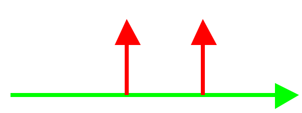
Life Cycle Cost Analysis

Life cycle cost (lcc) analysis is a tool to assist those persons responsible for making the difficult decision of pavement selection. The process can be used to make an economic evaluation between pavement types, hot-mix asphalt (hma) or Portland cement concrete (pcc), or to evaluate various rehabilitation strategies. The 1991 Intermodial Surface Transportation Efficiency Act (ISTEA) suggested lcc be used when evaluating bridge, tunnel and pavement designs. An FHWA memo, (based on the NHS Designation Act of 1995) sent all FHWA field offices, in April of 1996, hinged eligibility for Federal funds for National Highway Safety projects and those projects in excess of $25 million on the use of lcc as a tool in the decision making process. Most public agencies, be they state DOTs, cities, boroughs, townships, etc do not have an unlimited budget. Conversely, most are struggling to maintain their existing infrastructure; as such it is important they make fiscally responsible decisions. The use of life cycle cost analysis can be a valuable tool, to any agency, regardless of size, in making those decisions. This publication and enclosed software are intended to provide the ability to conduct a ***basic*** life cycle cost analysis. The factors that go into that analysis are:

- Initial Costs
- Periodic Maintenance/Rehabilitation Costs
- Annual Maintenance Cost
- User Delay Cost
- Salvage Value
- Analysis Period
- Performance Period
- Discount Rate (%)
- Present Worth

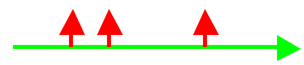
Initial Costs are those costs associated with the construction of a new pavement or reconstruction; clearing and grubbing, excavation, placement of the subgrade, subbase and pavement. Costs common to each of the alternatives need not to be included in the life cycle analysis. Every effort should be made to use realistic prices! The best source for that information is from recent projects that used similar quantities. The cost of mobilization and maintenance of traffic should be included in the life cycle analysis. If possible, you should consider the number of days required to build each pavement, with respect to user delay costs, should be included. In fact, this may be difficult to do and there will be times when structures, excavation, etc may be the critical time element.

Periodic Maintenance/Rehabilitation Costs are those costs associated with slurry seals, microsurfacing, chip seals, overlays, etc and/or rehabilitations during the analysis period. This requires that you have a realistic feel for the performance period of those applications



Example: 1.5-inch overlay may have a life of 10 years while a 4-inch overlay may have a life of 18 years. Possible sources for this information are your own historical data base, state DOT and LTPP data or the Asphalt Institute's LCC data base.

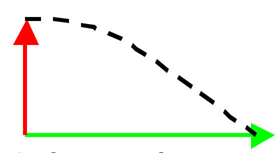
Annual Maintenance Costs are those cost associated with annual routine maintenance. Typically, these costs include: crack sealing and pothole patching. Under normal circumstances these annual costs are insignificant and do not effect pavement selection.



Salvage Value represents the value of the pavement at the end of the analysis period. When the analysis period is 40 years the present worth factor at a 4% discount rate is only 0.21 (Table 1). Therefore, if at the end of 40 years the current value of the pavement is $100,000 the present worth will be $21,000.

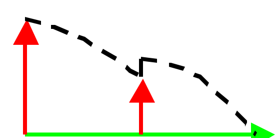
User Delay Cost are those costs to the motoring public due to lost time and vehicle expenses. User delay costs should be included in the lcc. Obviously, as the number of vehicles increase, user delay cost become more critical. In some cases user delay costs will be the controlling factor. What values to assign to user delay costs vary and are the subject of much discussion. The FHWA project, Demo. 115, suggested an average of $12.27/hour for passenger cars ($11.58/hr driver + $0.69 vehicle operating costs), $19.31/hour for single unit trucks ($18.54/hr +$0.77/hr voc) and $23.13/hour for combination trucks ($22.31/hr + $0.82 voc).

Analysis Period is that period of time, normally between 30 and 40 years, used to evaluate the total investment required to build (or reconstruct) and maintain the pavement at an agreed upon quality level. With few exceptions, the analysis period should include at least one major rehabilitation.



Analysis Period

Performance Period is that period of time one expects a particular treatment to perform before the pavement again drops below the agreed upon acceptable quality level.



Performance Period

Present Worth is the sum of all future costs, discounted to the year of initial construction, plus initial construction costs. Comparing the present worth of various pavement alternatives will provide a sound economic evaluation. There are other methods, notably equivalent uniform annual cost, to make the life cycle analysis, but the examples and the enclosed program use present worth.

<u>Discount Rate</u> represents the cost of doing business. If you invested your money in a Certificate of Deposit (CD) at 7% for five years, but inflation each of those years was 3%, then your real rate of return would have been 4%. The discount rate represents the real rate of return on the pavement investment. Statistics show that the discount rate is normally in a range of 3 – 5%. A point of interest is the present worth of an expenditure decreases as the time increases away from the year of the initial construction (approximate 50% and 25% at year 18 and 35 respectively).

<u>Example "A"</u>

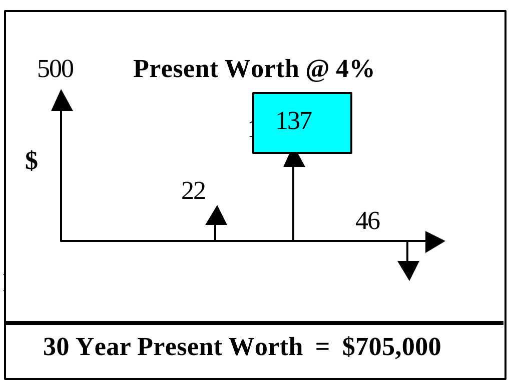
Initial Construction	$500,000
Preventive Maintenance @ year 15	40,000
Major Rehabilitation @ year 20	300,000
Salvage Value @ year 30	150,000

<u>Example "B"</u>

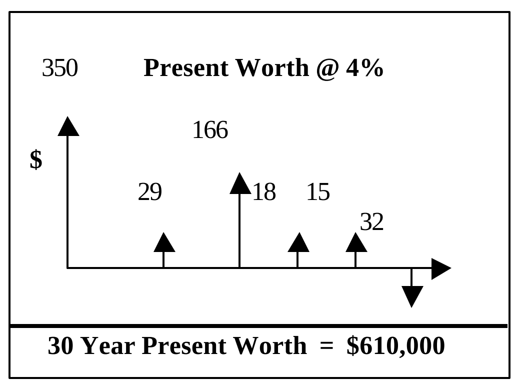
Initial Construction	$350,000
Preventive Maintenance @ year 8	40,000
Major Rehabilitation @ year 15	300,000
Preventive Maintenance @ year 20	40,000
Preventive Maintenance @ year 25	60,000
Salvage Value @ year 30	105,000

Year	8	15	20	25	30	
	0.7307	0.5553	0.4564	0.3751	0..3083	4% Discount Rate Factor

Example "A"



Example "B"



$300,000 x 0.4564 = 136,920

Example "B" would be 15% more economical

Step 1) Enter Name & Location of Project
Step 2) Input Discount Interest Rate (Suggest a rate between 3% and 5%; the analysis should look at other rates to evaluate sensitivity of evaluation to interest rates.)
Step 3) Enter Initial Construction / Material Items, Quantities and Cost per Unit; also to be included are Mobilization, Maintenance & Protection of Traffic and any User Delay Costs. Initial construction is year "0"
Step 4) Enter Preventive Maintenance or Rehabilitation Costs at designated time; again include Mobilization, Maint. & Protection of Traffic and User Delay Cost. Enter year when treatment takes place .

NOTES

Suggested discount rate is 4%, it is a good idea to look at sensitivity of analysis to discount rate by evaluating each project at several discount rates.

This example uses 5% for mobilization and 8% for maintenance & protection of traffic; percentages chosen should reflect current conditions in your area.

User Delay Example

Given

A work zone (traffic slowed from 65mph to 40mph) is set up for a distance of 1 mile (one direction)
The ADT on this 4-lane highway is 20,000 with 10% trucks
Trucks are split 70/30 : single unit/combination
50% of traffic travels in each direction

Travel time @ 65MPH/mile	55.4 sec	} Time difference 34.5/sec (0.0096/hr)
Travel time @ 40MPH/mile	89.9 sec	

Cost per Auto/mile	(0.0096 x $12.27) = $0.12/auto	$120/1000
Cost per Single Unit truck/mile	(0.0096 x $19.31) = $0.19/su truck	$190/1000
Cost per Combination/mile	(0.0096 x $23.13) = $0.22/comb. truck	$220/1000

Calculation

Traffic in one direction is 20,000 ADT x 50%	=	10,000 veh/day
Auto delayed is 90% x 10,000 veh/day	=	**9,000 auto/day**
Trucks delayed is 10% x 10,000 veh/day	=	1,000 trucks/day
Single unit trucks make up 70% of all trucks	=	**700 single-unit trucks/day**
Combination trucks make up 30% of all trucks	=	**300 combination trucks/day**

9,000 auto x $0.12	=	**$ 1080**	**$ 1279 / day User Delay** *
700 su trucks x $0.19	=	**133**	
300 comb trucks x $0.22	=	**66**	

* **Assumes no additional backup (que) of traffic**

An excellent reference to look at advanced life cycle analysis is Life Cycle Cost Analysis in Pavement Design (Demonstration Project No. 115), Publication No. FHWA-SA-98-040.

CONSIDER In this example the total User Delay Costs = 6% of Total Present Worth. In a highly urban area traffic may have an ADT in excess of 100,000. With an ADT of 100,000 the User Delay Costs would represent 24% of the Total Present Worth assuming no back (que) up of traffic. Almost certainly there would be a back up (que) and the percentage would increase significantly. The phrase, "GET IN, GET OUT and STA
no further explanation.