Recycled Materials in Road Pavement Construction

Welshpool Road – A City of Canning demonstration project

Collaborating with the road industry to turn **knowledge into practice**

Recycled Materials in Road Construction

Welshpool Road – A demonstration Project

Welshpool Road

- 4 lane undivided lane carrying significant heavy traffic including road trains and extra wide loads
- Widened to 4.5m each side to 4 lanes divided
- Design traffic 2 x 10^7 ESA (30 years)

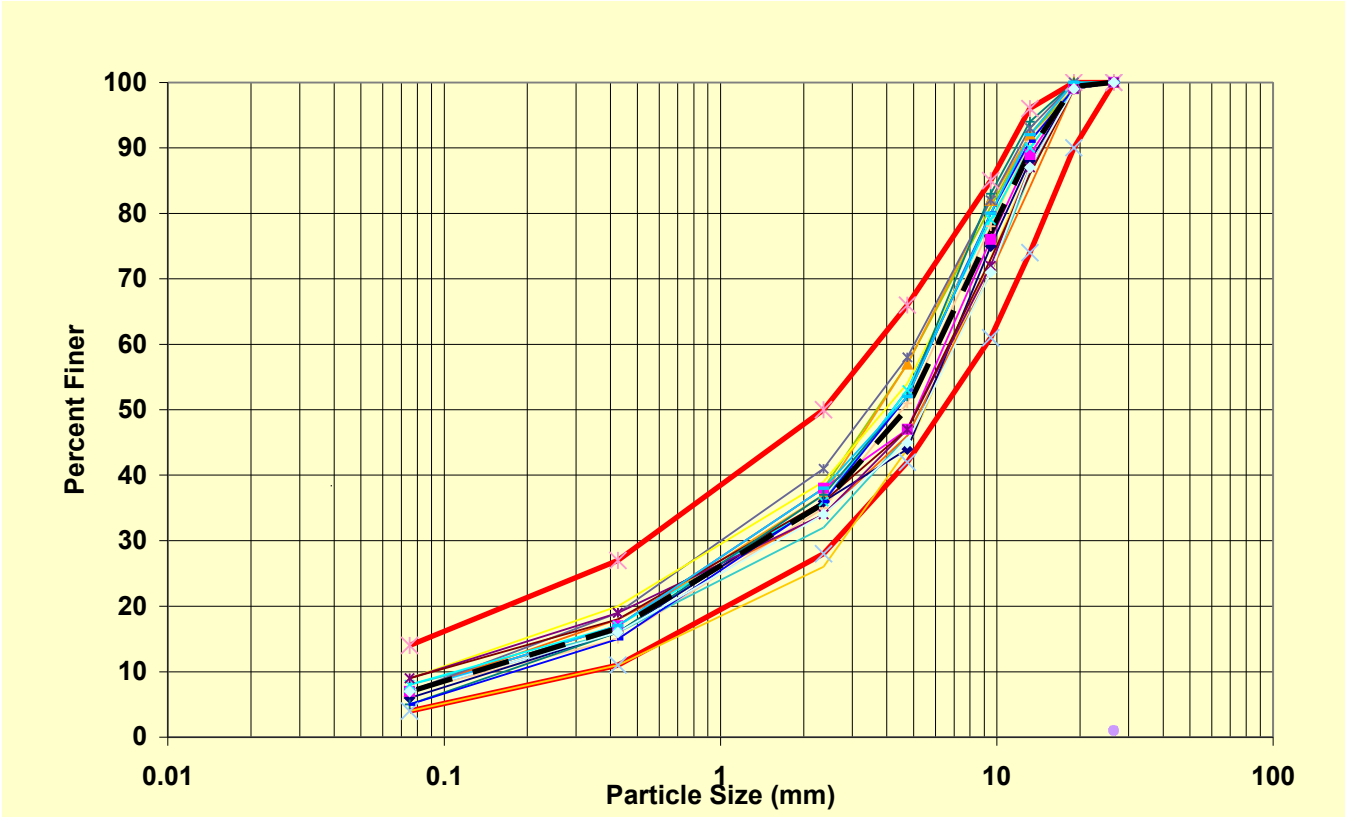
Pavement Profiles

- 250mm commingled recycled sub-base with 150mm new roadbase
- 400mm commingled recycled base
- 250mm 50mm commingled recycled sub-base with 150mm recycled concrete only base
- 400mm recycled concrete only base

- Determines workability, compactability and maximises compacted density (maximises modulus)
- PSD of recycled materials conform to specification
- PSD of recycled materials consistent indicating good process control

Uniformity in Manufacture

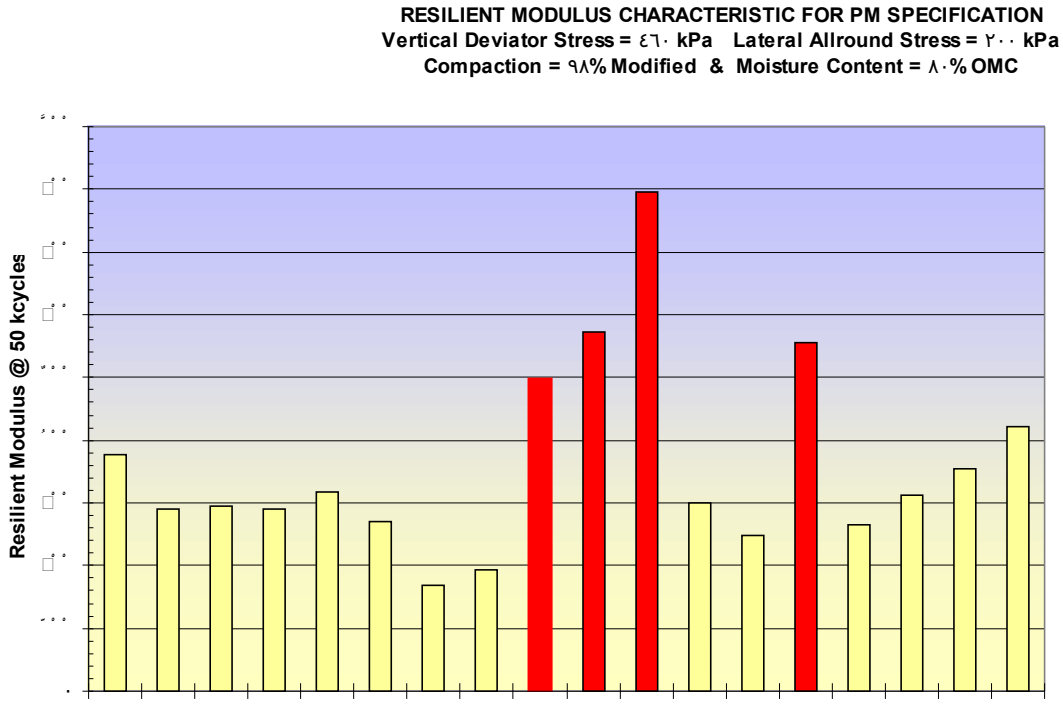
Example representing 200,000 tonnes production



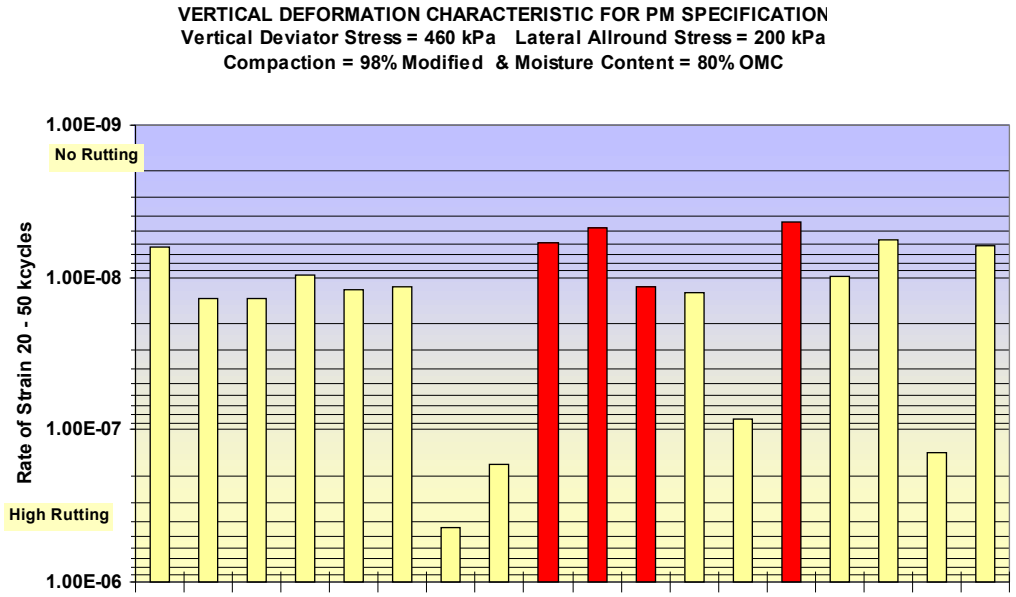
Performance of granular materials under load

- Modulus defines the deflection of material under load
- Higher modulus = less strain in asphalt and less strain on subgrade
- Modulus varies with confining stress and load
  - higher vertical load = greater modulus
  - higher confining stress = greater modulus

Performance - Resilient Modulus



Performance - Deformation



Repeat Load Triaxial Test Values

Commingled 25mm C & D Recycled Base	500MPa
Pure crushed concrete 25mm C & D Recycled Base	430MPa
20mm Non Plastic Roadbase Company A	410MPa
20mm Low Plasticity Roadbase Company A	370MPa
Cement Modified 20mm Roadbase Company A	470MPa
20mm Low Plasticity Roadbase Company B	650MPa

Statement: Recycled materials comparable to roadbase under test conditions

Repeat Load Triaxial Test Values – varying moisture conditions

Material	Dry Density (%MDD)	Moisture Content (%OMC)	Resilient Modulus (MPa)		
			Stage 1	Stage 2	Stage 3
Quarried Road Base	98.2	76	210	Failed	Failed
	98.3	66	250	260	Failed
	99.4	47	380	440	460
Recycled Commingled Base	97.5	77	250	270	220
	97.9	65	330	350	350
	98.0	60	400	430	440
Recycled Concrete Base	98.6	74	320	340	330
	98.3	66	500	530	490
	98.1	59	630	690	670

Shear Box Tests

- Shear measured at OMC and 98% MDD
- Tested at 3 normal stress levels – (vertical load applied whilst shearing sample)
- Results
  - apparent cohesion
  - shear strength
  - friction angle

Shear Test Results

Material	Normal Stress (kPa)	Max Shear Stress (kPa)	Apparent Cohesion (kPa)	Shear Angle (Deg)
Roadbase	146	339	16	64
	299	630		
	445	987		
Commingled Recycled	146	390	237	47
	229	592		
	445	724		
Recycled Concrete	146	414	24	68
	229	729		
	445	1185		

Construction observation

- Commingled material
  - very workable
  - very stable under traffic
  - dries back quickly
  - good surface finish
  - relatively moisture insensitive

Construction observation

- Crushed concrete material
  - quite workable
  - quite stable under traffic but some ravelling
  - dries back slowly
  - reasonable surface finish some variability
  - becomes spongy at high moisture content

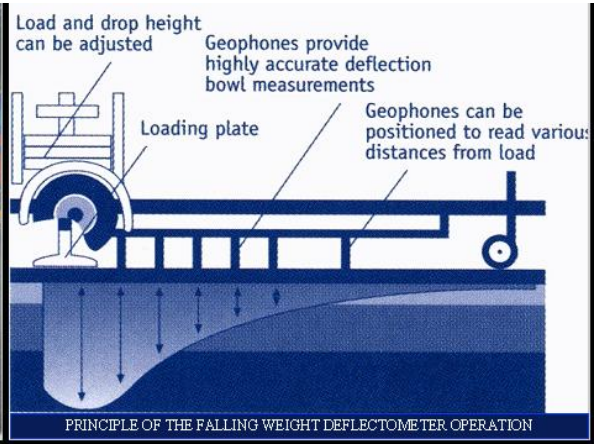
Construction observation

- Roadbase
  - quite workable
  - quite stable under traffic but ravels under turning traffic
  - dries back well
  - good surface finish
  - becomes spongy at high moisture content
- Roadbase under current contract better than average

FWD Testing

- Falling weight deflectometer used to determine load response

- Testing undertaken on:
  - completed roadbase base
  - completed commingled base
  - completed 50mm commingled sub-base
  - completed crushed concrete sub-base
  - completed crushed concrete base



FWD Test results

Pavement Construction	Test Level	Deflection (mm)		Curvature (mm)	
		Mean	95th %ile	Mean	95th %ile
150mm Roadbase/250mm Commingled Recycled	Top Base	0.59	0.65	0.21	0.25
400mm Commingled Recycled	Top Base	0.46	0.53	0.15	0.17
250mm 50mm Commingled Recycled	Top Sub-base	0.79	0.89	0.21	0.25
250mm Recycled Concrete	Top Sub-base	0.81	1.09	0.23	0.31
150mm Recycled Concrete/250mm 50mm Commingled Recycled	Top Base	0.46	0.51	0.13	0.16
400mm Recycled Concrete	Top Base	0.49	0.57	0.15	0.20

EfromD3 Back analysis for material modulus

Pavement Construction	EfromD3 Layer Modulus (MPa)			
	Test at Base Level		Test at Sub-base Level	
	Base Layer	Sub-base Layer	Top Sub-base	Bottom Sub-base
150mm Roadbase/250mm Commingled Recycled	641	722		
400mm Commingled Recycled	1024	678		
250mm 50mm Commingled Recycled			1366	357
250mm Recycled Concrete			940	484
150mm Recycled Concrete/250mm 50mm Commingled Recycled	1275	505		
400mm Recycled Concrete	1042	527		

Breakdown during compaction

Sieve (mm)	% Passing before compaction	% Passing after compaction
37.5	97	99
26.5	77	82
19.0	65	68
13.2	53	58
9.5	45	50
6.7	39	46
4.75	34	43
2.36	28	38
1.18	23	35
0.600	18	31
0.425	15	28
0.300	11	24
0.150	6	21
0.075	3	19

Risks with recycled materials

- Cement clinker around aggregate can possibly weaken pavement
- Changes in grading during construction due to breakdown
- Possibility of contamination

Welshpool Road findings

- Variation between tests can give differing conclusions
- Performance of recycled materials similar to new roadbase
- On going monitoring will give final answer

Cost comparisons

Material	Base price ($/t)	Transport Cost ($/t)		Max Dry Density (t/m³)	Insitu Cost ($/m³)	
		Actual	Adjusted for backload		Actual	Adjusted for backload
Limestone	6.60	5.50	5.50	1.85	22.38	22.38
Roadbase	10.80	3.14	3.14	2.21	30.80	30.80
Recycled Roadbase	8.80	2.36	1.18	1.95	21.76	20.58

Cost Comparisons - Disposal

Material	To Landfill		To C & D Recycling	
	Base Price ($/t)	Transport Cost ($/t)	Base Price ($/t)	Transport Cost ($/t)
Concrete	25.00	5.50	8.46	1.18*
Mixed Sand & Concrete	25.00	5.50	8.46	1.18*
Sand	5.00	5.50	4.23	1.18*
Mixed Grass & Concrete	60.50	5.50	12.69	1.18*

* Effective cost allows for backloading

Advantages of Recycled Pavement Materials

- Environmental
  - reduced drain on new resources
  - reduced habitat destruction
  - energy savings in processing
  - reduced landfill area
  - reduced fuel usage by backloading

- Economic
  - savings in material costs
  - savings in fuel costs and vehicle costs
  - reduced road wear

Conclusion

- Recycled materials can be successfully used in road construction
- There are considerable environmental and economic benefits in using recycled materials
- Recycled materials can be used with confidence as a base in light traffic roads and sub-base in heavy traffic roads
- Recycled materials are likely to be suitable as a base in heavy trafficked roads.

Completed Recycled Concrete Base

Completed Recycled Concrete Base

Completed Commingled Recycled Base