Review of Alternate Bid Tenders for Canadian Highway Construction Projects with Life Cycle Cost Component

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Abstract

The use of alternate bids with life cycle cost as part of the tender process for pavement choice evaluation has been evolving in Canada since the first contract tendered in 2001. This paper will review the history of how alternate tenders with a life cycle cost component were started in Ontario based on the initial Life Cycle Cost study of 1995. The paper will identify the key points to consider when performing a life cycle cost analysis (LCCA) including: use of equivalent bids, selection of accurate maintenance and rehabilitation (M&R) schedules, selection of discount rate, inclusion of user costs, and inclusion of sustainability issues. The advantage of utilizing a two pavement system (asphalt and concrete) is also discussed in this paper. Details will be provided on the nine (9) alternate bid tenders called in Canada since 2001 including: Highway 101 in Nova Scotia; Highway 410, Highway 417 East and West, and three sections of Highway 401 in Ontario; and Deerfoot Trail and Anthony Henday Drive in Alberta. Some of the details that will be provided on the alternate tender projects are as follows: asphalt and concrete pavement structures, maintenance and rehabilitation schedules, tender costs for the two pavement structures, life cycle cost analysis period and discount rates used in the analysis. For comparison, information will also be provided on Quebec's White Grey Black policy for pavement selection.

1.0 **Introduction**

Places such as Winnipeg, Windsor, Montreal and Toronto have extensive Portland cement concrete pavement (PCCP) and composite pavement networks and have been using PCCP for many years. However, unlike the United States which have 30 to 40 percent of its Interstate network constructed in PCCP, Canada does not have much PCCP on its Trans Canada Highway and major municipal roadways. In fact, the province of Quebec has the greatest percentage on concrete pavement on its roadway network and it is only four (4) percent. It is not know for sure why there is such a substantial difference in the amount of concrete pavement used in the US compared to Canada. Some of the more common reasons given for not utilizing concrete pavement are: familiarity of the DOT and municipalities with asphalt concrete pavement (ACP); question of the performance of PCCP in cold weather climates; and tradition of assuming concrete pavement is always the most expensive option.

The first argument on the familiarity of the product is gradually being eliminated as PCCP continues to grow in it usage throughout Canada. The Cement and Concrete Industry has also been giving courses and seminars on the design, construction and maintenance of PCCP which are also improving the DOT and municipalities comfort level with concrete pavement.

The second argument of questioning the performance of PCCP in cold weather climates can be easily addressed by identifying the improvements made in PCCP mix design and discussing the areas PCCP is currently used in. PCCP can be designed to withstand our extreme temperature ranges and freeze/thaw environment through proper mix design and strength requirements. This is evident in the good performance of PCCP in Winnipeg, Toronto, Windsor and Montreal. In addition, many northern states have substantial networks of PCCP including Michigan, Minnesota, North Dakota, Illinois, Idaho, Iowa, Pennsylvania, and Washington.

The focus of this paper will address the assumption that concrete pavement is always the more expensive pavement option. Many government agencies believe that concrete pavement is the more expensive option without even investigating a concrete pavement alternative. This paper identifies the key points a government agency should consider when calling an alternate tender with a life cycle cost analysis (LCCA) component. In addition, the results of nine different alternate bid tenders across Canada will be identified.

2.0 **Key Points in Alternate Bids with Life Cycle Cost Analysis**

The concept of Life Cycle Cost Analysis (LCCA) is to combine the incurred cost and accrued benefits over different periods of service lifetime in a consistent manner. Whether the basis is the present value, annualized cost, future cost, salvage value or some rate of return measure, the heart of the reduction is the use of an appropriate discount rate.

The Federal Highway Administration (FHWA) provides a more transportation specific definition of LCCA as follows:

> “LCCA is an analysis technique that builds on the well-founded principles of economic analysis to evaluate the over-all-long-term economic efficiency between competing alternative investment options. It does not address equity issues. It incorporates initial and discounted future agency, user, and other relevant costs over the life of alternative investments. It attempts to identify the best value (the lowest long-term cost that satisfies the performance objective being sought) for investment expenditures [Walls 98].”

The decision to use LCCA as part of the alternate bid process provides government agencies with better knowledge of the true cost of a roadway rather than just consider the initial cost of the pavement. The greater the level of detail provided in the LCCA the better the agency is equipped to make an informed decision on which pavement type is the best for that particular job. The key points to consider in a LCCA analysis are as follows:

1) Use of equivalent ACP and PCCP design sections
2) Selection of accurate maintenance and rehabilitation activities for both pavement types
3) Selection of appropriate discount rate
4) Inclusion of user costs such as user delay and accident costs
5) Inclusion of sustainability of pavement type

The American Concrete Pavement Association has prepared an in depth Engineering Bulletin entitled “Life Cycle Cost Analysis: A Guide for Comparing Alternate Pavement Designs” which gives a detailed review of the basic factors in the analysis such as Agency costs, user costs, and discount rate.

2.1 **Equivalent Pavement Designs**

Portland cement concrete pavements are rigid pavements while asphalt concrete pavements are flexible pavements. Therefore, the two pavement types perform very different in terms of structural characteristics. As illustrated in Figure 1 flexible pavements consist of asphalt layer(s) over granular base and subbase, on top of the roadway subgrade. The flexible pavement structure relies on the asphalt, base and subbase layers to transfer the applied load from heavy vehicles through each layer of the pavement structure. Therefore, each layer of the asphalt structure is important to the structural integrity of the pavement. Bases and subbases must be tested to ensure the materials meet the gradation requirements and the other properties. The subgrade type and strength are also an important factor to determining the required thickness of the layers in the pavement structure. Overall, the thickness of the flexible pavement layers is determined according to the applied traffic loads and subgrade soil conditions.

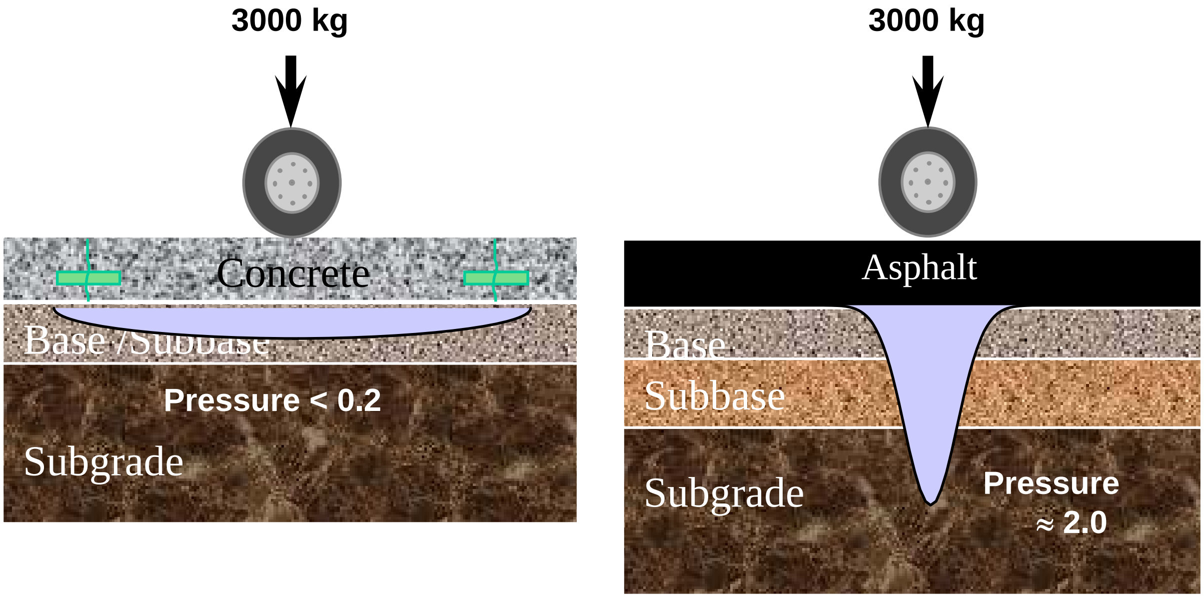


Figure 1: Typical Load Distribution for Flexible and Rigid Pavement Layers [CAC 00]

Conversely, rigid pavements do no not require the base or subbase layers for structural support and subgrade strength is not a critical element in the thickness design. Subgrade strength has minor impact on the overall thickness of a concrete pavement structure but is a consideration for drainage and uniform support. Uniform support is the key to good performing concrete pavement and must be kept in mind during design and construction. As illustrated in Figure 1 [CAC 00], the applied load is transferred across the rigid structure so that only a small bearing stress is applied to the underlying foundation. Bases or subbases provide a working platform during construction and a drainage layer to allow water to drain from under the concrete slabs. This layer can be either stabilized or unstabilized. If a rigid pavement is being constructed over poor subgrade materials, it is generally desirable to use subgrade stabilization in expansive soils or install subdrains to eliminate or reduce subgrade moisture levels [TAC 97]. One exception to the reduced amount of granular material under PCCP structures is when the agency designs the pavement structure strictly on frost penetration. In these designs the PCCP structure has almost the same amount of granular material as an ACP structure. This practice is not common, however, as it increases the cost of the pavement structure with little to no structural benefit.

The basis objective during pavement design is to provide structural alternatives that are both technically and economically feasible. This is achieved by specifying pavement layer thickness with quality materials based on the traffic and environmental conditions and by performing life cycle cost analysis on the designs. Figure 2 describes the general framework for pavement thickness design. The first step in design involves collecting information relating to materials, traffic, climate and costs. Other important inputs include the selection of a design period, structural and economic models, identification of objectives and constraints and variance on data inputs. Several thickness design programs are available to assist the designer to ensure the pavements are properly designed. For some agencies use the 1993 version of the AASHTO thickness design program for both ACP and PCCP thickness design. This program, however, actually over designs the concrete pavement thickness making non equivalent designs. In fact, the Ministry of Transportation of Ontario (MTO) uses modified ESAL input values for the program recognizing it over designs the PCCP thickness. The new M-E Design Guide, an upgrade to the AASHTO 1993 program, will provide equivalent pavement designs when it officially released. The old DOS based PCAPAV thickness design program has been upgraded to a windows based program, StreetPave, by the American Concrete Pavement Association (ACPA) and can be used for both PCCP and ACP designs. Information imputed into these programs enables for the generation of design alternatives with specified life cycle strategies, including the material types and thickness, criteria on structural and economic analysis and various other factors. The structural analysis and economic evaluation of alternatives would be carried out such that the best strategy for implementation would be selected. The most appropriate design should be selected based on both the technical and economic merits of the design [Tighe 01].

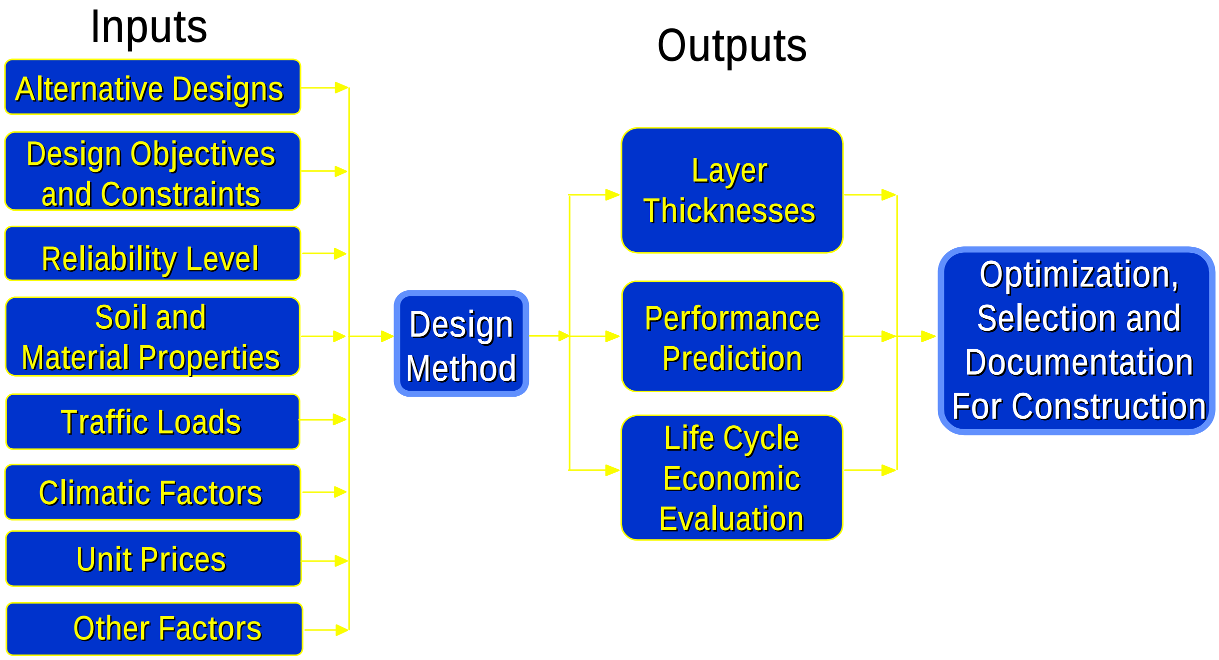


Figure 2: Framework For Pavement Design

2.2 **Selection of Accurate Maintenance and Rehabilitation Activities**

When performing a LCCA comparison it is important to collect quality data for input into the maintenance and rehabilitation (M&R) schedule. Pavement management systems, if kept up to date, provided an excellent source for this data. Chapter five of the ACPA engineering bulletin mentioned in section 2.0 looks at life cycle costs and performance studies. The document gives the results of several states’ historic pavement costs on both project and network levels over a several year period. In addition, Appendix 2 of the document provides expenditure streams used by several states in their LCCA procedures. Details on the M&R schedule used in the alternate bid tenders in Canada are provided in the following sections. [ACPA 2002]

2.3 **Discount Rate**

Discount rate is the value used in the LCCA analysis to take into the account the time value of money. The discount rate takes into account the fluctuation in inflation and interest rates to show the actual or real rate of increase in the value of money over time. [ACPA 2002] The discount rate is calculated as follows:

$$DR = (INT - IFL) / (1 + IFL)$$

Where:
DR = Discount rate
INT = Nominal interest rate
IFL = Inflation rate
(Note: A method commonly used to estimate the discount rate is to subtract the inflation rate from the interest rate.)

The two important advantages of using the discount rate in an analysis are as follows:

1) provides an indication on the difference between the two competing forces - interest rate and inflation rate
2) allows analyst to use constant or today's dollars

The analyst must know, however, that the values calculated using discount rates are artificial estimates of the totals cost to the owner. Therefore, since the results are not actual dollars the LCCA can only be used to compare alternatives and not to determine exactly how much a pavement will cost over its lifetime. See the reference entitled Life Cycle Cost Analysis: A Guide for Comparing Alternate Pavement Designs for more details on this subject.

In the LCCA of pavement material types, the influence of discount rate is very significant in the calculation of life cycle cost adjustment factors. Low discount rate favours high initial construction cost and low maintenance cost over the service life, and high discount rate has the opposite effects. The selection of an appropriate discount rate is sometimes related to the economic growth rate per capita for the region constructing the pavement, which would include the current investment rate of return (Government bond), inflation, and other societal factors.

The discount rate used by Canadian Agencies varies across Canada. For example, the Alberta Department of Infrastructure and Transportation (AIT) uses four (4) percent in their analysis while MTO uses 5.3 percent down from the 7 percent used in 2001.

2.4 **User Costs**

User costs are not commonly used in pavement tendering processes due to the difficulty of calculating the values and the fact that they can overwhelm the Agencies' pavement costs (i.e. initial costs and M&R costs). However, some agencies are beginning to use user costs in the United States and some Canadian DOTs are looking into this area too. The three main areas of user costs are as follows:

1) Delay - of - use costs
2) Roadway deterioration costs
3) Accident or crash costs

Delay – of – use costs are intended to cover the user cost associated with delays when the capacity of a roadway is reduced due to due roadway construction and rehabilitation lane closures. These costs include things such as idling costs and delay – of – time costs as the vehicles slow down through the work zone or wait at construction zones and take longer route due to detour.

Roadway deterioration costs are incurred by the roadway users when the condition of the road increases the vehicle operating costs and damage to goods being transported. However, these costs are seldom used due to the difficulty of calculating the values. Wisconsin has developed a method, known as Quality of Service, that may help quantify which pavements serve the public better. A brief description of this is given in the ACPA LCCA engineering bulletin.

Accident or crash costs are those costs attributed to motor vehicle accidents. Theses costs are normally considered when work zones are in effect during rehabilitation work. The costs are normally calculated by multiplying the estimated accident rate by the average cost per accident.

2.5 **Sustainability Benefits**

The Canadian Green Building initiative has many firms looking at the sustainability of materials when building new buildings in Canada. The three pillars of sustainability (i.e. social, environmental and economic issues) are being considered in the overall cost of the structure rather than just looking at the initial cost. This ensures government agencies make decisions on which structural material to build based a complete knowledge of the competing products. In the future, sustainability issues may migrate to the roadway tendering process, thereby, giving government agencies a more complete knowledge of the overall cost of choosing one pavement type over the other.

There are many benefits of using PCCP including the following:

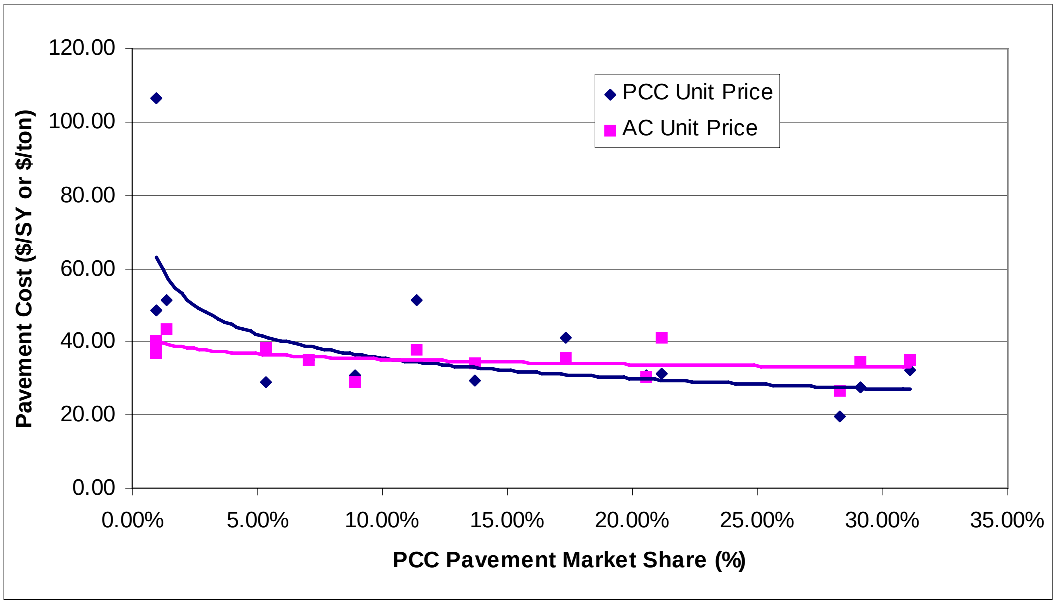
1) Social benefits – included in this area are improved safety issues such as reduced potential for hydroplaning, good night time visibility, reduced splash and spray and improved stopping distance.
2) Environmental benefits – included in this area are reduced energy usage, reduced CO_2 emissions due to heavy truck fuel saving when operating on concrete pavement,

concrete acts as CO_2 sink, can stabilize industrial by-products in PCCP, utilizes less aggregate and recyclable material.

3) Economic benefits – included in this area are reduced diesel fuel usage due to truck fuel savings, LCCA advantage, potential for reduced lighting requirements and no spring weight restrictions.

3.0 **Advantage of Two-Pavement System**

A study by ACPA of data from the Oman System, State data system, for 14 states confirmed that states who utilize a two-pavement system get a much larger "bang for the buck" than states that utilize only one pavement type. The research shows competition between the two paving industries lowers the average unit cost for both the concrete and asphalt pavement, thereby, allowing the government agencies to place more pavement for the same dollars spent. Figure 3 below illustrates that as the market share becomes more balanced between the amount ACP and PCCP being placed the average unit cost of the asphalt and concrete pavements goes down. This translates into government agency being able to pave more roadways with the same amount of funding levels compared to a single pavement system [ACPA 2005].



States: 5-year average for data for GA, IL,IN,KS,KY,MD,MO,NC,OH,PA,TN,VA,WI,WV
Source: Southeast Chapter American Concrete Pavement Association, "Who Says…"Concrete Pavement Cost too Much"?

Figure 3: Benefit of a Two-Pavement System on Pavement Costs

4.0 **Canadian Examples on Alternate Bid Tender Projects**

There have been nine alternate bid tenders called across Canada since 2000. Six of these projects were tendered in Ontario, two in Alberta and one in Nova Scotia. Table 1 below gives a summary of the projects with the year tendered, project length, concrete LCCA advantage, discount rate used in the analysis, analysis period and pavement type selected. The following sections give further details on each project including: concrete and asphalt pavement structures and maintenance and rehabilitation schedules (if available).

Table 1: Summary of Alternate Bid Tender Projects in Canada

Location	Tender Year	Project Length (Lane km)	Concrete LCCA Advantage ($)	Discount Rate	Analysis Period	Pavement Tpye Selected (ACP / PCCP)
Highway 101, NS	2003	21.8	$1.5 M or 20% more than ACP	NA	25	PCCP
Highway 417 E, ON	2001	78.2	433,321	7	50	PCCP
Highway 417 W, ON	2004	73.8	860,719	5.3	50	PCCP
Highway 401, Tilbury, ON-Stg 1	2004	63.6	620,219	5.3	50	PCCP
Highway 401, Tilbury, ON-Stg 2	2005	75.6	588,969	5.3	50	PCCP
Highway 401, Tilbury, ON-Stg 3	2006	93.6	548,551	5.3	50	PCCP
Highway 410, ON	2006	21.6 +	378,780	5.3	50	PCCP
Deerfoot Trail, AB	2002	44 + PCCP shoulders	3,522,000	4	30	ACP
Anthony Henday, AB	2004	58 + PCCP shoulders	2,372,800	4	30	PCCP

Source: Tender documents

4.1 **Highway 101 in Nova Scotia**

In 2003 the Nova Scotia Department of Transportation and Public Works (NSTPW) tendered an alternate bid tenders for a 10.9 km - 2 lane highway on Highway 101 near Halifax. As part of the alternate tender process NSTPW made a decision to give the concrete pavement option a $1.5 Million LCCA advantage. This $1.5 Million LCCA advantage was added to the asphalt tender price and then compared to the concrete pavement tender prices. No details are available on how LCCA value was determined. Table 2 below identifies the bidders and tender results for the Highway 101 alternate bid project. As shown in the table the two concrete tenders were the lower bids when the LCCA advantage was added to the tender price with St. Lawrence Cement having the lowest bid at $5.911 Million.

Table 2 Results of Alternate Bid Tender for Highway 101 in Nova Scotia

Bidder	Pavement Type Bid	Tender Value ($ Million)	Tender Value with LCCA Value Added ($ Million)
St. Lawrence Cement	Concrete	5.911	5.911
Lafarge Canada	Concrete	5.983	5.983
Dexter Construction	Asphalt	4.602	6.102

Source: Tender documents

Listed below are the details for the pavement structures:

Concrete	Asphalt
240 mm JPCP in driving lane	48 mm surface course ACP
220 mm JPCP in passing lane	105 mm base course ACP
100 mm granular Type 1	150 mm of Type 1 Gravel base
375 mm Type 2 - 50 mm minus	400 mm of Type 2 Gravel subbase
some material was placed under prior contract	
subgrade and subbase designed for asphalt	
to allow for alternate bid	
Geotextile used in some locations	

- Design program used for PCCP
    - DARWin Pavement Design and Analysis System (program based on AASHTO 1993 Guide for Design of Pavement Structures)

See Appendix A for more details on the concrete pavement design.

4.2 **Deerfoot Trail in Calgary Alberta**

The Alberta Department of Infrastructure and Transportation tender an alternate bid tender contract in 2002. This tender was for the construction of 13 km divided highway in the City of Calgary. Unlike the Nova Scotia tender individual LCCA estimates were developed for each pavement type and then added to the tender figure from the individual bidders. Table 3 below identifies the bidders and tender results for the Deerfoot Trail alternate bid project. As shown in the table the lowest bid was an asphalt bid even with the LCCA advantage was in the concrete pavement favour. The LCCA period was 30 years for this project. There were several reasons for the concrete pavement option not being competitive with the asphalt option on this project including the following:

- non equivalent structures (PCCP thickness was too thick for design traffic)
- PCCP option was required to have an open grade drainage layer (OGDL) under the concrete pavement while the asphalt option did not require one. This substantially increased the granular cost of the PCCP option compared to the asphalt option that did require an OGDL. It should be noted that the Cement and Concrete Industry went on record noting the concrete pavement structure in this tender was over designed from a pavement thickness and granular base requirement.
- The aggregate supply for the pavement structures was right on the job site so there was minimal additional hauling cost for the asphalt pavement structure. This is normally an advantage for the PCCP option due to less granular material required under the PCCP.

Table 3: Results of Alternate Bid Tender for Deerfoot Trail in Calgary, Alberta

Bidder	Pavement Type Bid	Tender Value ($ Million)	LCCA Value	Tender Value with LCCA Value Added ($)
South Rock Ltd	Asphalt	24,282,322	4,941,500	29,223,822
Border Paving Ltd	Asphalt	24,344,336	4,941,500	29,285,836
Carmacks Enterprises Ltd	Asphalt	24,553,126	4,941,500	29,494,626
Standard General Inc	Asphalt	26,715,813.6	4,941,500	31,657,313.6
Dufferin Construction	Concrete	33,444,789.75	1,690,200	35,134,989.75
Kiewit Management	Concrete	33,632,873	1,690,200	35,323,073
Richardson Bros.	Asphalt	34,988,300.8	4,941,500	39,929,800.8

Source: Tender documents

Listed below are the details for the pavement structures:

Concrete	Asphalt
270 mm JPCP in driving lane	250 mm of ACP
100 mm open graded drainage layer (OGDL)	500 mm of GBC
150 mm granular base course (GBC)	

- Design program used for PCCP
    - DARWin Pavement Design and Analysis System (program based on AASHTO 1993 Guide for Design of Pavement Structures)

See Appendix A for more details on the concrete pavement design and Appendix B for Deerfoot Trail Maintenance and Rehabilitation schedules.

4.3 **Anthony Henday in Edmonton Alberta**

Alberta Department of Infrastructure and Transportation tender a second alternate bid tender contract in 2004. This tender was for the construction of 14.4 km of 4-lane highway with full lane width concrete shoulders as part of the ring road in Edmonton Alberta. The results of this tender were different than the Deerfoot Trail tender as the lowest bidder was a PCCP tender. There were three key differences with this tender which influenced the outcome including the follows:

- more equivalent pavement structures
- an OGDL was not required under either pavement this time
- hauling distance for the granular aggregates was over 60 km which favoured the PCCP option due to requiring less aggregate.

As with the Deerfoot Trail project the LCCA period was 30 years. Table 4 below identifies the bidders and tender results for the Deerfoot Trail alternate bid project. The winning bib was Kiewit Management at $44,256,735.

Table 4: Results of Alternate Bid Tender for Anthony Henday in Edmonton, Alberta

Bidder	Pavement Type Bid	Tender Value ($)	LCCA Value	Tender Value with LCCA Value Added ($)
Kiewit Management	Concrete	40,619,835	3,636,900	44,256,735.0
Carmacks Enterprises Ltd	Asphalt	33,926,701.84	10,790,500	44,717,201.84
South Rock Ltd	Asphalt	35,500,778	10,790,500	46,291,278.00
Lafarge	Concrete	43,687,375.41	3,636,900	47,324,275.41
Dufferin Construction	Concrete	44,662,785	3,636,900	48,299,685.00
E Construction	Asphalt	38,750,530.42	10,790,500	49,541,030.42

Source: Tender documents
Note: HMA LCCA value includes estimated cost of $5,102,000 for year two final stage paving for the asphalt structure.

Listed below are the details for the pavement structures:

Concrete	Asphalt
230 mm JPCP in driving lane	250 mm of ACP
150 mm granular base course (GBC)	500 mm of GBC

- Design program used for PCCP
  - DARWin Pavement Design and Analysis System (program based on AASHTO 1993 Guide for Design of Pavement Structures) and PCAPav design program

See Appendix A for more details on the concrete pavement design and Appendix B for Anthony Henday Maintenance and Rehabilitation schedules.

4.4 **Ontario Alternate Bid Projects**

Since 2001, Ontario Ministry of Transportation has tendered 6 alternative bid tenders. Concrete pavement was the winning paving material in each of the 6 alternative bids. In four of the tenders a PCCP option was the lowest cost bid even without having to add the LCCA advantage assigned to the concrete pavement options. The life cycle cost adjustment values which were given to each concrete pavement job is identified in Table 1 on page 10. These values were calculated by subtracting the concretes' LCCA value identified in the tenders from the asphalts' LCCA values. Listed below are each project's concrete and asphalt pavement structures. The concrete pavement material, construction and jointing details are in Ontario Provincial Standard Specifications 350, 904, 1350, Special Provisions and OPSD. This information is ready accessible in the Ontario Ministry of Transportation web site (www.mto.gov.on.ca).

Highway 417 Eastbound was tendered in March 2001 from Dunvegan Road to Highway 17, for 36.4 kilometers reconstruction of 4-lane divided, with a discount rate of 7%. The opposite direction was tendered in February, 2004 for 36.9 kilometers with a discount rate of 5.3%. Both projects have been completed. Listed below is the pavement structures for the two options:

Concrete	Asphalt
200 mm JPCP	40 mm DFC
150 mm granular 'O'	100 mm HDB (2 – 50 mm lifts)
150 mm granular 'B'*	150 mm Granular "0"
	450 mm Modified Granular "B"*

* recycled asphalt pavement & cement stabilized base

Highway 401 between Tilbury and Windsor: reconstruction to 6-lane divided roadways with a discount rate of 5.3%,

- Stage 1: from Interchange 48 Easterly to 1 km east of Essex Road 42 for 10.6 kms, alternative bid was tender in April 2004,
- Stage 2: from Interchange 21 to 28 for 12.6 kms. It was tendered in March, 2005,

- Stage 3: from Interchange 34 to 48 for 15.6 kms and a commercial vehicle inspection facility;
- the concrete and asphalt pavement structures for the three tenders were as follows:

Concrete	Asphalt
260 mm JPCP	40 mm SMA
100 mm OGDL	50 mm Superpave 19.0
300 mm Granular A	50 mm Superpave 19.0
	80 mm Superpave 25.0
	80 mm Superpave 25.0
	100 mm OGDL
	500 mm Granular A

Table 5 below identifies the bidders and tender results for the Highway 401 – Stage 3 alternate bid project.

Table 5: Results of Alternative Bid for Highway 401 – Stage 3

Bidder	Pavement Type	Total Adjusted Tender ($)	Total Tender with LCCA Value Added ($)
COCO Group of Companies	Concrete	52,396,696.80	55,940,000.00
Dufferin Construction Company	Concrete	53,342,596.80	56,990,000.00
Aecon Construction & Materials Limited & Brennan/Miller Paving Limited Joint Bid	Concrete	57,755,796,80	61,884,000.00
Dunn Paving Limited	Asphalt	60,054,392.70	63,900,000.00

Source: Tender documents

Highway 410 Extension: from Bovaird Drive northerly to Mayfield Road in Brampton for 5.4 kms reconstruction of 4 & 6-lane divided, with a discount rate of 5.3%;

Concrete	Asphalt
250 mm JPCP	40 mm Superpave 12.5
100 OGDL	2 layers of 50 mm Superpave 19.0
300 Granular A	100 mm Superpave 25.0
	100 mm OGDL
	150 mm Granular A
	410 mm Granular B-Type I

Table 6 below identifies the bidders and tender results for the Highway 410 alternate bid project. See Appendix B for the Maintenance and Rehabilitation schedules.

Table 6: Results of Alternative Bid for Highway 410 – Brampton

Bidder	Pavement Type	Total Adjusted Tender ($)	Total Tender with LCCA Value Added ($)
Dufferin Construction Company	Concrete	45,994,441,20	50,207,000.00
PAVE-AL Limited	Asphalt	50,071,793.03	54,336,099.81
Bot Construction Limited	Asphalt	50,206,181.10	54,495,000.00
Aecon Construction & Materials Limited	Asphalt	50,645,703.20	54,980,000.00
B. Gottardo Construction	Asphalt	51,459,303.20	55,900,000.00
Graham Brothers Construction Limited	Asphalt	53,108,202.50	57,722,777.00

Source: Tender documents

5.0 **Quebec's Modified Alternative Bid Tender Process**

The Ministère de Transport du Quebec (MTQ) has developed a modification to the alternate bid tender process described above. MTQ developed a pavement selection policy that identifies a network of three zones specifying the use of different types of pavement. The Policy states:

"With regard to major rehabilitation work and the reconstruction of roads under its jurisdiction, the Department establishes three zones specifying the use of different types of pavement. These zones are shown on the above maps. Thus the Department recognizes that

- Concrete pavements are suited to that portion of the road network where the analyses have shown it to be the most cost-effective option;
- Asphalt pavement is suited to that portion of the road system where analysis has shown it to be the most cost-effective option;
- A more detailed analysis based on the LCCA and multicriteria methods must be done on those portions of the road system where no option is noticeably superior in terms of return on investment.

This type of system has some very good merits as it clearly identifies a two-pavement system, thereby, allowing a contractor base to be established in both pavement types. As noted in section 3.0 above, a two-pavement system provides government agencies with more competitive construction prices which in turn allows more roadway kilometres to be placed for the same amount of funds.

Details on MTQ's Pavement Selection Policy can be found at the following web links:

1) http://www.cement.ca/cement.nsf/e/49DC3A8819C6B15785256AF100652A20?OpenDocument
2) http://www2.mtq.gouv.qc.ca/reseau/chaussees/orientation.htm

6.0 **Conclusion**

For the general public to get the most cost effective pavement structure Government agencies must look at more than just the initial cost of the pavement structure. Several Departments of Transportations across Canada have started to recognize this fact and have called alternate bid tenders for paving projects including both asphalt and concrete pavement structures options. When tendering these types of projects it is important to ensure equivalent designs are developed for the competing pavement types and LCCA values be calculated as accurate as possible. To have an even better understanding of the true cost of the pavement options consideration should also be given to determining user costs and the sustainable benefits of one pavement structure compared to the other.

The results of the alternate bid tenders across Canada clearly show concrete pavement structures can be competitive with asphalt pavement structures when tendering equivalent pavement designs with LCCA components. In fact, in some of the above cases the PCCP options were even less expensive than the ACP options without the LCCA advantage. In addition, the paper shows having a two pavement system (i.e. PCCP and ACP) also enables Government agencies to pave more roadways with the same amount of money.

7.0 **References**

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Appendix A

Additional Design Details for Selected PCCP Alternate Bid Tender Projects

Design Item	Highway 101	Deerfoot Trail	Anthony Henday
Concrete Pavement Structure	240 mm JPCP in driving lane 220 mm JPCP in passing lane 100 mm granular Type 1 375 mm Type 2 50 mm minus	270 mm JPCP in driving lane 100 mm OGDL 150 mm granular base course (GBC)	230 mm JPCP in driving lane 150 mm granular base course (GBC)
Pavement width	3.7 metre lanes 2.0 m concrete shoulder in Driving lane	3.7 metre lanes	3.7 metre lanes
Transverse Joint Spacing	5.0 metres	4.5 metres	4.5 metres
Dowel Bar Size	32 mm epoxy coated 450 mm @ 300 mm	38 mm epoxy coated 450 mm @ 300 mm	32 mm epoxy coated 450 mm @ 300 mm
Joint Sealant	Preformed neoprene in transverse Hot pour in long.	Silicone specified	
Longitudinal Joint	15 M epoxy coated rebar 900 mm @ 900 mm	15 M epoxy coated rebar 760 mm @ 600 mm	15 M epoxy coated rebar 450 mm @ 600 mm
Design ESALs	13 million (70% in driving lane)	26.221 million	26.8 million
Pavement Strength	35 MPa @ 28 days 4.85 MPa @ 28 days	35 MPa @ 28 days 4.85 MPa @ 28 days	35 MPa @ 28 days 4.85 MPa @ 28 days

Appendix B

Life Cycle Cost Maintenance and Rehabilitation Strategies for Various Projects

PORTLAND CEMENT CONCRETE PAVEMENT

LIFE-CYCLE COST ANALYSIS CHART

Hwy 2:15 (Deerfoot Trail Extension)
Total Main Alignment - 18.233 km

Discount Rate 4.00%

YEAR	ITEM	CAPITAL	DISCOUNTED TO YEAR "0"	YEAR
0	WIN + Engineering	$ 232,600.00	$ 232,600	0
1	WIN + Line Painting	$ 38,000.00	$ 36,600	1
2	WIN + Line Painting	$ 38,000.00	$ 35,200	2
3	WIN + Line Painting	$ 38,000.00	$ 33,800	3
4	WIN + Line Painting	$ 38,000.00	$ 32,500	4
5	WIN + Line Painting	$ 38,000.00	$ 31,300	5
6	WIN + Line Painting	$ 38,000.00	$ 30,100	6
7	WIN + Line Painting	$ 38,000.00	$ 28,900	7
8	WIN + Line Painting	$ 38,000.00	$ 27,800	8
9	WIN + Line Painting	$ 38,000.00	$ 26,700	9
10	WIN + Line Painting	$ 38,000.00	$ 25,700	10
11	WIN + Line Painting	$ 38,000.00	$ 24,700	11
12	WIN + Line Painting + 50% Trans. & 25% Long. Joints	$ 274,200.00	$ 171,300	12
13	WIN + Line Painting	$ 38,000.00	$ 22,900	13
14	WIN + Line Painting	$ 38,000.00	$ 22,000	14
15	WIN + Line Painting	$ 38,000.00	$ 21,200	15
16	WIN + Line Painting	$ 38,000.00	$ 20,300	16
17	WIN + Line Painting	$ 38,000.00	$ 19,600	17
18	WIN + Line Painting + 100% Trans & 50 % Long Joints + Diamond Grind + Partial & Full Depth Repairs + Engineering	$1,121,000.00	$ 553,400	18
19	WIN + Line Painting	$ 38,000.00	$ 18,100	19
20	WIN + Line Painting	$ 38,000.00	$ 17,400	20
21	WIN + Line Painting	$ 38,000.00	$ 16,700	21
22	WIN + Line Painting	$ 38,000.00	$ 16,100	22
23	WIN + Line Painting	$ 38,000.00	$ 15,500	23
24	WIN + Line Painting	$ 38,000.00	$ 14,900	24
25	WIN + Line Painting	$ 38,000.00	$ 14,300	25
26	WIN + Line Painting	$ 38,000.00	$ 13,800	26
27	WIN + Line Painting	$ 38,000.00	$ 13,200	27
28	WIN + Line Painting + Partial & Full Depth Repairs + Engineering	$ 388,400.00	$ 129,600	28
29	WIN + Line Painting	$ 38,000.00	$ 12,200	29
30	WIN + Line Painting	$ 38,000.00	$ 11,800	30
	Totals	$3,042,200.00	$1,690,200.00	

Notes: Included in the LCC is the main alignment (18.233 km. 12.9 m wide) and climbing lanes (7.6 km, 3.7 m wide)
Weigh In Motion (WIM) capital cost of $150,000 at year 0; $8,000 maintenance annually

Assumptions:
Included traffic accommodation for maintenance items
Joint repairs, diamond grinding, and partial and full depth repairs include traffic accommodation
Lane rental included with diamond grinding
Lane rental for maintenance conducted during off-peak hours
Annual cost associated with the maintenance bond, 1% value of the maintenance bond ($5 million) divided equally over 30 year period

PORTLAND CEMENT CONCRETE PAVEMENT

LIFE-CYCLE COST ANALYSIS CHART

Hwy 2:15 (Deerfoot Trail Extension)
Total Main Alignment - 18.233 km

Discount Rate 4.00%

YEAR	ITEM	CAPITAL	DISCOUNTED TO YEAR "0"	YEAR
0	Weigh In Motion (WIN) + Line painting + engineering costs	$ 477,000	$ 477,000	0
1	line painting + WIM	$ 38,000	$ 36,600	1
2	final stage 100 mm (main alignment, climbing lane)+ line painting+WIN+Engineeering costs	$ 2,440,900	$ 2,256,800	2
3	line painting + WIM	$ 38,000	$ 33,800	3
4	chip seal coat + line painting + WIM	$ 377,200	$ 322,500	4
5	line painting + WIM	$ 38,000	$ 31,300	5
6	rout and seal cracks + line painting + WIN	$ 63,900	$ 50,600	6
7	line painting + WIM	$ 38,000	$ 28,900	7
8	line painting + WIM	$ 38,000	$ 27,800	8
9	spary patch small areas + line painting + WIM	$ 71,400	$ 50,200	9
10	line painting + WIM	$ 38,000	$ 25,700	10
11	line painting + WIM	$ 38,000	$ 24,700	11
12	line painting + WIM + small pothole repair	$ 64,400	$ 40,300	12
13	climbing lane (mill and inlay)+Engineering costs+line painting+WIM+small pothole repair	$ 237,400	$ 142,600	13
14	line painting + WIM + small pothole repair	$ 64,400	$ 37,200	14
15	line painting + WIM + small pothole repair	$ 64,400	$ 35,800	15
16	line painting + WIM + small pothole repair	$ 64,400	$ 34,400	16
17	line painting + WIM + small pothole repair	$ 64,400	$ 33,100	17
18	line painting + WIM + small pothole repair	$ 64,400	$ 31,800	18
19	rehab overlay (main alignment and climbing lane)+Engineering costs+ line painting+WIM	$ 1,822,300	$ 865,000	19
20	line painting + WIM	$ 38,000	$ 17,400	20
21	chip seal coat + line painting + WIM	$ 377,200	$ 165,600	21
22	line painting + WIM	$ 38,000	$ 16,100	22
23	rout & seal cracks + line painting + WIM	$ 63,900	$ 26,000	23
24	line painting + WIM	$ 38,000	$ 14,900	24
25	line painting + WIM	$ 38,000	$ 14,300	25
26	spray patch small areas + line painting + WIM	$ 71,400	$ 25,800	26
27	line painting + WIM	$ 38,000	$ 13,200	27
28	small pothole repair + line painting + WIM	$ 64,400	$ 21,500	28
29	line painting + WIM + small pothole repair	$ 64,400	$ 20,700	29
30	line painting + WIM + small pothole repair	$ 64,400	$ 19,900	30
	Totals	$ 7,038,200	$ 4,941,500	

Notes: Included in the LCC is the main alignment (18.233 km. 12.9 m wide) and climbing lanes (7.6 km, 3.7 m wide
Weigh In Motion (WIM) capital cost of $150,000 at year 0; $8,000 maintenance annually

Assumptions:
Included traffic accommodation for maintenance items
Final Stage pavement, rehabilitation overlays, mill and inlay and chip seal costs include traffic accommodation
Lane rental included with final stage, rehab overlays, chip seal and mill and inlay
Lane rental for maintenance conducted during off-peak hours
Modified binder in the final stage pavement; the rehabilitation overlay will be required at year 19
Climbing land rehabilitation; cold mill and inlay
annual cost associated with h maintenance bond, 1% of the value of the maintenance bond ($5 million)m
divided equally over the 30 year period

ANTHONY HENDAY DRIVE EXTENSION
LIFE CYCLE COST ANALYSIS
ASPHALT CONCRETE PAVEMENT OPTION

DISCOUNT RATE = 4%

Year	Item 1	Item 2	Item 3	Item 4	Item 5	Capital Cost	Total Present Worth Cost Discounted to Year '0'
						($)	($)
0	WIM	Engineering A	Bond A			$ 834,000.00	$ 834,000.00
1	WIM	Line Painting				$ 34,200.00	$ 32,900.00
2	WIM	Line Painting	Final Stage Paving	Engineering B		$ 5,518,300.00	$ 5,102,000.00
3	WIM	Line Painting				$ 34,200.00	$ 30,500.00
4	WIM	Line Painting	Chip Seal A			$ 641,700.00	$ 548,600.00
5	WIM	Line Painting	Bond A			$ 534,200.00	$ 439,100.00
6	WIM	Line Painting	Crack Sealing			$ 73,500.00	$ 58,100.00
7	WIM	Line Painting				$ 34,200.00	$ 26,000.00
8	WIM	Line Painting				$ 34,200.00	$ 25,000.00
9	WIM	Line Painting	Spray Patching			$ 103,800.00	$ 73,000.00
10	WIM	Line Painting	Bond B			$ 534,200.00	$ 360,900.00
11	WIM	Line Painting				$ 34,200.00	$ 22,300.00
12	WIM	Line Painting	Pothole Repair			$ 70,500.00	$ 44,100.00
13	WIM	Line Painting	Pothole Repair			$ 70,500.00	$ 42,400.00
14	WIM	Line Painting	Pothole Repair			$ 70,500.00	$ 40,800.00
15	WIM	Line Painting	Pothole Repair	Bond C		$ 470,500.00	$ 261,300.00
16	WIM	Line Painting	Pothole Repair			$ 70,500.00	$ 37,700.00
17	WIM	Line Painting	Pothole Repair			$ 70,500.00	$ 36,200.00
18	WIM	Line Painting	Pothole Repair			$ 70,500.00	$ 34,900.00
19	WIM	Line Painting	Widening	Rehab Overlay A	Engineering C	$ 4,153,800.00	$ 1,971,600.00
20	WIM	Line Painting	Bond D			$ 234,200.00	$ 106,900.00
21	WIM	Line Painting	Chip Seal B			$ 909,200.00	$ 399,000.00
22	WIM	Line Painting				$ 34,200.00	$ 14,500.00
23	WIM	Line Painting	Crack Sealing			$ 73,500.00	$ 29,900.00
24	WIM	Line Painting				$ 34,200.00	$ 13,400.00
25	WIM	Line Painting	Bond E			$ 234,200.00	$ 87,900.00
26	WIM	Line Painting	Spray Patching			$ 103,800.00	$ 37,500.00
27	WIM	Line Painting				$ 34,200.00	$ 11,900.00
28	WIM	Line Painting	Pothole Repair			$ 70,500.00	$ 23,600.00
29	WIM	Line Painting	Pothole Repair			$ 70,500.00	$ 22,700.00
30	WIM	Line Painting	Pothole Repair			$ 70,500.00	$ 21,800.00
				TOTALS:		**$ 15,327,000.00**	**$ 10,790,500.00**

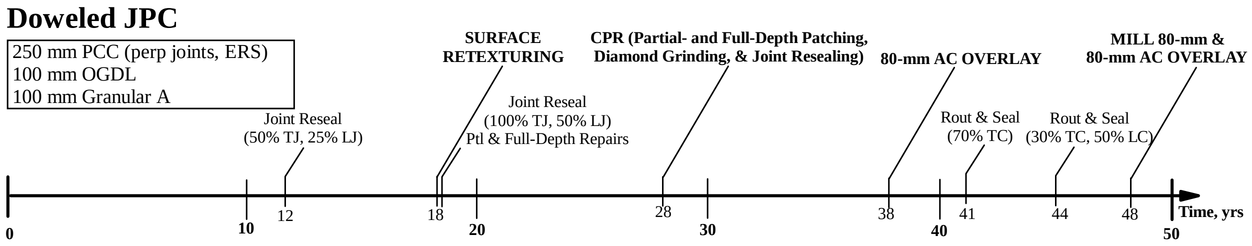
Weigh-in-Motion = WIM

ANTHONY HENDAY DRIVE EXTENSION
LIFE CYCLE COST ANALYSIS
ASPHALT CONCRETE PAVEMENT OPTION

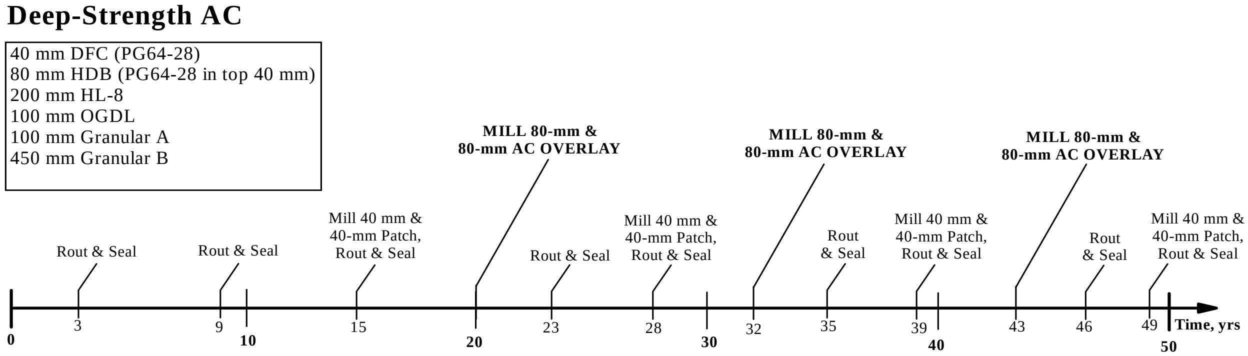
DISCOUNT RATE = 4%

Year	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Capital Cost ($)	Total Present Worth Cost Discounted to Year '0' ($)
0	WIM	Engineering A	Bond A				$ 761,500.00	$ 761,500.00
1	WIM	Line Painting					$ 34,200.00	$ 32,900.00
2	WIM	Line Painting					$ 34,200.00	$ 31,700.00
3	WIM	Line Painting					$ 34,200.00	$ 30,500.00
4	WIM	Line Painting					$ 34,200.00	$ 29,300.00
5	WIM	Line Painting	Bond A				$ 534,200.00	$ 439,100.00
6	WIM	Line Painting					$ 34,200.00	$ 27,100.00
7	WIM	Line Painting					$ 34,200.00	$ 26,000.00
8	WIM	Line Painting					$ 34,200.00	$ 25,000.00
9	WIM	Line Painting					$ 34,200.00	$ 24,100.00
10	WIM	Line Painting	Bond B				$ 534,200.00	$ 360,900.00
11	WIM	Line Painting					$ 34,200.00	$ 22,300.00
12	WIM	Line Painting	Joint Repairs (50% Trans., 25% Long.)				$ 392,000.00	$ 244,900.00
13	WIM	Line Painting					$ 34,200.00	$ 20,600.00
14	WIM	Line Painting					$ 34,200.00	$ 19,800.00
15	WIM	Line Painting	Bond C				$ 434,200.00	$ 241,100.00
16	WIM	Line Painting					$ 34,200.00	$ 18,300.00
17	WIM	Line Painting					$ 34,200.00	$ 17,600.00
18	WIM	Line Painting					$ 34,200.00	$ 16,900.00
19	WIM	Line Painting	Joint Repairs (100% Trans., 50% Long.)	Widening	Partial & Full Depth Repairs A	Engineering B	$ 906,950.00	$ 430,500.00
20	WIM	Line Painting	Bond D				$ 234,200.00	$ 106,900.00
21	WIM	Line Painting					$ 34,200.00	$ 15,100.00
22	WIM	Line Painting					$ 34,200.00	$ 14,500.00
23	WIM	Line Painting	Diamond Grinding				$ 865,600.00	$ 351,200.00
24	WIM	Line Painting					$ 34,200.00	$ 13,400.00
25	WIM	Line Painting		Bond E			$ 234,200.00	$ 87,900.00
26	WIM	Line Painting					$ 34,200.00	$ 12,400.00
27	WIM	Line Painting					$ 34,200.00	$ 11,900.00
28	WIM	Line Painting					$ 34,200.00	$ 11,500.00
29	WIM	Line Painting					$ 34,200.00	$ 11,000.00
30	WIM	Line Painting	Partial & Full Depth Repairs B	Engineering C			$ 586,850.00	$ 181,000.00
	Weigh-in-Motion = WIM					**TOTALS:**	**$ 6,202,100.00**	**$ 3,636,900.00**

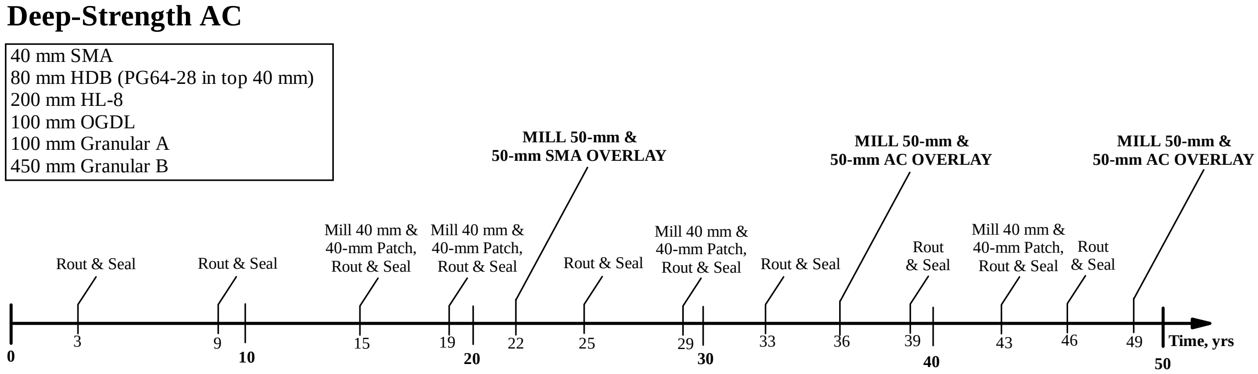
MTOs recommended LCCA models for joint plain concrete pavement, deep-strength asphalt and stone-master asphalt are as follows;



Life-cycle model for JPC combined-technology design



Life-cycle model for DSAC combined-technology design



Life-cycle model for SMA combined-technology design