AustStab

Life Cycle Costing of Stabilised Pavements

The following AustStab Guideline has been produced based on industry practice and the costs used in the two examples are indicative only. Please contact your regional AustStab contractor for current construction and maintenance costs.

1 Introduction

The important variable which industry commonly uses to chose between various pavement alternatives is that of cost. Life cycle costing alternatives are a responsible approach when various alternatives have different lives and maintenance costs. In terms of rehabilitation of road pavements and final pavement maintenance strategies, the engineer has several alternatives to chose between.

A choice should be made between the alternatives based upon the minimum life-cycle cost, but keeping in mind safety and service to both the road users and builders. This paper will discuss and compare these alternatives and the process of determining the life-cycle cost of pavements.

2 Net Present Worth

Life cycle costing depends upon predictions of future expenditure and income and determining expenditure in terms of net present worth (NPW) at the start of the project. The net present worth of an initial construction cost and future maintenance costs can be shown by the following equation:

$$NPW = A + \Sigma F_n \frac{1}{(1+i)^n}$$

where:

A = cost of construction spent on the project at year 0,
F_n = maintenance costs in the n^{th} year (in today's dollars),
I = discount rate,
n = number of years in the future

Maintenance costs are positive and salvage costs of the pavement in the final year negative, unless an expense is incurred in the removal of the pavement. Costs usually expressed in dollars per unit area.

3 Discount Rate

The discount interest rate should reflect long term monetary rates so to provide reasonable results of future values, however in recent years this

value has been open to some debate. The latest Austroads Pavement Design Guide used a discount rate of 10%. However, the RTA and VicRoads tend to use 7%, and a recent study by economists The Allen Consulting Group suggested to use a rate of 4% - 6%. Whereas the National Road Transport Commission (NRTC) recommends using 5% for road construction. based on the above information, it is suggested that a discount rate of 5% is used in life-cycle analysis of various pavement options.

4 Analysis Period

The chosen period of analysis should be not less than the longest design period of an alternate design. The period should also be the same length for each alternative.

5 Salvage Costs (Residual Value)

The residual value or salvage cost of a pavement varies according to the pavement type. The AUSTROADS Pavement Design Manual states the salvage value at the end of the analysis period depends upon several variables such as:

- ❑ Continued use of the existing alignment.
- ❑ Feasibility of upgrading or strengthening the pavement by a overlay.
- ❑ Possibility of recycling existing paving materials or recycling of the pavement insitu.
- ❑ Need to remove the pavement prior to reconstruction.

Thus, in the case of the stabilised pavement alone, the salvage value can be as high as 20% of the initial cost of the rehabilitation of the pavement. This is due to the need for less cementitious additive the second time a pavement is stabilised, and the fact that the seal is ‘mixed-in’, producing an improved particle size. Similar to salvage value, the residual value is the remaining value of an alternative at the end of the analysis period, thus if the analysis period was longer, the pavement would still have some value.

6 Disruption Costs

Although they are generally not included in the calculations, it is important to consider the disruption that an alternative may cause over another. It is important to maintain traffic flow and to minimise the time taken during the construction and maintenance of the pavement. This has the effect of reducing traffic delays, pollution and wasted fuel, and driver stress. Also, it is worth considering how an alternative can accommodate different weather conditions over another during its construction. Whilst these are important factors in selecting a rehabilitation option, this economic data is generally not available for use in the life cycle cost analysis.

7 Examples

7.1 General Input

Suggested inputs for the two stabilised pavement examples are:

- ❑ A discount interest rate of 5% is usually recommended.
- ❑ The required design life of a pavement.
- ❑ Stabilised pavement depth - use Austroads Pavement Design Manual, or refer to stabilisation contractor
- ❑ Cementitious additive and application rate for the stabilised pavement - refer to stabilisation contractor
- ❑ Sealing, asphalt, patching - refer to Council Annual Contract

Note that these prices are indicative only and will vary according to region and size of project. In addition, while the salvage value of a stabilised pavement is higher than a patched pavement, perhaps lower than a resheeted pavement, it is assumed to be the same for the purpose of these examples.

Refer to Appendix A for net present worth factors used for a 5% discount rate.

The values underlined in the examples highlight those numbers used to derive the total net present worth of the option.

7.2 Highway Maintenance Project

A sealed major two lane road in a rural environment is due for renewal over an area 15,000m^2. After testing, the Council engineer has two options to give a 20-year design life:

1 Remove the existing pavement material and place 200mm of fine crushed rock.
2 Insitu stabilise the 250mm of existing pavement with the top 75mm of clayey sand, giving a 325mm sealed layer.

These options are compared using the Net Present Worth Model (see Section 2) with a discount rate of 5%.

<u>OPTION 1</u>

Construction Cost
Resheet to 200mm depth plus 2 coat seal at <u>$26.00</u>/m^2

Maintenance
Patching unbound granular base to 200mm @ $40.00/m^2. Patch 1% of the pavement at year 15 (ie $40 x 0.01 x 0.481) equals <u>$0.19</u>/m^2

Resealing @ $2.50/m^2. Reseal at years 8 and 16 (ie $2.50 x (0.677 + 0.458)) equals <u>$2.84</u>/m^2

Residual value
Remaining life at end after patching in year 15 (ie 37.5%) $0.19 x 0.375 = <u>-$0.07</u>/m^2

Remaining life at end after resealing in year 16 (ie 50%) \$2.50 x 0.458 x 0.5 = -\$0.57/m^2

NPW cost of option 1 **\$28.39/m^2**
\$426,000

OPTION 2

Construction Cost
Deep lift stabilisation to 325mm with seal \$20.00/m^2

Maintenance
SAM seal @ \$3.00/m^2
SAM seal at year 1 \$3.00 x 0.952 = \$2.86/m^2

Patching stabilised base to 300mm @ \$60.00/m^2.
Patch 1% of the pavement at year 5 \$60 x 0.01 x 0.784 = \$0.47/m^2
Patch 2% of the pavement at year 15 \$60 x 0.02 x 0.481 = \$0.58/m^2

Resealing @ \$2.50/m^2
Reseal at years 9 and 17 \$2.50 x (0.645 + 0.436) equals \$2.70/m^2

Residual value
Remaining life at end after patching in year 15 (ie 50%) \$0.58 x 0.5 = -\$0.29/m^2
Remaining life at end after resealing in year 17 (ie 62.5%) \$2.50 x 0.436 x 0.625 = -\$0.68/m^2

NPW cost of option 2 **\$25.64/m^2**
\$385,000

Based on the net present worth analysis OPTION 2 (the deep lift stabilisation) program has the least cost.

7.3 Residential Street Rehabilitation

A sealed residential street with an area 3,000m^2 in an urban environment has a deteriorating pavement which has become quite plastic and so easily develops potholes. Council has presented two options giving the pavement an additional 20 year life:

1. 'Do Nothing' but continuously maintain the pavement for 20 years.
2. Insitu stabilise the 200mm of existing pavement material with 2% of cementitious material and reseal.

These options are compared using the Net Present Worth model with a discount rate of 5%.

OPTION 1

Construction Cost
Major patching to 200mm with granular material and a thin asphalt surface @ \$60.00/m^2
Place 3% of the pavement and seal \$60 x 0.03 x \$2.50 = \$4.50/m^2

Maintenance
Major patch 3% of the pavement at years 3, 6, 9, 12, 15, 18 (ie \$60 x 0.03 x (0.864 + 0.746 + 0.645 + 0.557 + 0.481 + 0.416) = \$6.68/m^2)

Minor patching to 200mm with granular material and a thin asphalt surface @ \$90.00/m^2
Minor patch 1.25% of the pavement at years 1, 2, 4, 5, 7, 8, 10, 11, 13, 14, 16, 17, 19 (ie \$90 x 0.0125 x (0.952, 0.907, 0.823, 0.784, 0.711, 0.677, 0.614, 0.585, 0.530, 0.505, 0.458, 0.436, 0.396) = \$9.43/m^2

Resealing @ \$2.50/m^2
Reseal at years 9 and 15 (ie \$2.50 x (0.645 + 0.481) = \$2.82/m^2

Residual value
Remaining life at end after patching in year 18 (ie 33%) \$60 x 0.03 x 0.416 x 0.33 = -\$0.25/m^2
Remaining life at end after resealing in year 15 (ie 44%) \$2.50 x 0.481 x 0.44 = -\$0.53/m^2

NPW cost of option 1 **\$22.65/m^2**
\$68,000

OPTION 2

Construction Cost
Insitu stabilisation to 200mm with seal \$18.00/m^2

Maintenance
Patching stabilised pavement to 200mm with asphalt @ \$90.00/m^2
Patch 1.5% of the pavement at year 10 (ie \$90 x 0.015 x 0.614 = \$0.83/m^2)

Resealing @ \$2.50/m^2
Reseal at year 15 (ie \$2.50 x 0.481 = \$1.20/m^2)

Residual value
Remaining life at end after resealing in year 15 (ie 50%) (ie \$2.50 x 0.481 x 0.5 = -\$0.60/m^2)

NPW cost of option 2 **\$19.43/m^2**
\$58,000

Based on the net present worth analysis OPTION 2 (the cement stabilisation) is the lowest cost option. The 'Do Nothing' option could be more viable over a shorter period, but a worthy consideration is that this option causes more inconvenience (disruption costs) to the local residents, as well as having a very poor rideability, thus jeopardising driver safety.

8 References

ARRB *Sealed Local Roads Manual - Guidelines to Good Practice for the Construction, Maintenance & Rehabilitation of Pavements* August, 1995

AUSTROADS *Pavement Design - A Guide to the Structural Design of Road Pavements* October, 1992

National Association of Australian State Road Authorities *Guide to Stabilisation in Roadworks* 1986

Vorobieff, G. *Life Cycle Costing* Cement and Concrete Association of Australia, January, 1996

APPENDIX A

The NPW factors in the table below have been based on the equation described in Section 2 and using a discount rate of 5%.

Year	NPW Factor
1	0.952
2	0.907
3	0.864
4	0.823
5	0.784
6	0.746
7	0.711
8	0.677
9	0.645
10	0.614
11	0.585
12	0.557
13	0.530
14	0.505
15	0.481
16	0.458
17	0.436
18	0.416
19	0.396
20	0.377

END

For further information, please contact the Secretary, AustStab, PO Box 1889, North Sydney 2059 or Email: vorobief@auststab.com.au