Comparison of the Financial, Social and Environmental Costs of Various Pavement Rehabilitation Design Solutions for Local Road Pavements using the Triple Bottom Line Concept

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1. Abstract

Many local roads in Australia are comprised of a thin marginal granular material base courses with a thin bituminous surface. When these pavements require rehabilitation, new granular reconstruction is the standard historical approach. However, in recent times, stabilisation of the existing pavement has also become popular. This research calculated seven structurally equivalent pavement rehabilitations, including a new granular and two stabilised pavement options, each with sprayed seal and asphalt surface options, as well as a full depth asphalt pavement. The social, financial and environmental cost of each was estimated, and a triple bottom line value was calculated. It was concluded that stabilisation of the existing pavement structure consistently provided the lowest cost solution, whereas new granular pavement reconstruction was consistently the most expensive option. It is recommended that existing pavement stabilisation be the preferred existing pavement rehabilitation for local roads, except where other factors render stabilisation unviable.

Keywords: Cost, Whole of life, Local road, Pavement

2. Introduction

In Australia, approximately 75% of the 876,000 km of road pavements are considered local [1], meaning they primarily service light vehicles accessing domestic and retail/service business outlets. These roads are often comprised of pavements that incorporate lower quality materials, rather than the higher quality crushed quarry rock that is typically used in highway and heavy-duty pavements. Consequently, local roads often require partial or full depth rehabilitation. Rehabilitation can take many forms [2] and local experience and estimated cost have traditionally been the focus of selecting the preferred rehabilitation technique for a given situation. However, as social and environmental impacts become more important for local government decision making, the embodied carbon (an environmental cost), consumption of non-renewable hard rock quarry resources (a social cost) and construction waste to landfill (a social cost) are also becoming increasingly important for comparing structurally equivalent pavement rehabilitation design options [3]. By structurally equivalent, it is meant that the different design options, which may include significantly different materials and thicknesses, have the same theoretical structural design life, for the same traffic loadings, and for the same subgrade bearing capacity. This is quite different to providing equivalent performance over the life cycle of the road.

White et al. [4] adapted the triple bottom line (TBL) concept from economics to combine and compare the social, environmental and financial costs associated with different pavement types and options. The initial work was based on different pavement strength upgrade options for a regional airport runway in Australia [4]. Since then, the same concept has been used to evaluate recycled material use in asphalt mixtures and different foamed bitumen stabilised gravel mixture designs [5], as well as a case study on a regional airport pavement upgrade [6].

The aim of this research was to compare the TBL cost of different rehabilitation design options for local road pavements, over a range of typical subgrade bearing capacity conditions, and for a range of typical local road traffic volumes. All pavement thicknesses were determined using the layered elastic software CIRCLY [7] and the designs were based on Australian guidance for road pavement rehabilitation and design [2].

3. Methods

Design scenarios

In total, 84 structurally equivalent pavement thicknesses were determined. The 84 pavements were comprised of seven different pavement rehabilitation types (Table 1), and each type was designed for three levels of traffic, and for four subgrade strengths (Table 2). That is, for each pavement type, the required pavement thickness was determined for 12 combinations of subgrade strength and traffic volume. The traffic levels and subgrade strengths were selected to span the range of typical of local road pavement design inputs across Australia.

Each pavement type was provided a designation code as shown in Table 1, using a “type_surface_traffic_subgrade” format, where the ‘type’ was the general approach to rehabilitation, the ‘surface’ was either a two coat sprayed seal or 50 mm of asphalt, the ‘traffic’ was the exponent of the number of equivalent single axle loads (ESALs) applied over the structural design life and the ‘subgrade’ was the characteristic subgrade Californian bearing ratio (CBR). For example, NG_S_4_3 indicates new granular pavement (NG) with a sprayed seal surface (S) for traffic loading 5×10^4 ESALs (4) on a CBR 3% (3) subgrade. Each pavement design is shown in Figure 1.

Table 1. Pavement rehabilitation types.

Pavement type	**Surface**	**Designation**
New granular reconstruction	Sprayed seal	NG_S
Lightly bound stabilisation of existing base	Sprayed seal	LBS_S
Foamed bitumen stabilisation of exiting base	Sprayed seal	FBS_S
New granular reconstruction	Dense asphalt	NG_A
Lightly bound stabilisation of existing base	Dense asphalt	LBS_A
Foamed bitumen stabilisation of exiting base	Dense asphalt	FBS_A
Full depth asphalt reconstruction	Dense asphalt	FDA

Table 2. Traffic loadings and subgrade conditions.

Traffic loadings		Subgrade conditions	
Input value	**Represents**	**Input value**	**Represents**
5×10^4 ESALs	Light traffic	CBR 3%	Weak clay
5×10^5 ESALs	Medium traffic	CBR 5%	Drained silt
5×10^6 ESALs	Heavy traffic	CBR 9%	Natural gravel
-	-	CBR 15%	Compacted sand

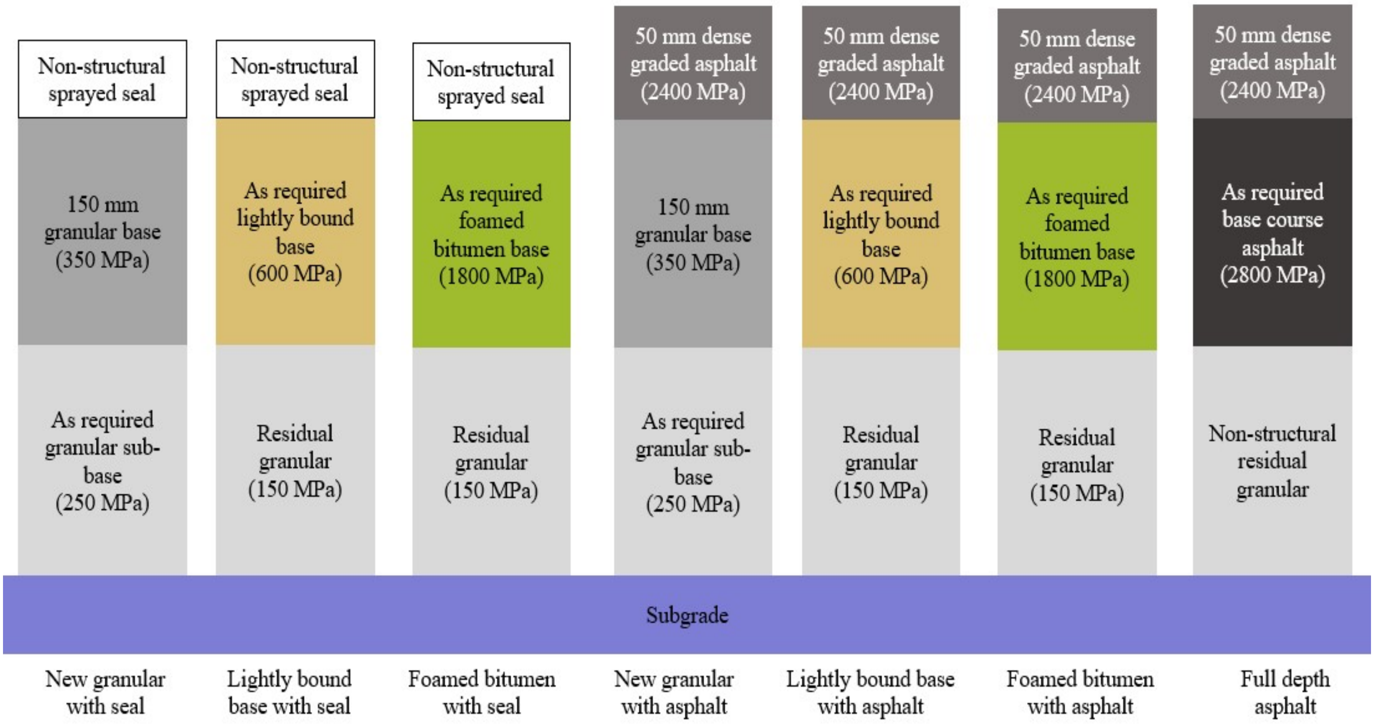

Figure 1. Schematic pavement rehabilitation design types.

Pavement thickness design

For pavement thickness determination in CIRCLY, materials that reflect Australian road pavement design practice were selected and the associated standard or common modulus values and failure criteria were adopted (Table 3). For the subgrade materials, the modulus (MPa) was calculated as 10 times the CBR value, and the failure criterion was the standard used for all flexible road pavements in Australia [2,7].

Table 3. Pavement materials and characterisation.

Material	Modulus (MPa)	Description
Fine crushed rock base	350	New quarried hard rock
Fine crushed rock sub-base	250	New quarried hard rock
Lightly bound base	600	New local gravel with 2.5% blended cementitious binder
Foamed bitumen base	1,800	Existing insitu gravel with 3.5% foamed bitumen and 1.5% hydrated lime
Residual existing sub-base	150	Existing insitu local gravel
Asphalt surface	2,400	14 mm mixture 5% bitumen
Asphalt base	2,800	20 mm mixture with 4% bitumen

The only non-standard materials used were the lightly bound base (LBB) and the foamed bitumen base (FBB). Lightly bound base was the existing pavement material stabilised with a blended cementitious binder to improve its properties and increase the modulus [8]. FBB was also the existing pavement gravel stabilised with foamed bitumen [9]. FBB provides a moisture resistant and crack resistant material that is well suited to marginal local gravels [10] and typically has a modulus that is closer to asphalt concrete than to crushed rock [11].

For some design scenarios, the required FBB and LBB stabilisation depth exceeded the 250 mm of existing marginal granular material assumed to represent a typical existing local road pavement. In these cases, either 50 mm, 100 mm or 150 mm of new crushed rock was first added as a granular overlay, to ensure adequate granular material was available, following common local road practice. Furthermore, for some of the asphalt surfaced pavement designs, an additional layer of asphalt was required to prevent asphalt fatigue artificially dominating the required pavement thickness, which is also common practice. Finally, the LBB and FBB were assigned minimum thicknesses of 200 mm and 150 mm, respectively, even when a reduced thickness was theoretically adequate, to reflect practical constructability restrictions.

Social costs

The social cost of each pavement design option was calculated as the mass of new quarried material consumed in the construction of the rehabilitated pavement, added to the mass of existing pavement excavated and sent to landfill. That is because quarried materials are non-renewable resources that are valuable to society in the future, and because waste to landfill is socially unfavorable. In contrast, the retained existing pavement material was considered to be 'free' from social cost. The social cost calculation used the thickness and density (Table 4) of each material, as detailed in Equation 1.

$$\text{Social Cost } (/\text{m}^2) = \textstyle\sum_{\text{layers}} \text{thickness (mm)} \times \text{density } (\text{kg/m}^3) \qquad (1)$$

Table 4. Material densities.

Material	**Density (kg/m³)**
Fine crushed rock base, sub-base and granular overlay	2,300
Lightly bound base	2,050
Foamed bitumen base	2,150
Residual existing sub-base	2,100
Asphalt surface and binder/base	2,400

Environmental cost

The environmental cost of each pavement design option was calculated as the quantity of each material, based on the thickness and density (Table 4), and the embodied carbon associated with each material's production, supply and construction (Table 5), summed for all materials in the pavements, per Equation 2. The embodied carbon rates were expressed in kilograms of equivalent carbon dioxide (e.CO_2) from greenhouse gas emissions, per unit of material, and were extracted from literature (Table 5). For the conglomerate materials, carbon rates were calculated from raw materials, such as two coat sprayed seal, LBB and FBB, based on typical material compositions (Table 3). The environmental cost of excavating the existing pavement was estimated at 8 kg.e.CO_2/m^3, reflecting the typical fuel burn and emissions associated with diesel fuel [4].

Environmental Cost (/m^2) = $\sum_{\mathrm{layers}} \mathrm{thickness\ (mm)} \times \mathrm{density\ (kg/m^3)} \times \mathrm{carbon\ (kg.e.CO_2)}$ (2)

For the LBB and FBB, the embodied carbon associated with the binders, which were a function of the layer thickness, were calculated separately to the production process, which was based on pavement area, because the stabilising equipment has approximately the same fuel consumption regardless of stabilisation depth, but the stabilisation depth directly influences the amount of binder required. Again, retained existing granular materials were considered to be 'free' of environmental cost.

Table 5. Material embodied carbon rates.

Material	**Embodied carbon (kg.e.CO_2)**	**Source and Notes**
Two coat sprayed seal	6 /m^2	Calculated from crushed rock and bitumen
Fine crushed rock	160 /tonne	[12]
Lightly bound base	7 /m^2	Construction only, plus binder
Foamed bitumen base	8 /m^2	Construction only, plus binders
Residual existing sub-base	nil	Existing material is environmentally free
Asphalt surface	345 /tonne	[5]
Asphalt base	305 / tonne	[5]
Cementitious binder	365 / tonne	[13] supply only
Unmodified bitumen	840 / tonne	[4] supply only
Hydrated lime	315 / tonne	[4] supply only

Financial cost

The financial costs were calculated in a similar manner to the environmental costs, except typical cost rates (in Australia) were used in place of the embodied carbon rates, as shown in Equation 3. The cost rates were set based on experience and included the material supply, production and construction costs, as appropriate (Table 6). The financial costs of LBB and FBB were again calculated based on the cost of the cementitious and bituminous binders, which were a function of layer depth, and the production cost, as a function of pavement area but not of stabilisation depth. Again, the retained existing granular material was considered to be 'free' and the excavation of the existing pavement was estimated to cost \$100/m^3.

Financial Cost (/m^2) = $\sum_{\mathrm{layers}} \mathrm{thickness\ (mm)} \times \mathrm{density\ (kg/m^3)} \times \mathrm{cost\ rate\ (A\$/m^2)}$ (3)

Table 6. Material financial cost rates.

Material	Financial cost (A$)	Notes
Two coat sprayed seal	11 /m^2	
Fine crushed rock sub-base, base and granular overlay	60 /tonne	
Lightly bound base	8 /m^2	Construction only, plus binder
Foamed bitumen base	10 /m^2	Construction only, plus binders
Residual existing sub-base	nil	Existing material is cost free
Asphalt surface	280 /tonne	
Asphalt base	260 /tonne	
Cementitious binder	250 /tonne	Supply only
Unmodified bitumen	450 /tonne	Supply only
Hydrated lime	1,400 /tonne	Supply only

Triple bottom line

The triple bottom line was calculated as the area of the triangular radar graph of the socio-enviro-financial costs. However, because these three costs have different units and different scales, it was first necessary to normalise each. To normalise each cost, the calculated cost for each pavement design was divided by the maximum cost of all the pavement designs and multiplied by 100. As a result, the highest cost pavement design had a normalised cost of 100 and all other designs had a cost less than 100, relative to the highest cost design. A lower TBL value is preferred. Once the TBL values were calculated, they were also normalised, resulting in a theoretical TBL range of 0-100, where 100 was the most expensive option and the other design options all had a TBL value less than 100, relative to the most expensive option. To interpretate the results, the average cost and average TBL value, of the 12 values for each traffic/subgrade combination were also calculated for each pavement type.

4. Results and discussion

Pavement thicknesses

The 84 pavement designs varied significantly. The total thickness of rehabilitation ranged from 100 mm to 758 mm (Appendix 1) and the range of thicknesses for each pavement type are compared in Figure 5. The lowest thickness for each pavement type was associated with the combination of the highest subgrade strength and the lowest traffic volume, while the greatest thickness resulted from the lowest subgrade strength and highest traffic volume. This reflects the general influences of traffic and subgrade support on pavement thickness requirements, regardless of pavement type.

On average, the 50 mm asphalt surface increased the average pavement thickness by 1%. This reflected the additional thickness required to prevent asphalt fatigue dominating the pavement design, which was not an issue for the sprayed seal surfaced pavements. This indicates that in many local roads, particularly where high traffic volumes are expected in low subgrade bearing capacity conditions, the theoretical benefit of proving an asphalt surface is unlikely to be realised, and a sprayed seal surface should be preferred. The exception would be for tight turning areas, such as roundabouts and heavy vehicle intersections, where sprayed seals are prone to surface scuffing and do not perform well.

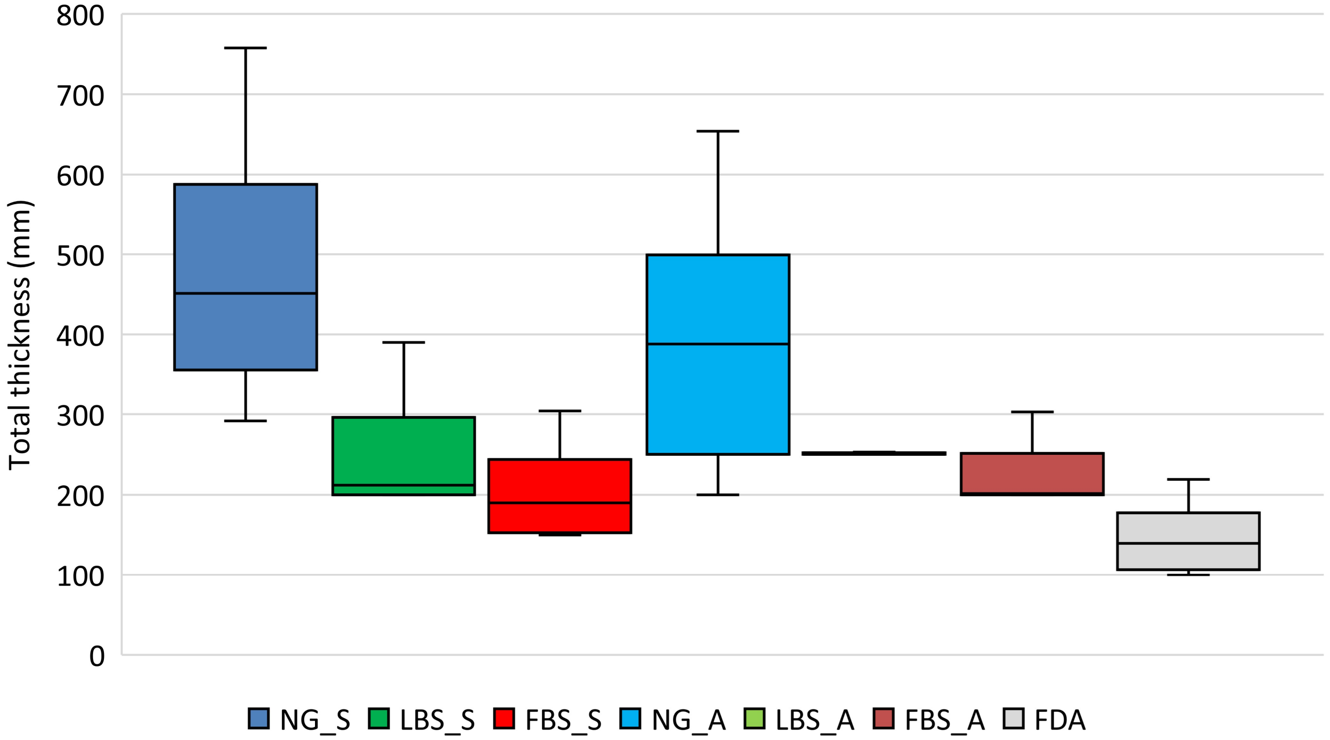

Figure 2. Ranges of pavement thickness

Social cost

The social costs (Appendix 2) ranged from 32 kg/m^2 for the stabilisation and sprayed seal surface designs, to 3,290 kg/m^2 for the new granular pavement with an asphalt surface. The range of social costs associated with each pavement type is compared in Figure 3. The lower social costs reflect the only new quarried material required for stabilisation and sealing (LBS_S and FBS_S) being the aggregate in the sprayed seal surface. In contrast, the new granular designs (NG_S and NG_A) required a significant depth of the existing pavement to be excavated and disposed of, followed by a comparable thickness of new quarried material in the crushed rock base and sub-base layers, and the sprayed seal or asphalt surface layer.

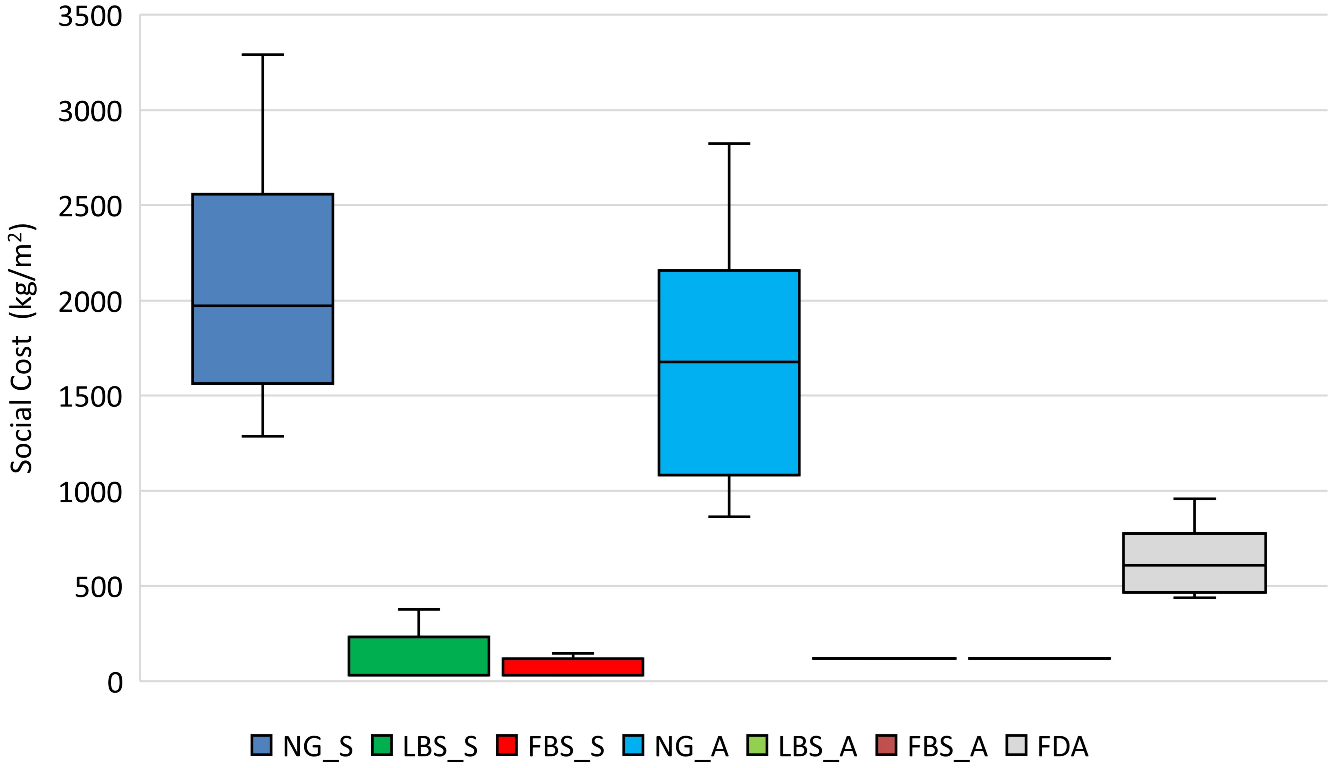

Figure 3. Ranges of social cost

Environmental cost

The environmental costs (Appendix 2) ranged from 17 kg.e.CO_2/m^2 up to 299 kg.e.CO_2/m^2, and the range of values for each pavement type are compared in Figure 4. The lowest environmental cost was associated with LBB surfaced with a sprayed seal (LBS_S) because this avoided the high environmental cost associated with asphalt and reused the existing granular material, thereby avoiding the importation of new crushed rock. It was closely followed by the FBB design, which also avoided new granular materials, but had a higher environmental cost than LBB due to the bitumen content, which has a high level of embodied carbon. The highest environmental cost was associated with the new granular pavement with an asphalt surface. Generally, the environmental cost of the granular pavements ranged by the greatest amount because of the high influence of the subgrade strength on the total pavement thickness required. The thickness of the bound (LBB and FBB) pavements was less sensitive to the subgrade strength.

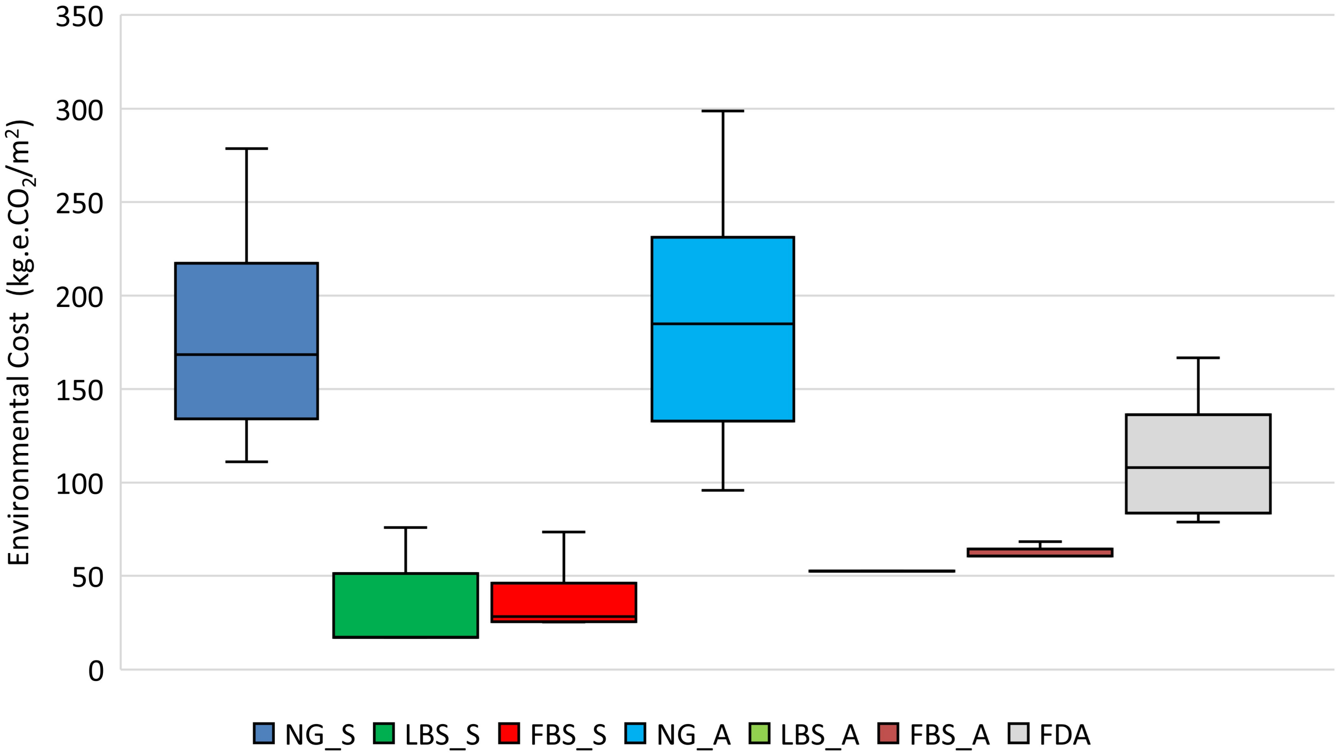

Figure 4. Ranges of environmental cost

Financial cost

The financial costs (Appendix 2) ranged from A$22/m^2 to A$219/m^2, and the range of values for each pavement type are compared in Figure 5. The lowest financial costs were associated with the LBB pavement, followed by the FBB pavement, both with a sprayed seal surface. This reflects the significant reduction in pavement thickness provided by the increased stiffness associated with stabilisation, compared to the required thickness of crushed rock in the new granular pavement. Overall, the new granular pavements (NG_A and NG_S) were the most expensive, followed by the full depth asphalt pavements, reflecting the high cost of bituminous binder and asphalt production. In fact, the sprayed seal surfacing was associated with 23% to 41% lower financial cost than the equivalent asphalt surfaced pavements.

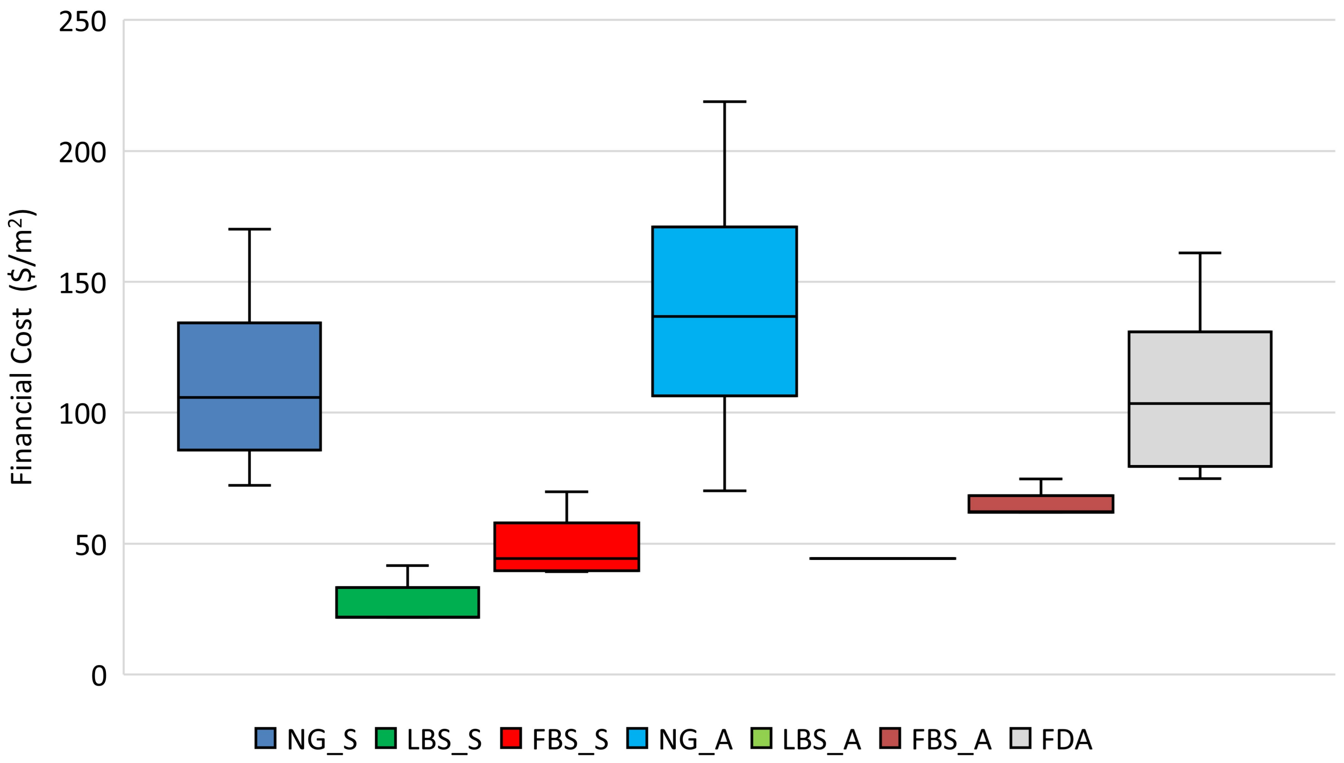

Figure 5. Ranges of financial cost

Triple bottom line

There were 12 TBL values for each pavement type, reflecting the 12 combinations of the 4 subgrade conditions and 3 traffic loadings considered. To allow comparison of the pavement types, the average of the 12 costs for each pavement type were calculated and these are shown in Figure 6 for the normalised social, environmental and financial costs, and in Figure 7 and Figure 8 for the TBL values.

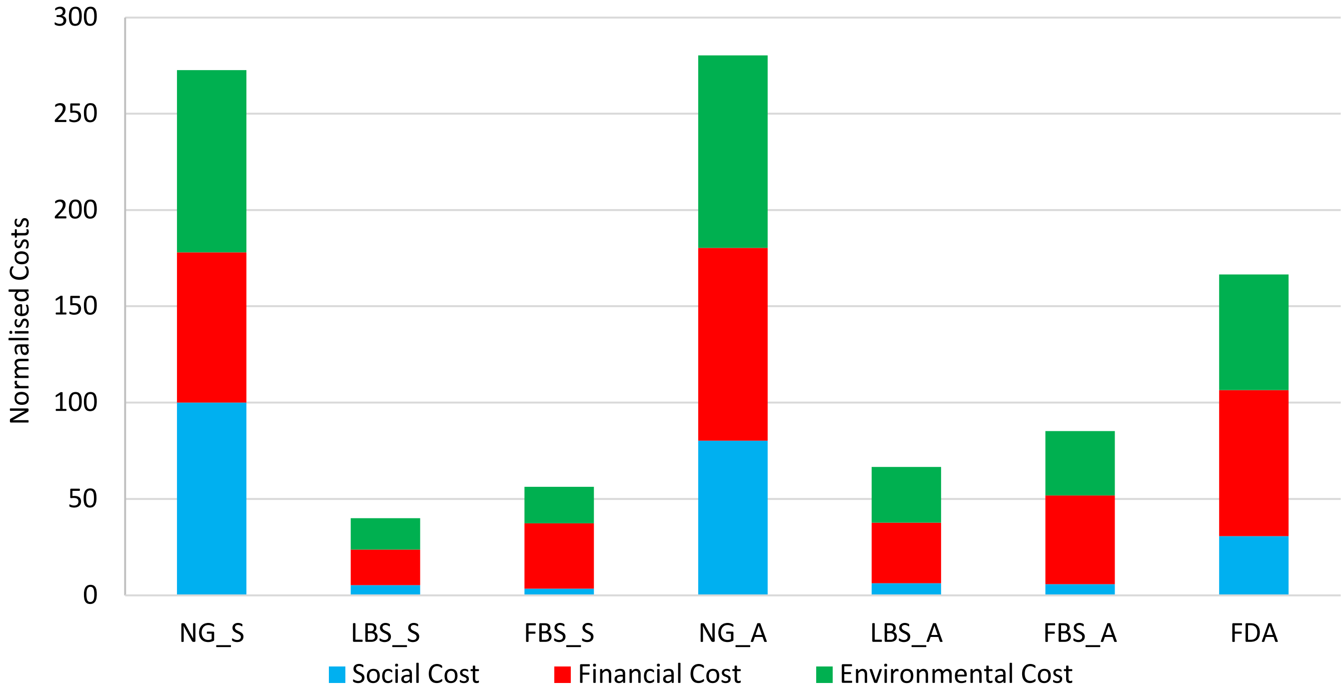

Figure 6. Normalised social, environmental and financial cost.

The high costs associated with the new crushed rock granular pavements and the asphalt surface are clear, with the new granular pavements with asphalt surface associated with the highest TBL value, followed by the new granular pavement with spray sealed surface, and then the full depth asphalt pavement. This highlights the benefit of improving granular materials via stabilisation, either as LBB or FBB. Overall, the average normalised TBL value for the stabilised pavements with a sprayed seal surface (LBS_S and FBS_S) were less than 2, compared to 43 for the new granular pavement with an asphalt surface, and 39 for the new granular pavement with a sprayed seal surface. On average, the asphalt surface added 9% (NG), 53% (LBS) and 54% (FBS) to the average normalised TBL values, and that is why sprayed seal surfaces are generally preferred for low volume roads.

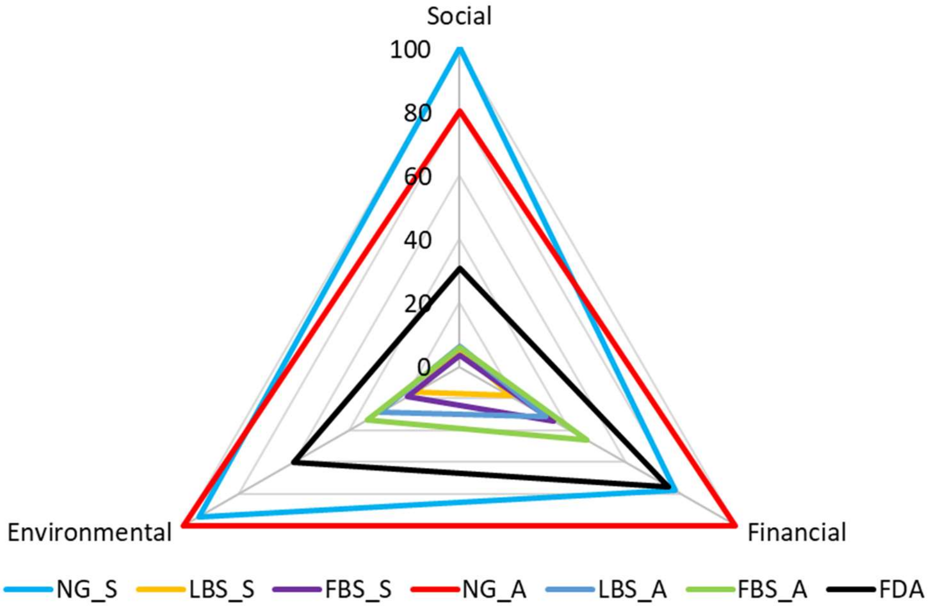

Figure 7. Average TBL radar graphs for different pavement types.

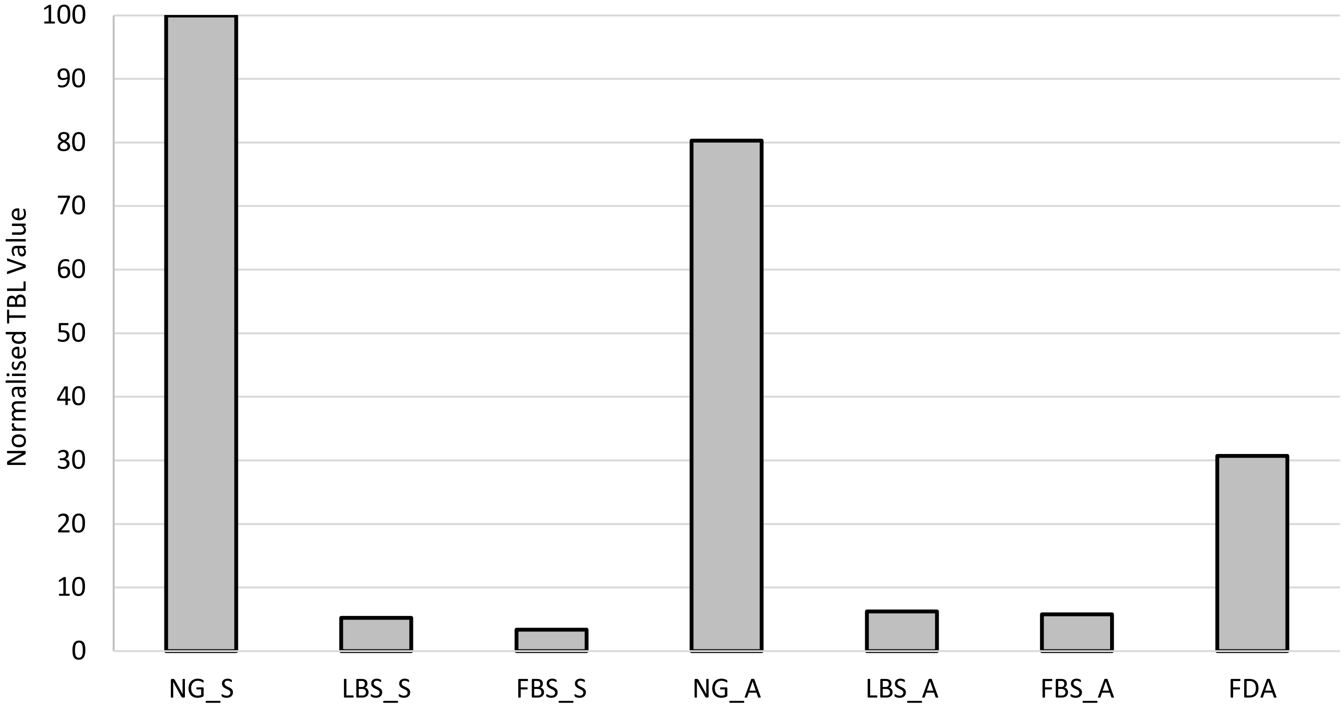

Figure 4. Average normalised TBL value for different pavement types.

5. Conclusion

The TBL approach is a novel method for objectively incorporating the social cost and environmental cost, as well as the financial cost, into pavement type selection. This example compared 7 different structurally equivalent flexible pavement designs and demonstrated the clear benefit of stabilisation of existing granular materials and the use of sprayed seal surfacing for local road rehabilitation. The high social and environmental cost of new granular pavement reconstruction is likely to be scrutinised and criticised in the future, as sustainability and recycling become more important. It is therefore recommended that existing pavement stabilisation be the preferred rehabilitation treatment for local road pavements, except where other factors render stabilisation unviable. Future research should also consider extending this research to include a whole of life cycle comparison of the different pavement types, also on a TBL basis.

6. References

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Appendix 1. Pavement thicknesses

Code	Seal	Asphalt W/C	Asphalt B/C	LBB	FBB	Granular overlay	Granular Base	Granular Subbase
NGS_4_3	1						150	365
NG_S_4_5	1						150	277
NG_S_4_9	1						150	196
NG_S_4_15	1						150	142
NG_S_5_3	1						150	476
NG_S_5_5	1						150	361
NG_S_5_9	1						150	255
NG_S_5_15	1						150	185
NG_S_6_3	1						150	608
NG_S_6_5	1						150	461
NG_S_6_9	1						150	326
NG_S_6_15	1						150	236
LBS_S_4_3	1			242		0		
LBS_S_4_5	1			200		0		
LBS_S_4_9	1			200		0		
LBS_S_4_15	1			200		0		
LBS_S_5_3	1			311		100		
LBS_S_5_5	1			224		0		
LBS_S_5_9	1			200		0		
LBS_S_5_15	1			200		0		
LBS_S_6_3	1			390		150		
LBS_S_6_5	1			328		100		
LBS_S_6_9	1			252		50		
LBS_S_6_15	1			200		0		
FBS_S_4_3	1				160	0		
FBS_S_4_5	1				150	0		
FBS_S_4_9	1				150	0		
FBS_S_4_15	1				150	0		
FBS_S_5_3	1				222	0		
FBS_S_5_5	1				203	0		
FBS_S_5_9	1				177	0		
FBS_S_5_15	1				160	0		
FBS_S_6_3	1				304	100		
FBS_S_6_5	1				280	50		
FBS_S_6_9	1				251	50		
FBS_S_6_15	1				222	0		
NG_A_4_3		50	50				150	90
NG_A_4_5		50	50				150	0
NG_A_4_9		50	50				150	0
NG_A_4_15		50	0				150	0
NG_A_5_3		50	66				150	250
NG_A_5_5		50	50				150	200
NG_A_5_9		50	68				150	0
NG_A_5_15		50	50				150	0
NG_A_6_3		50	104				150	350
NG_A_6_5		50	102				150	250
NG_A_6_9		50	96				150	150

Code	**Seal**	**Asphalt W/C**	**Asphalt B/C**	**LBB**	**FBB**	**Granular overlay**	**Granular Base**	**Granular Subbase**
NG_A_6_15		50	86				150	150
LBS_A_4_3		50		200		0		
LBS_A_4_5		50		200		0		
LBS_A_4_9		50		200		0		
LBS_A_4_15		50		200		0		
LBS_A_5_3		50		203		0		
LBS_A_5_5		50		200		0		
LBS_A_5_9		50		200		0		
LBS_A_5_15		50		200		0		
LBS_A_6_3		50		276		50		
LBS_A_6_5		50		221		0		
LBS_A_6_9		50		200		0		
LBS_A_6_15		50		200		0		
FBS_A_4_3		50			150	0		
FBS_A_4_5		50			150	0		
FBS_A_4_9		50			150	0		
FBS_A_4_15		50			150	0		
FBS_A_5_3		50			173	0		
FBS_A_5_5		50			153	0		
FBS_A_5_9		50			150	0		
FBS_A_5_15		50			150	0		
FBS_A_6_3		50			253	0		
FBS_A_6_5		50			229	0		
FBS_A_6_9		50			202	0		
FBS_A_6_15		50			200	0		
FDS_4_3		50	66					
FDA_4_5		50	54					
FDA_4_9		50	50					
FDA_4_15		50	50					
FDA_5_3		50	111					
FDA_5_5		50	98					
FDA_5_9		50	81					
FDA_5_15		50	64					
FDA_6_3		50	169					
FDA_6_5		50	152					
FDA_6_9		50	132					
FDA_6_15		50	114					

Appendix 2. Costs and triple bottom line values

Code	Social Cost	Financial Cost	Environmental Cost	TBL Value
NG_S_4_3	68	54	64	42.5
NG_S_4_5	57	46	53	29.7
NG_S_4_9	46	38	44	19.9
NG_S_4_15	39	33	37	14.5
NG_S_5_3	83	65	77	61.8
NG_S_5_5	68	54	64	41.9
NG_S_5_9	54	44	51	26.9
NG_S_5_15	45	37	42	18.8
NG_S_6_3	100	78	93	89.4
NG_S_6_5	81	64	76	59.0
NG_S_6_9	63	51	59	36.5
NG_S_6_15	51	42	49	24.5
LBS_S_4_3	1	10	6	0.3
LBS_S_4_5	1	10	6	0.3
LBS_S_4_9	1	10	6	0.3
LBS_S_4_15	1	10	6	0.3
LBS_S_5_3	8	16	19	2.3
LBS_S_5_5	1	10	6	0.3
LBS_S_5_9	1	10	6	0.3
LBS_S_5_15	1	10	6	0.3
LBS_S_6_3	11	19	25	3.9
LBS_S_6_5	8	16	19	2.3
LBS_S_6_9	4	13	12	1.1
LBS_S_6_15	1	10	6	0.3
FBS_S_4_3	1	19	9	0.8
FBS_S_4_5	1	18	8	0.8
FBS_S_4_9	1	18	8	0.8
FBS_S_4_15	1	18	8	0.8
FBS_S_5_3	1	22	10	1.1
FBS_S_5_5	1	21	10	1.0
FBS_S_5_9	1	20	9	0.9
FBS_S_5_15	1	19	9	0.8
FBS_S_6_3	8	32	25	4.9
FBS_S_6_5	4	28	18	2.8
FBS_S_6_9	4	28	17	2.8
FBS_S_6_15	1	22	10	1.1
NG_A_4_3	45	57	55	30.2
NG_A_4_5	33	49	44	19.3
NG_A_4_9	33	49	44	19.3
NG_A_4_15	26	32	32	10.0
NG_A_5_3	68	78	79	61.5
NG_A_5_5	59	68	69	46.7
NG_A_5_9	35	55	49	23.4
NG_A_5_15	33	49	44	19.3
NG_A_6_3	86	100	100	100.0
NG_A_6_5	73	90	87	76.3
NG_A_6_9	59	78	74	54.2

Code	Social Cost	Financial Cost	Environmental Cost	TBL Value
NG_A_6_15	57	75	71	50.7
LBS_A_4_3	4	20	18	2.0
LBS_A_4_5	4	20	18	2.0
LBS_A_4_9	4	20	18	2.0
LBS_A_4_15	4	20	18	2.0
LBS_A_5_3	4	20	18	2.0
LBS_A_5_5	4	20	18	2.0
LBS_A_5_9	4	20	18	2.0
LBS_A_5_15	4	20	18	2.0
LBS_A_6_3	7	21	24	3.3
LBS_A_6_5	4	20	18	2.1
LBS_A_6_9	4	20	18	2.0
LBS_A_6_15	4	20	18	2.0
FBS_A_4_3	4	28	20	3.1
FBS_A_4_5	4	28	20	3.1
FBS_A_4_9	4	28	20	3.1
FBS_A_4_15	4	28	20	3.1
FBS_A_5_3	4	30	21	3.3
FBS_A_5_5	4	28	20	3.1
FBS_A_5_9	4	28	20	3.1
FBS_A_5_15	4	28	20	3.1
FBS_A_6_3	4	34	23	4.1
FBS_A_6_5	4	33	22	3.9
FBS_A_6_9	4	31	22	3.6
FBS_A_6_15	4	31	22	3.6
FDS_4_3	15	39	30	8.7
FDA_4_5	14	35	27	7.0
FDA_4_9	13	34	26	6.5
FDA_4_15	13	34	26	6.5
FDA_5_3	21	54	41	16.4
FDA_5_5	20	50	38	13.9
FDA_5_9	17	44	34	11.0
FDA_5_15	15	39	30	8.4
FDA_6_3	29	74	56	29.9
FDA_6_5	27	68	52	25.5
FDA_6_9	24	61	47	20.8
FDA_6_15	22	55	42	17.0