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Innovation Driven

REAAA 12th Business Forum

National Transport Research Organisation

Port Melbourne, Australia

5th May 2025

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Assessment and Performance of Asphalt Materials and Mixes

THE CENTRE OF TRANSPORT INNOVATION

NTRO

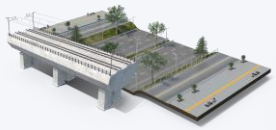
INTERNATIONAL CONFERENCE

THE TRANSPORT REVOLUTION

SOLUTIONS LED BY INNOVATION


REAAA
REAAA
Welcome to
NTRO

Integrated Transport Solutions



Asset Performance

Infrastructure Measurement

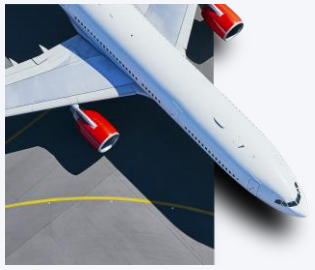
Safer Smarter Infrastructure

Sustainability and Materials Performance

Structures & Certification

Data and Technology

Transport Futures



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Context of Change 2025 and Beyond

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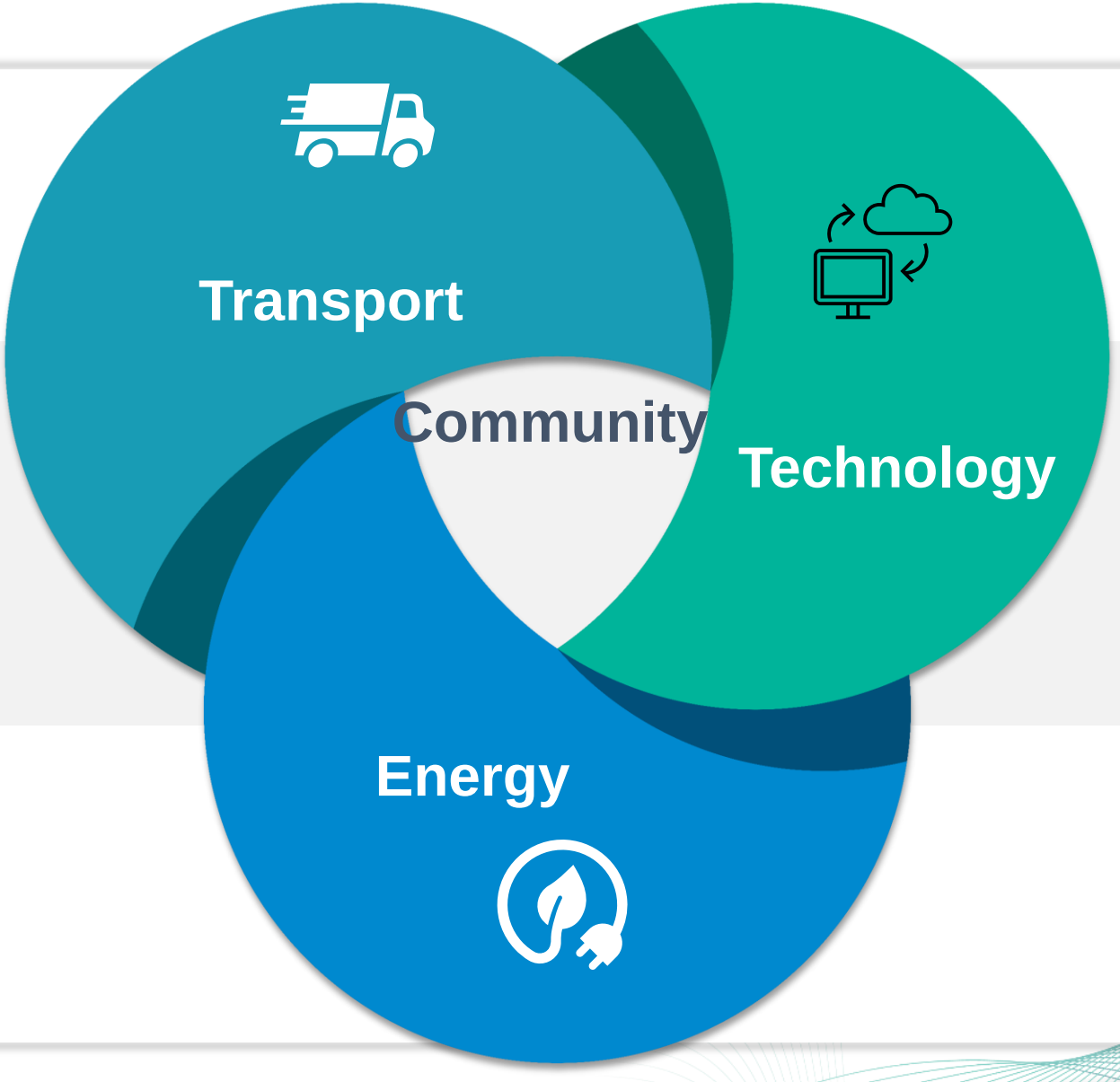

Societal Transition

Integrated
Energy-Transport-Technology
System


“The best way to predict the future is to invent it.”
Peter Drucker

NTRO Vision Statement

To lead the world in innovative transport solutions


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Business Forum Coordinator Welcome

Lydwina (Nonon) Marchiela Wardhani

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Housekeeping

Jaimi Harrison

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Pervious Pavements System for Flooding Resilience

Dr Suthakaran Sivagnanasuntharam

NTRO NATIONAL TRANSPORT RESEARCH ORGANISATION

Pervious Pavements System for Flooding Resilience

Dr Suthakaran Siva *B.Sc.(Eng) (Hons), PhD (Civil)*\

Senior Professional, Safer Smarter Infrastructure, Pavement Research Leadership

INNOVATION DRIVEN

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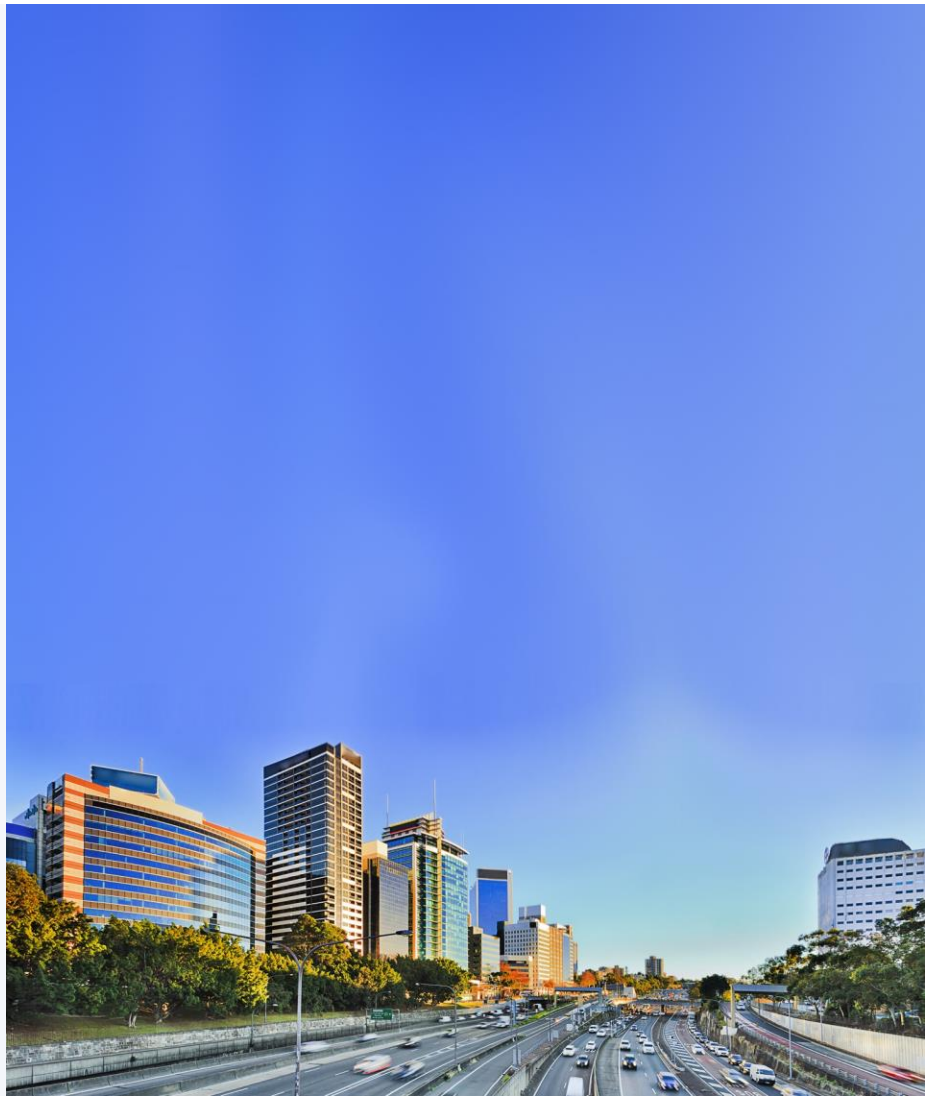
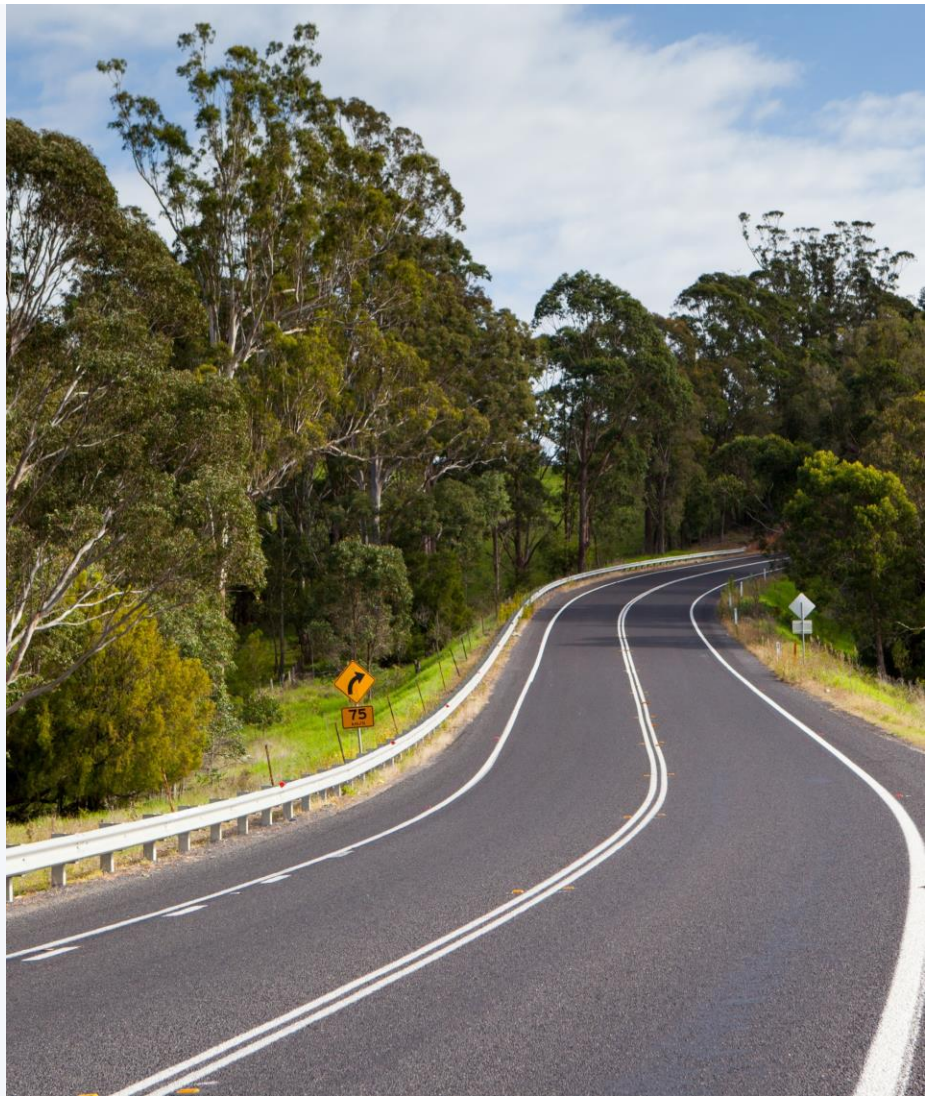


Background

- Heavy rain and flooding are becoming more common
- There is an interest around the world to develop permeable/pervious pavements for flood resilience



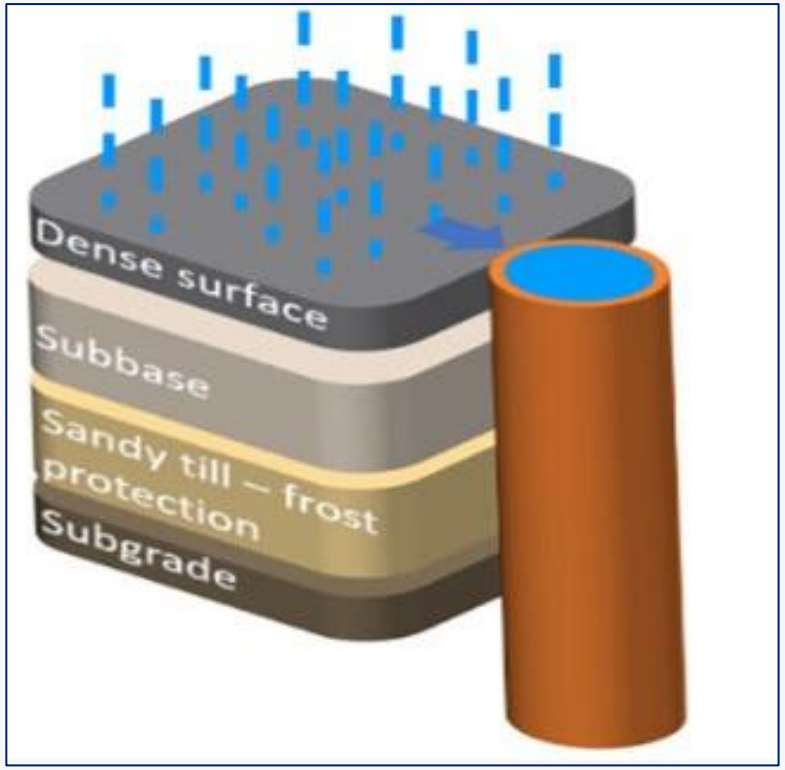
Aim

This study is aimed at identifying which are the most appropriate permeable and pervious treatments for different parts of the network in New Zealand, namely, mountainous, low-lying and urban areas.

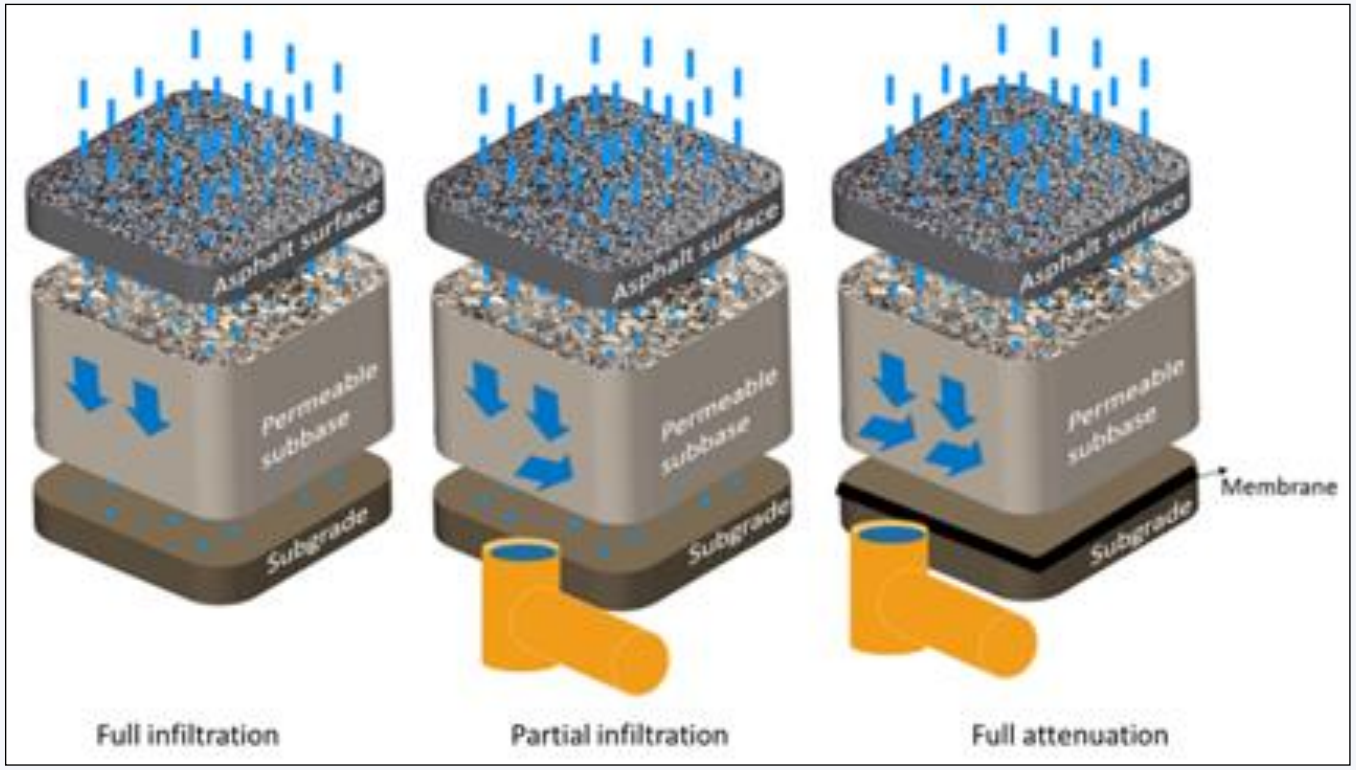
Methodology

- Literature review
  - Traditional pavement vs permeable/pervious pavement
  - Demonstrations around the world
  - Benefits
  - Limitations
- Developing Conceptual Approaches to Mitigate Limitations

Traditional Pavement Vs Permeable/ Pervious Pavement



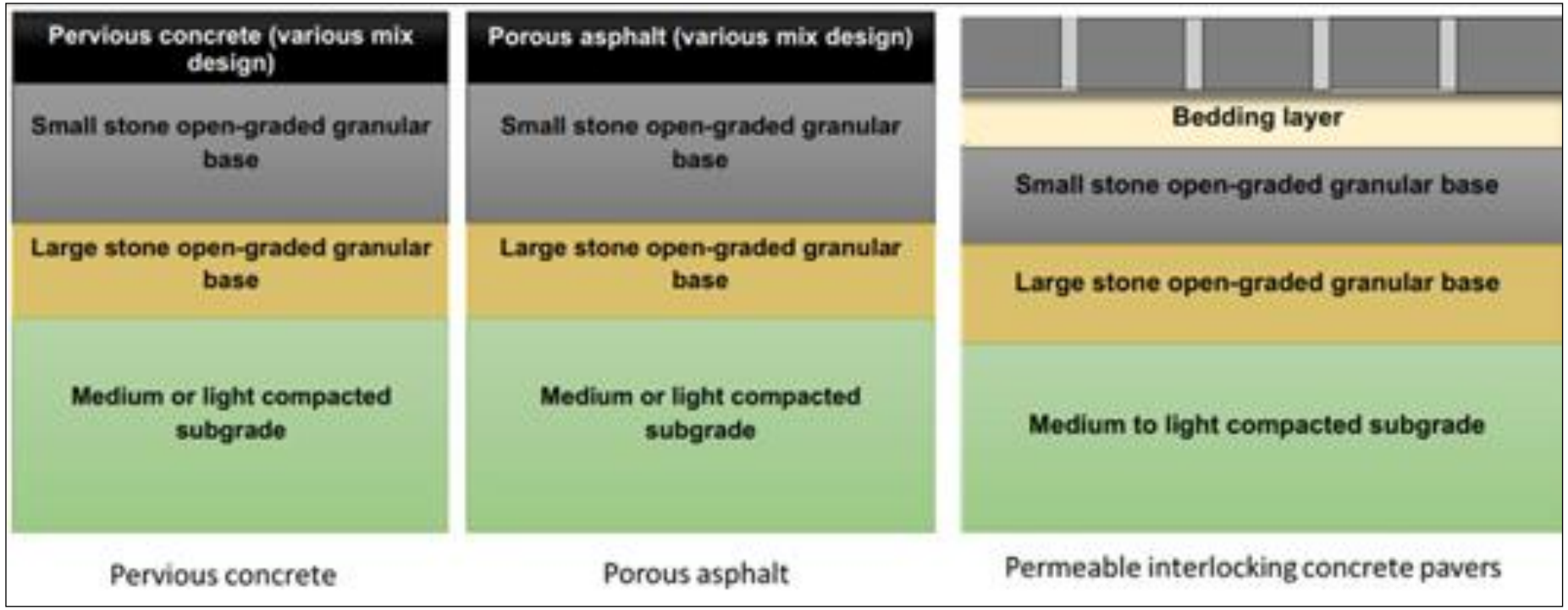
(a) Traditional pavement



(b) Permeable/ pervious pavement

(Muttuvelu & Kjems 2021)

Types of Permeable/ Pervious Pavements

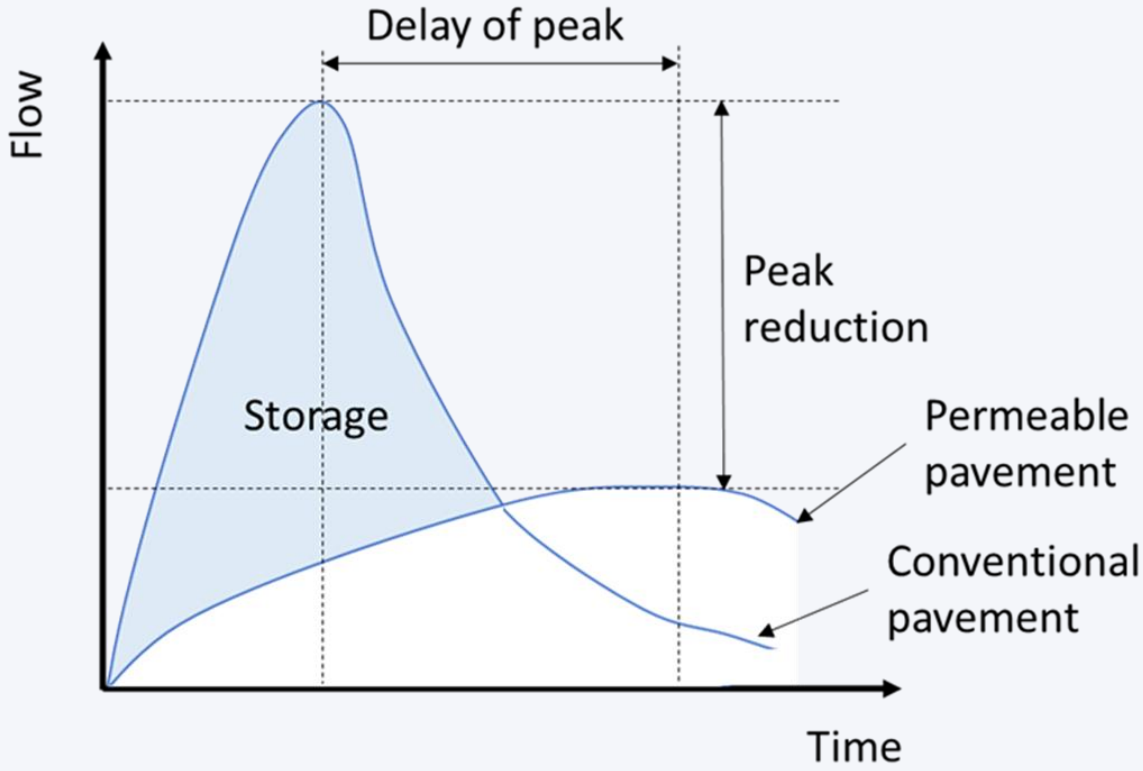


(Weiss et al. 2019)

Benefits of Permeable/ Pervious Pavements

- Runoff reduction → Peak flow reduction → Improved **flood resilience**

- Recharging ground-water table
- Noise reduction
- Reduction of wet weather accidents → reduction of aquaplaning



Use of Permeable/ Pervious Pavements in Urban Region

Widely adopted for urban setting around the world

- China (sponge cities: 30 pilot cities in the initial stage)
- Texas
- California
- Greater Sydney
- England and Wales
- France
- Malaysia
- Japan
- Korea
- Calgary

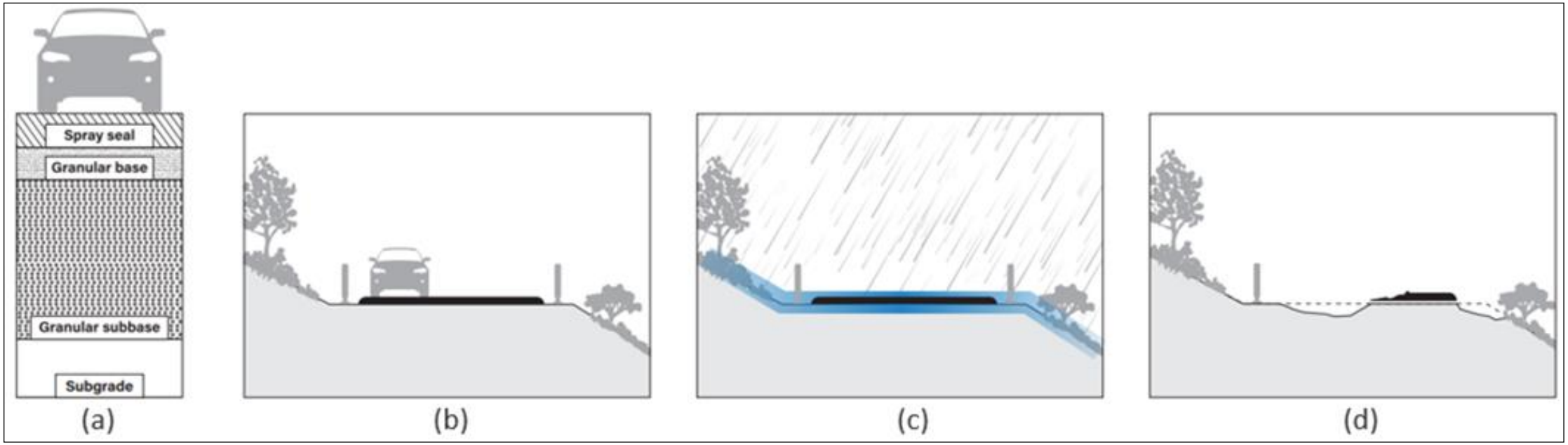
(engineeringinfinity.com)

Limitations

- Site should be nearly flat (slopes of 0.5 percent or less) – Challenge for mountainous regions
- Depth to seasonal high ground water table (at least 600 mm) – Challenge for low-lying regions

Potential of Permeable/ Pervious Pavements in Mountainous Region

Problem



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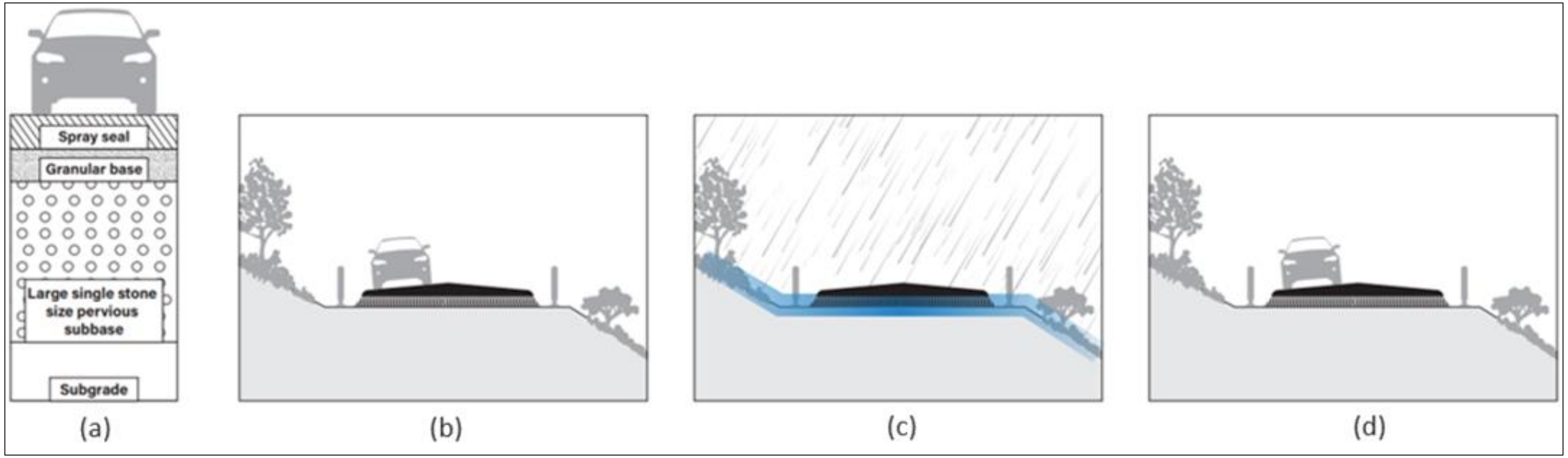
Potential of Permeable/ Pervious Pavements in Mountainous Region

Potential Solution 1: Horizontally Pervious Capping Layer



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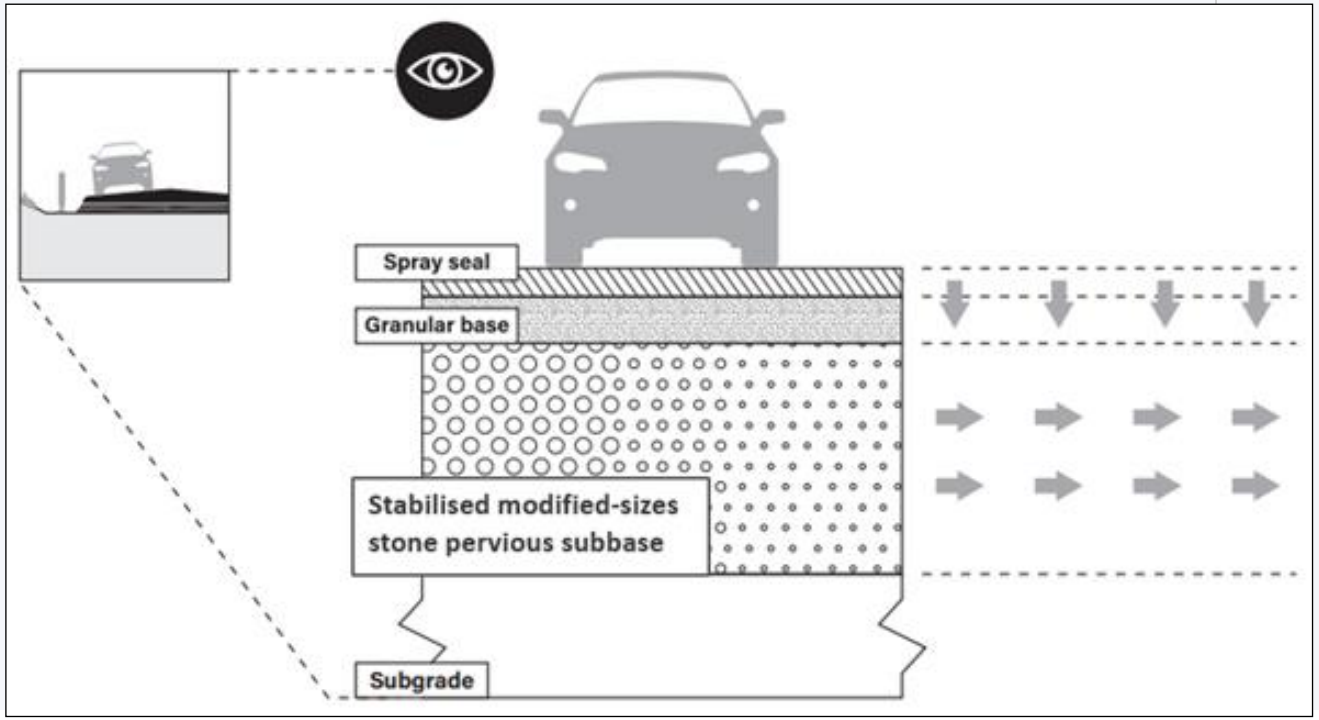
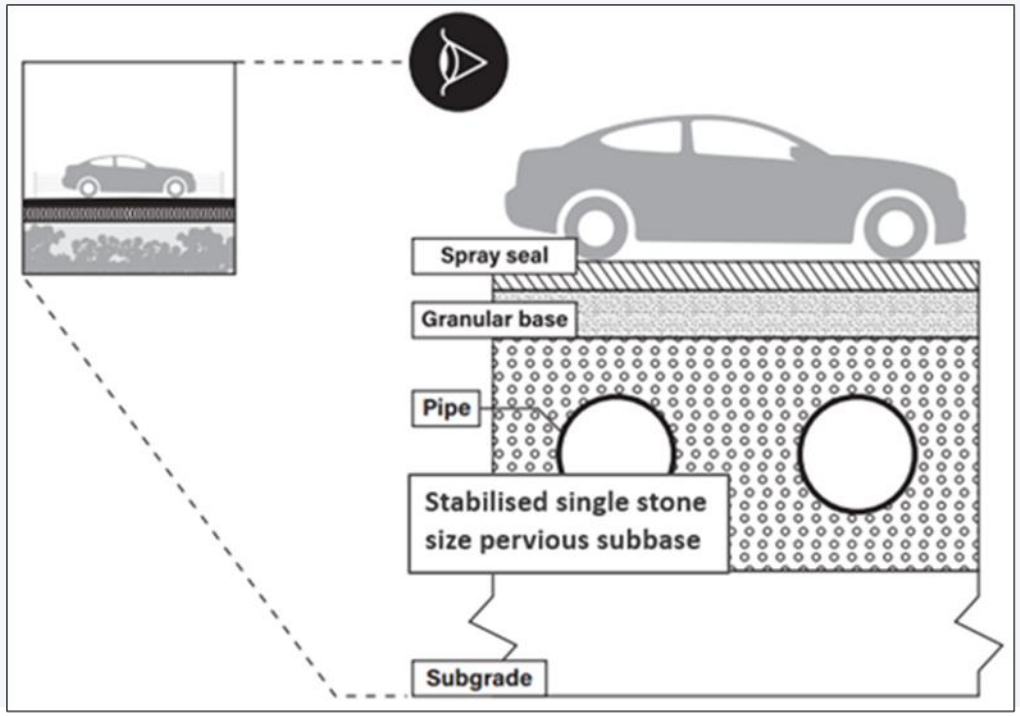
Potential of Permeable/ Pervious Pavements in Mountainous Region

Potential Solution 2: Modified Sizes of Stone to Control Runoff Intake and Slow Release

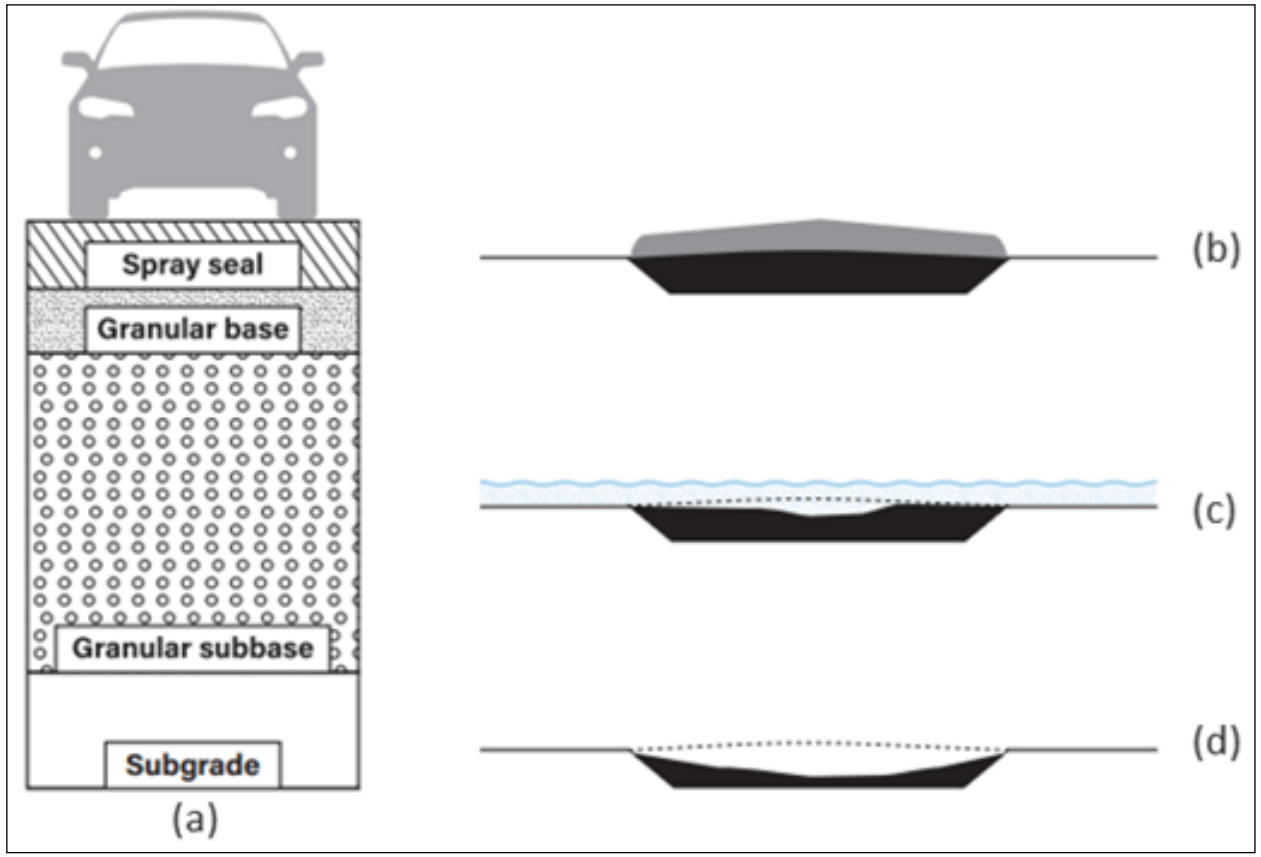


Potential Solution 3: Stabilised Subbase Material and Installed Pipes for Drainage



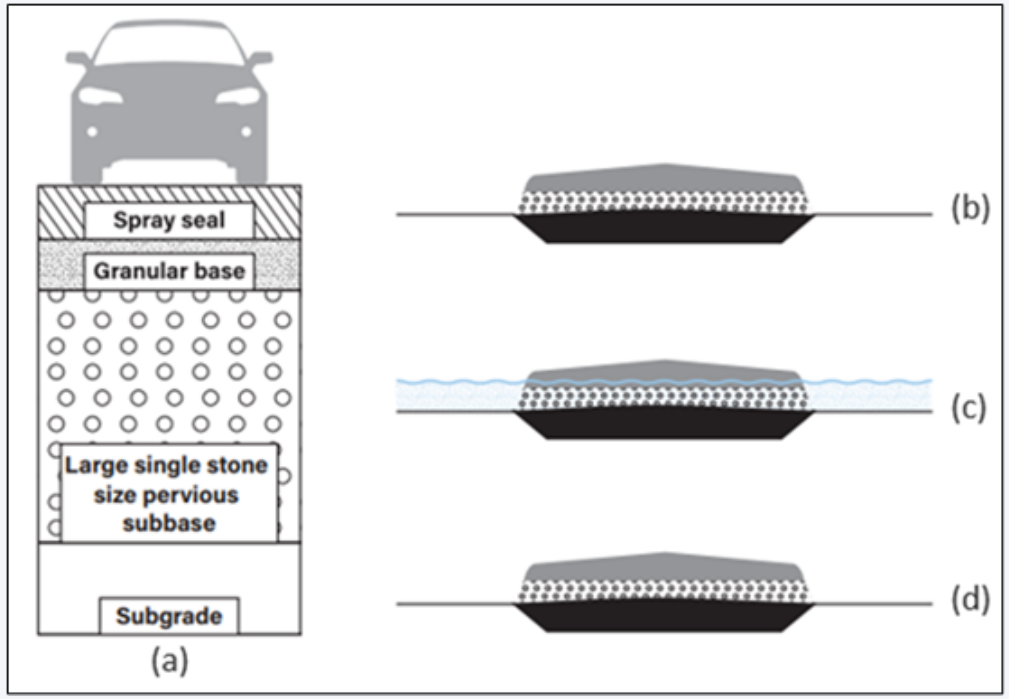
Potential of Permeable/ Pervious Pavements in Low-Lying Region

Problem



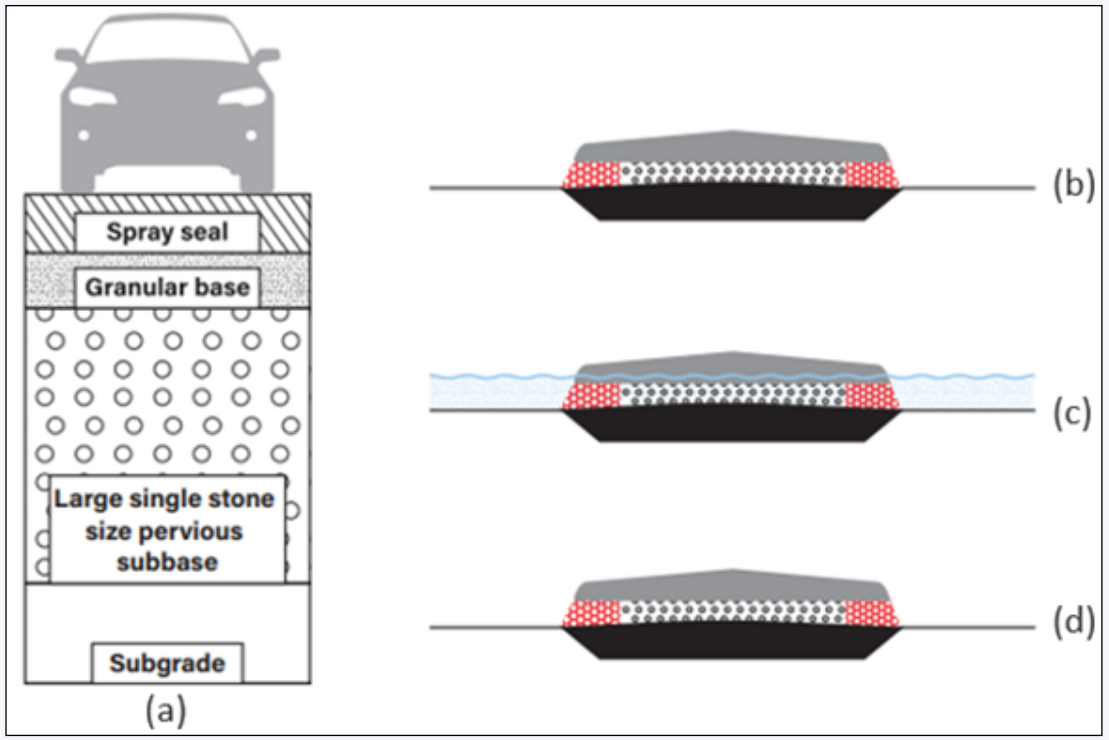
Potential of Permeable/ Pervious Pavements in Low-Lying Region

Potential Solution 1: Granular Pavement with Horizontally Pervious Capping Layer

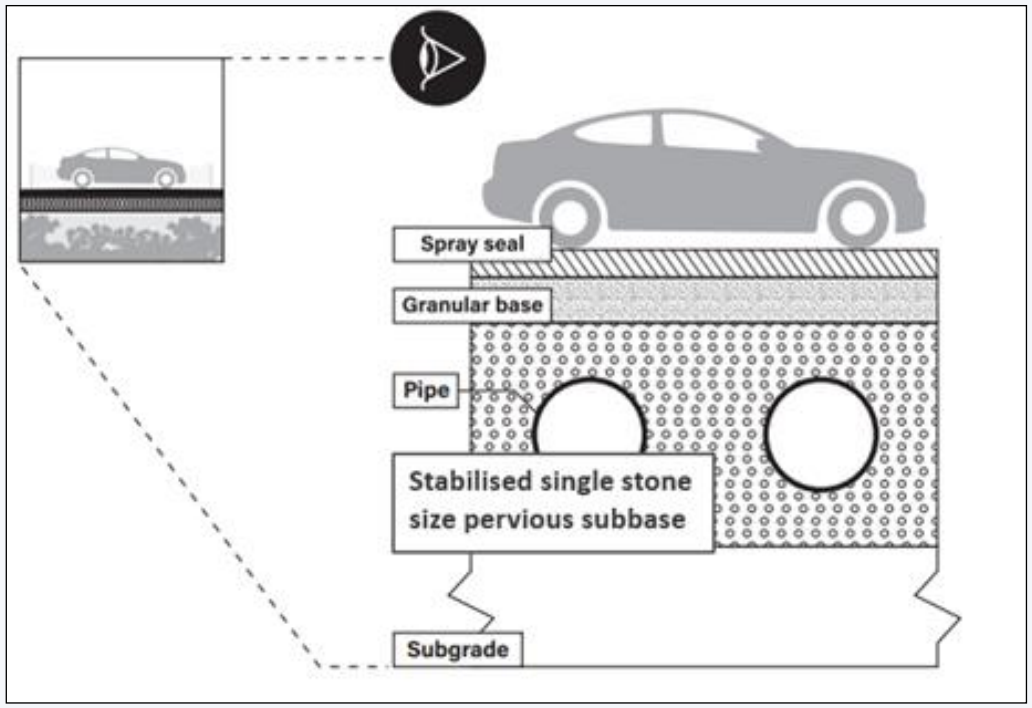


Potential of Permeable/ Pervious Pavements in Low-Lying Region

Potential Solution 2: Installation of Geogrid Reinforcement at the Sides of Pavement



Potential Solution 3: Stabilised Granular Material and Add Culverts/pipes



Conclusion and Recommendation

- Literature Review:
  - Helps to reduce runoff
  - Successful trials in locations like China and Australia
  - Demonstrated effectiveness in urban settings
  - Challenges in mountainous areas: slope requirements
    Challenges in low-lying areas: minimum depth to seasonal high groundwater table
- Study Recommendations:
  - Raise pavement systems with a pervious granular subbase
  - Horizontal permeability to allow water flow underneath impervious

NTRO

Thank you

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ntro.org.au

Adelaide, Brisbane, Canberra, Launceston, Melbourne, Perth, Sydney, and Wellington

DISCOVER NTRO

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The foresight and development of pavement engineering in Taiwan to achieve net zero by 2050

Professor Jia-Ruey Chang

123rd REAAA Governing Council meeting
12th REAAA Business Forum
5th - 6th May, 2025 in Port Melbourne Australia

The Foresight and Development of Pavement Engineering in Taiwan to Achieve Net Zero by 2050

Prof. Jia-Ruey Chang

National Ilan University, Taiwan
Vice Chair, International Affairs Committee, China Road Federation (CRF)
Former President, Chinese Society of Pavement Engineering (CSPE)
Editor-in-Chief, International Journal of Pavement Research and Technology

2025.05.05

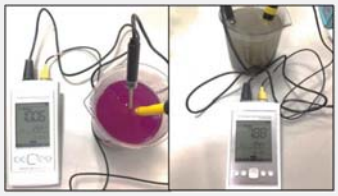
國立宜蘭大學 National Ilan University NIU
中華民國道路協會 CHINA ROAD FEDERATION
社團法人中華鋪面工程學會 Chinese Society of Pavement Engineering

CONTENTS

1. Materials: Oyster shell powder (OSP)

- The OSP as a substitute for 6% of the fine aggregate and filler enhances the performance (Marshall stability, Marshall flow, immersion–compression, indirect tensile strength, TSR, boil, and Cantabro abrasion tests) of AC, providing effects similar to hydrated lime anti-strip additives and increases moisture damage resistance.
- Through a carbon footprint verification (CFV) to survey the carbon footprints of different AC types, using OSP to replace high carbon-emitting materials like cement can significantly lower the carbon emissions of AC.

1. Materials: Steel furnace slag (SFS)



- Asphalt cement is separated from aggregates to analyze pH value and magnetic attraction test. If one or both indicate SFS characteristics, further confirmation is needed.
- The separated aggregates are grinded to ≤0.075 mm (No. 200) to analyze composition. When the results indicate ≥30% CaO and ≥10% Fe_2O_3, it can be regarded that SFS has been used in the AC.

Case Studies in Construction Materials

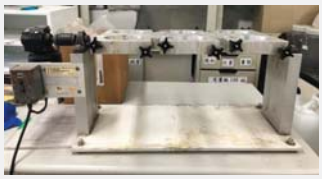
Determining the content of steel furnace slag in asphalt concrete

1. Materials: Oxidizing Slag (OS)

- Evaluation of asphalt film thickness and heavy metal leaching of OS used as an aggregate material in DGAC.
- In comparison to natural aggregates, OS exhibits superior performance in terms of increased asphalt film thickness and improved water resistance.
- In addition, the results of TCLP, Flame AAS, and microwave-assisted aqua-regia digestion meet regulatory. However, we should prohibit the use of materials such as OS and other SFSs in the roadways adjacent to edible crop farmlands.

Evaluation of asphalt film thickness and heavy metal leaching of oxidizing slag used as an aggregate material in dense-graded asphalt concrete

Toxicity Characteristic Leaching Procedure (TCLP)



Flame Atomic Absorption Spectroscopy (Flame AAS)

1. Materials: Unsaturated polyester (UP) resin






- UP resin, non-toxic and has good weather resistance, is selected as the adhesive material for blending with natural aggregates under ambient temperature for a surface course. RAP designed with open-graded gradation is used as the subbase.
- The mixture has a very high strength and its stability can reach 2~3 times of that of asphalt mixture within a few hours. Moreover, the mixture's coefficient of permeability is nearly 40 times higher than that of porous asphalt mixture.

Aggregates mixed with unsaturated polyester resin as the surface layer for permeable pavements

1. Materials: Cold-mix recycling asphalt concrete as base and subbase







Mix design for cold-mix recycling emulsified asphalt concrete

Mix design for cold-mix recycling foamed asphalt concrete

Construction specifications for public works: Chapter 02727

第 02727 章 V0.1

冷拌再生瀝青混凝土

1.通則

1.1 本章概要

說明冷拌再生瀝青混凝土之材料、鋪築施工及檢驗等相關規定。

1.2 工作範圍

本項工作包括冷拌再生瀝青混凝土之粒料及發泡瀝青(亦稱泡沫瀝青，以下統稱發泡瀝青)聯泥或乳化瀝青之供應、廠中拌合、拌合料之搬運、鋪築與壓實，並按設計圖說及本規範之相關規定辦理。本規範所提之冷拌再生瀝青混凝土僅適用於道路基底層。

1.3 相關章節

1.3.1 第 02336 章--路基整理

1.3.2 第 02714 章--瀝青處理底層

1.3.3 第 02722 章--級配粒料基層

1.3.4 第 02726 章--級配粒料底層

1.3.5 第 02741 章--瀝青混凝土之一般要求

1.3.6 第 02742 章--瀝青混凝土鋪面

1.3.7 第 02745 章--瀝青透層

1.3.8 第 02747 章--瀝青黏層

1.3.9 第 02966 章--再生瀝青混凝土鋪面

1.4 相關準則

1.4.1 中華民國國家標準（CNS）

(1) CNS 61　卜特蘭水泥

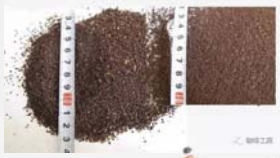
(2) CNS 486　細骨粒料篩析法

(3) CNS 490　細粒料（37.5mm 以下）洛杉磯磨損試驗法

02727　社團法人中華鋪面工程學會 Chinese Society of Pavement Engineering　V0.1 2024/08/06

Publication Date: August 2024

1. Materials: Used coffee grounds

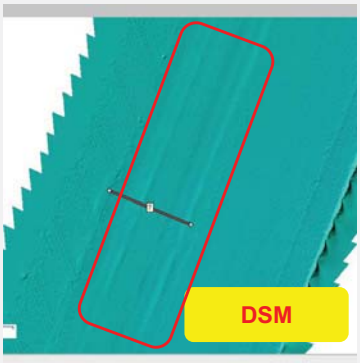



TCLP

Flame AAS


Entrusted by National Science and Technology Council (August 2024 till now)

2. Data-driven asset management: Distress Survey and Pavement Inspection



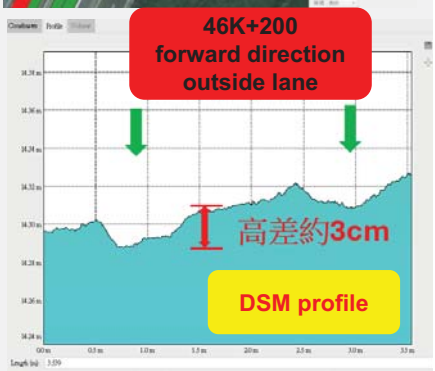
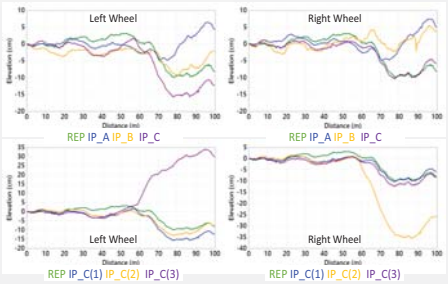
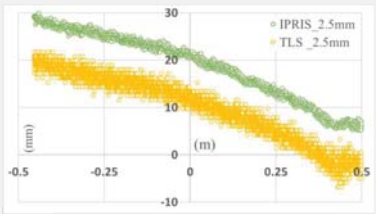
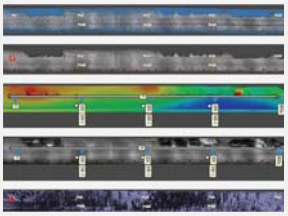
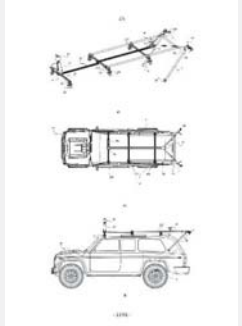


Image-based Pavement Roughness Inspection System (IPRIS)









2. Data-driven asset management: Project of Taiwan Highway Bureau (THB)'s PMS

General information of roads

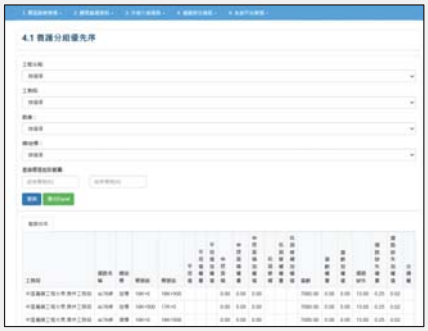
Road Condition: Potholes

Road Condition: IRI

Pipelines and road excavation spot

Duration: July 2023 till now

Statistical analyses



Priority of maintenance activities

2. Data-driven asset management: Project of Northern Region Branch's PMS (THB)

General information

System management

Full life cycle management and analysis

Smart Road Management and Operation Center

- A General information
  - A1 General information of roads
  - A2 Current pavement condition for roads
- B Road condition inspections
  - B1 Road inspections - inspection track
  - B2 Performance index - PCI / IRI
- C Road construction and Maintenance
  - C1 Construction projects
  - C2 Maintenance projects
  - C3 Create and examine new projects
- D System management
  - D1 Account examination
  - D2 Account management
  - D3 Update user data
  - D4 System operation tracking
- E Road condition prediction
  - E1 Performance prediction
- F Full life cycle cost analysis (LCCA)
  - F1 Maintenance priority for road sections
  - F2 Cost optimization - LCCA

E1 Road condition prediction

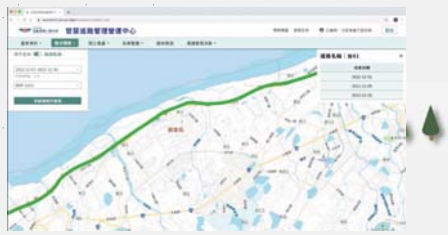
F1 Maintenance priority

F2 Cost optimization

Duration: February 2023 till now

A1 General information of roads

A2 Current pavement condition for roads



B1 Road inspections - inspection track

B2 Performance index - PCI / IRI

C1 Construction projects

C2 Maintenance projects

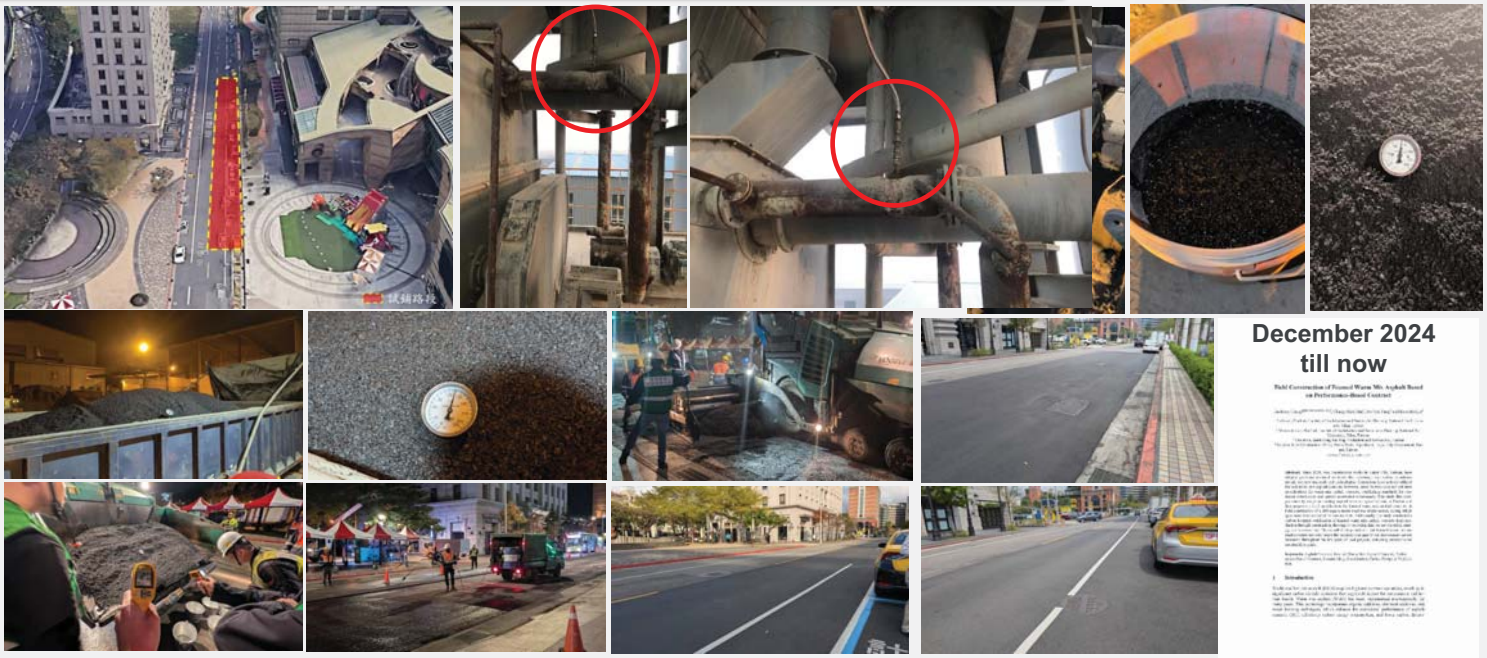
C3 Create and examine new projects

D System management

F Full life cycle cost analysis (LCCA)

2. Data-driven asset management: Taipei City's PMS with Visualization / Panorama

3. Warm Mix Asphalt (WMA) in Taipei City



December 2024 till now

According to CFV, WMA is with an emission reduction of about 23% during the production stage.

4. Pavement longevity: PBC in Taipei City

Performance-Based Contract (PBC) for Road Inspection, Maintenance and Repair in Zhongshan / Xinyi District, Taipei City

- **Public sector**: Reduce regulatory pressure, improve governance quality, provide quality roads
- **Contractor**: Loosen traditional technical (specification-based) contracts, provide with flexible execution, independently introduce new materials and new construction methods, develop new equipment and new achievements
- **The public**: The public and contractors become partners and serve as the backing of contractors

➔ **Public-Private Partnership: Win-Win-Win**

International Journal of Pavement Research and Technology (IJPRT)

Chinese Society of Pavement Engineering (CSPE)

2023 Journal Metrics

- **Emerging Sources Citation Index (ESCI Edition)**
- **Journal Impact factor (JIF): 3.0 (2023)**
- **CiteScore 2023: 4.9 (6.0 in April 2025)**
- **Acceptance Rate: 36%**
- **Rejection Rate: 49%**
- **Numbers of usages: 65,241 (93,907 in 2024)**

Editors-in-Chief

- Prof. Jia-Ruey Chang (Taiwan)
- Prof. Musharraf Zaman (USA)

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中華民國交通部公路局
Highway Bureau, MOTC

臺北市政府
TAIPEI Taipei City Government

Thank you for your attention

超鈺科技股份有限公司

聖東營造股份有限公司

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NTRO
Innovation Driven

Recycled fibre innovations

Petar Davcev

NATIONAL TRANSPORT RESEARCH ORGANISATION

Fibre Product Presentation

REAAA – Business Forum, 2025

Petar Davcev – Portfolio Leader Materials Performance & Testing

NTRO Product Innovation

Key Notes;

- Australian First Research
- Building on existing NTRO Research
- Patent Pending
- Excellent Potential for new markets
- Excellent Potential to lead to Australian First Trial

The Current Pathway for Fibres

- 100% Imported from Germany
- Orders take up to 30 days to ship
- Can Cost up to $20,000 per container
- Produced from waste-paper pulp industry
- Has no performance improvements, strictly a drain down inhibitor

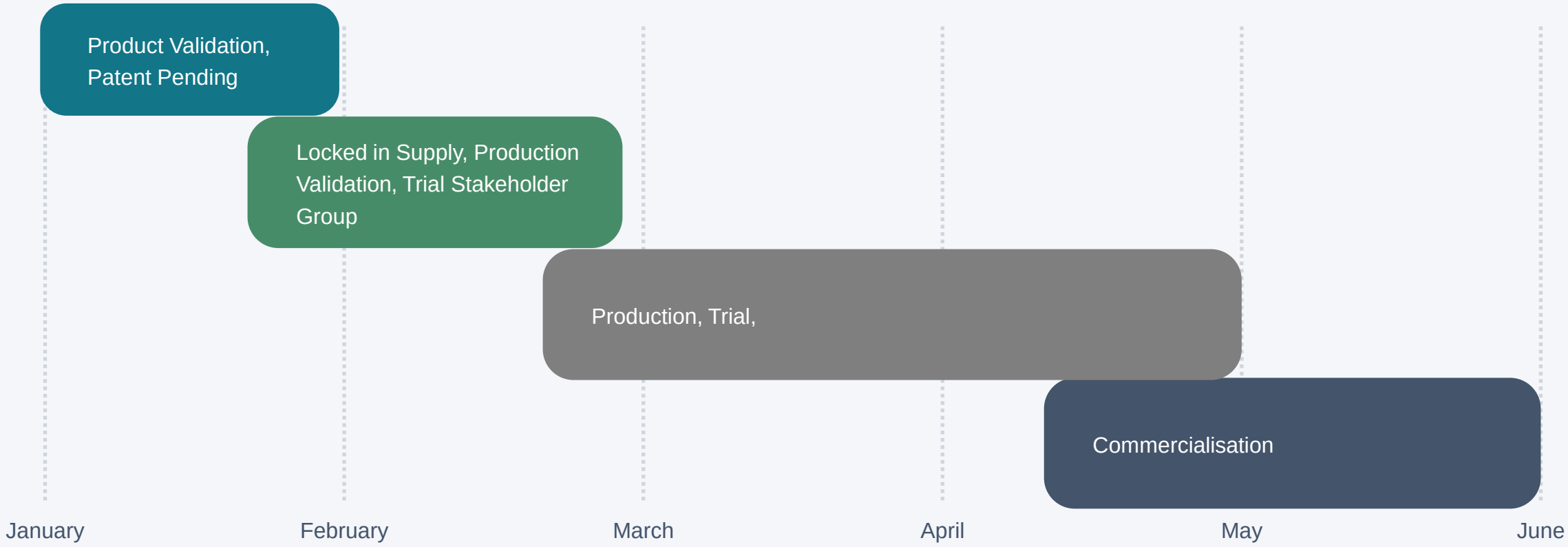
ReEnforce - Fibre

- 100% Made and remade in Australia
- Comprised of waste high performance fibres;
    - Nylon
    - Rayon
    - Polyester
- Competitive price point
- Has increased binder and asphalt improvements, including excellent drain down characteristics

Challenges Addressed by ReEnforce

- Australia First Innovation
- Currently there is a cost to dispose of the components in ReEnforce
- Landfill Environmental Issues (Light fibres can become airborne and fly outside boundaries)
- High value materials landfilled
- Stimulate local manufacturing and resource efficiency

The last 6 months - Timeline



NTRO Fibre Product

ReEnforce - Benefits

- Superior Performance (with addition of high-performance waxes, antistripping agents and rubber)
- Sustainable Story
- Local Resource Recovery & Upcycling

Waste Fibre

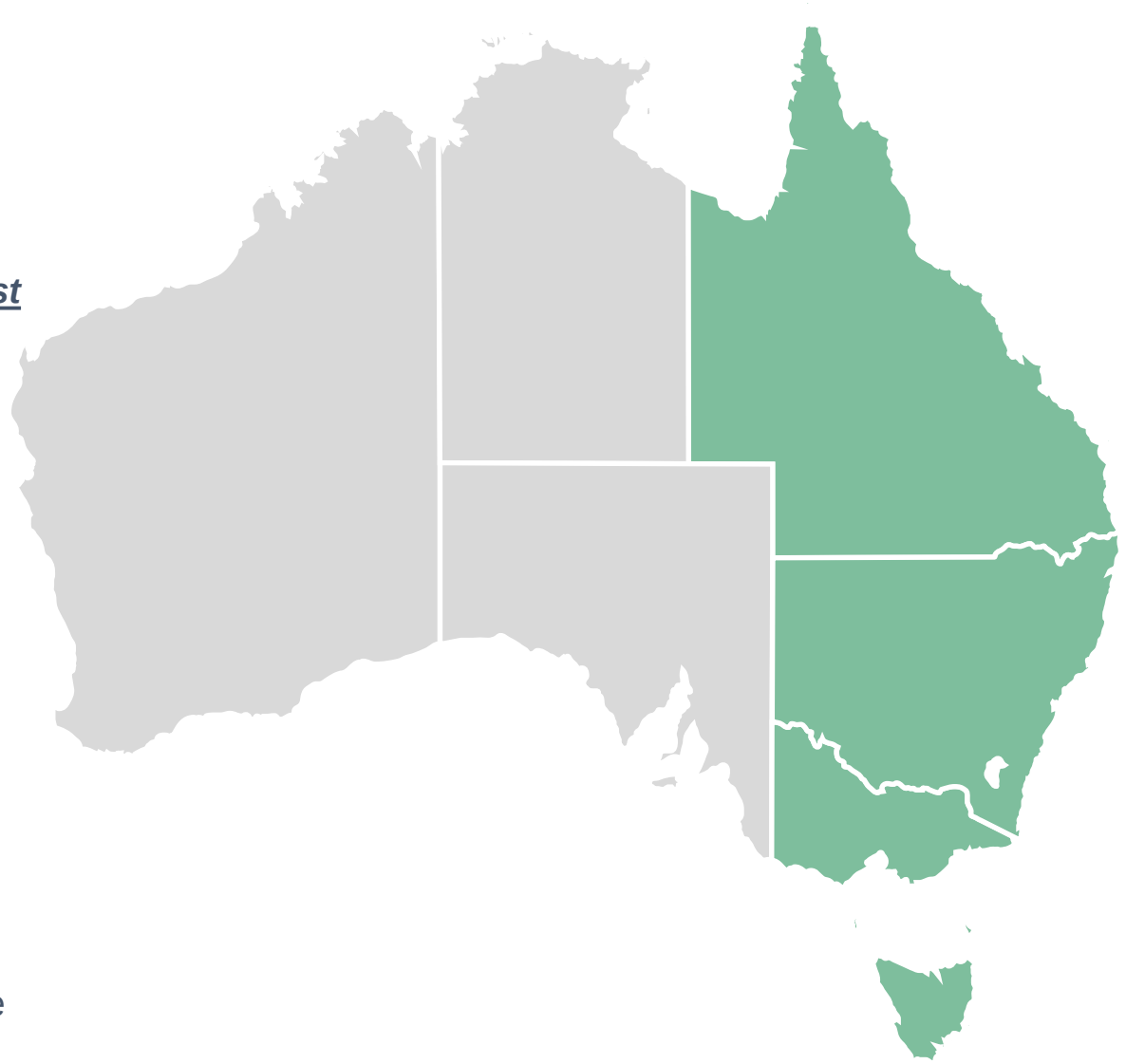
Imported Product Fibre

ReEnforce Fibre

Validation - Program Coverage

Coverage of Specified Testing – ***Compliant Mix Design in all East Coast***

- Victoria
- New South Wales
- Queensland
- Tasmania



Why?

- Ensures largest market
- Variable climatic regions from Snow, Dessert, Tropical and Temperate

Test Result – Condition 2 - Queensland

	1 Hour - 175°C							
Fibre Description	Industry Product #1		Industry Product #2		Industry Product #3		ReEnforceX	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Sample ID	8249	8254	8248	8252	8251	8256	0070	0076
Total Time (Minutes)	60	60	60	60	60	60	60	60
Average	0.08%		0.10%		0.06%		0.06%	

Test Result – Condition 2 - Victoria

	1 Hour - 185°C							
Fibre Description	Industry Product #1		Industry Product #2		Industry Product #3		ReEnforceX	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Sample ID	8249	8254	8248	8252	8251	8256	0070	0076
Total Time (Minutes)	60	60	60	60	60	60	60	60
Average	0.08%		0.10%		0.06%		0.06%	

Test Result – Condition 3 – New South Wales

	4 Hour - 185°C							
Fibre Description	Industry Product #1		Industry Product #2		Industry Product #3		ReEnforceX	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Sample ID	8249	8254	8248	8252	8251	8256	0070	0076
Total Time (Minutes)	240	240	240	240	240	240	240	240
Average	0.12%		0.14%		0.10%		0.07%	

Potential Growth Area

- Performance may be suitable for
    - Concrete
    - Microsurfacing
    - Sealcoating & Bitumen Paint
    - Low grade PMB

- Consistent Annual Market

NTRO

DISCOVER NTRO

Thank you

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THE CENTRE OF TRANSPORT INNOVATION

NTRO
Innovation Driven

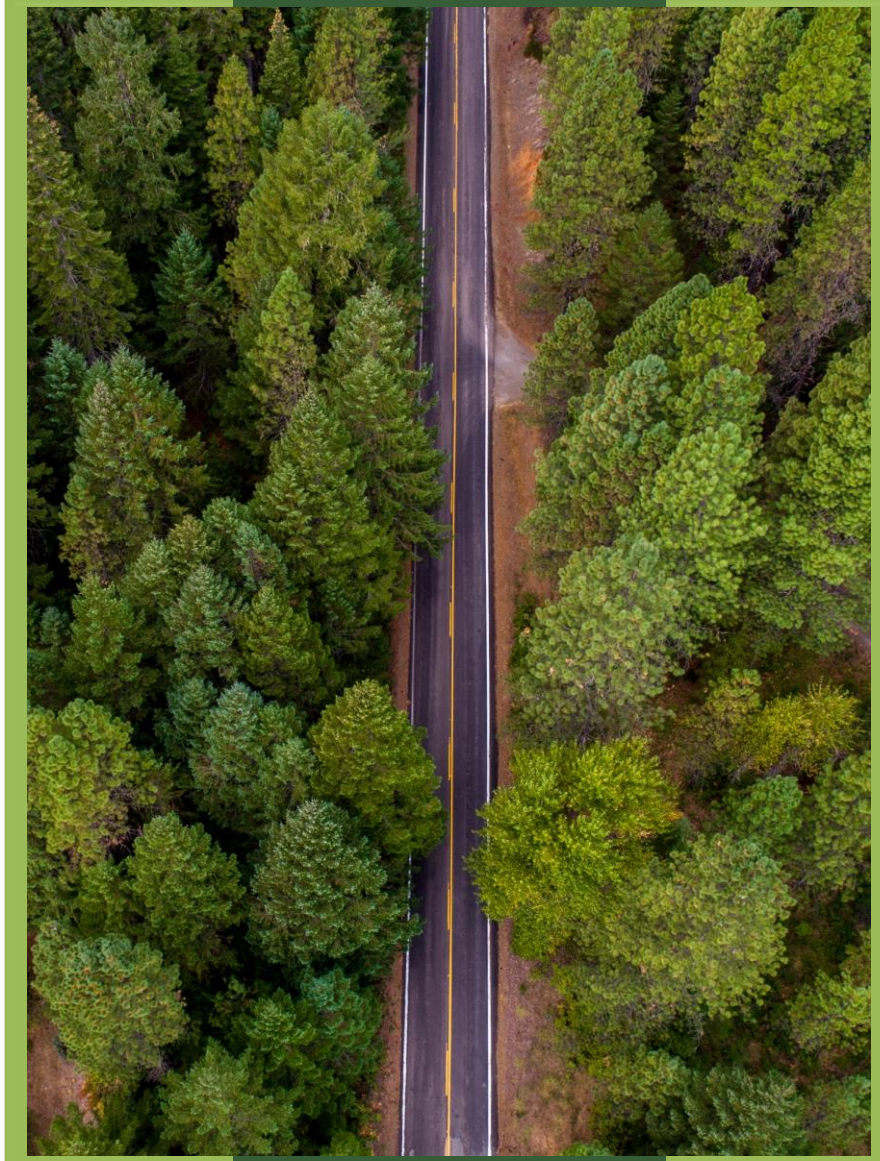
Research and Development on Innovative Energy-saving and Carbon-reducing Road Materials

Resin-added Cold Mix Concrete Pavement and Resin-added Cold Mix Reclaimed Asphalt Pavement

Tony Tang

REAAA Business Forum

Sustainable Roads, Connecting Nations



Research and Development

Innovative Energy-saving and

Carbon-reducing Road Materials

- Resin-added Cold Mix Concrete Pavement
- Resin-added Cold Mix Reclaimed Asphalt Pavement

Tony Tang

KING HO TAI INTERNATIONAL CO., LTD.

Environmental burden caused by road construction

Road construction

New road development

Vehicle emissions pollution

Recycled material inventory problem

large amounts of planing waste.
Stock in pile hazard to environmental protection

Road construction Produce pollution

Energy consumption

Carbon Dioxide emissions

Waste gas risks to health

Development of cold-mixed cold-paved concrete

Recycled

Without the use of heat sources

Achieve green roads and sustainable development.

Environmental hazard

in northern Taiwan

Hazardous substance

Granular substances, sulfur oxides, nitrogen oxides, volatile organic compounds

Thermal dissipation

189 billion kcal

Annual demand

1.5 million tonnes of asphalt concrete

Carbon dioxide emissions

40,000 tonnes

Electric energy consumption

4,050,000 kWh

Pavement Materials

NO HEAT SOURCE

100% Reclaimed

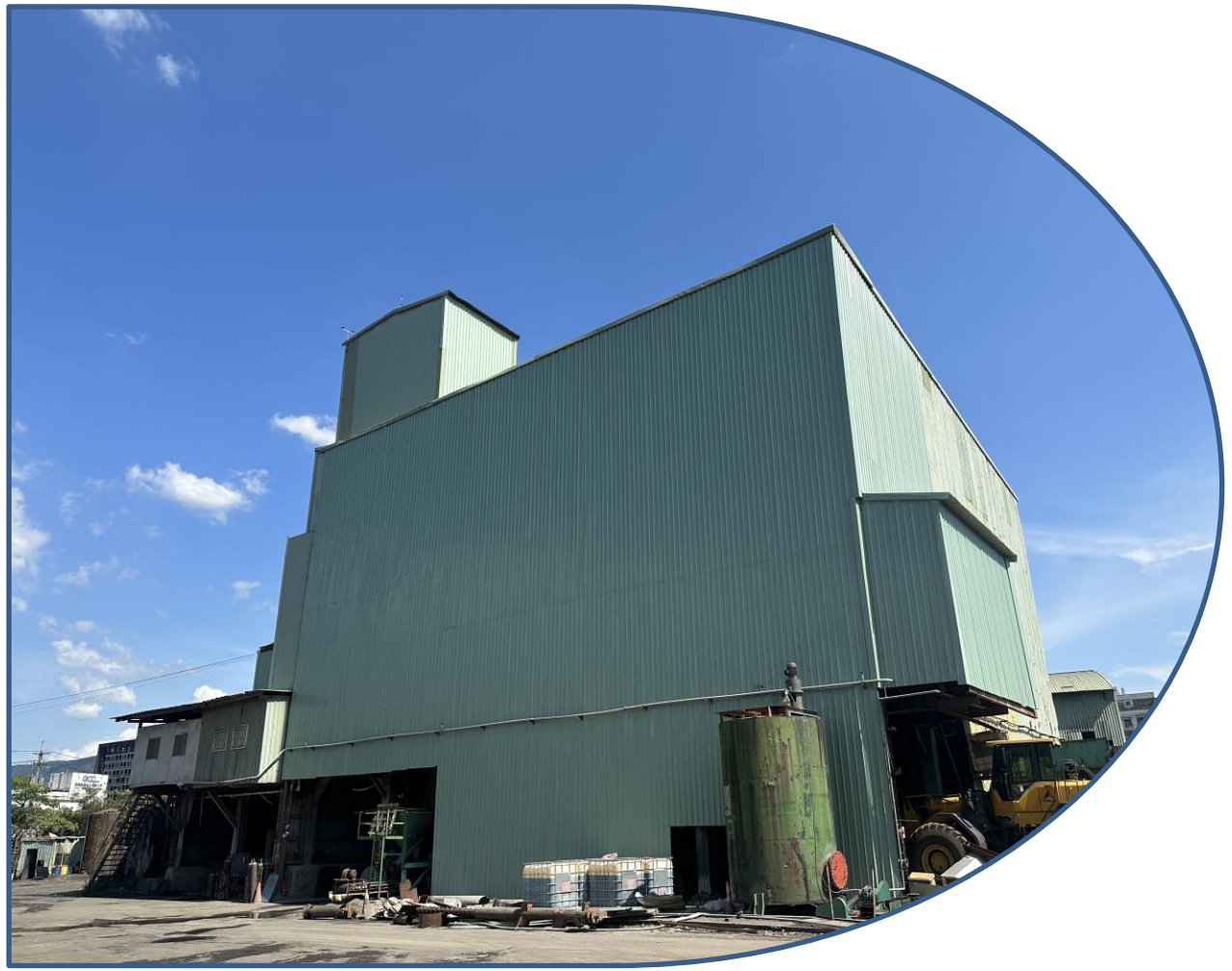
Solving asphalt removal waste stockpiles

New aggregate

For countries w/o asphalt import

KING HO TAI INTERNATIONAL CO., LTD.

Production Process



Cold Mix Material

- Resin solvent
- Interface coagulant
- Retarder

Process description

No Asphalt added

Similar to Hot-mix’s

Same equipment

Cold Paving

- Mixture Complete
- loading
- Paving
- Compaction
- Sampling

Loading

Paving

Compaction

Successful Practices

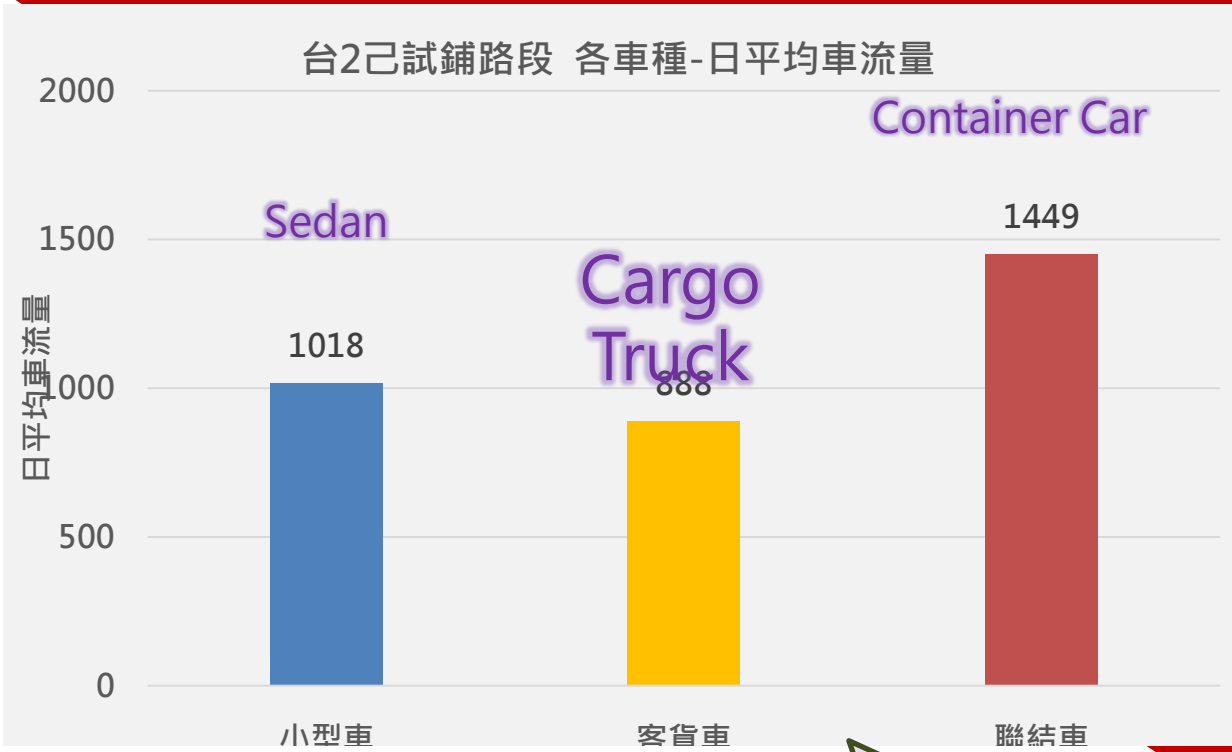
Paved in Highway

1 1K+218~1K+315，Cold Mix Surface 5cm

2 1K+315~1K+405，Cold Mix Base 5cm (+5cm DGAC Surface)

3 1K+405~1K+517，Hot-Mix Control group (5cm DGAC surface)

Traffic to Harbor



Heavy Traffic Rainfall Section

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Cold Paving Process

Achieveing Zero Carbon emissions

Outside Lane: Cold-Mix (light grey)

Inside Lane: Hot-Mix

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Sampling test

Marshall Test (CNS 12395)

Hamburg Wheel Tracking Test (AASHTO T324-17)

Dioxin and heavy metal dissolution testing (NIEA M801, NIEA R222)

Compaction Test (CNS8759 Asphalt Mixture Specific Gravity Test)

Indirect Tensile Strength (AASHTO MP 31 及ARRA CR201)

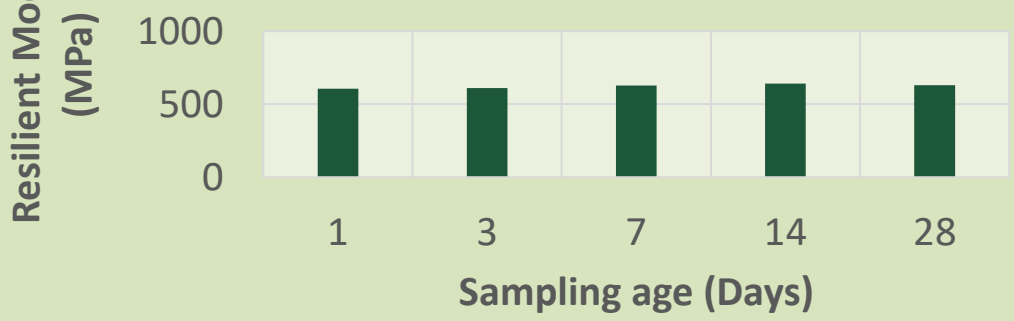
Soaking Residual Strength (AASHTO MP 31 及ARRA CR201)

The resilient modulus (Mr) test (ASTM D4123)

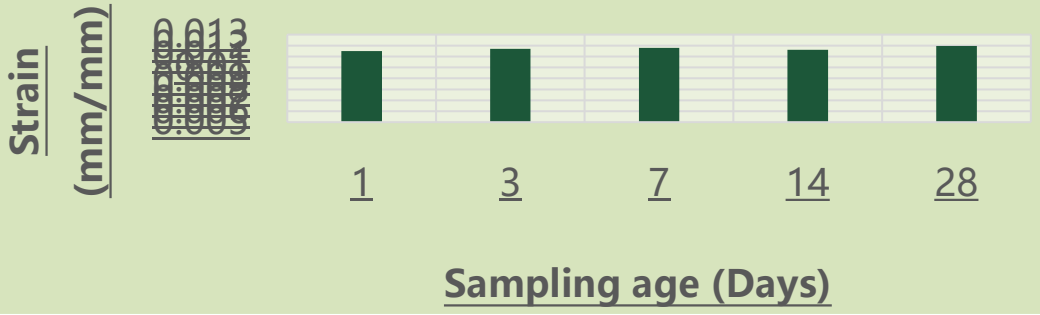
Static creep (ASTM D4123)

the material can resist water damage

The resilient...

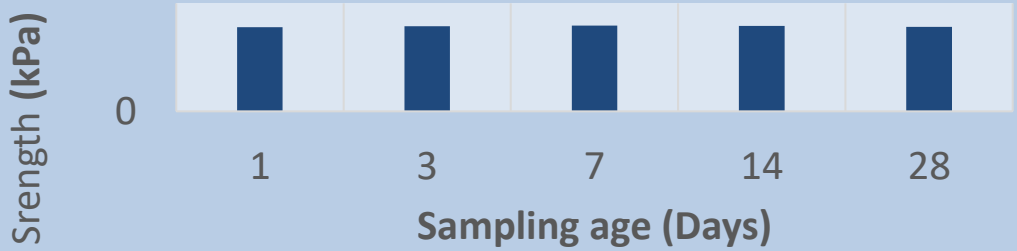


Static creep



The resilient modulus and static creep reached stability on the first day of the test, indicating that the elastic recovery ability and strain will not be affected by the long-term traffic load.

indirect tensile strength test



The indirect tensile strength was in a stable state on the first day, and the strength also met the requirements of AASHTO MP 31 and ARRA CR201's specification ≧310(kPa).

Soaking Residual Strength

> 70% (standard)

Sampling test

Marshall Test (CNS 12395)

Marshall Test (CNS 12395)

The on-site mixture was taken, and the Marshall test was carried out to obtain the stability and fluidity value.

The test body was rammed 75 times on each side, and was cured in a constant temperature water tank at 60°C for 30 to 40 minutes, the stable value must be ≧4500lbf (6 in.) or ≧1800lbf (4 in.).

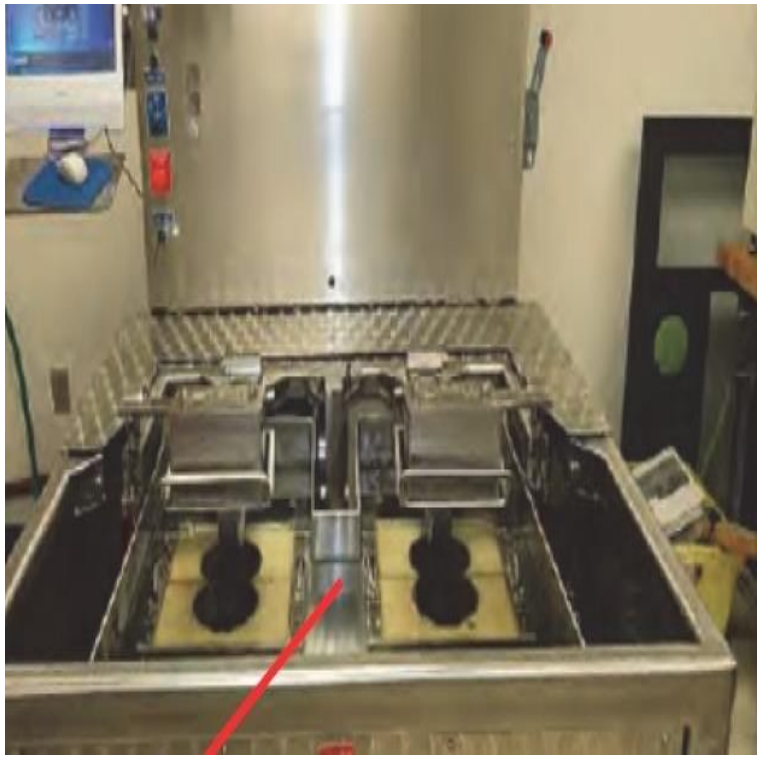
The test body was also sent to domestic university quality assurance center for verification.

Sampling test

Hamburg Wheel Tracking Test

(AASHTO T324-17)

- **The average value of the maximum number of rolling times with a rut depth of 12.5mm**
- **The average test results of the trial paving must be over 12000 times**



Sampling test

Hamburg Wheel Tracking Test

(AASHTO T324-17)

■ **Case sharing of a road renovation project in New Taipei City, Taiwan**

1. For the densely graded asphalt concrete used for repairing the on-site pavement, 4 cylinder samples shall be taken from the paved section on the same day (except the bridge section) and sent for a Hamburg wheel tracking test.
2. Using 4 pieces in a group, taking the average value of the maximum rolling times of the rut depth of 12.5mm, if the average times of the on-site samples are greater or equal to the average value of the trial paving, then it is qualified.
3. If unqualified, manufacturers can re-sample the paved section on that day and conduct the Hamburg wheel tracking test again.
4. if the inspection data is qualified, the paving on that day can be accepted.

Sampling test

Hamburg Wheel Tracking Test

(AASHTO T324-17)

■ **Case sharing of a road renovation project in New Taipei City, Taiwan**

3. If the testing result is unqualified again, and the average value is greater than 80% of the trial paving, asphalt concrete will be used for paving on that day.

4. If the testing result is unqualified again, and the average value is lower than 80% of the trial paving, the asphalt concrete paved on that day will be removed, and the densely graded asphalt concrete will be paved, the Hamburg wheel tracking test is still required.

Sampling test

CNS8759 Specific Gravity of Compacted Bituminous Mixtures

- **The specific gravity can be obtained according to CNS8759, and then divided by the specific gravity of the Marshall test, the compaction result can be obtained.**
- **If the compaction result is greater than 95%, then the compaction condition is good.**

Cutting and leveling

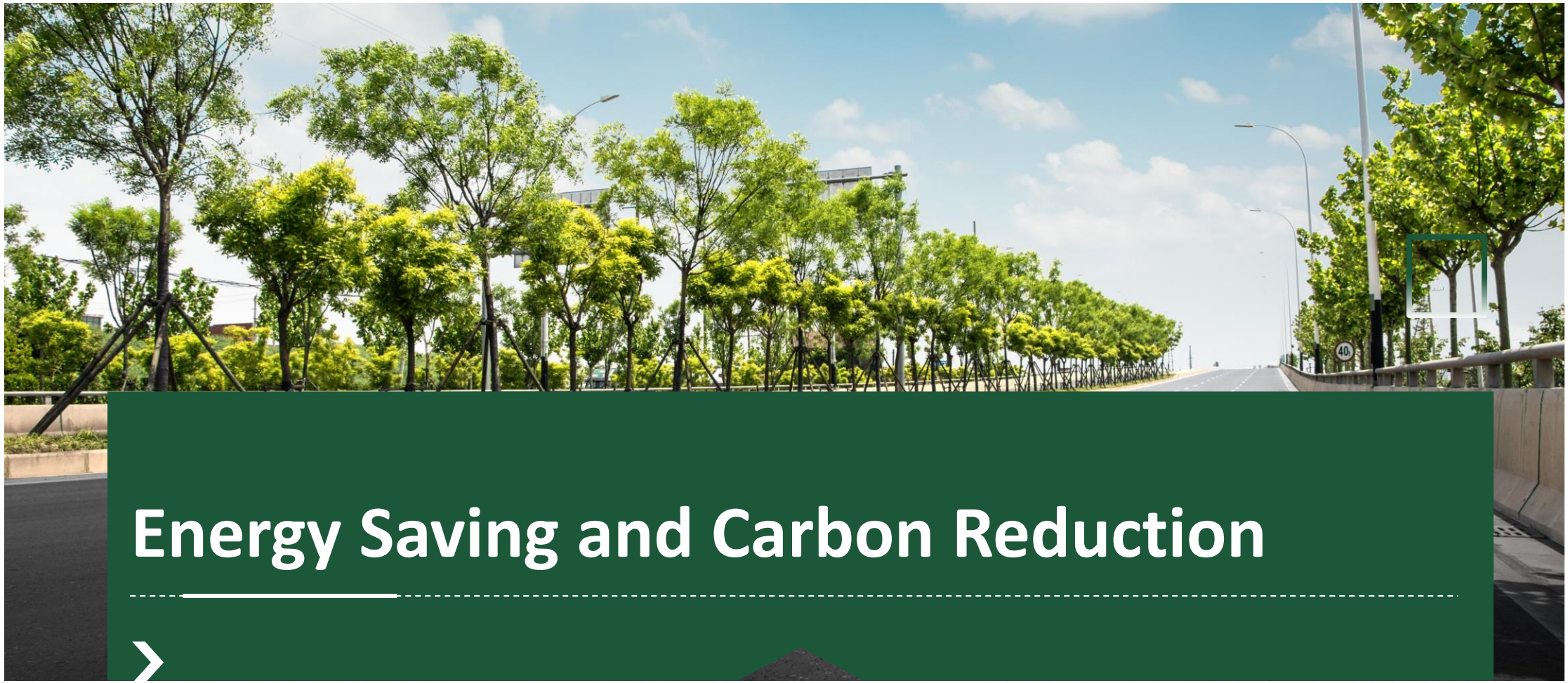
Weighing in water

Wet weigh

Dry weigh

Sampling Test - Conclusion

	Hot Mix		Cold Mix	
	Hot Mix 3/8" Asphalt Concrete	Hot Mix 3/4" Asphalt Concrete	Resin-added Cold Mix Concrete Pavement	Resin-added Cold Mix Reclaimed Asphalt Pavement
Marshall test	Specification ≥1800lbf	Specification ≥1800lbf	≥ 1800 (Ref.)	≥ 1800 (Ref.)
Test value	≒ 3600lbf	≒ 3800lbf	Above 4738 lbf	Above 4851 lbf
Hamburg Wheel Tracking Test	Set the test temperature to 60°C , the rut to 12.5mm the rolling times need to exceed 12,000			
Test value	7000~8000 times	15000 times	16000 times	16000 times



Energy Saving and Carbon Reduction

Comparison of Carbon Emissions

in Northern Taiwan

Carbon dioxide	Thermal dissipation	Power saving
1.5 million tonnes asphalt **39,480** tonnes of CO_2	A total of **189 billion** Kcal	**4,050,000** kilowatt-hours of electricity
Granular substances, sulfur oxides, nitrogen oxides, volatile organic compounds		Environmentally friendly new material
Non-toxic & odorless		Zero emission

Production Carbon Emissions Comparison

The carbon emissions of the three production methods of cold mix, hot mix and CLSM are summarized as follows

Method	Fuel Usage (L)	Electricity (kilowatt-hour)	Carbon emission factor (Kg-CO2-e/T)
Hot-mix	12	7.48	41.6
CLSM	0	1.747	0.97
Cold-mix emulsified asphalt	0	1.747	0.97
Cold-mix Foamed asphalt	0.18	0	0.47

Cold mix method has lower carbon emission factor

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Comparison of each design

Emissions of Resin-added Cold Mix Reclaimed Asphalt Pavement

Items	Ratio (%)
RAP (coarse)	40
RAP (fine)	60
Cement	0.5
resin solvent	4
Mixing water	1.5
Total carbon emissions Kg-CO2-e/T	20.04

Emissions of Resin-added Cold Mix Concrete Pavement

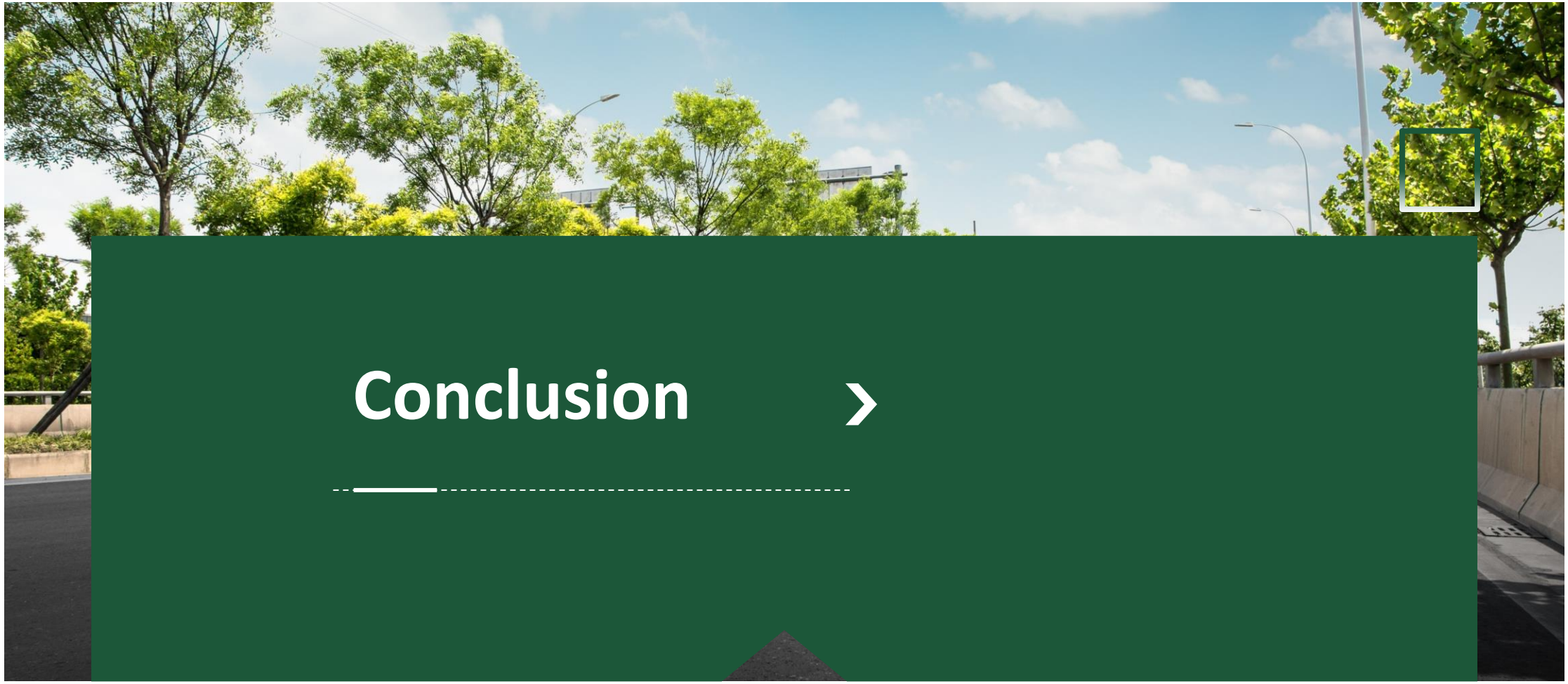
Items	Ratio(%)				
	RCCP-1	RCCP-2	RCCP-3	RCCP-4	RCCP-5
coarse aggregate	30	30	30	21	40
Fine aggregate	68	47	66	76	57
Cement	2	3	4	3	3
resin solvent	2.5	2.5	2.5	2.5	2.5
Mixing water	7.5	7.6	8.6	7.7	7.9
Total carbon emissions(Kg-CO2-e/T)	32.86	42.24	51.61	42.24	42.24
Average carbon emissions(Kg-CO2-e/T)	42.24				

Carbon emissions of hot-mix method in northern Taiwan

Items	Ratio(%)				
	A	B	C	D	E
8/8” gravel	22	11	-	8	17
6/8” gravel	12	12	32	18	23
3/8” gravel	15	24	15	21	13
2/8” gravel	10	7	16	10	13
Natural sand	38	43	33	40	31.5
Stone dust	3	3	4	3	2.5
Asphalt cement	4.3	4.3	4.2	4.2	4.4
Total carbon emissions Kg-CO2-e/T	49.5	49.5	56.48	49.01	46.26
Average carbon emissions Kg-CO2-e/T	50.15				

CLSM backfill material emissions

Items	Ratio(%)			
	A	B	C	D
Coarse aggregate	18	21	17	20
Fine Aggregate	65	58	65	59
Cement	7.5	8.8	8.5	8.7
Additive	0.25	0.15	0.15	0.25
Mixing water	10	13	10	12
Total carbon emissions Kg-CO2-e/T	77.82	88.83	86.18	88.87
Average carbon emissions Kg-CO2-e/T	85.43			



Conclusion ›

New Cold-mix Paving Materials

① **Eco-friendly**: Reduces dependence on traditional asphalt and reduces consumption of natural resources

② **Reduce waste**: RCRAP and RCCP road engineering materials are in a circular economy that recycles reclaimed asphalt pavement (RAP), which means zero waste.

③ **Reduce emissions**: No heat energy is used in the production process. According to domestic research, if the usage of RCRAP and RCCP is increased by 10% every year, carbon emissions can reduce by 52% by 2030, and reach net zero by 2050.

④ **Low resource solution**: The low cost and ease of operation of RCRAP and RCCP make them ideal for developing countries.

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THANK YOU

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Use of ALF and IM technologies for the use, adoption and assessment of new and innovative asphalt materials and mixes

Dr Richard Yeo


NTRO
Innovation Driven


TOURIST DRIVES
4
5
3
SULTANA SAM VINEYARD 2
Merbein
Wentworth

NTRO
Innovation Driven

Bridgetown, WA, Source The Australian

Source: Department of Fire and Emergency Services, Western Australia

Learmouth near Ballarat

Near Bendigo

Integrated Transport Solutions

Asset Performance

Infrastructure Measurement

Safer Smarter Infrastructure

Sustainability and Materials Performance

Structures & Certification

Data and Technology

Transport Futures

Laboratory Materials Performance and Testing

NTRO provides a full range of materials engineering and performance testing services

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Field Performance Assessment

NTRO provides a full range of field performance assessment

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The Role for Accelerated Pavement Testing (APT)

Various approaches:

- Observe performance
- Dedicated field trials

Accelerated Pavement Testing

- Laboratory studies

Accelerated Pavement Testing (APT):

provides a means to link real performance and laboratory testing using a simulation of full scale accelerated traffic loading

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Pavement Technology Knowledge

Accelerated Pavement Testing (APT)

- used to learn about performance of pavements
- need for knowledge in a short timeframe
- test new materials, reclaimed materials or marginal materials
- proof test pavement designs
- investigate construction issues
- investigate impacts of axle loading changes





APT Applications

1. **Rank relative performance of materials or processes**
   - assess marginal materials, pavement stabilisation, fatigue and rutting of asphalt, modified binders, laboratory tests, resilience – impacts of operating environment etc

2. **Investigate parameters used in pavement design**
   - assess effects of changes in traffic loading
   - proof test new or rehabilitation pavement designs

3. **Improve network deterioration models such as HDM4**
   - calibrate deterioration models
   - quantify works effects on deterioration

Accelerated Pavement Testing

Aim is to simulate effect of traffic loading:

- controlled wheel loads and passes
- controlled traffic pattern
- controlled section of test pavement
- controlled environment conditions
  - temperature
  - moisture
- accelerated loading using:
  - higher wheel loads
  - thinner test pavements
  - environment effects – moisture, temperature

Accelerated Loading Facility (ALF)

Granular Base




Test Pavement Design and Construction

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Thin Asphalt Surfacings

Test Pavement Design and Construction

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Test Pavement Trafficking

Test Pavement Design and Construction

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Heavy vehicle axle loading

Test Pavement Design and Construction

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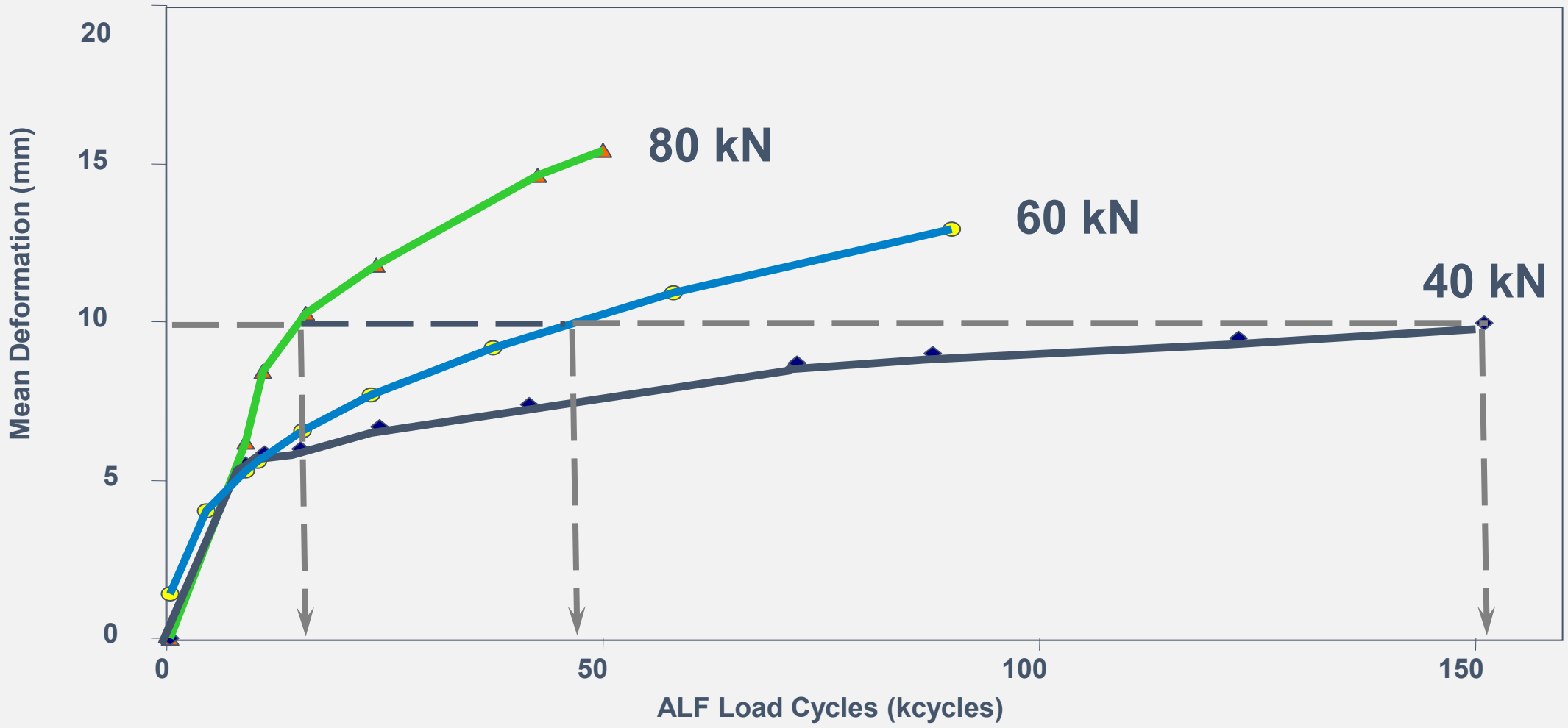
Effect of axle loading on performance



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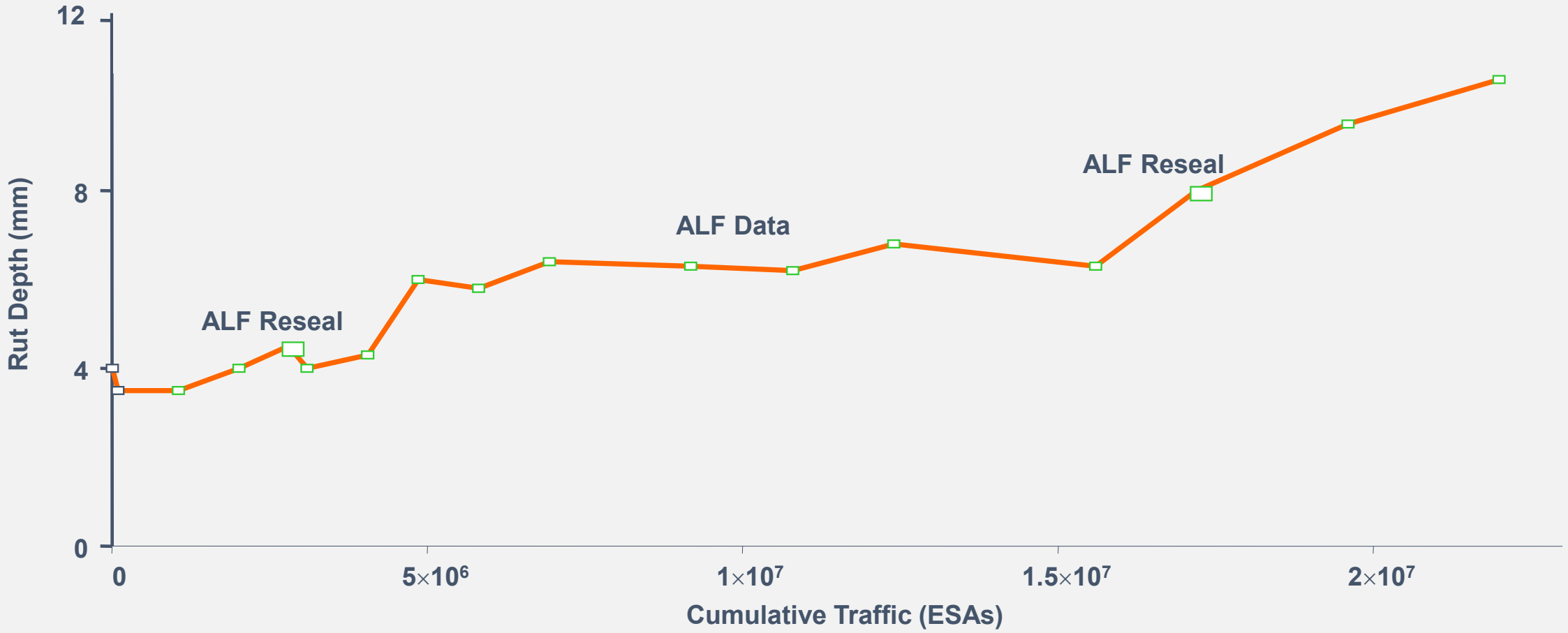
Unbound Granular Pavement Rutting



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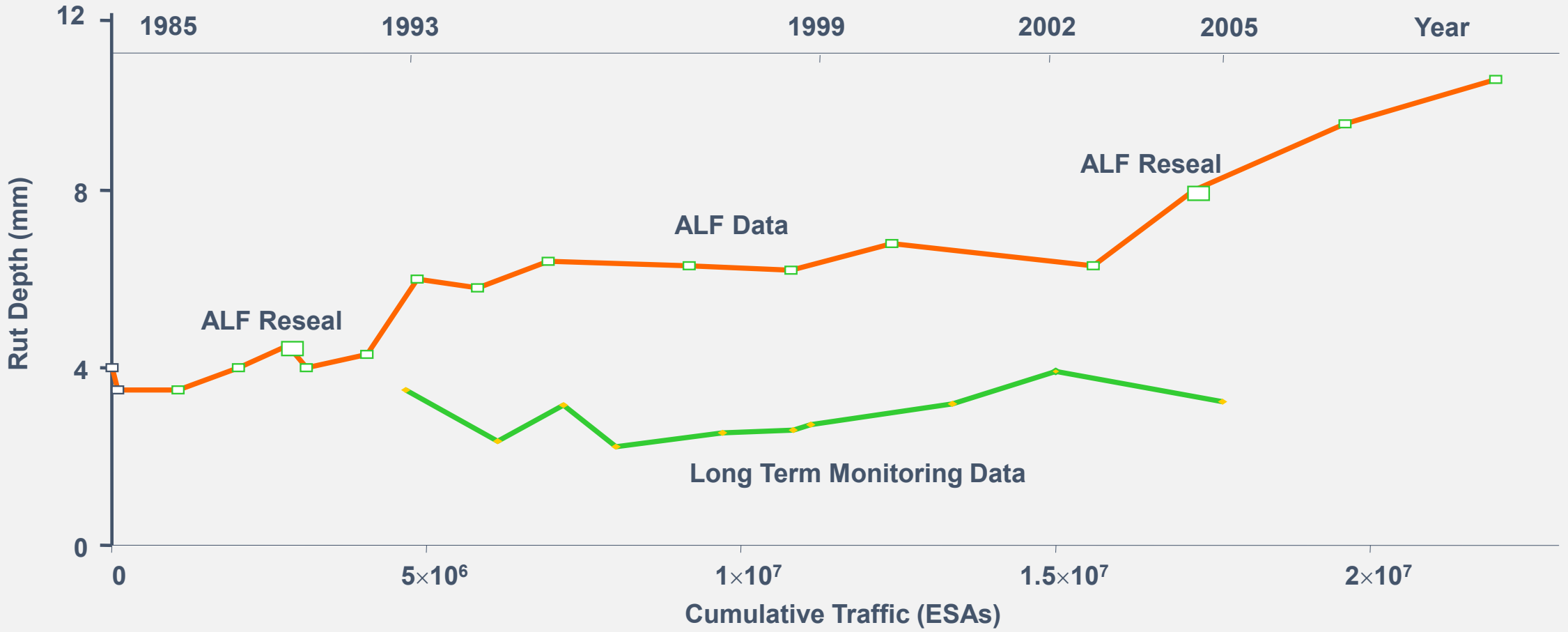
Unbound Granular Pavement Rutting



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Thank you


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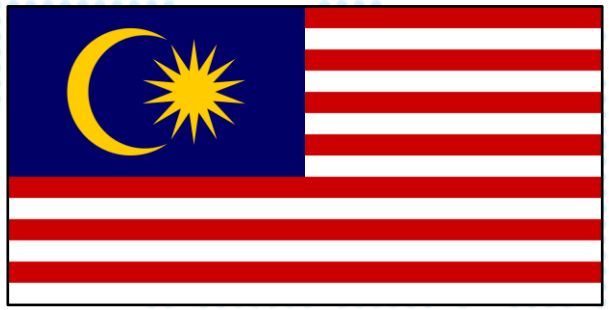
Super Fiber Mixes: Pushing the Limit

Abdul Hamid bin Othman

AHN VERTEX
SDN BHD



JKR

SUPER FIBER MIX:
PUSHING THE LIMIT

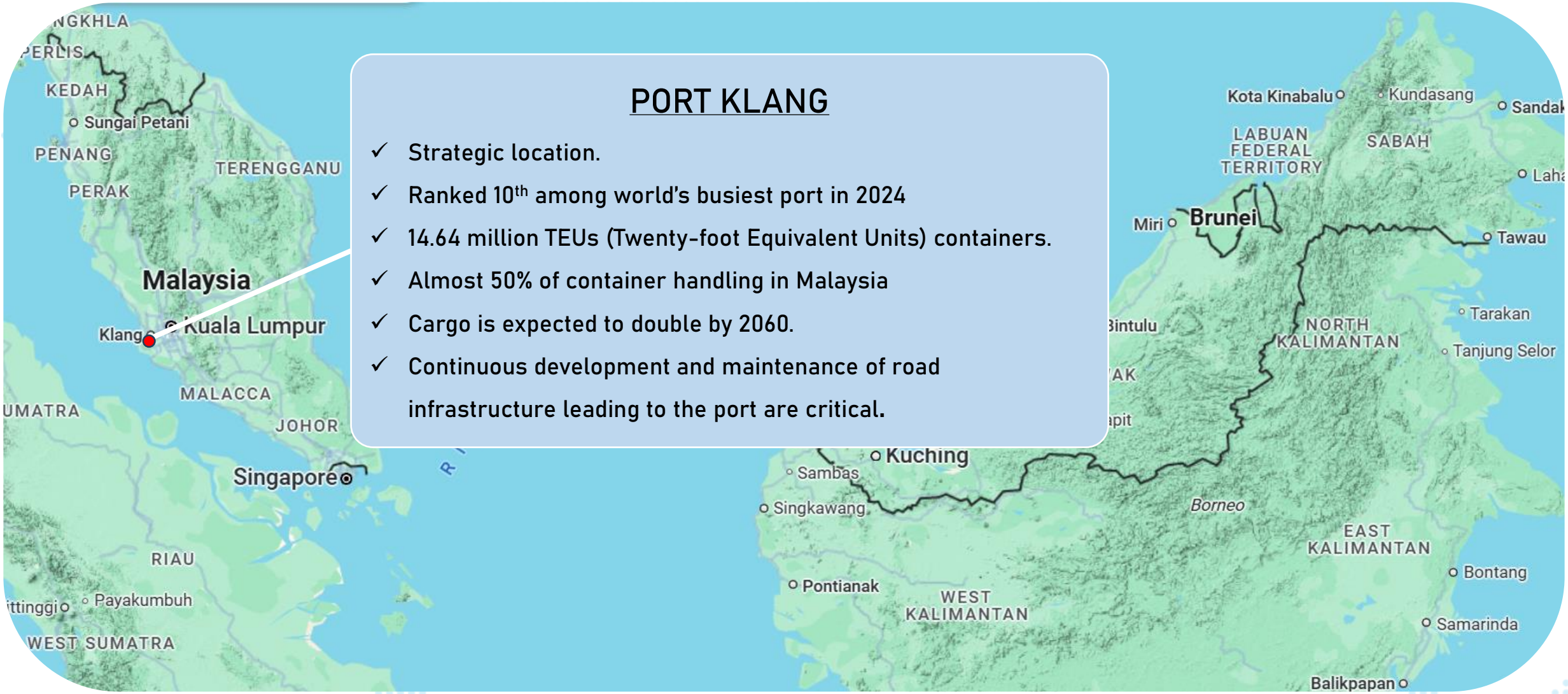
OUTLINE

1. Background – Port Klang
2. Challenges
3. Super Fiber Mix (SFM)
4. Super Fiber Mix – FR^+ (SFM-FR^+)
5. Pavement Analysis
6. Proof of Concept (POC)
7. Findings
8. Conclusion

BACKGROUND


Pakistan
UK
Nepal
AR
RJ
BR
ML
NL
East China Sea
Saudi Arabia
GJ
India
WB
Myanmar
(Burma)
Oman
MH
OD
Philippine Sea
TS
Thailand
Yemen
South
China Sea
KA
AP
Bay of Bengal
Gulf of Aden
Arabian Sea
Vietnam
Philippines
TN
Gulf of
Thailand
Ethiopia
KL
Laccadive Sea
Malaysia
Somalia
Kenya
Indonesia
zania
Banda Sea
Papua New
Guinea
Arafura Sea
Mozambique
NT
Coral Sea
QLD
Madagascar
Indian
Ocean
Australia
WA
SA
NSW
Great
Australian
Bight
VIC

BACKGROUND



PORT KLANG

- ✓ Strategic location.
- ✓ Ranked 10th among world's busiest port in 2024
- ✓ 14.64 million TEUs (Twenty-foot Equivalent Units) containers.
- ✓ Almost 50% of container handling in Malaysia
- ✓ Cargo is expected to double by 2060.
- ✓ Continuous development and maintenance of road infrastructure leading to the port are critical.

CHALLENGES OF MAINTAINING "THE LAST MILE TO THE PORT"

PORT KLANG

1. High volume of heavy vehicles
2. Fuel spillage
3. High stress at turnings, traffic lights, intersections
4. Overloading
5. Impact of climate change
6. Limited time window for maintenance
7. Budget constraints

OBJECTIVE & STRATEGY

PRODUCT EXPECTATION

Strong, durable, easy application, minimize reconstruction work, moisture resistant, fuel spillage resistance & cost effective.

"TIME IS OF THE ESSENCE"

OBJECTIVE

To enhance proven high performance mix, Super Fiber Mix (SFM), to address the identified challenges.

STRATEGY

To carry out top priority R&D with collaboration with all stakeholders ie. Public Works, concessionaire & universities etc.

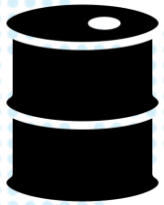
SUPER FIBER MIX (SFM)

SUPER FIBER MIX (SFM)

Hot Mix Asphalt

Aggregate Gradings: AC10, AC14, ACW20, AC28, ACB28, DBM40, Gap-Graded 14.

+



Bitumen Penetration 60/70

+

FORTA-Fi Fiber

Aramid Fiber

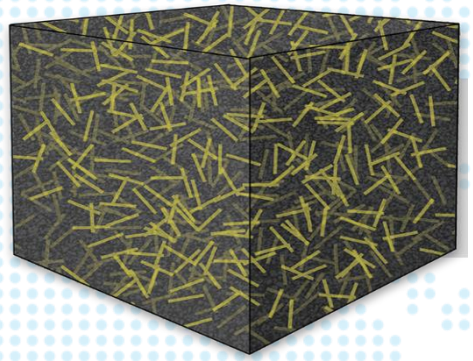
Physical Reinforcing Agent

+

Polyolefin Fiber

Distribution & Chemical Enhancement Agent

=



3D Reinforcement

Properties

- ✓ Tensile strength 6x times higher than steel. (2,758 MPa vs. 420 MPa)
- ✓ Operating temperature: -73°C → 427 °C

Advantages of SFM

- ✓ Improved resistance to rutting.
- ✓ Improved resistance to fatigue cracking.
- ✓ Improved mechanical properties.
- ✓ Improved moisture resistance.
- ✓ Increased durability of the asphalt.
- ✓ Easy & fast production and construction – Conventional method
- ✓ Cost-effective – Low maintenance and life-cycle cost

AHN VERTEX SDN BHD

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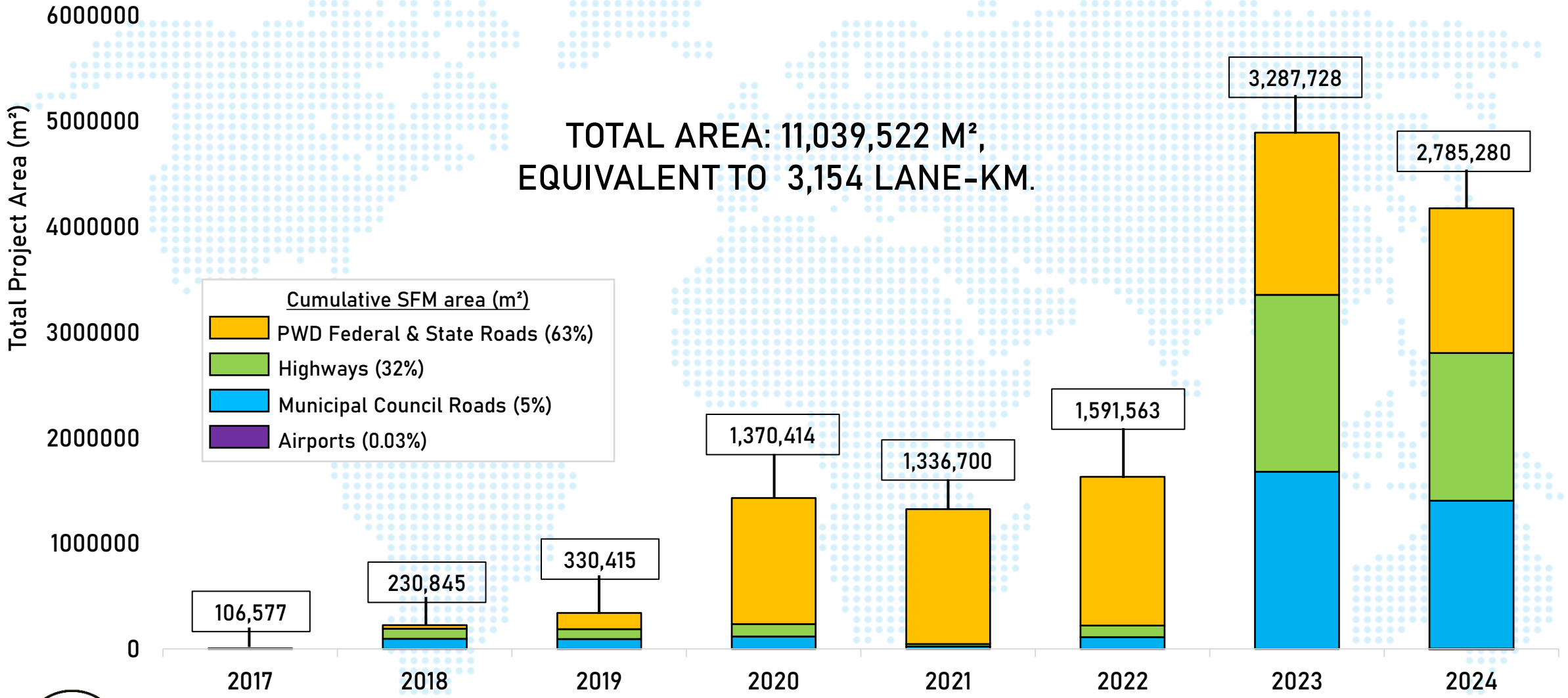
SFM PROVEN TRACK RECORD



AHN VERTEX SDN BHD

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PUSHING THE LIMIT

Super-Fiber-Man

- HOW TO MAKE SFM FUEL RESISTANT?
- HOW TO MAKE SFM STRONGER AND MORE DURABLE?

AHN VERTEX SDN BHD

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SUPER FIBER MIX-FR+ (SFM-FR+)

DEGRADATION OF CONVENTIONAL ASPHALT MIX DUE TO FUEL SPILLAGE ON ROADS

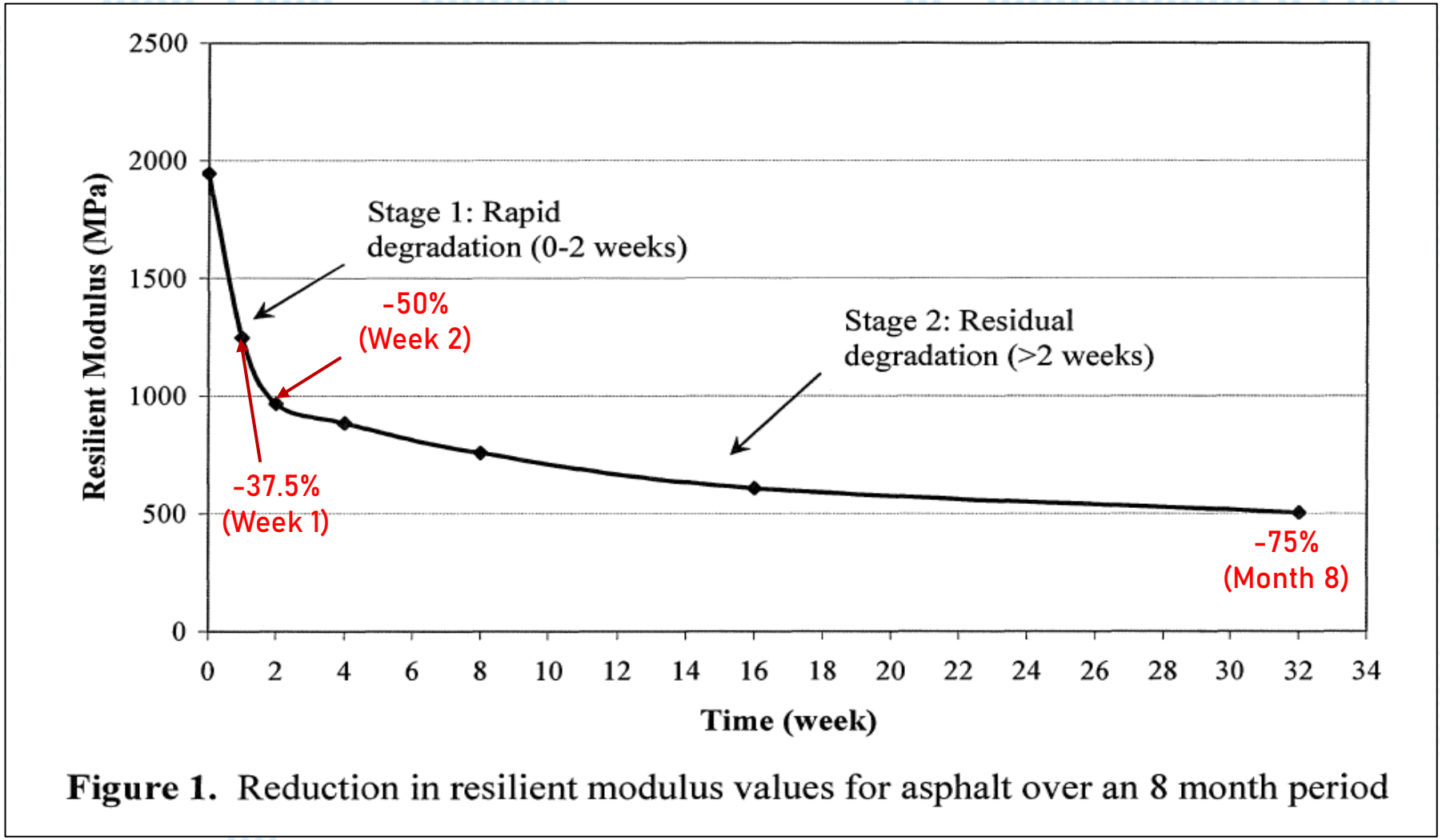


Figure 1. Reduction in resilient modulus values for asphalt over an 8 month period

Balwin, B., Carmody, O., & Collins, T. (2005). *Degradation of asphalt due to diesel spills on roads*.

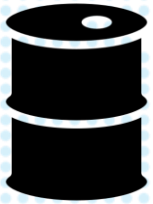
PUSHING THE LIMIT : SFM-FR+

SFM

Hot Mix Asphalt

Aggregate Grading

+



Bitumen Penetration 60/70

+

FORTA-Fi Fiber

Aramid Fiber

Physical Reinforcing Agent

+

Polyolefin Fiber

Distribution & Chemical Enhancement Agent

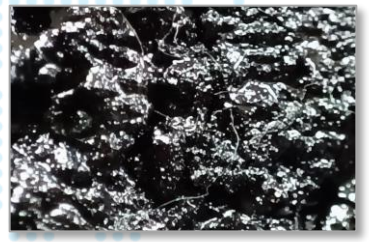
+

Polymeric Blend

Polymer Compound

=

SFM-FR+



Novel Technology of Super Fiber Mix-
Fuel Resistant

Advantages of SFM-FR+

- ✓ Fuel resistance
- ✓ Improved resistance to rutting.
- ✓ Improved resistance to fatigue cracking.
- ✓ Improved mechanical properties – Tensile strength, resilient modulus, stability, stiffness, resistance to permanent deformation.
- ✓ Improved moisture resistance.
- ✓ Increased durability of the asphalt.
- ✓ Easy & fast production and construction – Conventional method
- ✓ Cost-effective – Low maintenance and life-cycle cost

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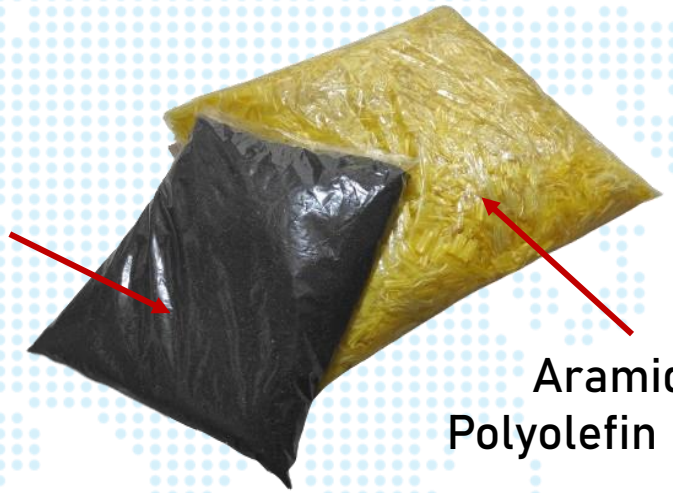
SFM-FR+ : EASY MIXING OF ADDITIVIES

g
e
1
1
6

BLACKTOP SALAK TINGGI
(2 TAN PER BATCH)

Polymer Compound.



Aramid & Polyolefin Fibers.

1. No modification required at batch plants.
2. Dry mix – no preblending of bitumen required.
3. Same construction equipment and processes as conventional mix.

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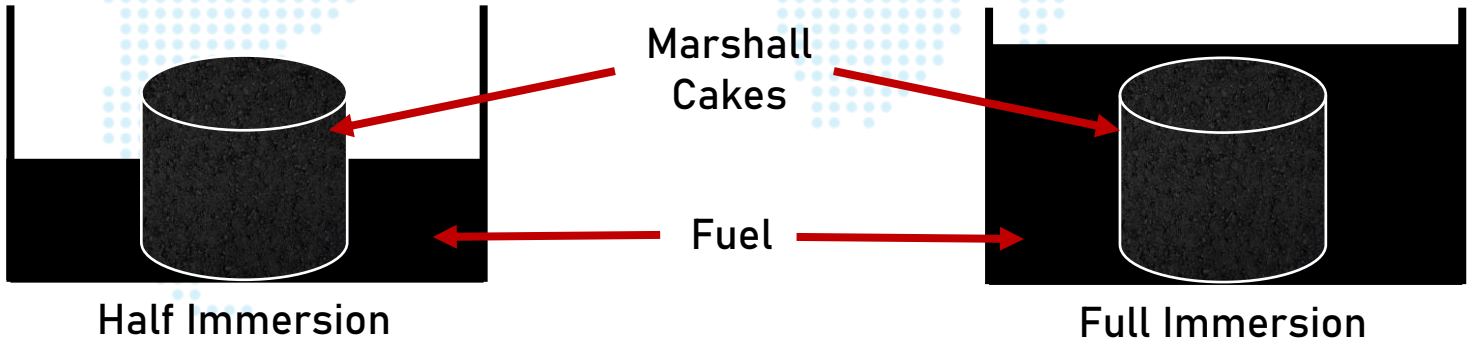
LAB PERFORMANCE : FUEL RESISTANCE TEST

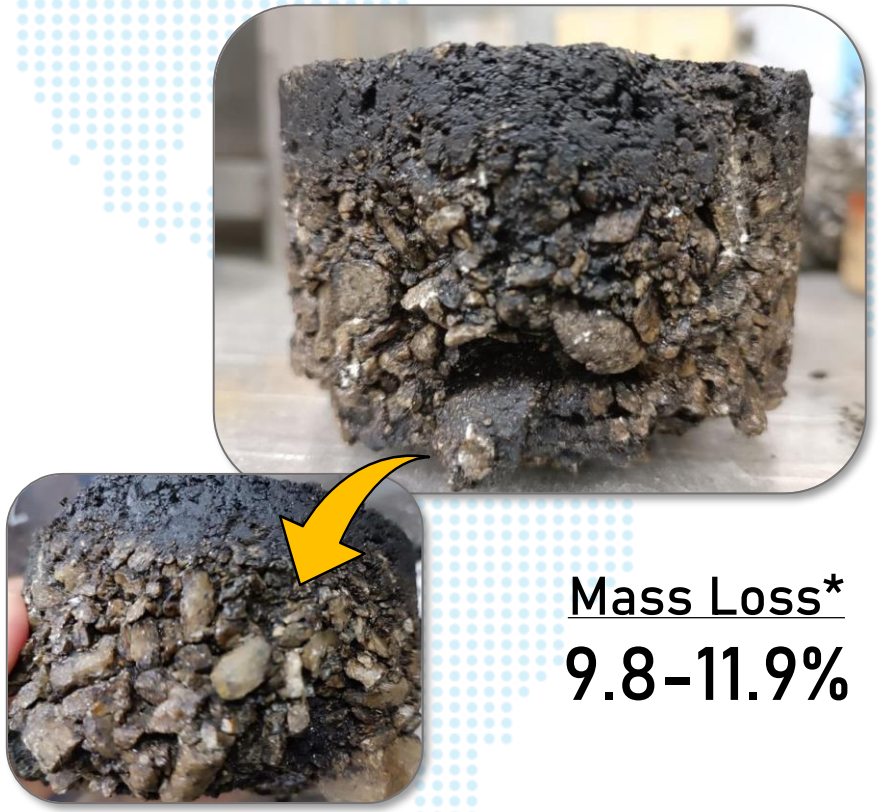
No.	Fuel Type	Depth of Immersion in Fuel	Mass Loss of Asphalt Mix After Fuel Immersion	Requirement for Mass Loss of Asphalt Mix (%)	Test Method/Standard Specification
1	Petrol (RON-97)	Half Immersion (50% of Marshall Cakes' Thickness Immersed in Fuel)	1.97 %	< 4.0%	BS EN 12697-43 PWD Road Specs
2	Diesel	Full Immersion (100% of Marshall Cakes' Thickness Immersed in Fuel)	1.70 %	< 15.0%	PLUS SERIES 900 (SMA)
3	Aviation Kerosene (Jet A1 Fuel)		0.76 %	< 1.0%	PLUS SERIES 900 (SMA)



LAB PERFORMANCE : FUEL RESISTANCE TEST

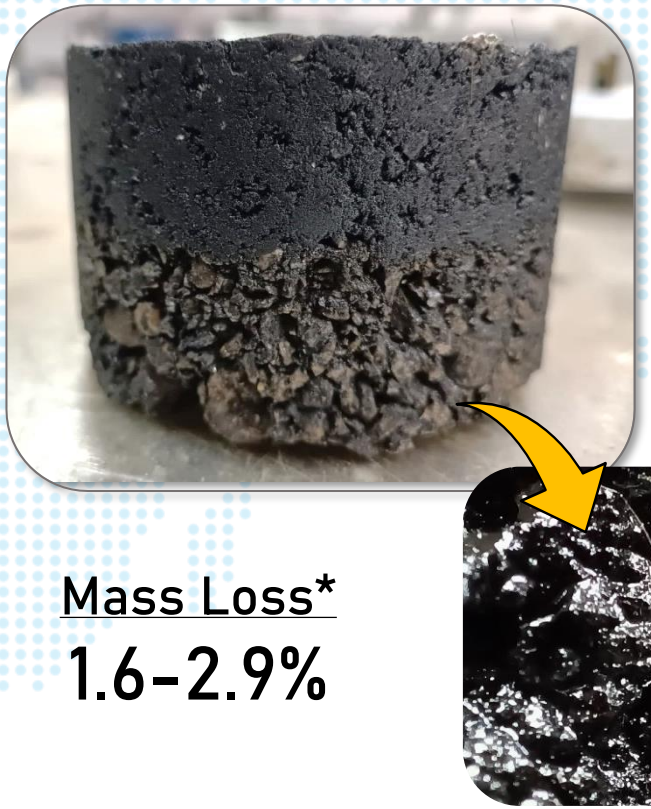
MARSHALL CAKES AFTER 24 HOURS SUBMERGED IN PETROL (RON-97)

CONTROL
CONVENTIONAL AC14



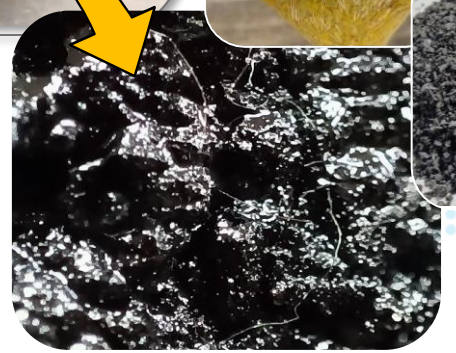
Mass Loss*
9.8-11.9%

SFM-FR+



Aramid &
Polyolefin
Fiber

Fuel
Resistant
Additive



Mass Loss*
1.6-2.9%

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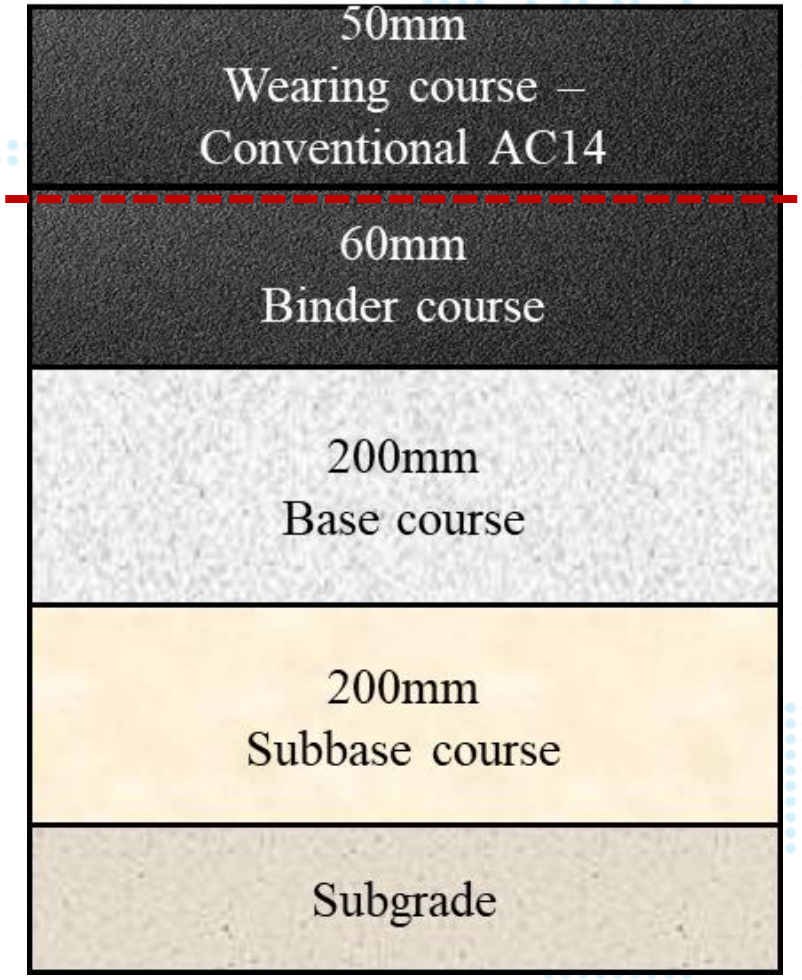
LAB PERFORMANCE : MARSHALL AND ADVANCE PROPERTIES

NO.	MIX FEATURES	CONVENTIONAL AC14	SFM (Relative to AC14)	SFM-FR+ (Relative to AC14)
1	Resistance To Fuel Spillage* - Average loss of weight after 24H immersion in RON-97 (%)	10.68% Failed To Comply	9.90% Failed To Comply	Excellent 1.97% 82% Better
2	Resistance To Rutting - Hamburg Wheel Tracking	Fair 10mm	Excellent 5.07 mm 49% Better	Excellent 5.65 mm 49% Better
3	Resistance To Fatigue Cracking - Resilient Modulus	Fair 2,776 MPa	Excellent 5,813 MPa 109% Better	Excellent 8379 MPa 202% Better
4	Resistance To Ravelling - Dry Tensile Strength	Fair 869 kPa	Excellent 1,214 kPa 24% Better	Excellent 1,466 kPa 52% Better
5	Resistance To Shoving - Marshall Stability	Fair 10,468 N	Excellent 14,697 N 40% Better	Excellent 17,821 N 70% Better
	Resistance to Moisture Damage - Tensile Strength Ratio, TSR	Fair 75.2%	Excellent 88.7% 18% Better	Excellent 90.2% 20% Better

PAVEMENT ANALYSIS

COMPARISON OF PAVEMENT STRUCTURES FOR LIFE CYCLE ANALYSIS



ACWC14 Wearing Course

SFM14 Wearing Course

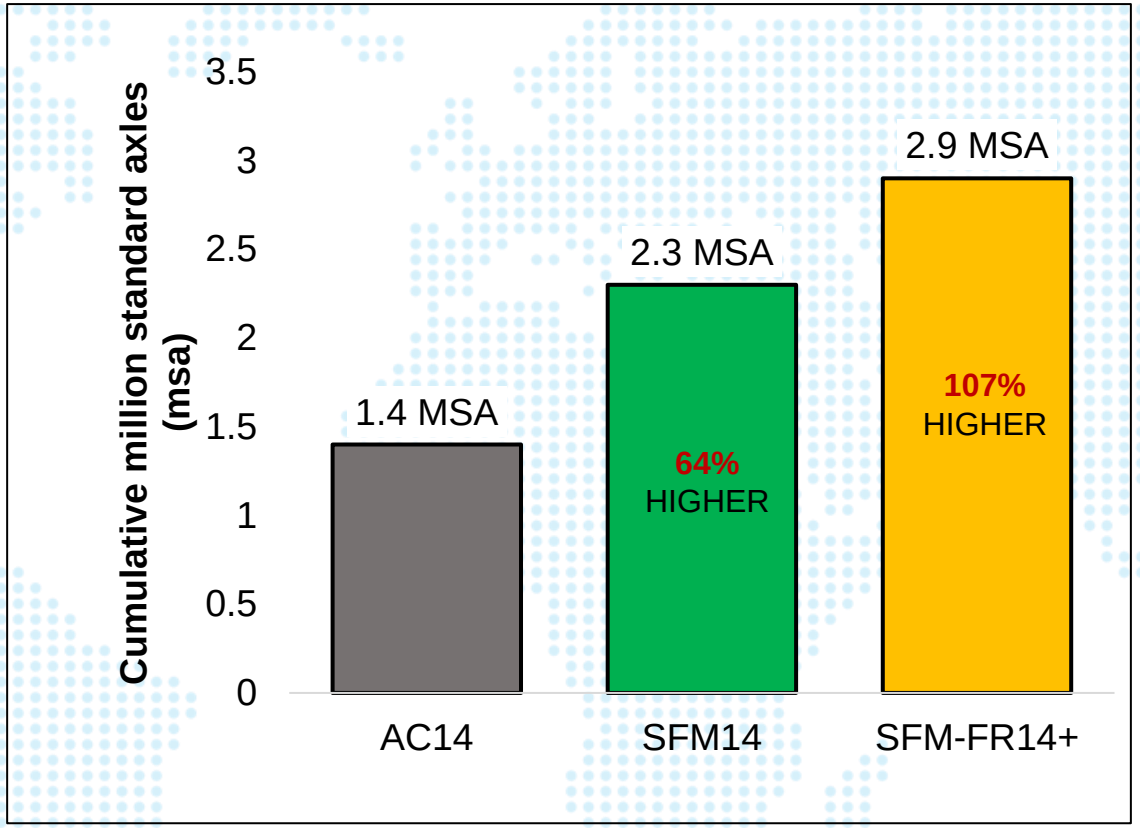
SFM-FR14+ Wearing Course

COMPARISON OF PAVEMENT STRUCTURES

DESIGN ASSUMPTIONS

LAYER	Resilient Modulus		
	CONVENTIONAL AC14	SFM14	SFM-FR14+
Wearing Course	2,500 MPa	5,000 MPa	7,000 MPa
Binder Course	2,500 MPa		
Base Course	350 MPa		
Subbase Course	250 MPa		

PAVEMENT ANALYSIS : MECHANISTIC APPROACH – RUBICON SOFTWARE



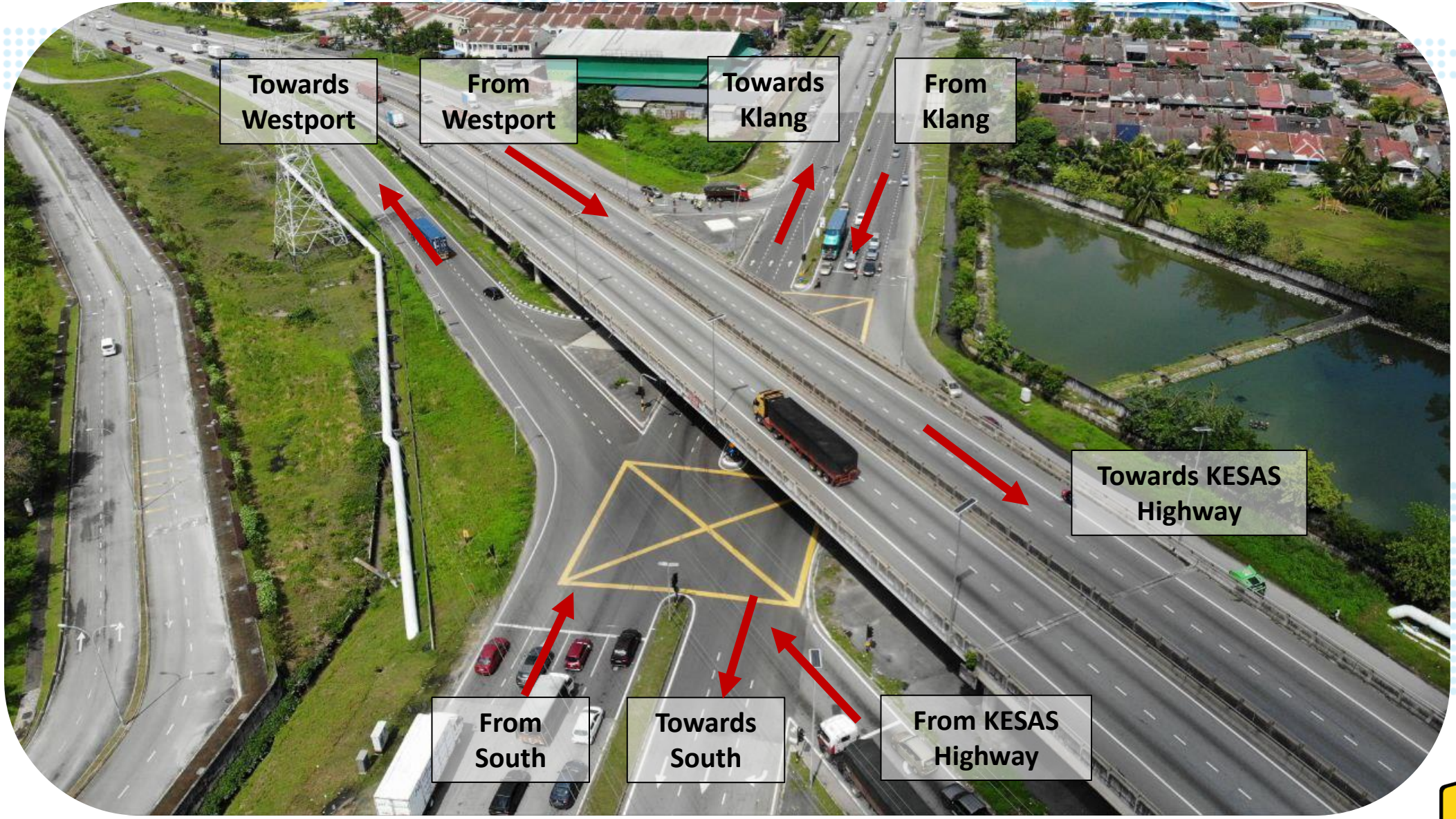
Comparison of cumulative MSA

SFM-FR+ can withstand traffic load conservatively 2 times that of conventional pavement.

PROOF OF CONCEPT (POC):

FT 3218, SECTION 4.0-5.0, JALAN PANDAMARAN, PORT KLANG, SELANGOR

SITE LOCATION : PORT KLANG



COMPARISON OF HEAVY TRAFFIC VEHICLES

ROAD SERVING PORT VS TYPICAL MAJOR ROAD

Location Description For Traffic Census Station					Number of Heavy Vehicles		
Year	State	District	Type of Road	Description	24 Hours	5 Months	6.4 years
2024	Selangor	Klang	Road Serving Port	Lebuhraya Pulau Indah, Port Klang	14,726	2,208,900	33,928,704
2024	Selangor	Petaling	Typical Major Road	Kuala Lumpur - Petaling Jaya	959	143,850	2,208,900

Source: Road Traffic Volume Malaysia (RTVM) – 2024, Heavy Vehicle: 3-axles & above

1. Road serving port recorded 15 times higher heavy traffic volume than typical major road!
2. Volume of 5 months heavy vehicles at road serving port, is equivalent to 6.4 years of typical major road.

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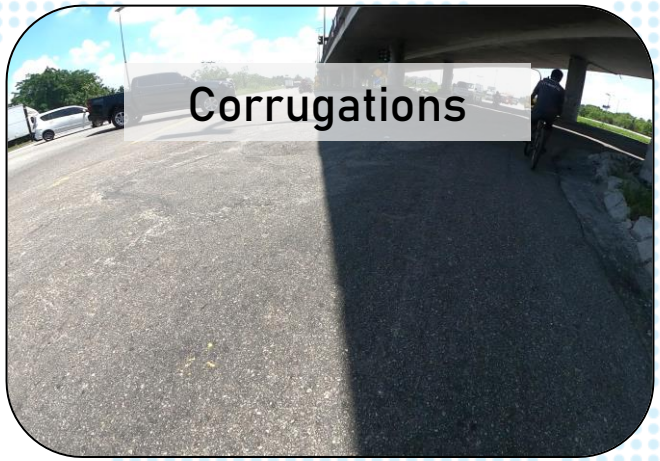
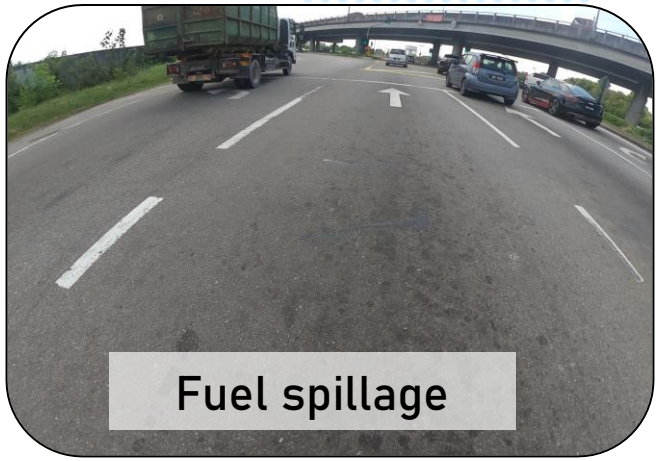
CONDITION BEFORE REHABILITATION WORK

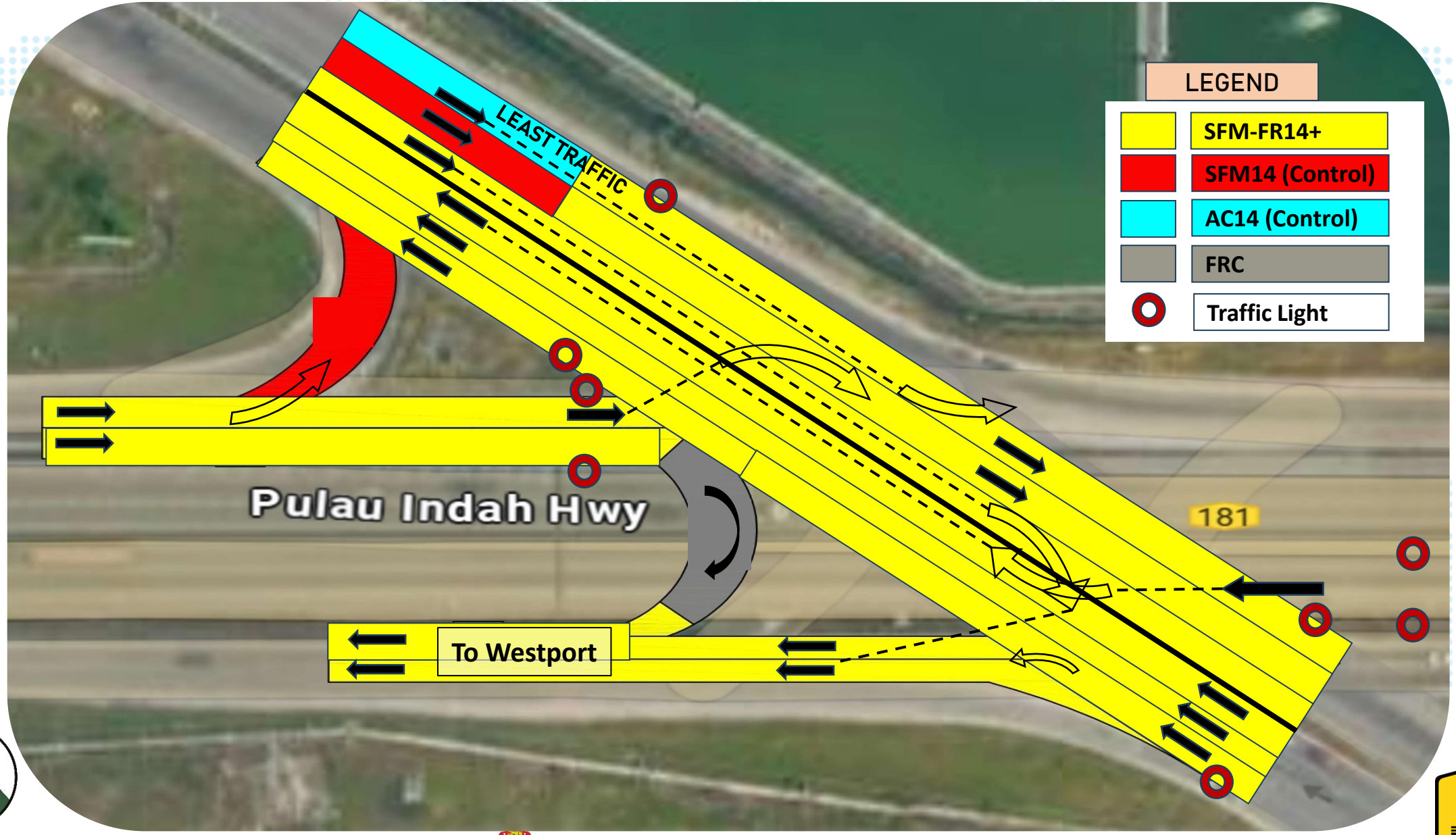


21 OCTOBER 2024 – Previous maintenance was done in January 2024 (Less than one year old)

Premature distresses due to extreme high volumes of heavy vehicles and fuel spillage.



TREATMENT METHODS – TRAFFIC FLOW



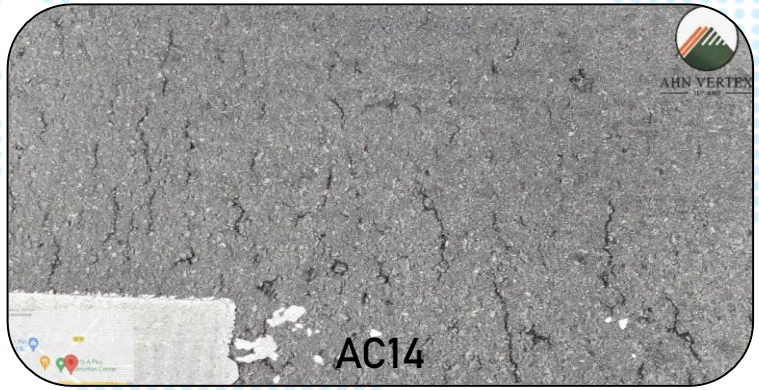
FINDINGS:
FIELD PERFORMANCE AFTER 5 MONTHS

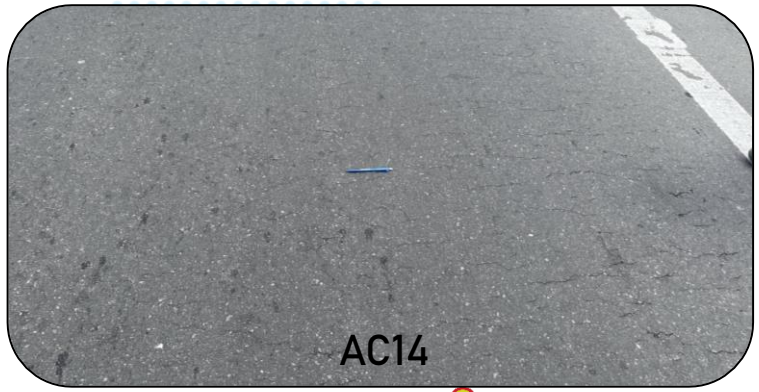
FT 3218, SECTION 4.0-5.0, JALAN PANDAMARAN, PORT KLANG, SELANGOR

FINDINGS : CRACK MONITORING AFTER 5 MONTHS

No.	Mix Type	Total Length (m)	Average Crack (% Area)	Rating
1	AC14 (Control)	90	25.5%	Bad
2	SFM (Control)	90	0%	Good
3	SFM-FR+	1550	<1%	Good

Source: Malaysia Highway Authority (MHA) and JKR Road Asset Management System (RAMS)

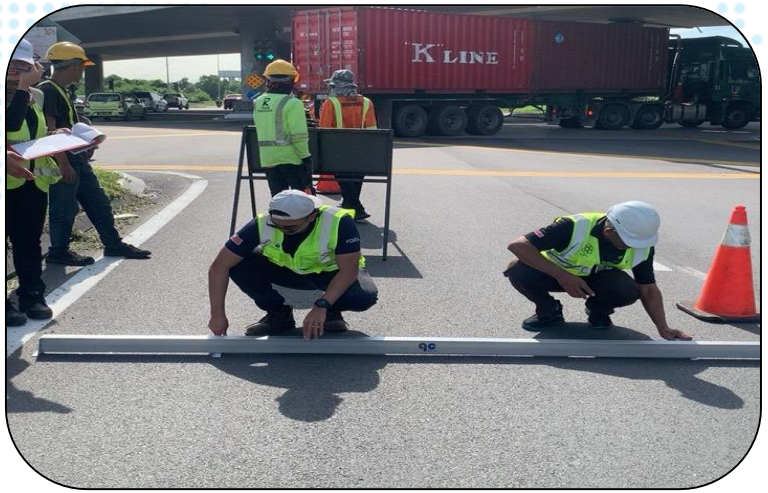




FINDINGS : RUTTING MONITORING AFTER 5 MONTHS

No.	Mix Type	Total Length (m)	Average Rut Depth (mm)	Minimum Rut Depth (mm)	Max Rut Depth (mm)	Rating
1	AC14	90	1.5	0	7	Fair
2	SFM	90	0.9	0	3.5	Good
3	SFM-FR^{+}	1550	0.9	0	4.5	Good

Source: Malaysia Highway Authority (MHA) and JKR Road Asset Management System (RAMS)



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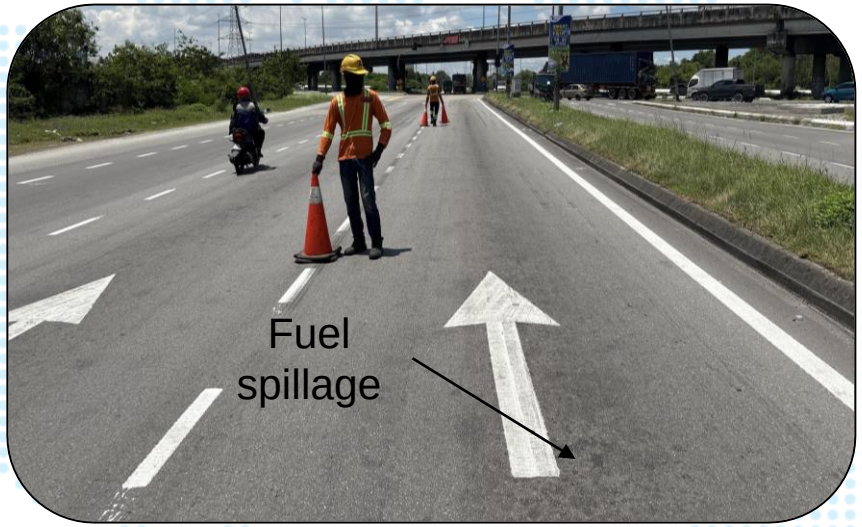
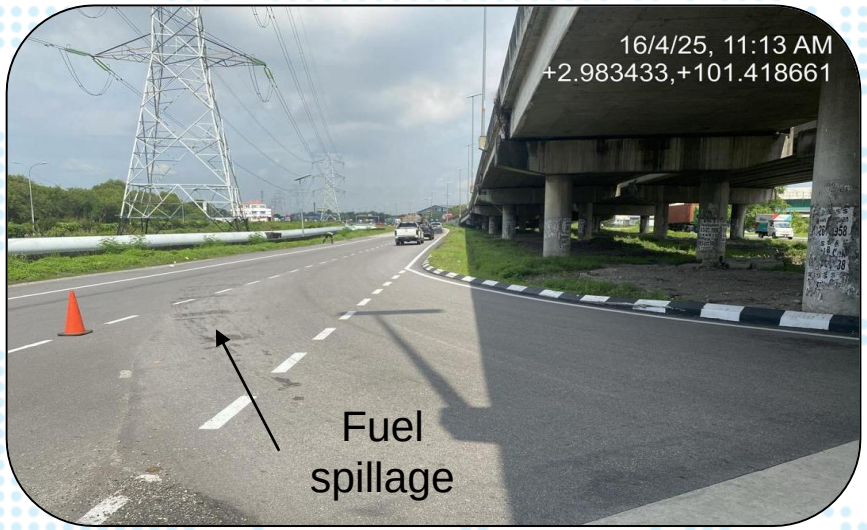
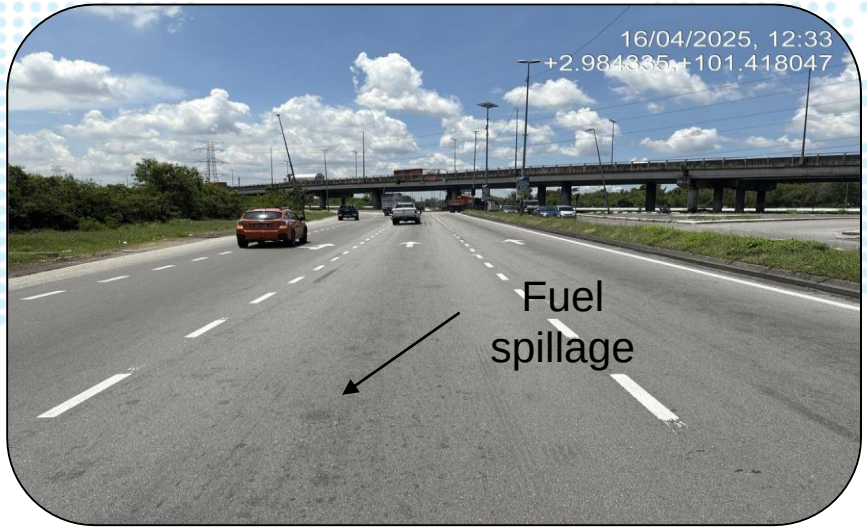
FINDINGS : FUEL RESISTANCE PERFORMANCE AFTER 5 MONTHS





No defects were observed despite the fuel spillage.



FINDINGS : MECHANISTIC PROPERTIES OF SFM-FR+

NO.	MIX PROPERTIES	SFM-FR+	SPECIFICATIONS	REFERENCES
1	Resistance To Fuel Spillage* - Average loss of weight after 24H immersion in RON-97 (%)	Excellent 1.81 %	< 4.0 %	BS EN 12697-43 & JKR/SPJ 2008/S4-61
2	Marshall Stability	Excellent 16,139 kN	> 13 kN	ASTM D 6927-15 & JKR/SPJ 2008/S4-113
3	Resilient Modulus	Excellent 7097 Mpa	> 3000 MPa	ASTM D 4123-82 (1995) & JKR/SPJ 2008/S4-113
4	Flow	Excellent 3.1 mm	2 – 5 mm	ASTM D 6927-15 & JKR/SPJ 2008/S4-113
5	Stiffness	Excellent 5.67 kN/mm	> 2.6 kN/mm	ASTM D 6927-15 & JKR/SPJ 2008/S4-113

Note: Sample from actual project at FT3218 Section 4.0 – 5.0 Pandamaran, Klang

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CONCLUSION

CONCLUSIONS

- ✓ SFM-FR^{+} addresses all the identified challenges.
- ✓ Mechanistic properties of SFM has been enhanced with additional feature of fuel resistant.
- ✓ SFM-FR^{+} performed better compare to conventional AC14 & SFM.
- ✓ Proven to be an easy technology to be applied in the industry.
- ✓ Stronger wearing/binder course offers opportunity to optimize pavement structure (thinner).
- ✓ Use of high performance, longer lasting and fuel resistant SFM-FR^{+} mix in critical roads like road serving port, industrial area, airports etc will minimise needs for maintenance.

SFM-FR $^{+}$ - APPLICATIONS

R&R or Layby Areas

Toll Booths

Airport

Bus Station/Stop

Intersections

Industrial Areas/
Sea Ports

Prolong life cycle of road.
Optimizes pavement structure.

Roads frequently used by commercial vehicles

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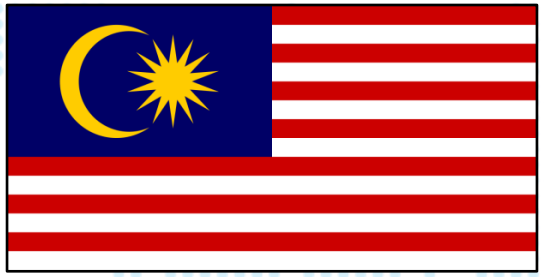

THANK YOU!

NTRO
Innovation Driven

Panel: Informed asset management decision making

Rhys Owen-Roberts

Rochelle Leach

Simon Hunt

NTRO
Innovation Driven

Thank you

Dr Richard Yeo

NTRO

THE TRANSPORT REVOLUTION

SOLUTIONS LED BY INNOVATION

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