

GLASS ASPHALT DEVELOPMENT

**ROAD PAVEMENTS FORUM
THIRTY-FOURTH MEETING
CSIR International Convention Centre,
Pretoria, Gauteng**

14 & 15 November 2017

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CSIR Built Environment

Acknowledgements

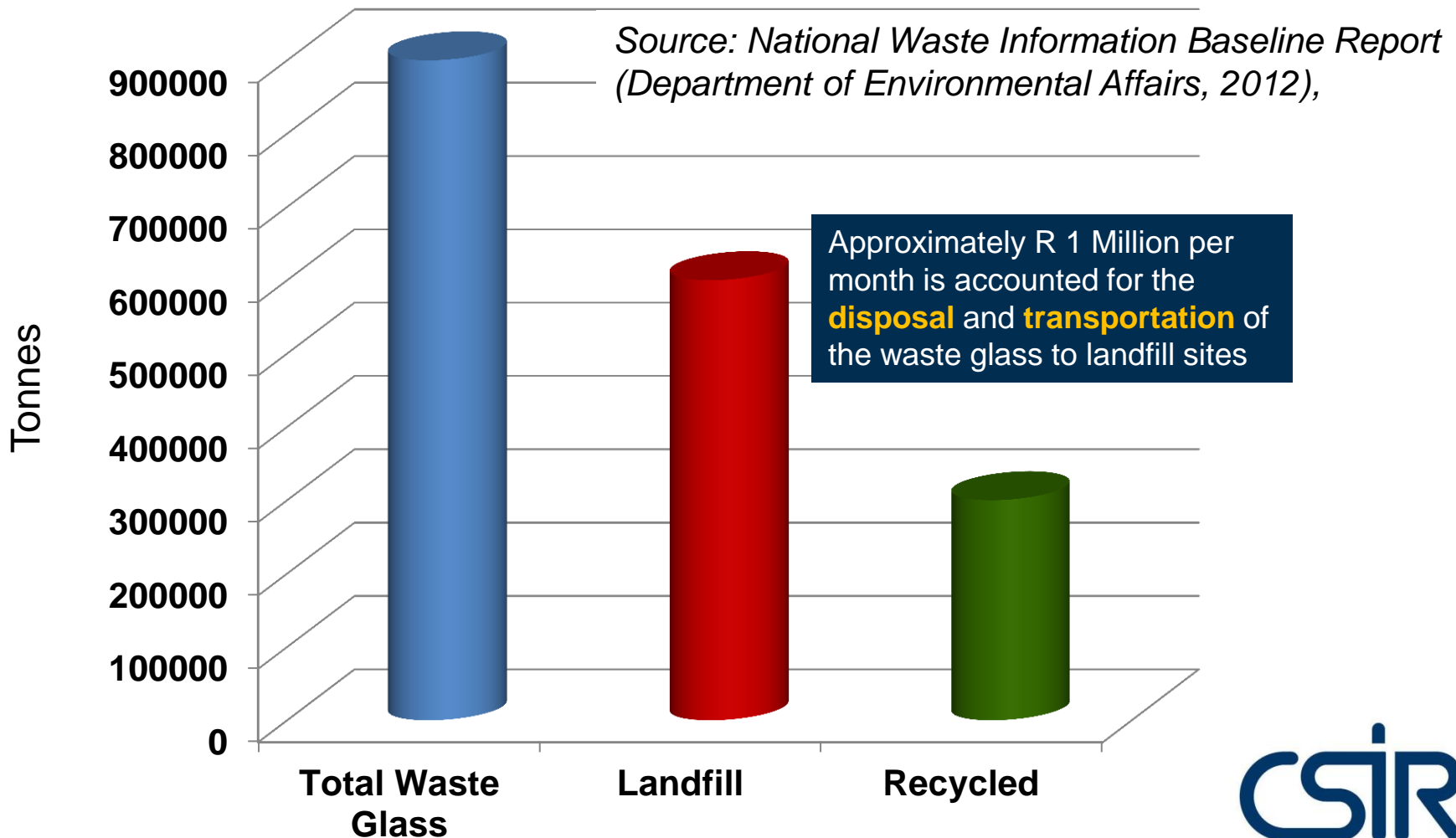
- ***FUNDING FOR THE STUDY WAS PROVIDED BY THE CSIR R&D OFFICE***
 - ***CONSOL GLASS***
 - ***MUCH ASPHALT***

Core Team

Joseph A Boateng, PI

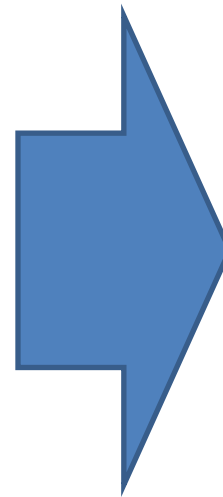
Theresa George, Researcher

Background: Waste glass generated in SA (2011)



Background: Waste glass generated in SA

- CONSOL GLASS recycles **13 000 t** crushed glass per month
 - **3 000 t**, representing glass < 5 mm, is considered as waste
- **Substantial quantity of waste glass is available for exploitation in SA...!**



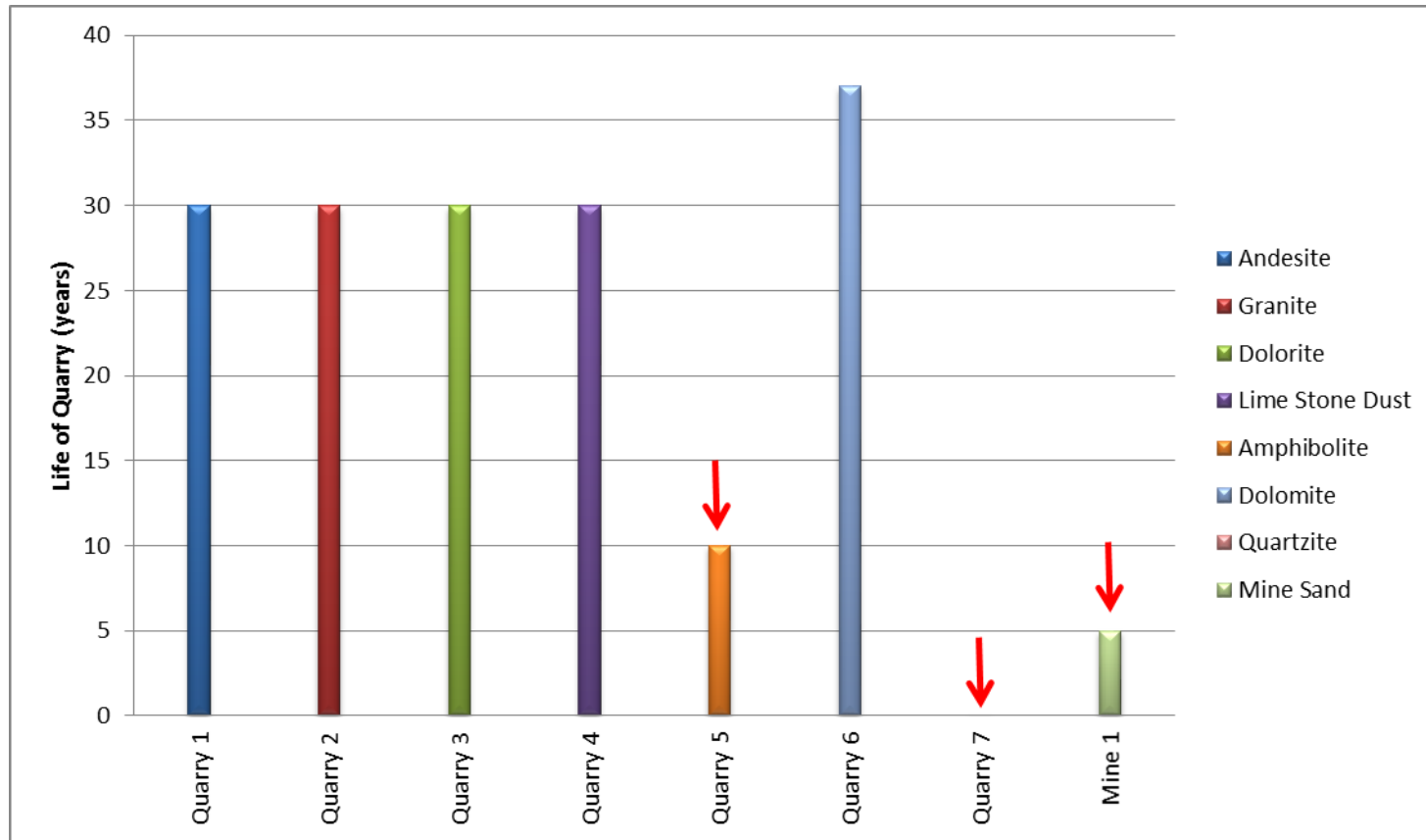
Background: Need for waste glass asphalt..???

DST has launched a Waste Research, Development and Innovation roadmap, which aims to reduce the amount of waste products taken to landfills by 20% by 2022



- ***CSIR BE: Develop asphalt mix that utilises waste crushed glass as aggregate replacement***

Eight aggregate quarries in GP



Benefits of glass in asphalt

- **Glass is reflectiveness** – assist with improving visibility under lights
- **Water-resistant** – roads drying faster after rainfall thereby improving safety
- Crushed glass can be used to **reduce the amount of bitumen** – the most expensive component – **reducing the cost of road construction**
- Glass is **recyclable and biodegradable**
- Can be easily sourced, as significant amounts are readily available at South African landfills
- Crushed glass' **low density** means that it provides **more volume per tonne**

Waste glass utilisation in roads



Countries utilising waste glass

- USA
- Australia
- New Zealand
- Taiwan
- Japan
- UK

Initial costs

Alternative Materials					
	Glass		Slag		RAP
COST OF MATERIAL/TON					
Delivered Price (C_{DP})	R 200.00		R 300.00		R 270.00 + *Testing
Price of Raw Material (P _{RM})	R 0.00		R 140.00		R 0.00
Cost of Processing the Material (C _{PR})	R 0.00		Included in P _{RM}		R 90.00+ *Testing
Cost of Stockpiling the Material (C _{ST})	R 0.00		Included in P _{RM}		R 0.00
Cost of Loading the Material (C _{LD})	R 70.00		Included in P _{RM}		R 20.00
Cost of Transporting the Material (C _{TR})	R130.00		R 160.00		R 160.00
Virgin Materials					
	Andesite (9.5 mm)	Andesite (6.7 mm)	Andesite (Crusher Dust)	Granite (Crusher Sand)	Mine Sand
COST OF MATERIAL/TON					
Delivered Price (C_{DP})	R 330.00	R 330.00	R 355.00	R 340.00	R 340.00
Price of Raw Material (P _{RM})	R 170.00	R 170.00	R 195.00	R 180.00	R 180.00
Cost of Processing the Material (C _{PR})	Included in P _{RM}	Included in P _{RM}	Included in P _{RM}	Included in P _{RM}	Included in P _{RM}
Cost of Stockpiling the Material (C _{ST})	Included in P _{RM}	Included in P _{RM}	Included in P _{RM}	Included in P _{RM}	Included in P _{RM}
Cost of Loading the Material (C _{LD})	Included in P _{RM}	Included in P _{RM}	Included in P _{RM}	Included in P _{RM}	Included in P _{RM}
Cost of Transporting the Material (C _{TR})	R 160.00	R 160.00	R 160.00	R 160.00	R 160.00
Profit (P)	-	-	-	-	-

*Cost of additional testing prior to processing (binder recovery, penetration and softening point)

Glass Asphalt Mix

- *Design of hot mix asphalt that utilises a waste crushed glass (< 5 mm) as a substitute material to a conventional aggregate (crushed sand)*
- *Reference mix*
 - **13.2 mm medium dense-graded**
 - **50/70 pen grade binder**
- Mix design method (Sabita Manual 35, 2016)
- Mix performance-related /engineering properties
 - durability
 - Stiffness
 - Permanent deformation
 - Fatigue cracking

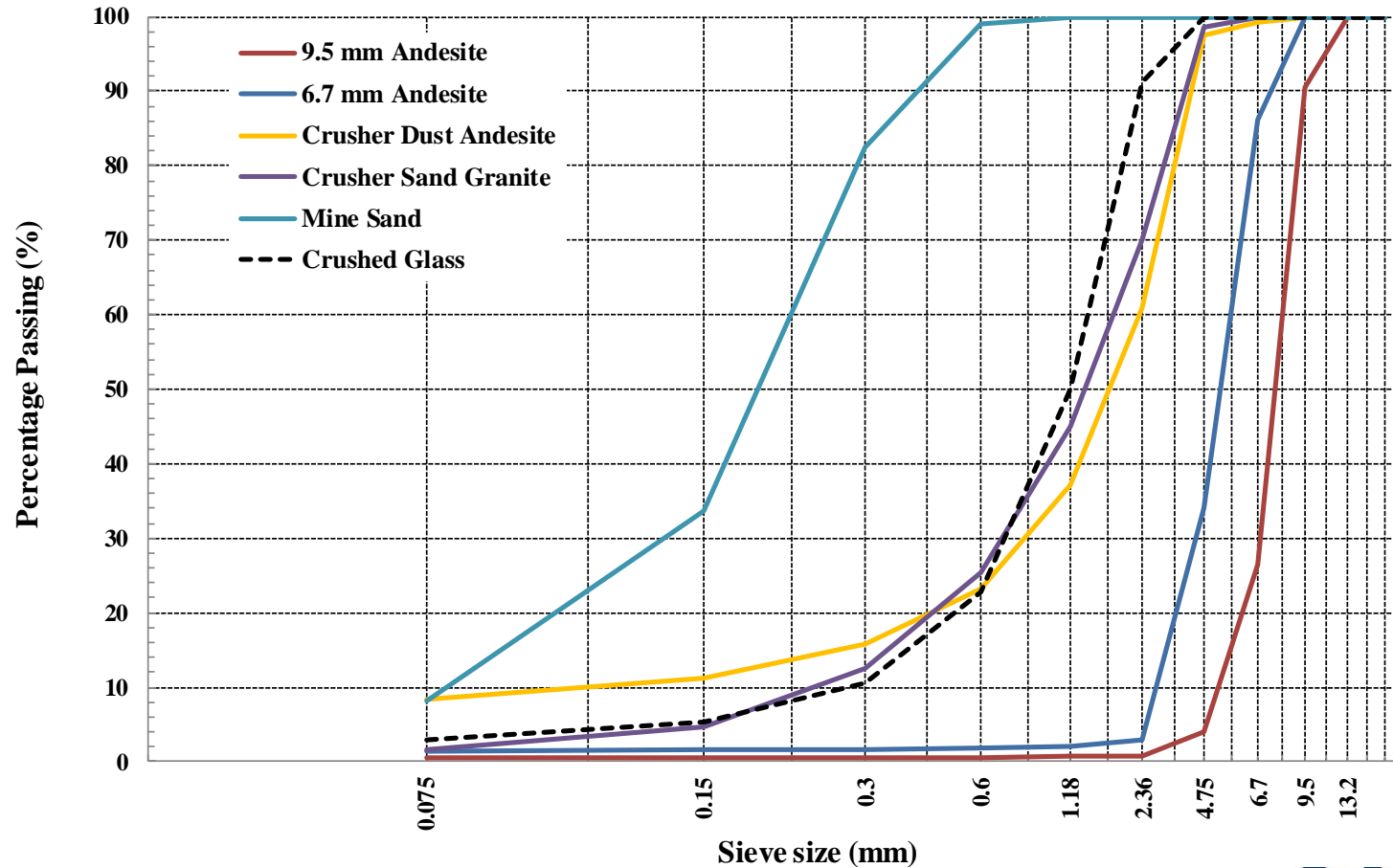
Glass Asphalt Mix

Reference Asphalt Mix

Aggregate grading & properties

Aggregate Property	Aggregate Type	Andesite 9.5 mm	Andesite 6.7 mm	Andesite Crusher Dust	Granite Crusher Sand	Mine Sand	Waste Crushed Glass	Hydrated lime
Grading	19.0mm	100	100	100	100	100	100	100
	13.2mm	100	100	100	100	100	100	100
	9.5mm	91	100	100	100	100	100	100
	6.7mm	26	86	99	100	100	100	100
	4.75mm	4	34	98	99	100	100	100
	2.36mm	1	3	61	70	100	91	100
	1.18mm	1	2	37	45	100	50	100
	0.6mm	1	2	23	25	99	23	100
	0.3mm	1	2	16	13	82	11	100
	0.15mm	1	2	11	5	34	5	100
	0.075mm	0.4	1.4	8.3	1,5	8.1	2.8	99
Density	Bulk Relative Density	2.884	2.887	2.816	2.628	2.600	2.489	2.861
	Apparent Relative Density	2.919	2.928	2.956	2.676	2.634	2.519	--
	Absorption	0.4	0.5	1.7	0.7	0.5	0.5	--
Sand Equivalent	Criteria ≥ 50	N/A	N/A	69	77	56	74	--
FAA	Criteria of 45 min, 30 M E80	N/A	N/A	39.7	38.3	48.3	51.3	--

Aggregate Grading & Properties



X-Ray Diffraction (XRD) analysis

Glass Cullet Fraction (mm)	Crystalline Silica (Quartz) (%)	Amorphous Silica (Glass) (%)
-0.075	10.56	89.05
0.075	10.21	89.62
0.150	9.39	87.51
0.300	12.02	90.59
0.425	9.39	95.08
0.600	3.13	96.71
1.180	1.82	97.94
2.360	1.40	98.60

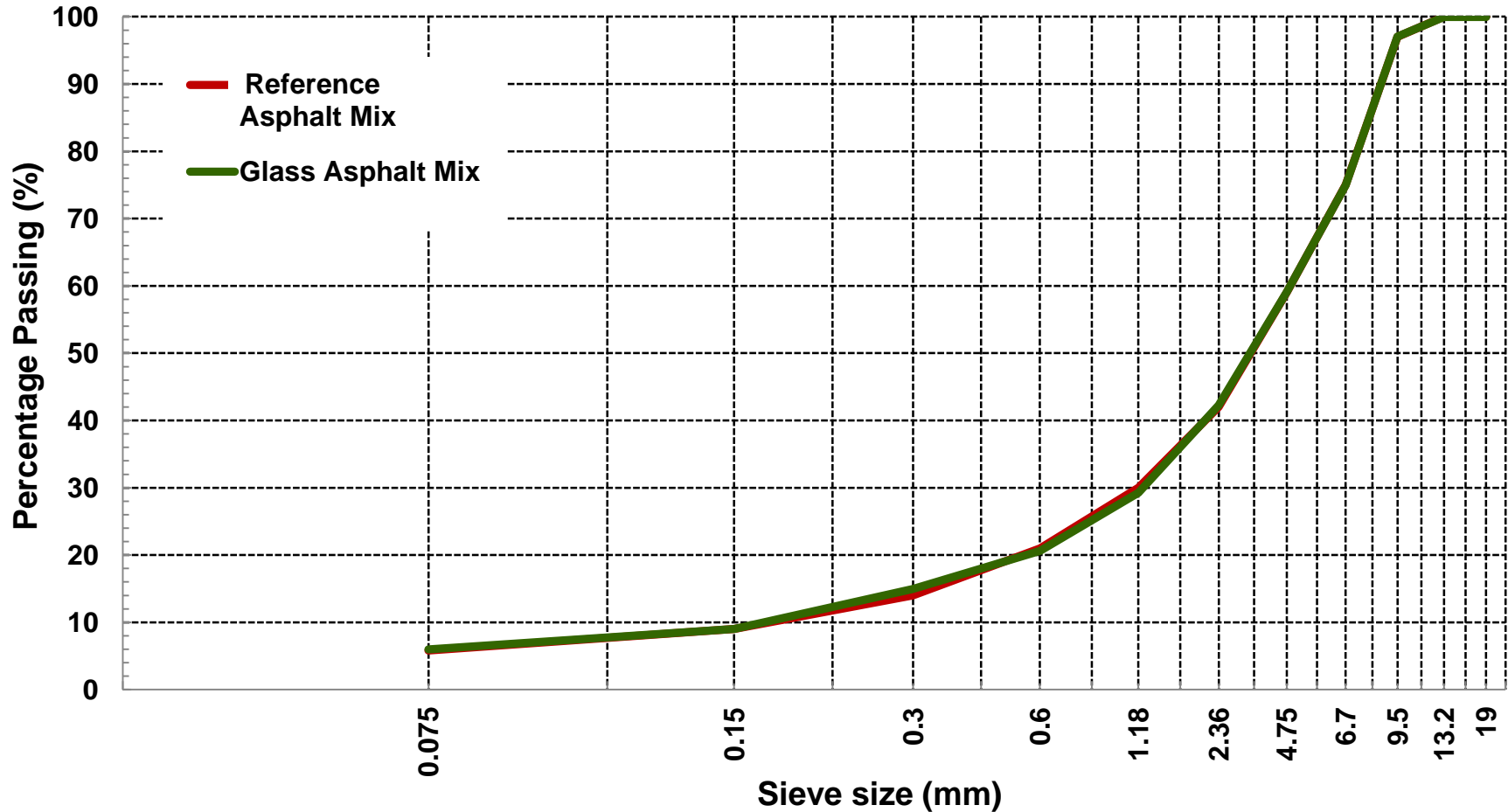


Mix proportions & design grading

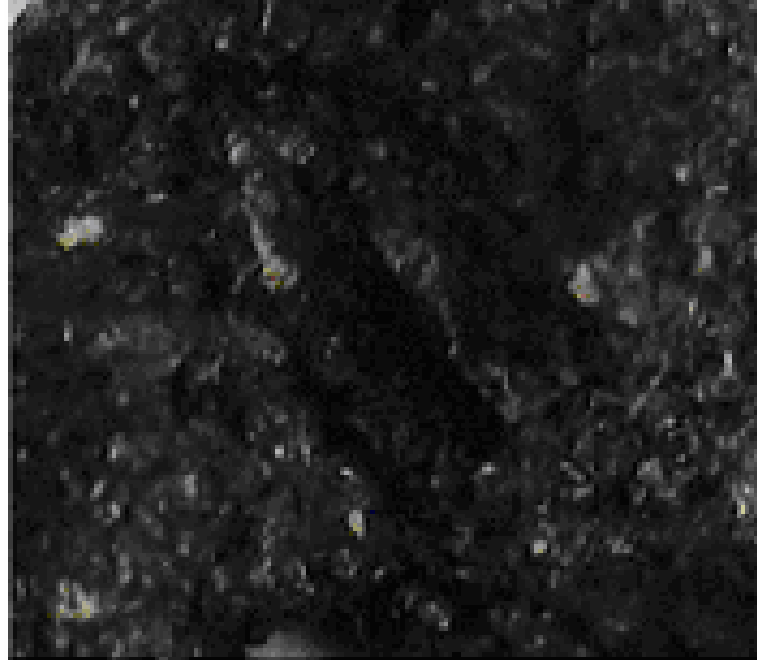
Nominal size (mm)	Aggregate Type	Reference Mix Proportion	Glass Mix Proportion	Sieve Size (mm)	Ref. Mix Design Grading (% Passing)	Glass Mix Design Grading (% Passing)
9.5	Andesite	21%	31%	13.2	100	100
6.7	Andesite	24%	16%	9.5	97	97
Crusher dust	Andesite	26%	18%	6.7	75	75
Crusher Sand	Granite	25%	10%	4.75	59	59
Mine Sand	Mine Sand	3%	7%	2.36	42	42
Crushed Glass	Glass	--	15%	1.18	30	29
Filler	Mineral Filler	1%	--	0.6	21	21
Filler	Hydrated Lime	--	3%	0.3	14	15
				0.15	9	9
				0.075	5.8	6.0

OBC: Glass = 5.1%; Ref = 5.0%

Mix Design: Design Grading



Durability (Stripping potential)



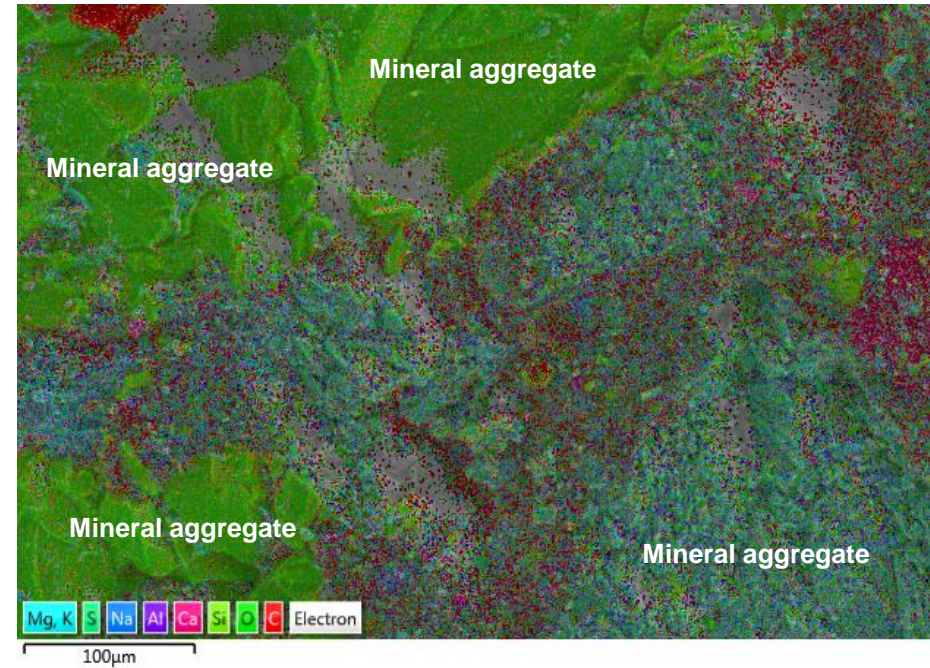
Characteristic	Glass Asphalt		Reference Asphalt	
	Wet Subset	Dry Subset	Wet Subset	Dry Subset
Tensile Strength	721 kPa	845 kPa	808 kPa	946 kPa
TSR	0.85 > 0.80		0.85	
Visual moisture damage	No moisture, minor stripping	No moisture, minor stripping	No moisture, minor stripping	No moisture, minor stripping
Cracked / broken aggregates	None	None	None	None

Scanning electron microscopy (SEM)

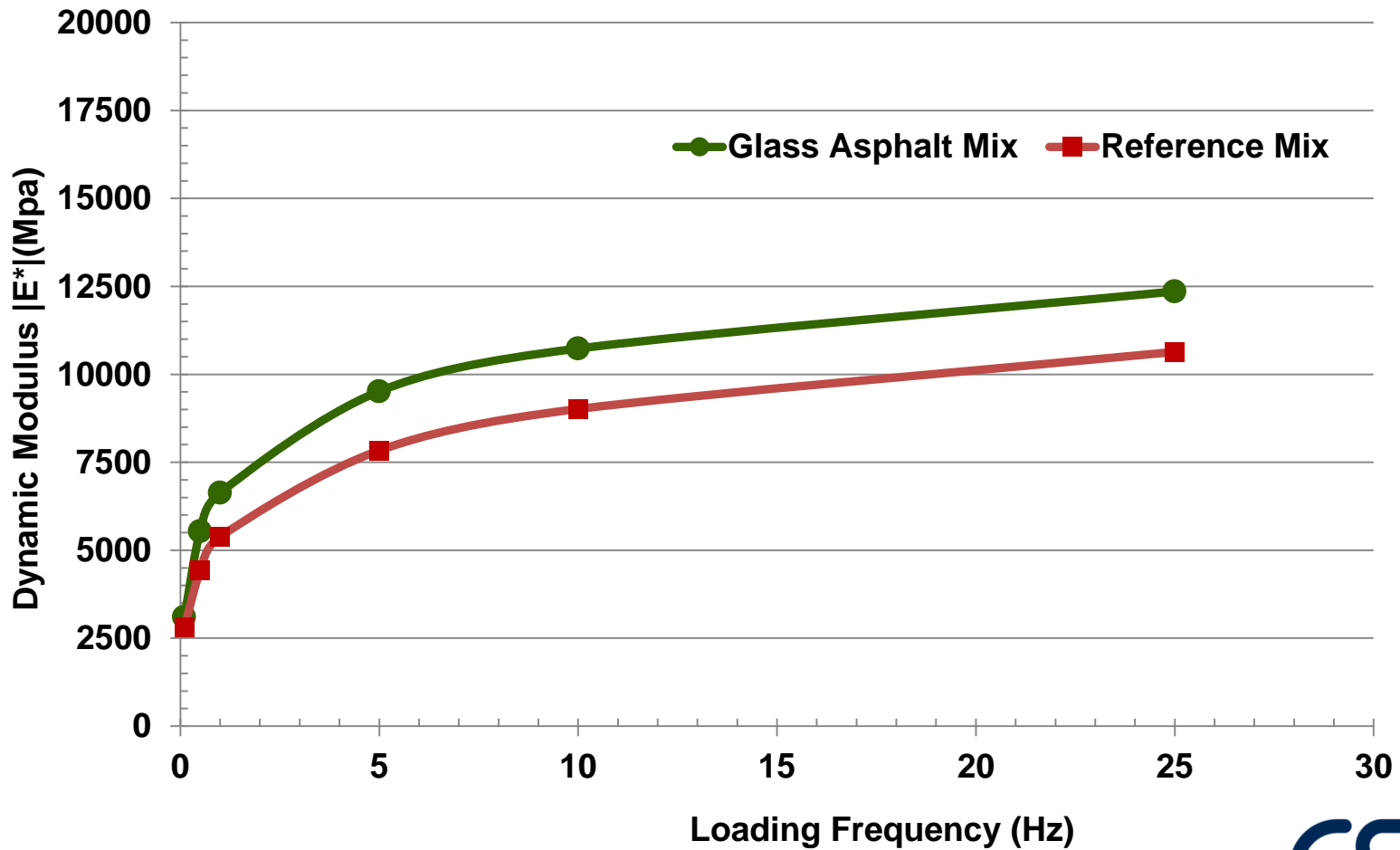
Asphalt mix with waste glass



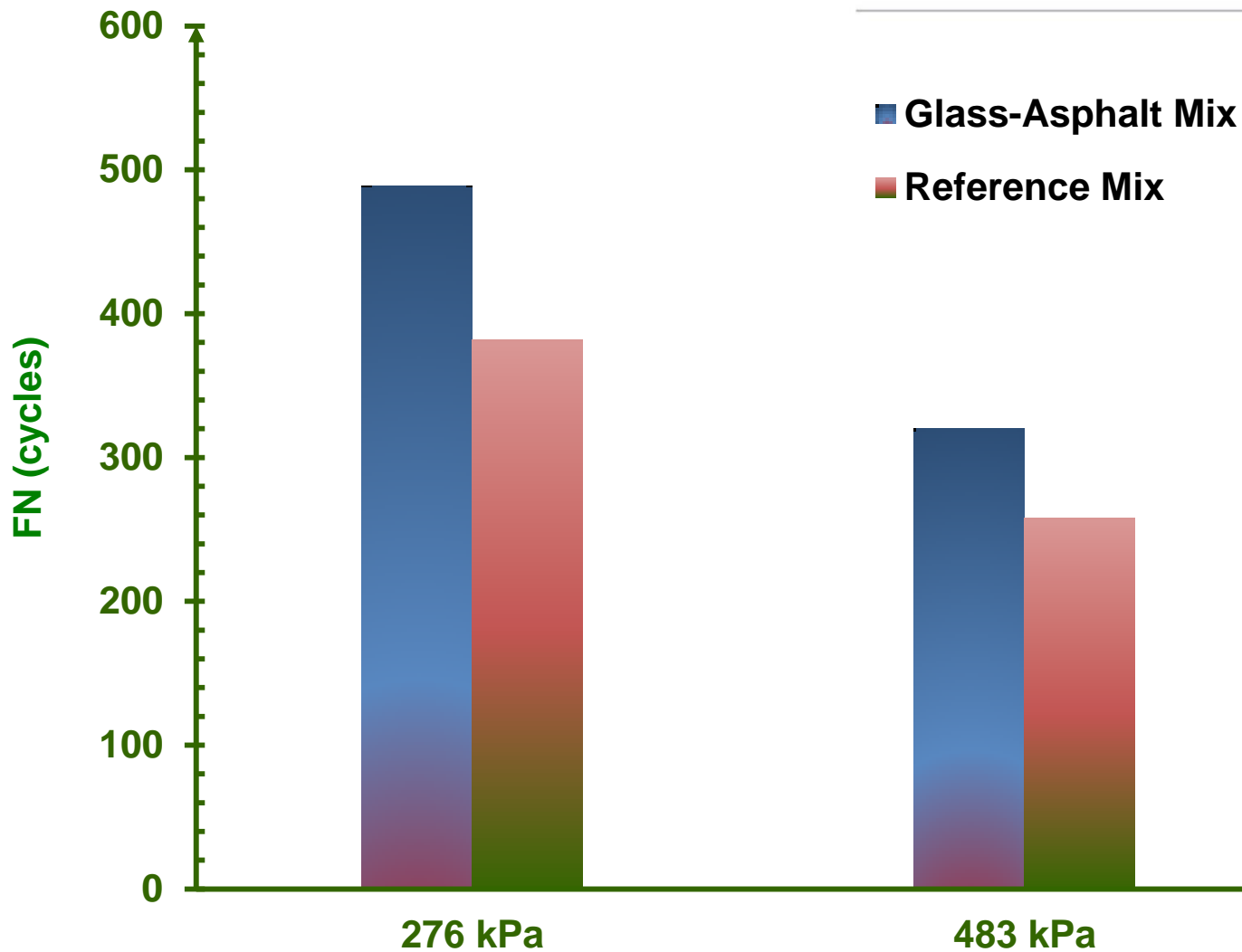
Asphalt mix without waste glass



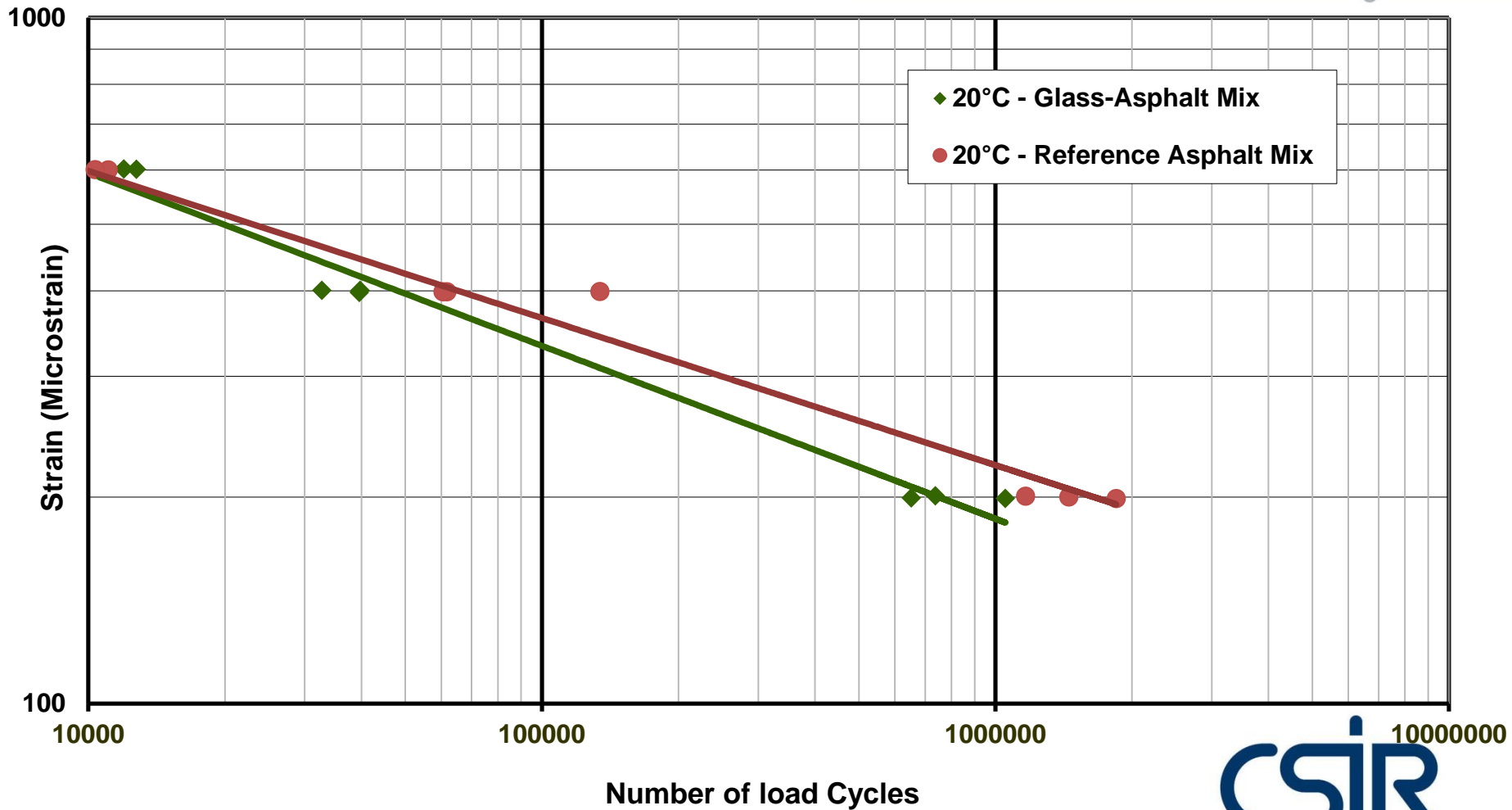
Stiffness



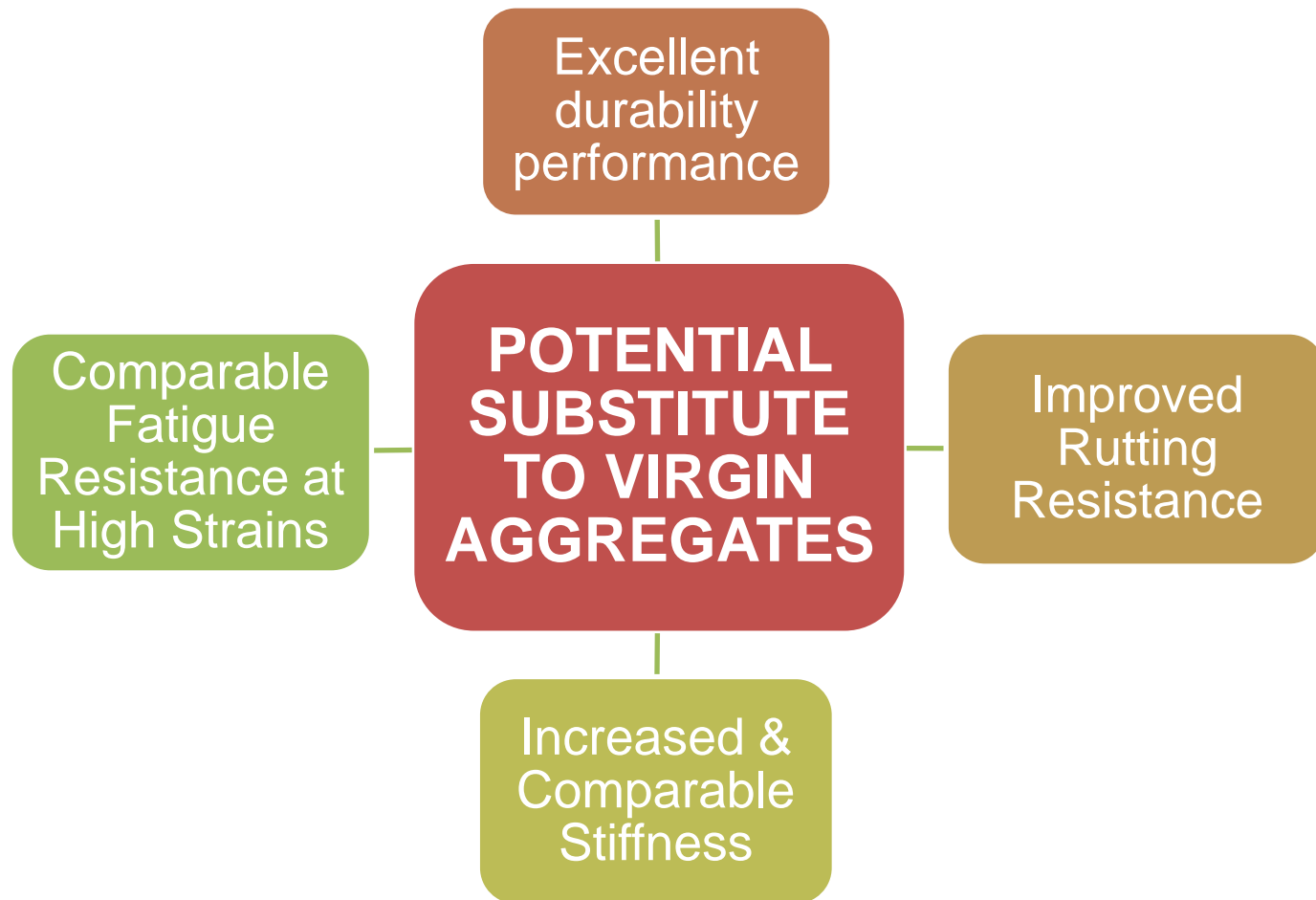
Flow number (Rutting potential)



Fatigue cracking resistance



Summary



Economical, Environmental & Performance benefits

Roadmap

Finalise glass
asphalt mix
design

Develop glass
asphalt design
guideline

Construct
demonstration
sections; cost
benefit
analysis



CSIR investigates road applications for waste materials



25th November 2016

By: [Nadine James](#)
Journalist

Photo by Duane Daws

THE BUS STOPS HERE Transport systems depend on the quality and sustainability of the associated infrastructure, therefore government has to invest in infrastructure to increase mobility and grow the economy