FIELD SAMPLING & LABORATORY TESTING

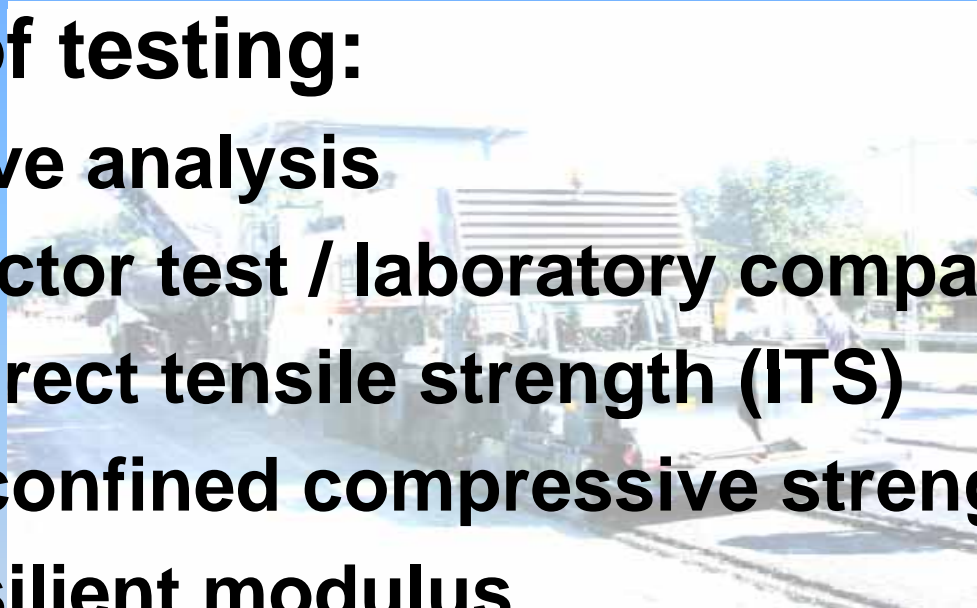
- To determine the engineering properties of the existing materials, quality and suitability for stabilized FDR.
- For mix design purposes - to establish the expected grading of the material to be recycled, optimum moisture content and amount of stabilizing agents required.



LABORATORY TESTING (Pre-Construction)

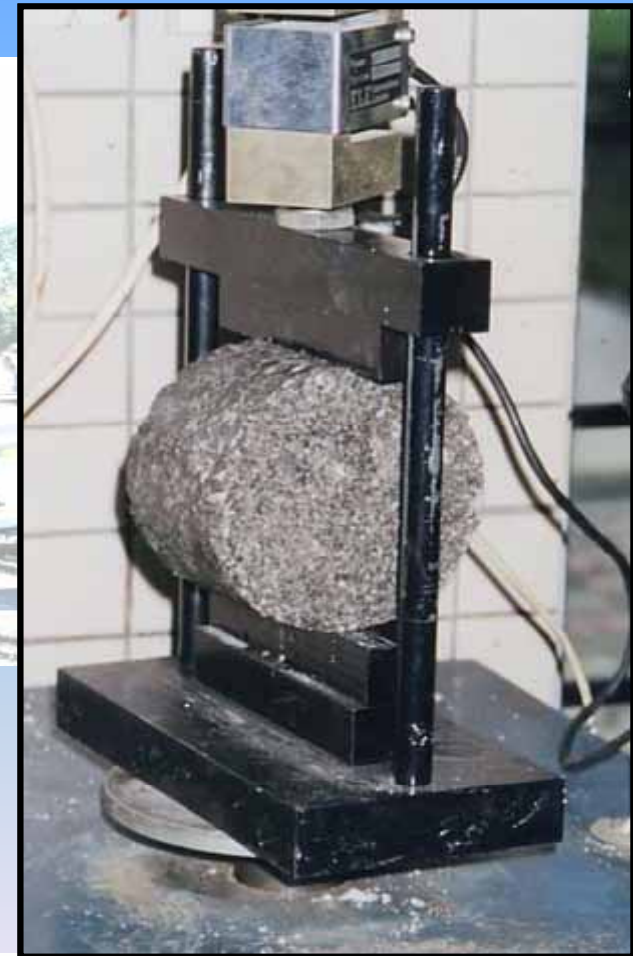
Types of testing:

- Sieve analysis
- Proctor test / laboratory compaction test
- Indirect tensile strength (ITS)
- Unconfined compressive strength (UCS)
- Resilient modulus



LABORATORY TESTING (Pre-Construction)

Indirect Tensile Strength (ITS)



LABORATORY TESTING (Pre-Construction)

Unconfined Compressive Strength (UCS)



QA/QC Works

To ensure that recycling works at site conform with design and specification:

- Moisture content of existing pavement
- Moisture content of recycled material
- Depth of recycling
- Grading analysis
- ITS and UCS
- Field density



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QA/QC Works



Field density test in progress to check degree of compaction



Preparation of UCS & ITS samples at site

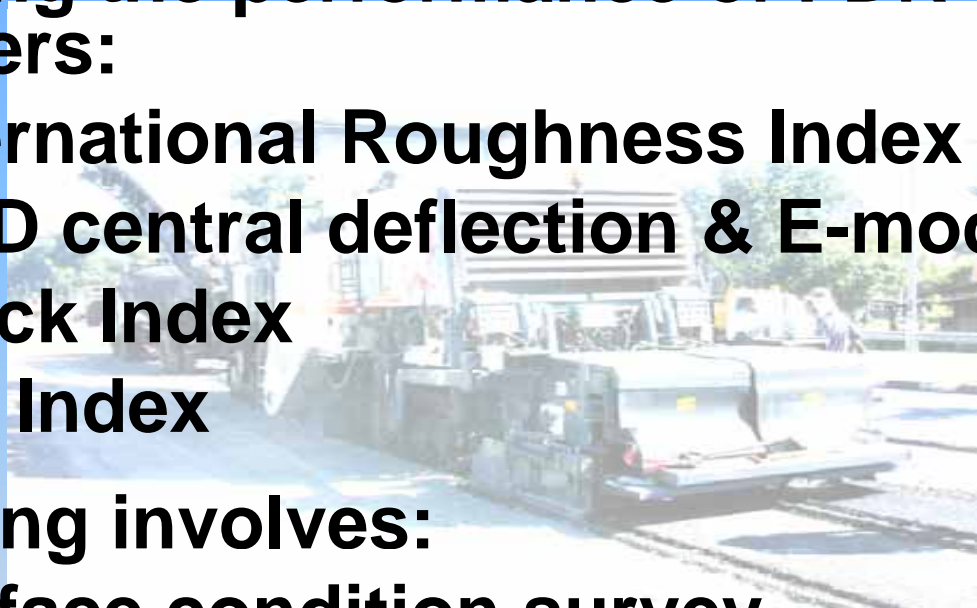
FIELD TESTING (Stage 2 - Post Construction)

Monitoring the performance of FDR using parameters:

- International Roughness Index (IRI)
- FWD central deflection & E-modulus
- Crack Index
- Rut Index

The testing involves:

- Surface condition survey
- Falling Weight Deflectometer (FWD)
- Walking Profiler



TECHNICAL PAPERS

Six (6) papers have been presented in international conferences:

- 1. Cold In Place Recycling in Malaysia – International Symposium on Pavement Recycling, Sao Paolo, Brazil, 2005**
- 2. Research on FDR – Early Findings On Pavement performance – 7th Malaysian Road Conference, 2007**
- 3. Mix Design for Cold-In Place Pavement Recycling: Does it Guarantee Performance – 3rd European Pavement and Asset Management (EPAM3) Conference, Coimbra, Portugal, 2008**

TECHNICAL PAPERS

- 4. Influence of Active Filler, Curing Time and Moisture Content on the Strength Properties of Bitumen Emulsion and Foamed Bitumen Stabilized Mix – RILEM, Rhodes Island, Greece, 2009**
- 5. Full Depth Reclaimed Pavements Using Cement and Hydrated Lime as Stabilizing Agents – REAAA Conference, Incheon, Korea, 2009**
- 6. Construction and Performance of Recycled Roller Compacted Concrete Pavement (RCCP) in Malaysia – 1st International Conference on Pavement Preservation, California, 2010**

TECHNICAL PAPERS

One (1) paper will be presented next week:

7. Challenges in Design and Construction of Cold In-Place Recycling Pavements In Malaysia – 24th ARRB Conference, Melbourne, Australia, 2010



FINDINGS

1. Cold In-Place Recycling in Malaysia International Symposium on Pavement Recycling, Sao Paolo, Brazil, 2005

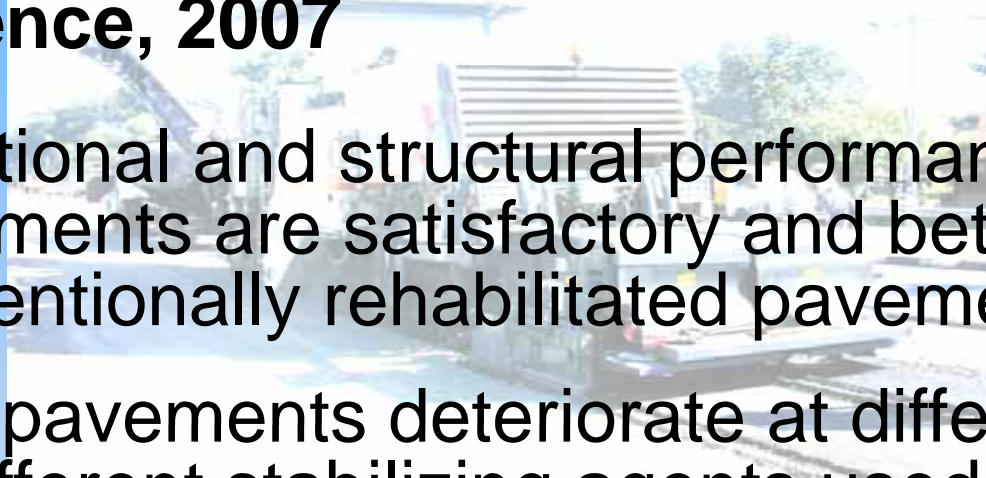
- o Cold In-Place Recycling have demonstrated a cost saving of up to 30% compared to conventional methods.



FINDINGS

2. Research on FDR – Early Findings on Pavement Performance – 7th Malaysian Road Conference, 2007

- o Functional and structural performance of FDR pavements are satisfactory and better than conventionally rehabilitated pavements.
- o FDR pavements deteriorate at different rate for different stabilizing agents used.



FINDINGS

3. Mix Design for Cold In-Place Recycling: Does it Guarantee Performance – EPAM3, Coimbra, Portugal, 2007

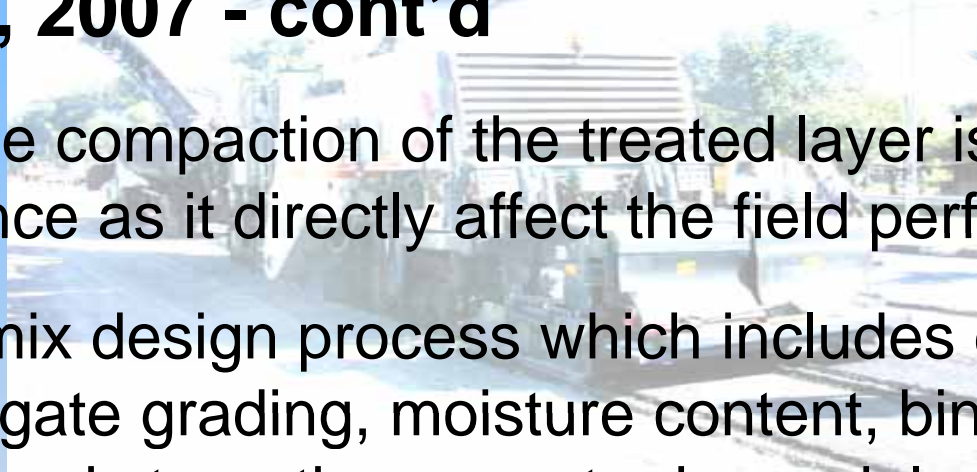
- o The design parameter in the current Malaysian specification for CIPR are suitable and adequate to ensure field performance.
- o There were variations in aggregate gradation between laboratory mix design and the field samples due to different method of sampling, crushing and mixing.
- o The variations between laboratory OMC and site moisture content do not appear to affect field performance.



FINDINGS

3. Mix Design for Cold In-Place Recycling: Does it Guarantee Performance – EPAM3, Coimbra, Portugal, 2007 - cont'd

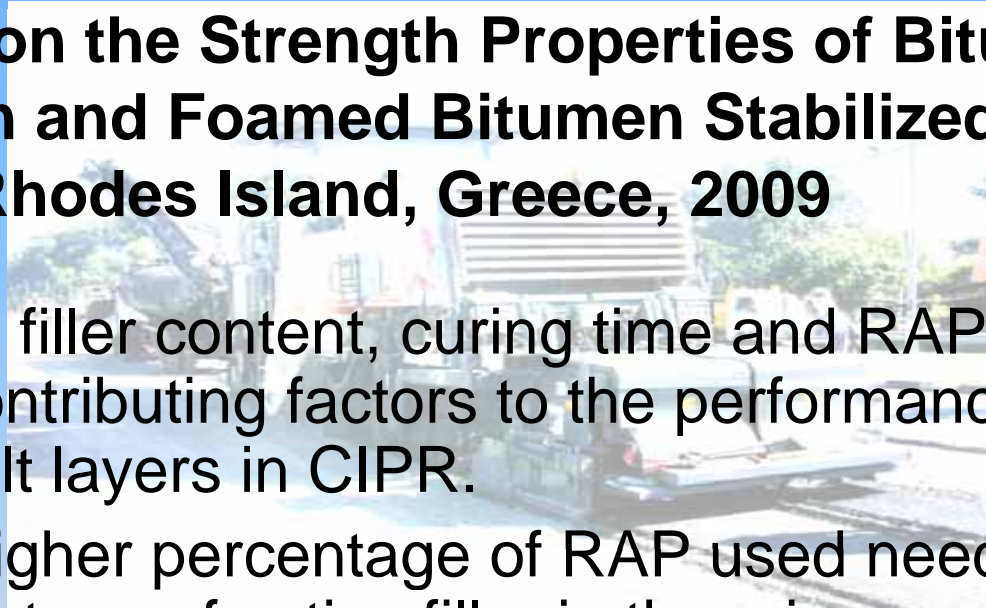
- o Adequate compaction of the treated layer is of great importance as it directly affect the field performance.
- o Proper mix design process which includes derivation of aggregate grading, moisture content, binder content and strength parameter is crucial as it will simulate and guarantee field performance.



FINDINGS

4. Influence of Active Filler, Curing Time and Moisture Content on the Strength Properties of Bitumen Emulsion and Foamed Bitumen Stabilized Mixes – RILEM, Rhodes Island, Greece, 2009

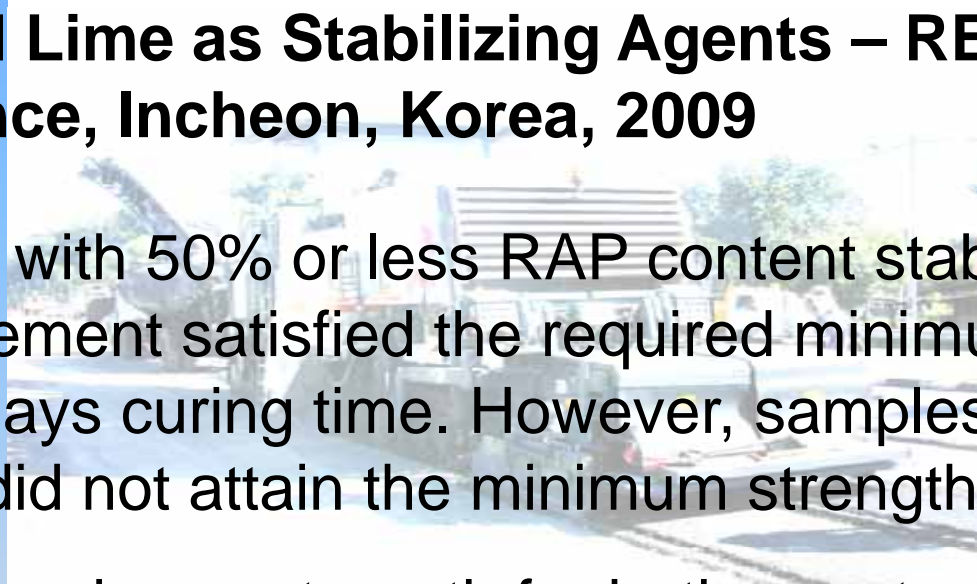
- o Active filler content, curing time and RAP proportions are contributing factors to the performance of recycled asphalt layers in CIPR.
- o The higher percentage of RAP used need higher percentage of active filler in the mix.
- o The effect of moisture content variation on foamed bitumen and emulsion treated samples with higher RAP proportion is not significant.



FINDINGS

5. Full Depth Reclaimed Pavements Using Cement and Hydrated Lime as Stabilizing Agents – REAAA Conference, Incheon, Korea, 2009

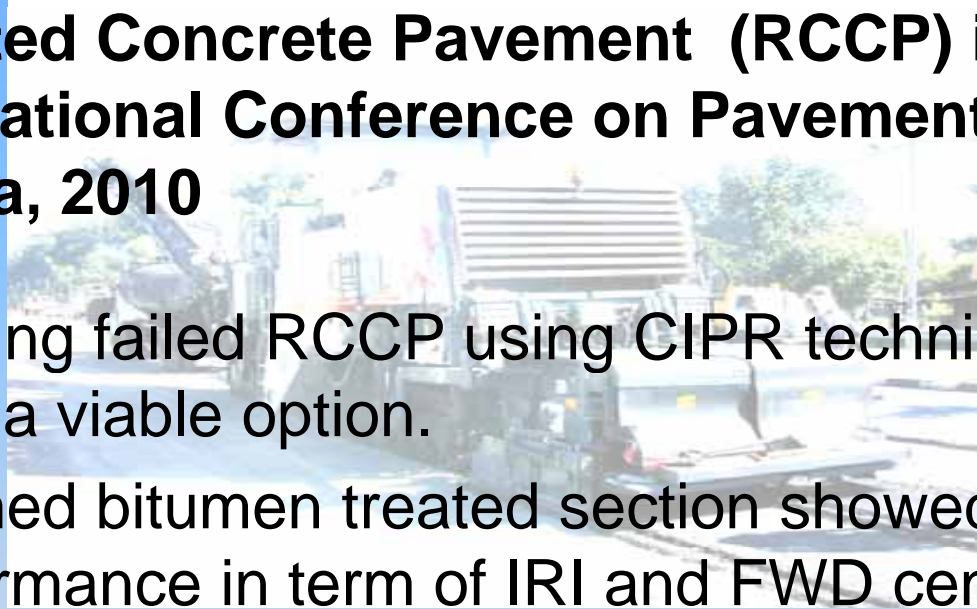
- o CIPR with 50% or less RAP content stabilized using 3% cement satisfied the required minimum strength at 3 days curing time. However, samples treated with lime did not attain the minimum strength.
- o The maximum strength for both agents generally occurred at moisture contents lower than the OMC.



FINDINGS

6. Construction and Performance of Recycled Roller Compacted Concrete Pavement (RCCP) in Malaysia – 1st International Conference on Pavement Preservation, California, 2010

- o Treating failed RCCP using CIPR technique is proven to be a viable option.
- o Foamed bitumen treated section showed better performance in term of IRI and FWD central deflection.
- o The aggregate gradation greatly influence the strength parameters of the recycled mix.



FINDINGS

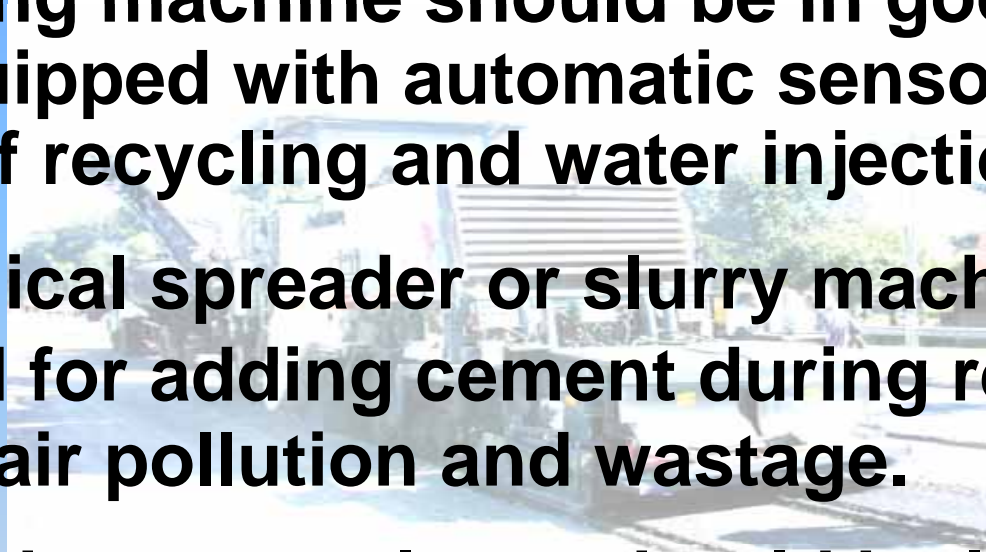
7. Challenges in Design and Construction of Cold In-Place Recycling Pavements in Malaysia – ARRB Conference, Melbourne, Australia, 2010

- o The assumed design seed values were found to be reasonable, but need further validation with laboratory simulation test. Structural design must be carried out to ensure performance.
- o More representative sampling in terms of number of trial pits, coring & DCP tests should be carried out.
- o Higher RAP content requires more cement to achieve the required UCS strength.



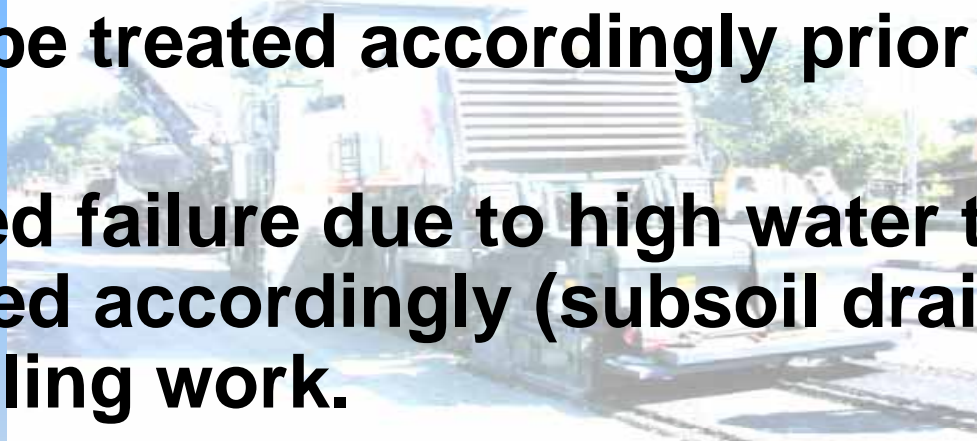
LESSONS LEARNT

- Recycling machine should be in good condition and equipped with automatic sensor to control depth of recycling and water injection.
- Mechanical spreader or slurry machine should be used for adding cement during recycling to reduce air pollution and wastage.
- The binder course layer should be laid immediately after the strength of recycled layer achieved the target.



LESSONS LEARNT

- Areas with localized structural failure such as depression due to weakness of subgrade should be treated accordingly prior to recycling work.
- Localized failure due to high water table should be treated accordingly (subsoil drain etc) prior to recycling work.
- Treated pavements in areas with good drainage system perform much better.



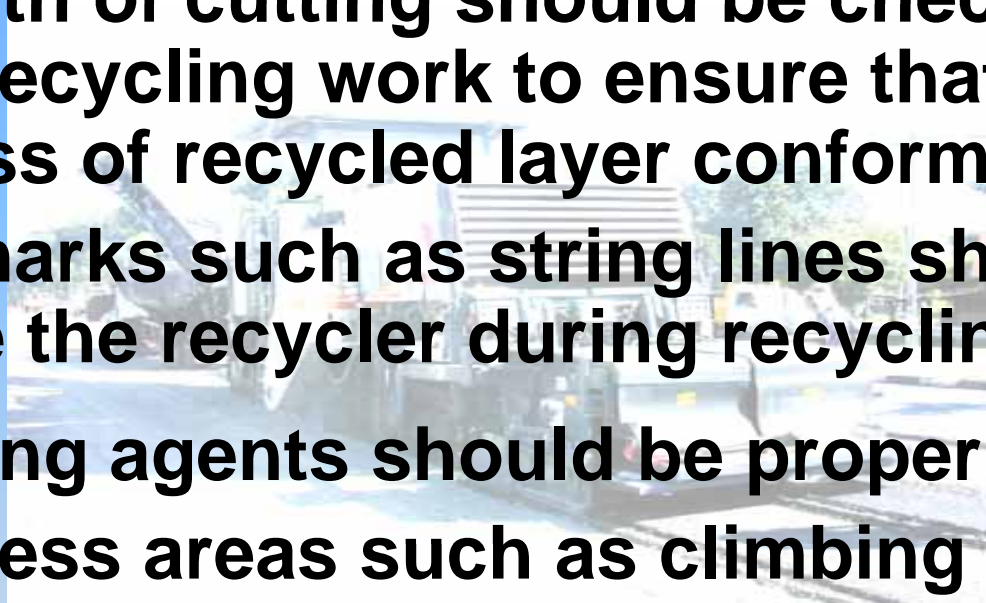
LESSONS LEARNT

- Traffic should not be allowed on the recycled layer until it has set to protect from damage such as premature surface cracks.
- Spreading cement by manual method should be done at short stretches to prevent the stabilising agent from being blown away by passing traffic and wind. The cement could easily be covered when it rains.
- Access aggregate/materials after trimming by motor grader should be removed and should not be left on the road shoulders.



LESSONS LEARNT

- The depth of cutting should be checked regularly during recycling work to ensure that the thickness of recycled layer conforms to design.
- Guide marks such as string lines should be used to guide the recycler during recycling work.
- Stabilizing agents should be properly stored.
- High stress areas such as climbing lanes may need special structural and mix design to cater for extreme traffic loading etc.



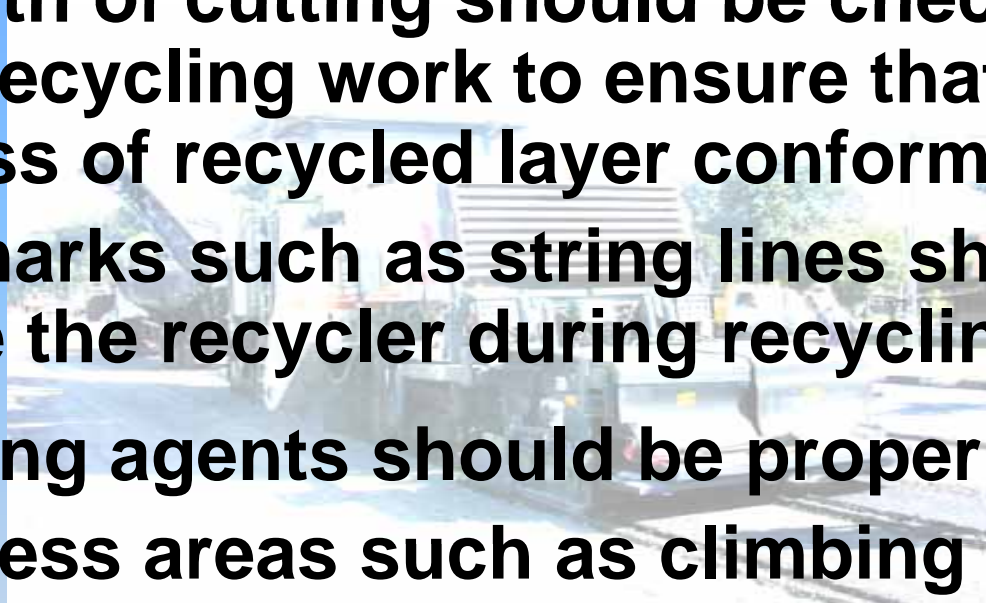
LESSONS LEARNT



Recycling work done without guide marks

LESSONS LEARNT

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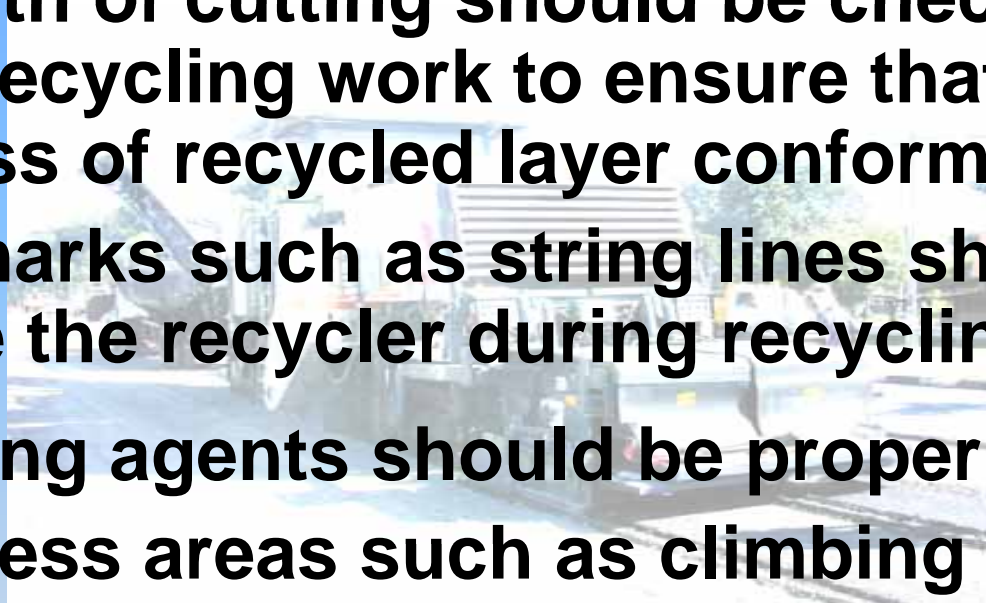
LESSONS LEARNT



Improper storage of stabilizing agent

LESSONS LEARNT

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- Guide marks such as string lines should be used to guide the recycler during recycling work.
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LESSONS LEARNT



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