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Monash Institute of Railway Technology

Next Generation Recycled Materials in Railways

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Monash Institute of Railway Technology (IRT)

- Railway research capability was established in 1972 at BHP's Melbourne Research Laboratories
- Successfully conducting applied railway research since 2000 at Monash University
- \Monash IRT is now regarded as the premier track and vehicle research centre in Australia
- Fully funded by the industry

Monash IRT Snapshot

51 years of railway innovation starting at BHP

23 years as part of Monash University

160+ partners

600+ projects

Since 2000

90+ engineers, scientists, technicians and research associates

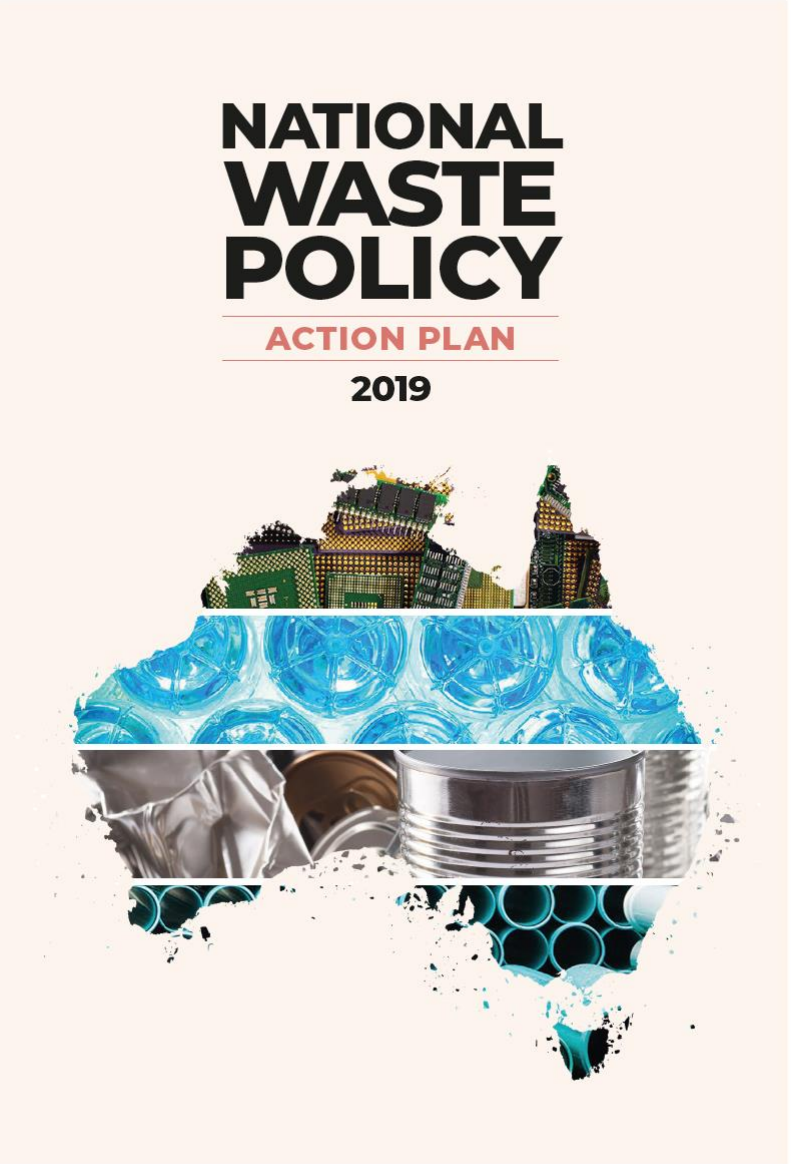
World first technologies

- Asymmetric wheel-rail profiles
- Instrumented Ore Car
- Phased array

National and international recognition for staff and projects

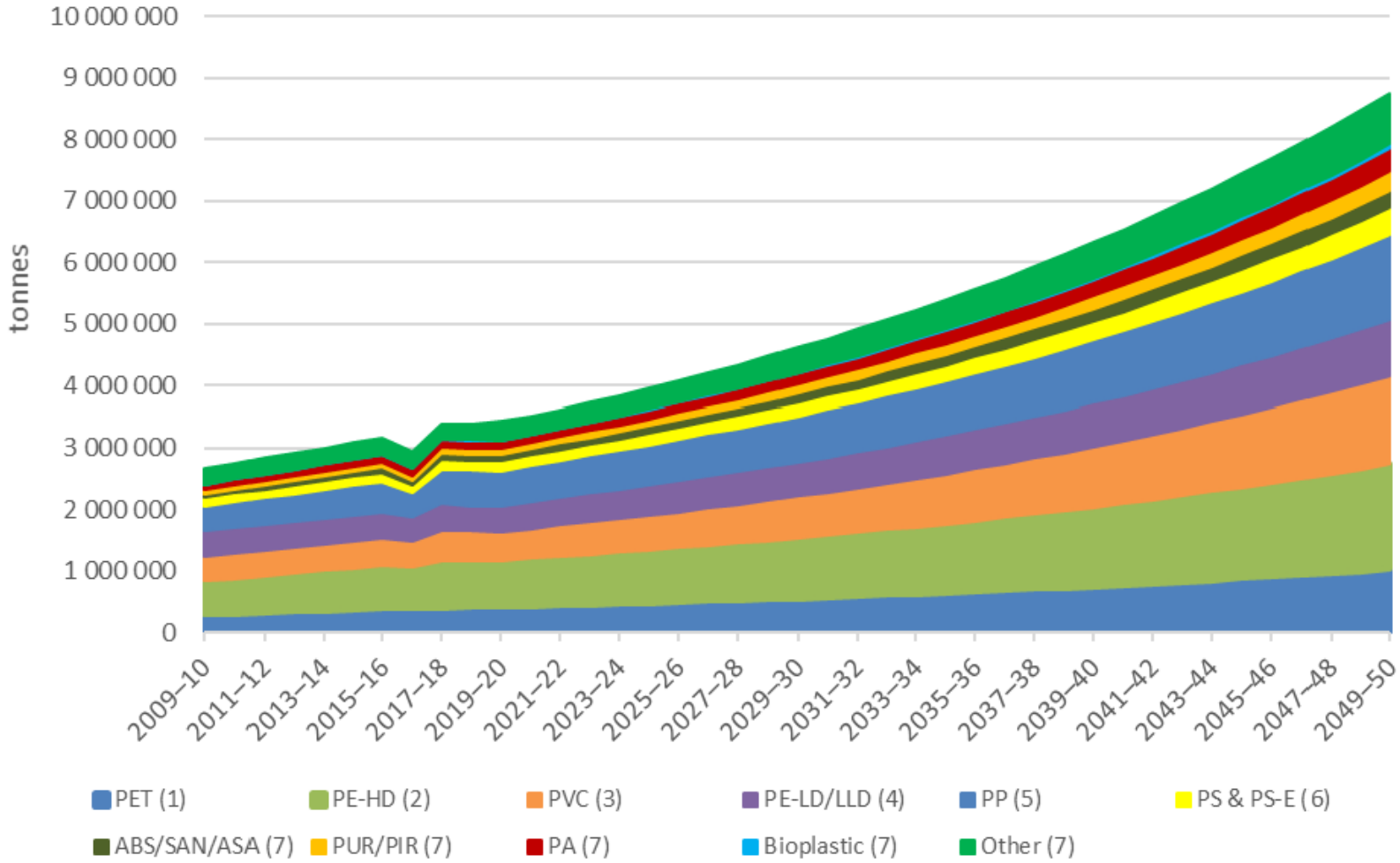
Australian Plastics Consumption

- In 2019-20, annual Australian plastic consumption was more than 3.46 million tonnes
- Less than 9.5% being recovered (326,600 tonnes)
- Of these recovered plastics, around 60% (200,300 tonnes) were locally reprocessed or recycled
- National Waste Policy Action Plan has set target of 70% of Australia's plastic packaging being recycled or composted



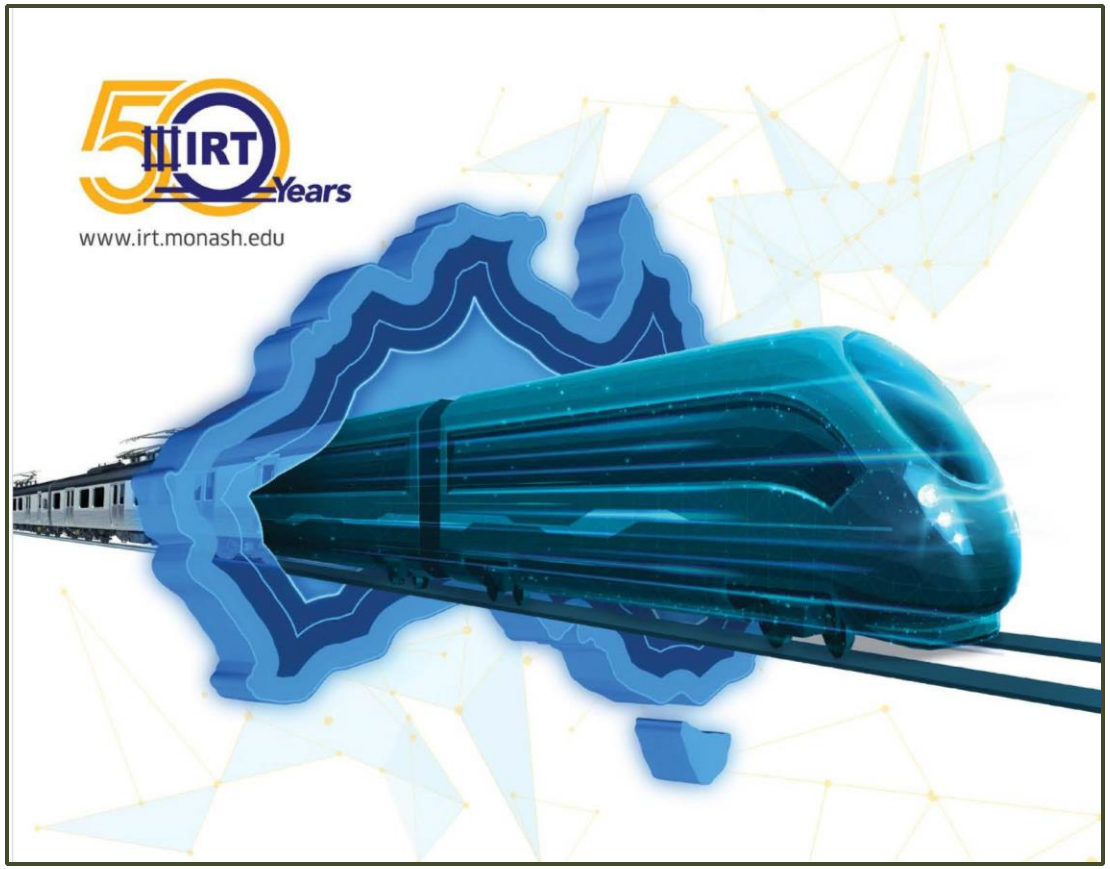
Projected Plastic Consumption

- Plastic consumption is projected to keep increasing
- Collection and recycling plastics will assist to meet Australia's net zero targets
- The critical step is expanding the capacity to transform recovered plastic waste and repurpose them into usable products



Australian plastics consumption 2009–10 to 2049–50, by polymer type
Australian Plastic Flows and Fates Study 2019-20 National Report

Monash IRT Strategic Pillars



- Advancing the Railway Industry Through Technology
- Promulgating Broader Cross Disciplinary Railway Research
- Shaping the Future of Railway

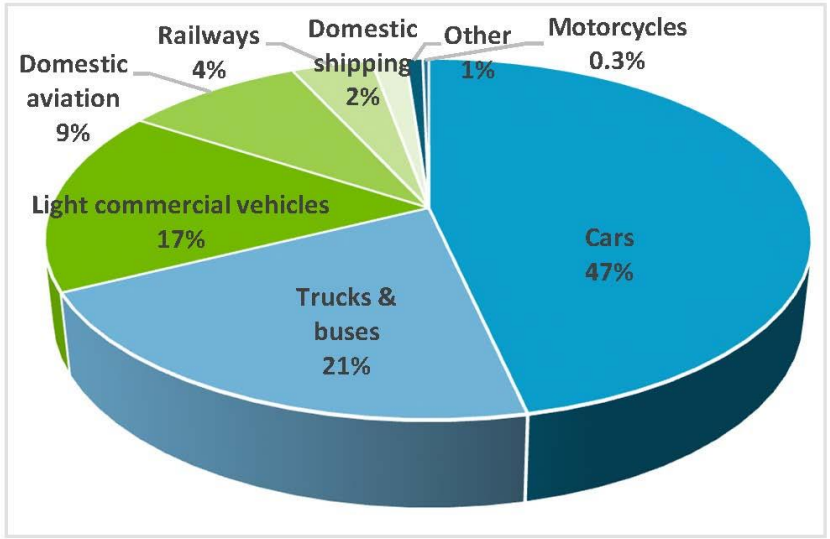
Railway System – Sustainable Transport Mode

- Monash Institute of Railway Technology has been involved in holistic applied railway research with a commitment to delivering the objectives of the United Nations' Sustainable Development Goals

Transport accounts for 18% of all of Australia's carbon dioxide emissions

Road transport accounted for around 85% of transport emissions (or about 16% of Australia's total emissions) in 2018.

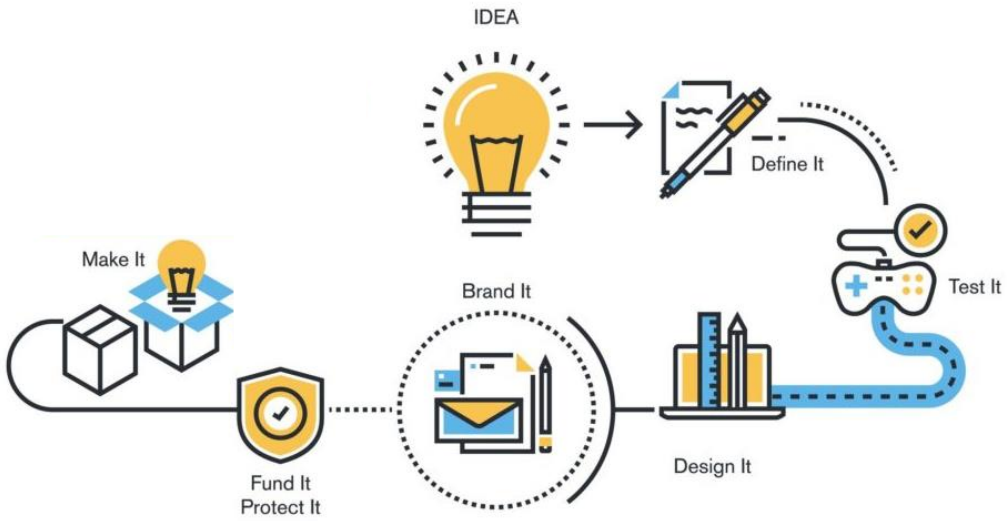
Rail transports half of Australia's freight, but produces only 4% of transport emissions.



Climate Change Authority

Contribution to Circular Economy in Railways

- Next Generation Recycled Plastic Railway Sleepers
- Develop Next Generation Easy Access Tram Stop Platforms Using Recycled Materials
- Innovative Plastic Paver Blocks for Pedestrian Walkways



Thought Leadership

Source: Sustainability Victoria

Supply Chain Collaboration – Industry, Academia and Government

Monash University
- Research Institution

Australian Circular Polymer
- Feedstock supplier

Integrated Recycling
- Manufacturer

Railway Industry
ARTC, Yarra Trams, RPV
- End user

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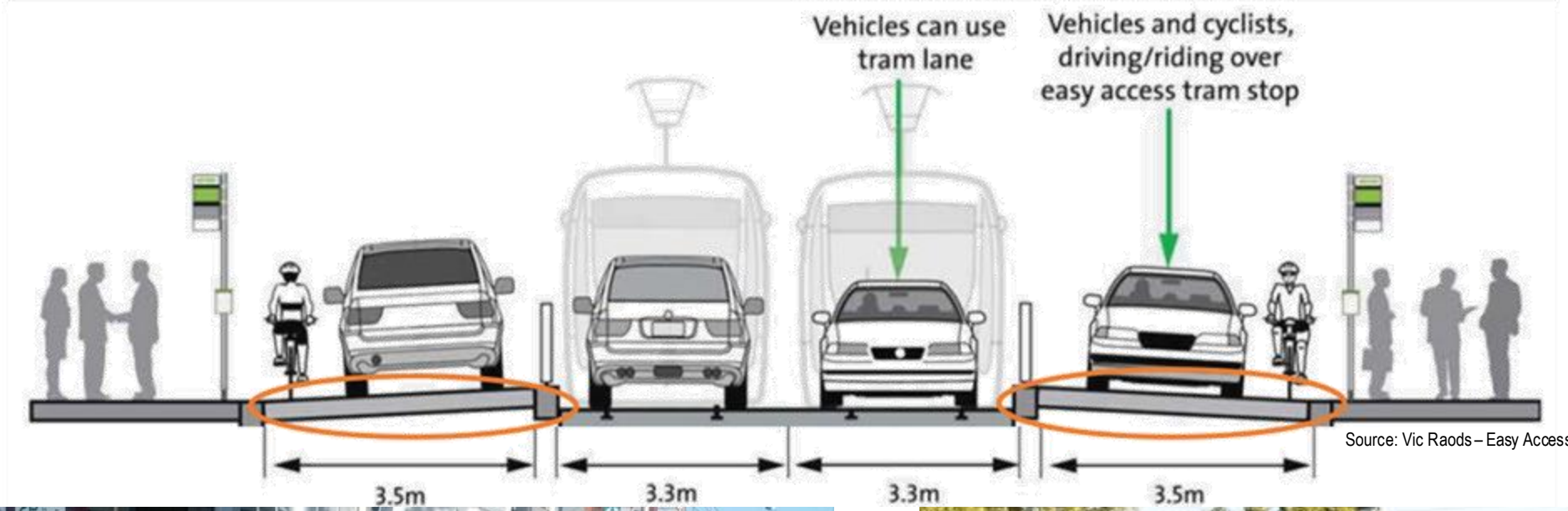
Modular Sustainable Tram Stop Platforms Using Recycled Materials

Melbourne's Tram System

- Melbourne has the largest light rail network and 2nd oldest in the world
- 24 routes, double track network stretching 250km
- 5000 services each day
- Convenient, comfortable and economical option for daily commuters
- 1669 tram stops
- Only 27% are currently level-access stops
- Level-access tram stops are one of the key enablers of accessibility
  - elderly passengers
  - people travelling with young children
  - using temporary mobility aids like crutches

Level Access Stops

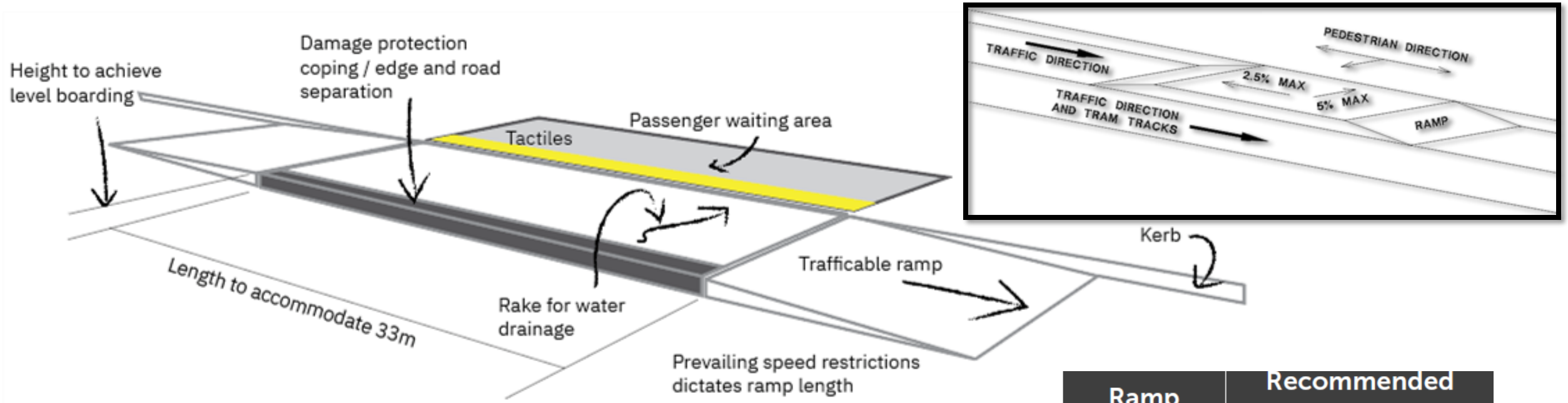


Source: Vic Raods – Easy Access Stops

Safe and Inclusive Transport Systems

Source: Public Transport Victoria

Modular Tram Stop Platform

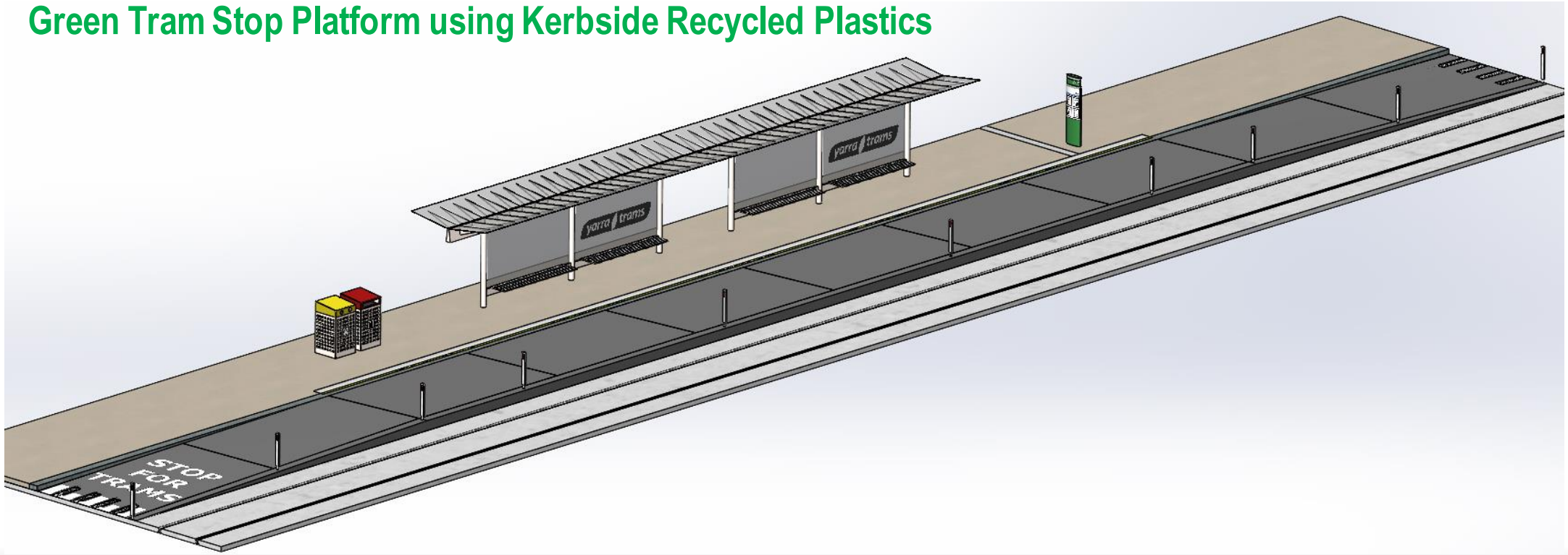


- Typical platform width: 3.1m minimum
- Typical platform length: 33.0m unless other approved
- Typical platform height: 290mm (adjacent to tram track) with 5.0% maximum crossfall to bridge the height of kerb)
- Maximum 2.5% grade

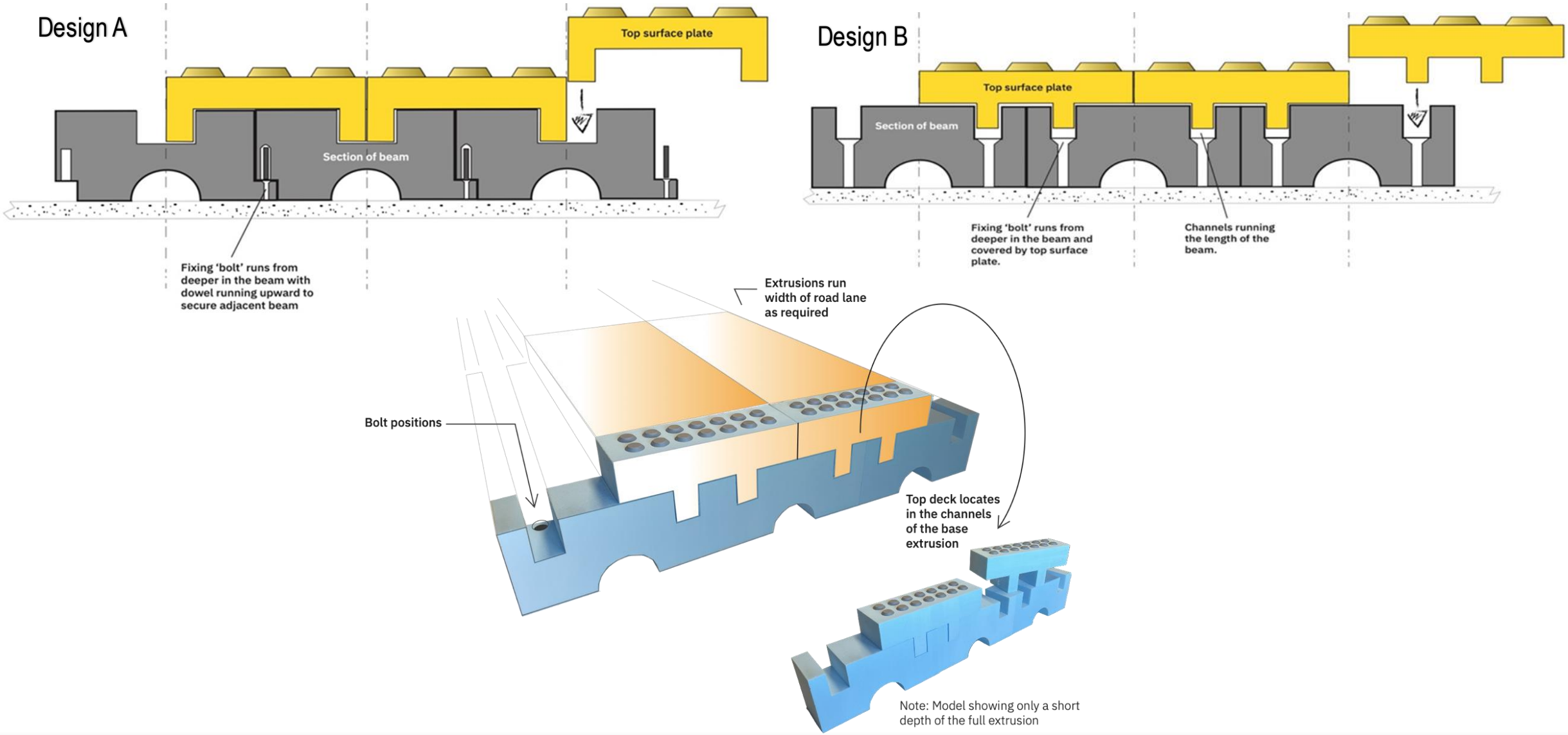
Ramp grade	Recommended maximum speed (km/h)
1:12	10
1:20	20
1:40	60
1:55	70

Functionality of Modular Tram Stop Platform

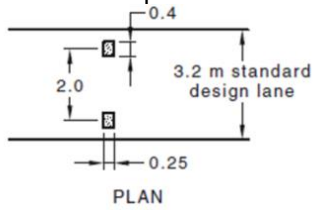
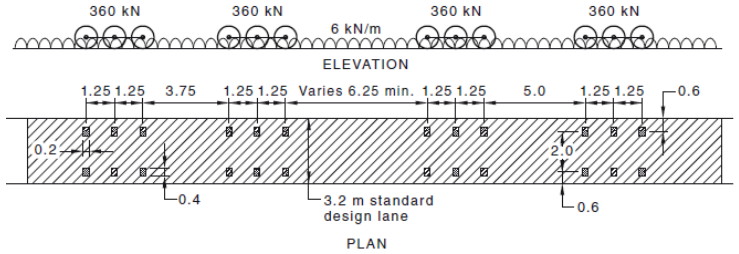
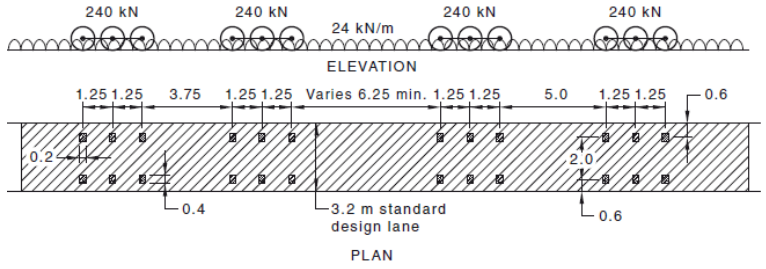
- The key requirements for innovative modular tram stop platform
  - Supporting the load
  - Level access
  - Modularity
  - Constructability and maintainability
  - Minimise impact on water ingress
  - **Green Tram Stop Platform using Kerbside Recycled Plastics**



Simple Concept Designs

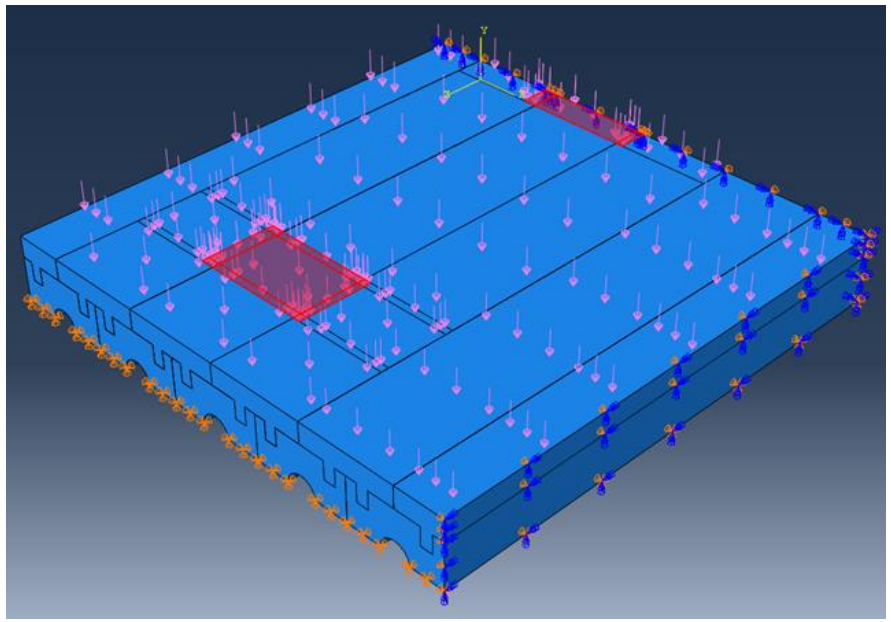


Design Loads Used in the FEA Analyses

Load Case	Type	Load	Load Application
W80	Single wheel load	80kN	Load distributed to 400 mm X 250 mm wheel/road contact area; application to anywhere on the roadway surface
A160	Single axle load	160kN axle load	The axle shall be positioned as below: 
M1600	Moving traffic load	360kN tri-axle load + 6kN/m uniform load distribution	The uniformly distributed load shall be superimposed to tri-axle load as below: 
S1600	Stationary traffic load	240kN tri-axle load + 24kN/m uniform load distribution	The uniformly distributed load shall be superimposed to tri-axle load as below: 

Design Loads Used in the Preliminary FEA Analyses

Example Of M1600 Loading Case With A Quarter Model Established, 360kN Tri-axle Load Is Applied onto The Highlighted Areas



Load Case	Current Study		Previous Study [1]	
	σ_{Max} (MPa)	μ_{Max} (mm)	σ_{Max} (MPa)	μ_{Max} (mm)
W80-1	1.15	0.16	2.1 – 18.8	0.2 – 6.0
W80-2	1.16	0.32		
W80-3	1.61	0.43		
A160	1.17	0.15	2.3 – 13.5	0.3 – 3.5
M1600	0.94	0.22	6.3 – 14.9	0.7 – 4.6
S1600	0.64	0.08	4.3 – 10.1	0.5 – 3.2

Maximum stress and deformation obtained from FEA

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Next Generation Composite Plastic Railway Sleeper for Mainline Rail Application

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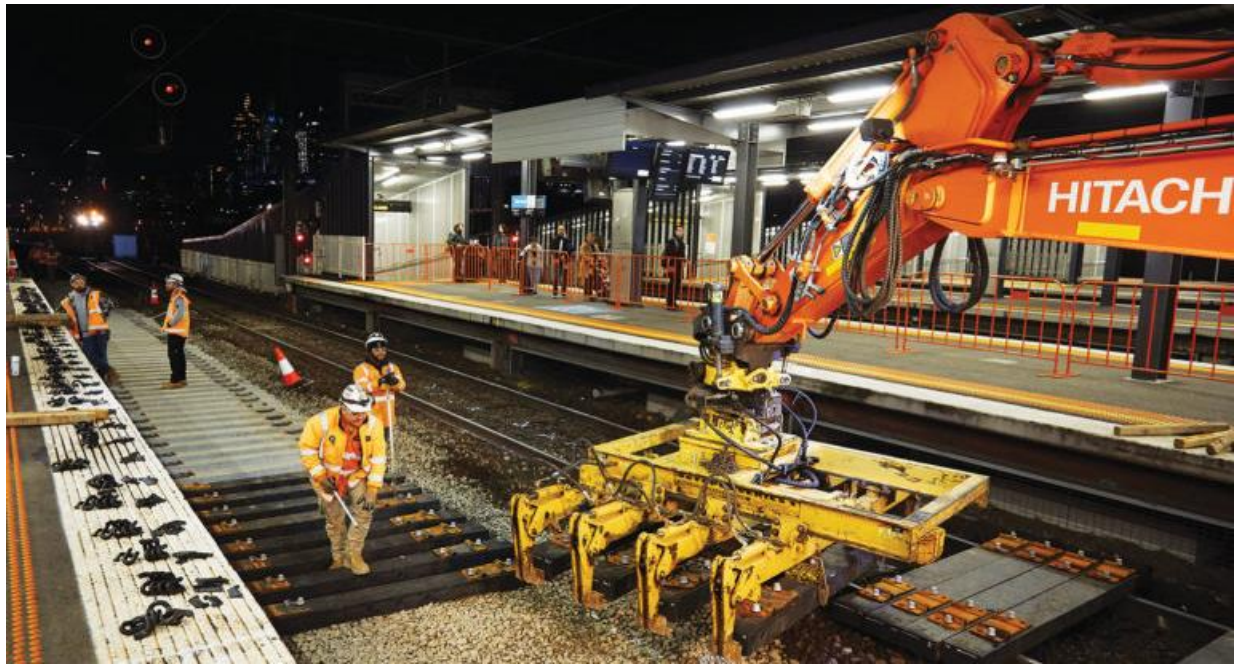
Environmental Benefits of Plastic Sleepers

- One kilometer of sleepers (approximately 1,500 sleepers) will utilise a total of ~80 tonnes of recycled plastic
- This equates to ~150 trees saved and 210 m^3 of landfill space saved
- Current expectations are that composite plastic sleepers will last 3 times longer than timber sleepers



Australian Railway Sleepers

- Australian recycled composite plastic sleepers are currently replacing timber sleepers in low speed sidings
- Next generation recycled plastic railway sleepers project aims to meet the mainline railway requirements
- Next generation recycled plastic railway sleepers will be fit-for-purpose concrete sleeper substitution and to replace timber and steel sleepers
- Next generation recycled plastic railway sleepers will be a game changer for the current plastic waste crisis

State		Track Length (km)	Timber	Concrete	Steel	Other	Total
Number Sleepers	NSW	8,314	868,547	8,205,779	4,451,955	32,131	13,558,412
	VIC	6,518	5,498,000	3,552,000	-	-	9,505,000
	QLD	7,469	1,869,813	7,720,112	1,568,284	-	11,158,209
	SA	3,559	691,716	4,133,134	486,940	-	5,311,791
	WA	6,206	1,749,084	5,364,921	1,746,979	-	8,860,984
	NT	1,742	-	2,599,552	-	-	2,599,552
	TAS	521	309,262	99,098	444,918	-	853,279
	AUS	34,329	10,986,422	31,674,596	8,699,076	32,131	51,847,227

Objectives - Next Generation Recycled Plastic Railway Sleepers

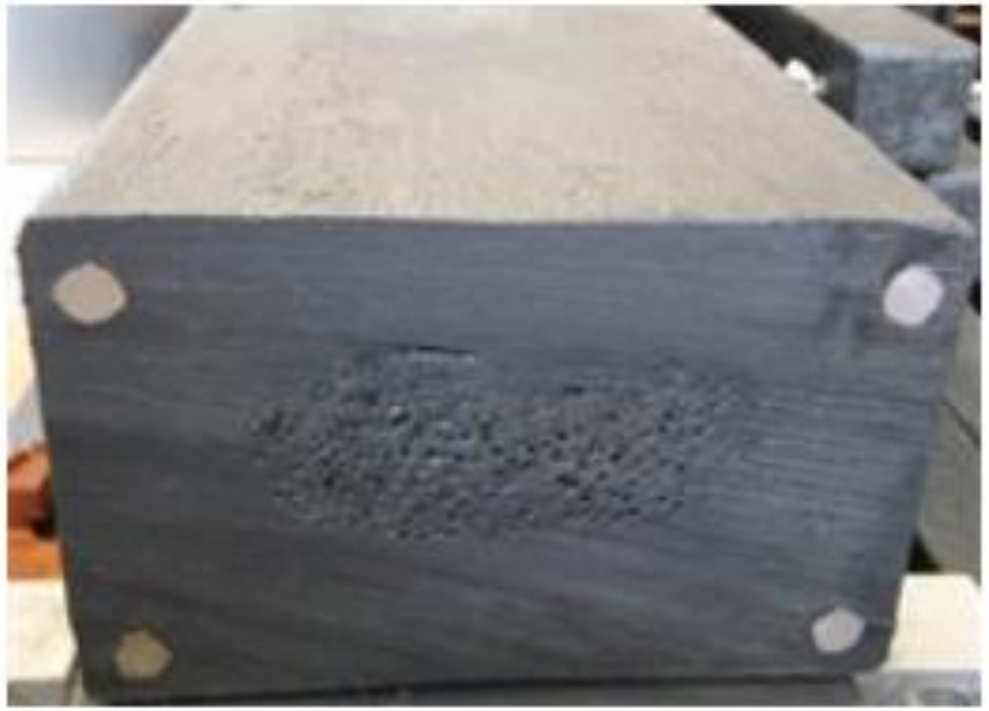
- Improve strength and stiffness
- Improve the capacity of fastening system
- Improve fatigue performance
- Eliminate or minimise permanent deformation due to creep with temperature variations
- Eliminate local failure before design life due to formation of voids in the body of sleepers
- Improve understanding of the long term performances of composite sleepers and remove misconception
- Reduce manufacturing cost of sleepers

Most Suitable Recycled Plastic Mix

- The formulation currently in use for recycled plastic sleepers (as a timber replacement) within Australia is similar to many products trialed across the world
- Failures have occurred both in terms of **bending strength (fatigue)** and **fastener performance**
- Research to improve the formulation to improve both the fatigue properties of the material as well as fastener performance
- Utilising available recyclable materials including quantity, ability to recover and likely cost
- Formulation focus on
  - Increase product density
  - Reduce porosity in the core
  - Minimise the deformation under loading

Strengthening of Composite Sleepers

- Unreinforced composite sleepers typically have much lower strength than existing sleeper types
- Introducing reinforcement to withstand the loads and tonnages imposed by mainline railway traffic including freight and heavy haul railroads



Combination of strengthening to form hybrid structure to strengthen recycled composite to compete with concrete sleepers

Cast-in Shoulder Design

- All concrete sleepers use a cast-in shoulder design to achieve the maximum fastening capacity and efficient rail installation
- Composite sleepers with cast-in shoulders is not currently available in the market
- Cast-in shoulders will further reduce carbon foot print of composite plastic sleepers

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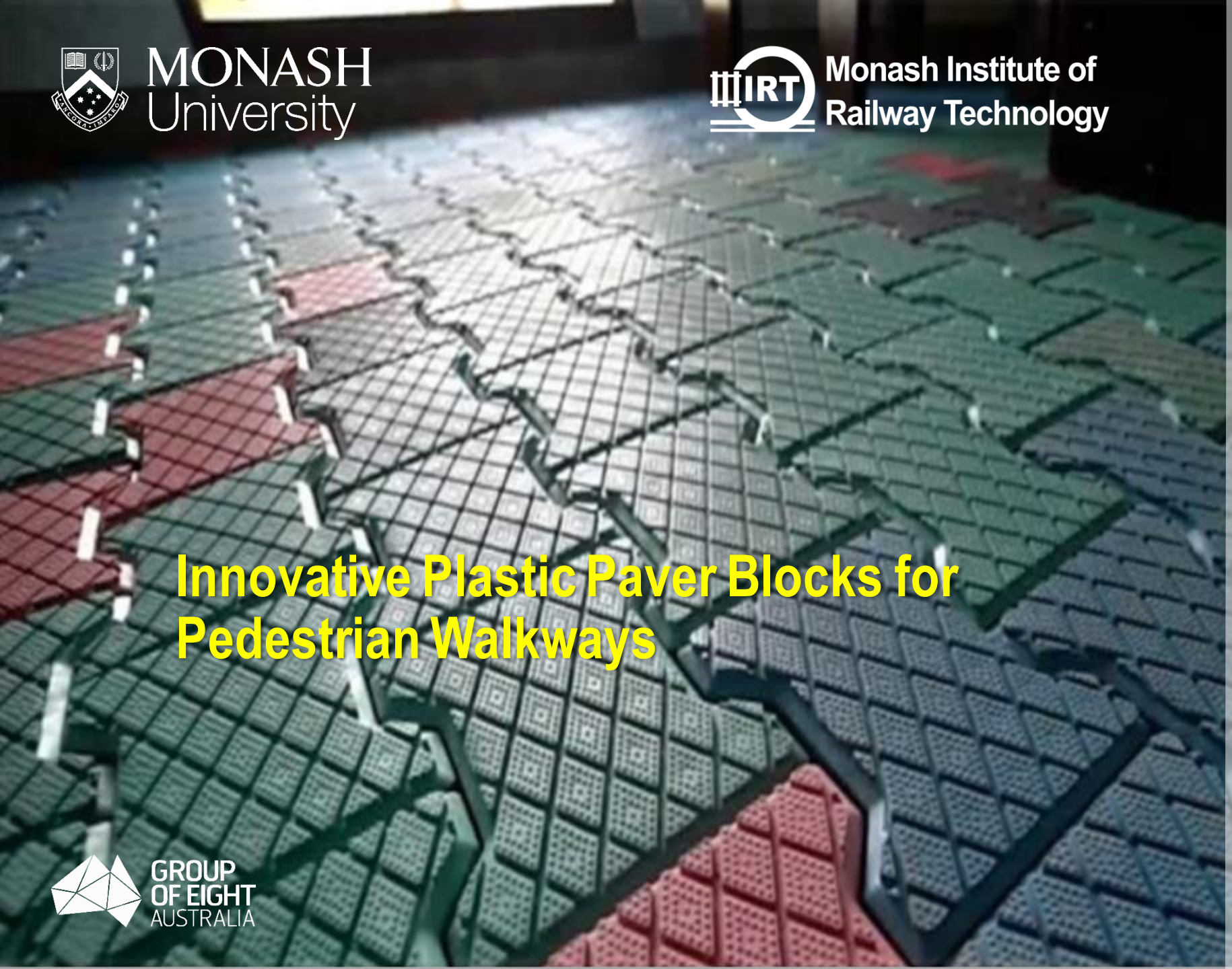

Innovative Plastic Paver Blocks for Pedestrian Walkways

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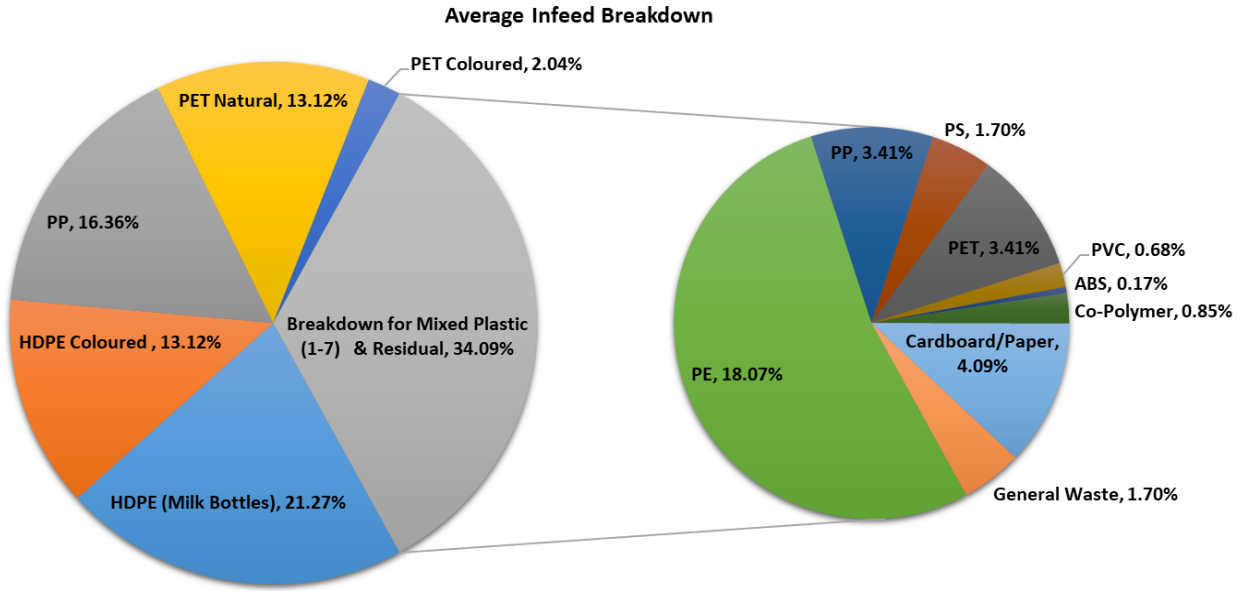
Low Value Feed Stock

- In 2019-20, 3.5 million tonnes of plastic was consumed[1]
- National plastic recovery rate was less than 10%
- Only 62% of this is reprocessed locally
- Low value mixed HDPE + PP stream
- Consideration of soft plastics



Plastic Waste Processing Breakdown[2]
(data from Advanced Circular Polymers processing facility)

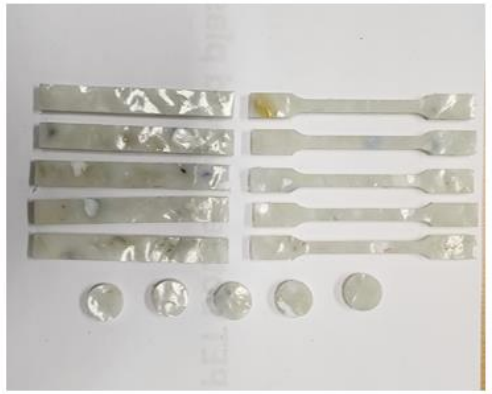
1. https://www.sustainability.vic.gov.au/research-data-and-insights/waste-data/annual-waste-data-reports
2. Position paper prepared by Monash Institute of Railway Technology, 15 Feb 2021, Contribution to the circular economy through improved railway sleepers manufactured using recycled plastics

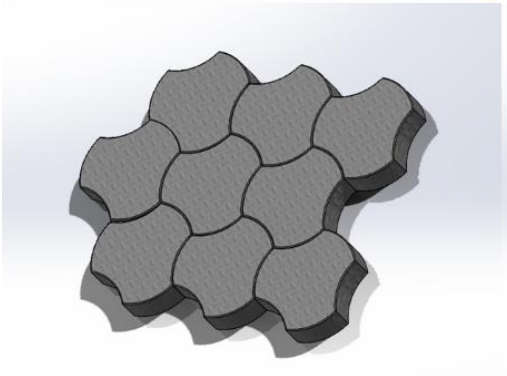
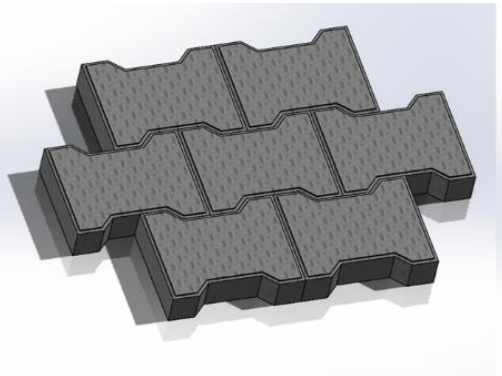
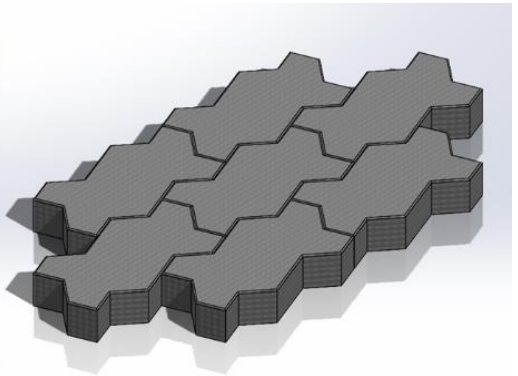
Low Value Plastic Recovered from Recycled Stream

Project Focus

- Material formulation
- Sample evaluation
- Interlocking modular design



Next Generation Recycled Materials in Railways

- Improved Environment
  - 2.8 million tonnes of plastic
- Enabler to motivate to recycle household plastics
- Significant contribution towards achieving net zero targets
- More permanent jobs through smart manufacturing
- Economical benefits
  - Global railway sleeper market worth an estimated A$1.01 billion in 2020
  - Expected to continue to grow at a Compound Annual Growth Rate of 4.0% during 2021-2026

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