Final Report

Methodology for the Development of Equivalent Pavement Structural Design Matrix for Municipal Roadways- Ontario

Including Maintenance & Rehabilitation Schedules and Life Cycle Cost Analysis

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LIST OF ABBREVIATIONS

AADT	Average Annual Daily Traffic
AADTT	Average Annual Daily Truck Traffic
ESAL	Equivalent Single Axle Load
HMA	Hot-Mix Asphalt
JPCP	Jointed Plain Concrete Pavement
LCCA	Life-Cycle Cost Analysis
MEPDG	Mechanistic-Empirical Pavement Design Guide
MTO	Ministry of Transportation, Ontario
M&R	Maintenance and Rehabilitation
OPSS	Ontario Provincial Standard Specification
PCC	Portland Cement Concrete
PW	Present Worth

1.0 INTRODUCTION

Both rigid and flexible pavements are commonly used in Ontario for both provincial highways and municipal streets. Each pavement type is designed and constructed based on local traffic and site conditions.

Rigid pavements in Ontario typically consist of a Jointed Plain Concrete Pavement (JPCP) over a granular base which provides uniform support for the concrete slabs. The structural strength of a concrete pavement is largely within the concrete itself due to its rigid nature. Concrete's rigidness spreads the load over a large area and keeps the pressure on the subgrade low, which is why less base material is required. Portland Cement Concrete (PCC) pavements have been used in many areas of the Province ranging from low volume residential roadways to our major 400 series highways.

Flexible pavements typically consist of Hot-Mix Asphalt (HMA) pavement over a granular base and subbase to distribute the traffic loads over the underlying layers. The asphalt concrete materials used in Ontario municipalities typically consist of Superpave asphalt mix designs.

Government agencies can benefit from a two-pavement system, where an agency is able to pave more roadways with the same amount of funding when compared to a single pavement system. Although concrete and asphalt have been used for municipal roads for decades, the use of alternate bids with life cycle cost as part of the tender process for pavement choice evaluation is fairly new. This process has been evolving in Canada since the first MTO contract tendered in 2001. 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 considering the initial cost of the pavement. The Ministry of Transportation of Ontario (MTO) uses an alternative bid process for major highways to ensure that the pavement selected is the most appropriate for the particular location and site conditions. This process uses an established Life-Cycle Cost Analysis (LCCA) procedure (ARA 2006) to help evaluate the ongoing maintenance and rehabilitation (M&R) costs against any differences in initial construction costs. While the MTO procedure focuses on the high volume highways across the province, a similar procedure can be used for pavement type selection of municipal roadways. The purpose of this report is to describe the pavement type selection process between concrete and asphalt pavements and to provide typical pavement cross-section information and accompanying M&R plans that are appropriate for use by Ontario municipalities.

These designs are established to be structurally equivalent and have the same design life such that a fair comparison may be made. The M&R plans have been developed for both pavement types to ensure that the minimum level of service will be maintained through preventative maintenance and rehabilitation activities commonly used by Ontario municipalities. It should be noted that the maintenance and rehabilitation plans for provincial highways tend to be more frequent than for municipal roadways due to differences in posted speed and the higher focus on pavement smoothness for the faster moving highways. The recommended municipal maintenance and rehabilitation plans have been established to provide a reasonable level of service throughout the asset life.

Creating equivalent pavement designs has historically been difficult due to differences in the pavement design procedures used for rigid and flexible pavements. However, the most recent release of the AASHTO pavement design guide, the Mechanistic-Empirical Pavement Design Guide (MEPDG) (AASHTO 2008), provides a more robust design procedure that uses substantially more design information and a larger source of data to calibrate the performance predictions than previous editions. Equivalent designs used in this document are based on the MEPDG.

This study includes pavement designs and maintenance plans for collector, minor arterial and major arterial roadways in Southern and Eastern Ontario.

2.0 MECHANISTIC-EMPIRICAL PAVEMENT DESIGN GUIDE

The MEPDG is the pavement design guide developed for AASHTO under the U.S. National Cooperative Highway Research Program (NCHRP) Project 1-37A. The MEPDG uses mechanistic-empirical principles to predict the deterioration of pavements and their expected service lives. The design procedure is very comprehensive. It includes procedures for the analysis and design of new and rehabilitated rigid and flexible pavements, procedures for evaluating existing pavements, procedures for subdrainage design, recommendations on rehabilitation treatments and foundation improvements, and procedures for life cycle cost analysis.

The MEPDG uses state-of-the-practice mechanistic models to predict the accumulation of pavement distresses based on the traffic loads and the material properties. This process is repeated hundreds of thousands of times to account for all of the possible traffic load combinations and the changes in materials due to age and climatic conditions.

To ensure that the models closely represent the distress conditions of in-service pavements, the process was calibrated to match known performance information from the Long Term Pavement Performance study and other test tracks across North America. These comprehensive data sources have been used to perform an empirical calibration to the field conditions documented from over 20 years of detailed performance observations. The design procedures used in the Guide are based on mechanistic-empirical concepts, which are a quantum leap from the old AASHO Road Test empirical designs that are used by many Canadian transportation agencies.

Mechanistic-empirical design focuses on pavement performance and accounts for many factors that have not been well addressed previously. All of these new design inputs that directly affect pavement performance such as materials, climate, traffic loads and construction procedures are used to estimate the distress condition of the pavement over time (Figure 2.1).

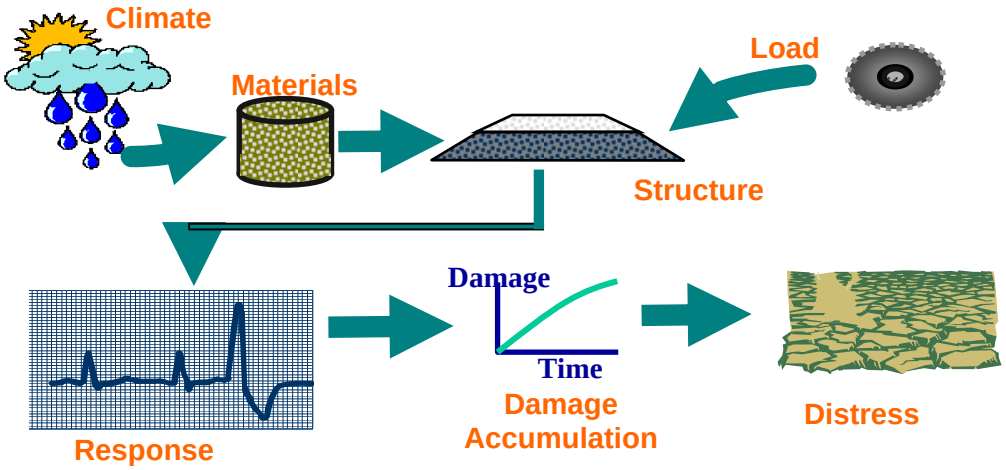


Figure 2.1: General Pavement Design Procedure and Analysis

One of the other major advancements of the MEPDG and the accompanying software is the ability to establish local calibration of the models. Since there are many differences in both the climate and materials used by different agencies, there are many factors that are expected to contribute to the variability in the analysis. As a part of the implementation of the MEPDG by Canadian transportation agencies, local calibration efforts are being completed to both develop the appropriate inputs as well as to monitor the performance of their pavements. The list of design inputs and applicable values developed for Ontario are discussed in this report.

The design inputs have been subdivided into categories for ease of implementation. The following inputs are used by the MEPDG to model the pavement performance:

- General Inputs
- General Information
- Site/Project Identification
- Analysis Parameters
- Traffic
- Traffic Volume Adjustment Factors
- Axle Load Distribution Factors
- General Traffic Inputs
- Climate
- Structure
- Drainage and Surface Properties
- Pavement Structural Layers
- Asphalt Concrete Layers
- Rigid Concrete Layers
- Granular Layers
- Foundation/Subgrade
- Thermal Cracking
- Distress Potential

2.1 Traffic Information

The volume and composition of traffic has always been a major focus of pavement design due to the impact it has on determining the thickness of the pavement. Traffic has been traditionally described as the number of vehicles using the road in terms of the Average Annual Daily Traffic (AADT). In the 1993 AASHTO Design Guide (AASHTO 1993), the traffic was described in terms of Equivalent Single Axle Loads (ESALs), which described the total damage caused by different vehicles in terms of the damage caused by 80 kN (18,000 lbf) single axles.

The MEPDG takes a different approach to more accurately evaluate the damage caused by each axle load on a specific cross-section over the range of conditions it is expected to endure, commonly known as axle load spectra. To accomplish this, the MEPDG uses a large range of traffic parameters. This level of traffic detail is not commonly available for municipal roadways and some assumptions or regional defaults are necessary.

2.1.1 Traffic Volume

The most common traffic input is the number of vehicles expected to pass over a roadway during its design life. As the load applied by passenger vehicles is very low, the MEPDG does not consider them in the analysis. The number of load applications from trucks and buses is summarized using the Average Annual Daily Truck Traffic (AADTT). For the purpose of providing equivalent designs a range of AADTT values are used ranging from 250 to 10,000 trucks per day. These traffic levels represent collector, minor arterial, and major arterial roadways.

For the purposes of this analysis, it is assumed that half of the traffic travels are in each direction. Collector and minor arterial roadways are assumed to have only one lane in each direction, while major arterial roadways are assumed to have 2 lanes in each direction, with 80 percent of the commercial

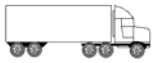
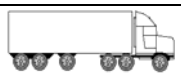
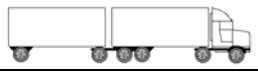
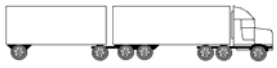
vehicle traffic in the design lane. A compound growth rate of 2 percent was used to account for increases in vehicle volume over time.

2.1.2 Truck Type Distribution

The MEPDG uses a rigorous process to estimate the traffic loads on a roadway. To complete this part of the process, the traffic volume for each month, is divided into the 13 vehicle classes as established by the US Federal Highway Administration (FHWA). Light vehicles, class 1 through 3 (motorcycles and light passenger vehicles), are ignored with the remaining vehicle classes being the focus of the pavement structural design.

The types of vehicles that travel a roadway are typically dependent on the functional classification, the location, and the proximity to industry and natural resources. While conditions may vary locally, typical distributions for the three functional classifications being modelled are shown in Table 2.1.

Table 2.1. Expected Commercial Vehicle Distribution for Municipal Roadways

FHWA Class	Commercial Vehicle		Distribution of Commercial Vehicles		
			Collector	Minor Arterial	Major Arterial
4		Two or Three Axle Buses	2.9 %	3.3 %	1.8 %
5		Two-Axle, Six-Tire, Single Unit Trucks	56.9 %	34.0 %	24.6 %
6		Three-Axle Single Unit Trucks	10.4 %	11.7 %	7.6 %
7		Four or More Axle Single Unit Trucks	3.7 %	1.6 %	0.5 %
8		Four or Less Axle Single Trailer Trucks	9.2 %	9.9 %	5 %
9		Five-Axle Single Trailer Trucks	15.3 %	36.2 %	31.3 %
10		Six or More Axle Single Trailer Trucks	0.6 %	1.0 %	9.8 %
11		Five or Less Axle Multi-Trailer Trucks	0.3 %	1.8 %	0.8 %
12		Six-Axle Multi-Trailer Trucks	0.4 %	0.2 %	3.3 %
13		Seven or More Axle Multi-Trailer Trucks	0.3 %	0.3 %	15.3 %

The commercial vehicle distributions are used in conjunction with axle type and load distributions for Southern and Eastern Ontario. The default values for the following list of parameters were used to represent Ontario municipal conditions:

- Hourly vehicle distribution
- Monthly vehicle distribution
- Vehicle length and axle spacing

2.2 Climate Conditions

A significant factor influencing the performance of pavements is climate. While the climate conditions do not differ substantially across Ontario, Mount Forest was selected as having a typical climate representing Southern and Eastern Ontario. Extreme temperatures located in other locations are often accounted for by adjusting materials such as the asphalt binder type. Table 2.2 is a summary pavement surface temperatures expected based on the Mount Forest climate data.

Table 2.2. Average Monthly Quintile Surface Temperature – Mount Forest

Month	1st Quintile (ºC)	2nd Quintile (ºC)	3rd Quintile (ºC)	4th Quintile (ºC)	5th Quintile (ºC)	Mean Temp. (ºC)	Std. Dev. (ºC)
January	-13.0	-8.4	-5.5	-2.9	0.3	-5.9	4.8
February	-13.2	-8.7	-5.5	-2.7	1.4	-5.7	5.2
March	-7.9	-3.4	-0.6	2.3	7.3	-0.4	5.4
April	-1.1	3.3	6.7	10.7	17.4	7.4	6.7
May	5.2	10.4	14.1	18.4	26.0	14.8	7.4
June	11.9	16.9	20.7	25.2	32.4	21.4	7.3
July	14.6	19.6	23.4	27.8	34.4	23.9	7.1
August	13.3	17.9	21.3	25.6	32.1	22.1	6.7
September	8.3	13.1	16.6	20.3	26.7	17.0	6.6
October	2.8	6.8	9.9	13.3	19.2	10.4	5.9
November	-2.2	1.1	3.1	5.3	9.1	3.2	4.1
December	-9.3	-5.4	-3.1	-0.7	2.8	-3.1	4.3

2.3 Pavement Materials

The other major advancement in using mechanistic pavement models is the ability to better describe the pavement materials and any changes in their behaviour throughout the year, and over their expected service life. With the climate data available, the effects of temperature on pavement materials can be accounted for, as well as the effects of drainage and freezing.

2.3.1 Portland Cement Concrete

PCC used across Ontario is primarily based on OPSS 350 (MTO 1998), with the following exceptions. All non-structurally reinforced concrete exposed to chlorides and freezing & thawing is 32MPa, Class C-2, with Air Category 1 (varying depending on aggregate size used) with a maximum water to cementing materials ratio (W/CM) of 0.45 (as per CSA A23.1-09). Based on the minimum specifications, the concrete properties in Table 2.3 were used in the analysis.

Table 2.3. Portland Cement Concrete Properties

Property	Value
Concrete Strength	32 MPa - 28-day Compressive Strength 5.6 MPa - 28-day Modulus of Rupture 29.6 GPa - 28-day Elastic Modulus
Unit Weight	2,324 kg/m^3
CSA Exposure Class	C-2
Water to cementing materials Ratio	0.45

Concrete pavements 200 mm or thicker are dowelled in this analysis with 32M dowel bars placed at 300 mm intervals across the transverse joints. The slabs for collector roads are 4.0 m in length, and the slabs for minor and major arterial roads are 4.5 m in length. Collector, minor arterial and major arterial (2,500 and 5,000 AADTT) roads have a tied concrete shoulder/curb on the outside of the pavement, whereas major arterial roads (7,500 and 10,000 AADTT) have a widened slab on the outside lane. For urban sections, a tied concrete curb or a monolithic slab and curb can be used as a tied should or widened slab respectively. All roads are constructed with concrete using Type GU Portland cement, and cured with a white pigmented curing compound.

2.3.2 Hot Mix Asphalt (HMA)

The HMA used for municipal roadways in Ontario is primarily based on the MTO's specification OPSS 1151 (MTO 2005). This specification provides guidance on the mix design and placement of the different types of mixes commonly used for municipal roadways. The mixes most commonly used as a surface course for collector and arterial roadways are Superpave 12.5, Superpave 12.5 FC1, and Superpave 12.5 FC2. For the base course asphalt, Superpave 19 is assumed. The properties of the HMA materials used in the analysis are shown in Table 2.4.

Table 2.4. Hot Mix Asphalt Properties

Property	Superpave 12.5 (Surface Course)	Superpave 12.5 FC1 (Surface Course)	Superpave 12.5 FC2 (Surface Course)	Superpave 19 (Base Course)
Asphalt Cement Type	PG 58-28	PG 64-28	PG 64-28	PG 58-28
Asphalt Cement	5.0 to 5.5 %	5.0 to 5.5 %	5.0 to 5.5 %	4.0 to 5.5 %
Voids in the Mineral Aggregate (VMA)	14.0 % minimum	14.0 % minimum	14.0 % minimum	13.0 % minimum
Air Voids	4.0 %	4.0 %	4.0 %	4.0 %
Gradation Retained 19 mm	0 %	0 %	0 %	0 to 10 %
Gradation Retained 9.5 mm	10 to 72%	10 to 55%	10 to 55%	20 to 77 %
Gradation Retained 4.75 mm	40 to 55%	40 to 55%	45 to 55%	35 to 77 %
Gradation Passing 75 μm	2 to 10 %	2 to 10 %	2 to 10 %	2 to 8 %

The surface HMA is selected based on the expected traffic volume (MTO 2009). Superpave 12.5 is commonly used for lower traffic volume roadways and replaced the traditional HL 3, HL 3 Fine and HL 4 mixes. Superpave 12.5 FC1 replaced the traditional HL 1 mix and is typically recommended for most collector and minor arterial roadways. The MTO also uses Superpave 12.5 FC2 for very high traffic volume roadways to replace traditional DFC, and is utilized for the high volume, major arterial roadway classification.

2.3.3 Granular Base and Subbase

The most commonly available aggregates used in pavement construction in Ontario consist of Granular A base and Granular B subbase. These materials, described in OPSS 1010 (MTO 2004), can both used beneath the flexible and rigid pavement structures (Table 2.5).

Table 2.5. Granular Base and Subbase Properties

Property		Granular A		Granular B	
Aggregate Gradation (min. and max. percent passing)	106 mm	N/A	N/A	100	100
	26.5 mm	100	100	50	100
	19.0 mm	85	100	N/A	N/A
	13.2 mm	65	90	N/A	N/A
	9.5 mm	50	73	N/A	N/A
	4.75 mm	35	55	20	55
	1.18 mm	15	40	10	40
	300 µm	5	22	5	22
	75 µm	2	8	0	10
Plasticity Index		0		0	
Modulus		250 MPa		200 MPa	
Poisson's Ratio		0.35		0.35	
Coefficient of Lateral Pressure (k_0)		0.5		0.5	

These materials are commonly available and widely used across Ontario. For municipal roadways, the use of an open graded drainage layer is not common and has not been included in any of the pavements in this study. It is however assumed that adequate drainage is provided for both flexible and rigid pavement sections.

2.4 Subgrade Materials

The selection of appropriate properties for the subgrade is an important component of any pavement design. For all detailed pavement designs, geotechnical investigations are required to determine specific conditions for the purposes of providing support to the roadway as well as information on the constructability of the pavement. This is an important step for all pavement design projects.

For this project, a more generic pavement design process was used to develop the pavement designs based on typical subgrade materials for Ontario. To characterize the sensitivity of this parameter and to describe the range of potential conditions across the province, the subgrade parameters shown in Table 2.6 were used in the analysis.

Table 2.6. Subgrade Properties

Soil Properties	Low Plasticity Clay	Inorganic Silt	Silty Sand
Subgrade Strength Category	Low	Medium	High
Representative Resilient Modulus (annual average)	30 MPa	40 MPa	50 MPa
Equivalent CBR	3	4	5
Soil Classification	CL	ML	SM
Liquid Limit	30	20	8
Plasticity Index	20	5	2

2.5 Recommended Terminal Service Level

When designing a pavement, the performance criteria of terminal serviceability represents the lowest acceptable condition that will be tolerated before rehabilitation is required. The limits selected represent those typical for a municipality for an arterial roadway and are shown in Table 2.7. Traditionally, the performance parameters are set based on the importance of the roadway and other factors such as the design speed. The level of reliability is higher for higher trafficked roadways to reflect the importance of preventing premature failures.

Table 2.7. Design Performance Parameters

General Pavement Limits	
Initial Design Life	25 years
Design Reliability	Collector - 75% Minor Arterial - 80 % Major Arterial - 90% (2,500 to 5,000 AADTT) Major Arterial - 95% (7,500 to 10,000 AADTT)
Flexible Pavement Terminal Serviceability Limits	
Fatigue (Alligator) Cracking	10 %
Thermal (Transverse) Cracking	200 m/km
Rutting	10 mm
International Roughness Index (IRI)	3.0 mm/m
Rigid Pavement Terminal Serviceability Limits	
Cracked Slabs	10 %
Faulting	6 mm
International Roughness Index (IRI)	3.0 mm/m

3.0 DEVELOPMENT OF RECOMMENDED PAVEMENT DESIGNS

In order to develop pavement designs for both the concrete and asphalt pavements, a defined process was used to assess the structural capacity of various trial cross-sections. Since the pavement designs were established for municipal pavements in Ontario, the materials chosen as well as many of the design features were established based on current Ontario design standards and common practice.

The thickness of the granular and bound surface layers was the primary factor used to satisfy the design requirements. An initial design was selected based on typical municipal cross-sections and then evaluated within the MPEDG. For each trial section, the MEPDG analysis was completed and results were examined to determine when and how the pavement was expected to fail. The results were then used to modify the trial design to either address premature failure due to one or more of the distresses, or to prevent the over-design of a pavement. The cycle was repeated as necessary to obtain appropriate pavement cross-sections for all traffic and subgrade combinations.

The design process was completed for each combination of subgrade, traffic volume, and pavement type. The primary mode of failure for the pavements was not always the same. For low traffic flexible pavements, the most common cause of failure was a reduction in smoothness. For higher traffic flexible pavements however, fatigue cracking was the limiting factor, with some surface defects expected before the end of the 25 year design life.

For rigid pavements, the modes of failure were primarily based on the pavement design features such as slab length and steel properties. The low traffic designs without dowels typically failed due to a reduced joint load-transfer and subsequent faulting of the joints. However with the addition of dowel bars and a widened slab for higher volume designs, the load transfer was substantially improved and smoothness became the critical distress.

In order to ensure that the results were fair and reasonable, all of the design cross-sections were then reviewed by a panel of design experts. The proposed designs were compared to municipal standards and other design procedures such as StreetPave (ACPA 2005) and the 1993 AASHTO Guide for the Design of Pavement Structures (AASHTO 1993). The review was completed to ensure that the cross-sections matched conditions and municipal performance expectations in Ontario.

The resulting pavement designs are shown in Table 3.1. These designs are considered to be typical for municipal pavements across Ontario. It is however important to note that conditions do vary across the province and some adjustments may be necessary to ensure that they are appropriate for local conditions. A detailed pavement design report should be prepared for each project by a qualified engineer.

Table 3.1 – Representative Pavement Designs for Ontario Municipalities

			Average Annual Daily Truck Traffic (AADTT) - 25 Year Pavement Design							
			Collector		Minor Arterial		Major Arterial			
			250	500	1,000	1,500	2,500	5,000	7,500	10,000
Subgrade Strength	30 MPa (CBR=3)	PCC	180 mm PCC 200 mm Granular A	190 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	210 mm PCC 200 mm Granular A	230 mm PCC 200 mm Granular A
		HMA	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 350 mm Granular B	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 400 mm Granular B	40 mm SP 12.5 FC1 90 mm SP 19 150 mm Granular A 450 mm Granular B	40 mm SP 12.5 FC1 100 mm SP 19 150 mm Granular A 450 mm Granular B	40 mm SP 12.5 FC1 110 mm SP 19 150 mm Granular A 450 mm Granular B	40 mm SP 12.5 FC1 120 mm SP 19 150 mm Granular A 600 mm Granular B	40 mm SP 12.5 FC1 130 mm SP 19 150 mm Granular A 600 mm Granular B	40 mm SP 12.5 FC2 140 mm SP 19 150 mm Granular A 600 mm Granular B
	40 MPa (CBR=4)	PCC	180 mm PCC 200 mm Granular A	190 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	210 mm PCC 200 mm Granular A
		HMA	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 300 mm Granular B	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 350 mm Granular B	40 mm SP 12.5 FC1 80 mm SP 19 150 mm Granular A 350 mm Granular B	40 mm SP 12.5 FC1 100 mm SP 19 150 mm Granular A 350 mm Granular B	40 mm SP 12.5 FC1 100 mm SP 19 150 mm Granular A 400 mm Granular B	40 mm SP 12.5 FC1 120 mm SP 19 150 mm Granular A 450 mm Granular B	40 mm SP 12.5 FC1 130 mm SP 19 150 mm Granular A 500 mm Granular B	40 mm SP 12.5 FC2 140 mm SP 19 150 mm Granular A 550 mm Granular B
	50 MPa (CBR=5)	PCC	180 mm PCC 200 mm Granular A	190 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A	200 mm PCC 200 mm Granular A
		HMA	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 300 mm Granular B	40 mm SP 12.5 80 mm SP 19 150 mm Granular A 300 mm Granular B	40 mm SP 12.5 FC1 80 mm SP 19 150 mm Granular A 300 mm Granular B	40 mm SP 12.5 FC1 100 mm SP 19 150 mm Granular A 300 mm Granular B	40 mm SP 12.5 FC1 100 mm SP 19 150 mm Granular A 350 mm Granular B	40 mm SP 12.5 FC1 110 mm SP 19 150 mm Granular A 400 mm Granular B	40 mm SP 12.5 FC1 130 mm SP 19 150 mm Granular A 450 mm Granular B	40 mm SP 12.5 FC2 140 mm SP 19 150 mm Granular A 500 mm Granular B
Concrete Slab and Joint Properties			No dowels Slab length = 4 m Tied shoulder/curb *		32M Dowel bars, 300 mm spacing Slab length = 4.5 m Tied shoulder/curb *		32M Dowel bars, 300 mm spacing Slab length = 4.5 m Tied shoulder/curb *		32M Dowel bars, 300 mm spacing Slab length = 4.5 m 0.5 m Widened outside slab or integral curb *	

Notes:

- All materials are based on current OPS Specifications
- Subgrade levels are based on three common subgrade materials in Ontario
  - Low Category (30 MPa) - Low Plasticity Clay Subgrade
  - Medium Category (40 MPa) - Low Plasticity Silt Subgrade
  - High Category (50 MPa) - Sandy Silt Subgrade

Reliability Levels

- AADTT 250 to 500 - 75%
- AADTT 1,000 to 1,500 - 80%
- AADTT 2,500 to 5,000 - 90%
- AADTT 7,500 to 10,000 - 95%

* For urban sections, a tied concrete curb or a monolithic slab and curb can be used as a tied shoulder or widened slab respectively.

4.0 LIFE CYCLE PAVEMENT COSTS

When selecting a pavement alternative, it is important to understand the expected pavement performance and costs for the entire life-cycle of the pavement. The overall costs and value need to be determined over many years to effectively consider the different options in terms of pavement type, design life, and future rehabilitation. Life-cycle cost analysis (LCCA) has been used for many years in the Province of Ontario to help make decisions regarding pavement type as well as selecting pavement preservation options.

In a typical LCCA, two or more alternate choices are available for an initial pavement design or cross-section. Based on the initial pavement designs, the expected maintenance and rehabilitation over the design life are then determined and incorporated into a single, inflation adjusted, cost in order to evaluate and compare the different options in a fair and consistent manner.

The pavements designed for this project have an initial design life of 25 years. At the end of the initial service life, some form of rehabilitation, such as a mill and overlay for a flexible pavement, or slab repairs for a rigid pavement, is usually required. An analysis period of 50 years was used for this project to include the initial service life as well as at least one major rehabilitation activity.

The maintenance and rehabilitation plans provided were developed for municipal roadways with speeds between 50 km/h and 80 km/h. The maintenance and rehabilitation plans for provincial highways tend to be more frequent than for municipal roadways due to differences in posted speed and the higher focus on pavement smoothness for the faster moving highways. The recommended municipal maintenance and rehabilitation plans have been established to provide a reasonable level of service throughout the asset life.

4.1 Concrete Pavement Maintenance and Rehabilitation Plans

Concrete pavements are often constructed for their long service life and the reduced level of maintenance expected due to their slower rate of deterioration. Four maintenance and rehabilitation plans for each pavement type have been developed to coincide with the different functional classifications of the roadways. The initial pavement designs were developed based on the three subgrade types shown in Table 2.6.

For the maintenance and rehabilitation of concrete pavements, the most common activities include improving joint performance through resealing, partial depth repairs, and slab replacements with full depth repairs. On higher volume roadways, the smoothness of the roadway has more significance and some surface texturization is recommended to ensure an acceptable performance.

The recommended maintenance and rehabilitation plans are outlined in Table 4.1 through Table 4.4. These plans were developed to provide a consistent level of service in a cost effective manner. The maintenance and rehabilitation quantities provided are for a 1km length of roadway and will need to be adjusted for different section lengths.

Table 4.1 Rigid Collector Pavement Preservation Plan (AADTT 250-500)

Expected Year	Activity Description	Quantity (per 1 km of road)
12	Reseal joints	10 %
25	Partial depth PCC repair	2 %
25	Full depth PCC repair	5 %
25	Reseal joints	20 %
40	Partial depth PCC repair	5 %
40	Full depth PCC repair	10 %
40	Reseal joints	20 %

Table 4.2 Rigid Minor Arterial Pavement Preservation Plan (AADTT 1,000-1,500)

Expected Year	Activity Description	Quantity (per 1 km of road)
12	Reseal joints	20 %
25	Partial depth PCC repair	5 %
25	Full depth PCC repair	10 %
25	Reseal joints	25 %
40	Partial depth PCC repair	5 %
40	Full depth PCC repair	15 %
40	Reseal joints	25 %

Table 4.3 Rigid Major Arterial Pavement Preservation Plan (AADTT 2,500-5,000)

Expected Year	Activity Description	Quantity (per 1 km of road)
12	Reseal joints	25 %
12	Partial depth PCC repair	2 %
25	Partial depth PCC repair	5 %
25	Full depth PCC repair	10 %
25	Reseal joints	25 %
40	Partial depth PCC repair	5 %
40	Full depth PCC repair	15 %
40	Reseal joints	25 %

Table 4.4 Rigid Major Arterial Pavement Preservation Plan (AADTT 7,500-10,000)

Expected Year	Activity Description	Quantity (per 1 km of road)
12	Reseal joints	25 %
12	Partial depth PCC repair	2 %
25	Partial depth PCC repair	5 %
25	Full depth PCC repair	10 %
25	Reseal joints	50 %
25	Texturize	25 %
40	Partial depth PCC repair	5 %
40	Full depth PCC repair	15 %
40	Reseal joints	50 %
40	Texturize	50 %

4.2 Hot Mix Asphalt Pavement Maintenance and Rehabilitation Plans

Hot mix asphalt pavements have been commonly used by Ontario municipalities due to their history of use and experience with maintenance and rehabilitation. HMA pavements typically deteriorate faster than PCC pavements and require a more extensive maintenance schedule to maintain an acceptable level of service.

The recommend maintenance and rehabilitation schedules for HMA pavements are outlined in Table 4.5 through Table 4.8. These plans use a combination of preventative maintenance and rehabilitation to ensure a cost effective preservation plan. The maintenance and rehabilitation quantities provided are for a 1km length of roadway and will need to be adjusted for different section lengths.

Table 4.5 Flexible Collector Pavement Preservation Plan (AADTT 250-500)

Expected Year	Activity Description	Quantity (per 1 km of road)
10	Rout and seal	250 m
10	Spot repairs, mill 40 mm/patch 40 mm	2 %
20	Mill HMA	40 mm
20	Resurface with Superpave 12.5	40 mm
25	Rout and seal	500 m
30	Spot repairs, mill 40 mm/patch 40 mm	5 %
35	Mill HMA	40 mm
35	Full depth asphalt base repair	5 %
35	Resurface with Superpave 12.5	40 mm
40	Rout and seal	500 m
43	Spot repairs, mill 40 mm/patch 40 mm	5 %
48	Mill HMA	40 mm
48	Resurface with Superpave 12.5	40 mm

Table 4.6 Flexible Minor Arterial Pavement Preservation Plan (AADTT 1,000-1,500)

Expected Year	Activity Description	Quantity (per 1 km of road)
10	Rout and seal	250 m
10	Spot repairs, mill 40 mm/patch 40 mm	2 %
15	Spot repairs, mill 40 mm/patch 40 mm	10 %
20	Mill HMA	40 mm
20	Resurface with Superpave 12.5FC1	40 mm
25	Rout and seal	500 m
30	Spot repairs, mill 40 mm/patch 40 mm	5 %
35	Mill HMA	40 mm
35	Full depth asphalt base repair	10 %
35	Resurface with Superpave 12.5FC1	40 mm
40	Rout and seal	500 m
43	Spot repairs, mill 40 mm/patch 40 mm	5 %
48	Mill HMA	90 mm
48	Resurface with Superpave 19	50 mm
48	Resurface with Superpave 12.5FC1	40 mm

Table 4.7 Flexible Major Arterial Pavement Preservation Plan (AADTT 2,500-5,000)

Expected Year	Activity Description	Quantity (per 1 km of road)
5	Rout and seal	200 m
10	Rout and seal	500 m
10	Spot repairs, mill 40 mm/patch 40 mm	5 %
20	Mill HMA	40 mm
20	Resurface with Superpave 12.5FC1	40 mm
25	Rout and seal	1000 m
30	Spot repairs, mill 40 mm/patch 40 mm	10 %
35	Mill HMA	90 mm
35	Resurface with Superpave 19	50 mm
35	Resurface with Superpave 12.5FC1	40 mm
40	Rout and seal	1500 m
45	Spot repairs, mill 40 mm/patch 40 mm	10 %
48	Mill HMA	40 mm
48	Full depth asphalt base repair	5 %
48	Resurface with Superpave 12.5FC1	40 mm

Table 4.8 Flexible Major Arterial Pavement Preservation Plan (AADTT 7,500-10,000)

Expected Year	Activity Description	Quantity (per 1 km of road)
8	Rout and seal	200 m
8	Spot repairs, mill 40 mm/patch 40 mm	5 %
13	Rout and seal	1000 m
13	Spot repairs, mill 40 mm/patch 40 mm	15 %
18	Mill HMA	50 mm
18	Full depth asphalt base repair	10 %
18	Resurface with Superpave 12.5FC2	50 mm
23	Rout and seal	500 m
28	Rout and seal	1500 m
28	Spot repairs, mill 40 mm/patch 40 mm	10 %
32	Mill HMA	90 mm
32	Resurface with Superpave 19	50 mm
32	Resurface with Superpave 12.5FC2	40 mm
37	Rout and seal	1500 m
40	Spot repairs, mill 40 mm/patch 40 mm	10 %
45	Mill HMA	50 mm
45	Full depth asphalt base repair	10 %
45	Resurface with Superpave 12.5FC2	50 mm
48	Rout and seal	1500 m

4.3 Pavement Construction Unit Costs

To estimate the cost of various items over the life of a pavement, unit costs of various construction tasks are required. These unit costs are then multiplied by the expected quantities required at different times throughout the service life.

In order for the LCCA to be realistic, it is important to have accurate unit costs for the initial construction and the expected maintenance and rehabilitation plans. These unit costs are typically provided in a format that is consistent with the way construction estimates and bids are generated.

Actual unit costs can vary significantly from project to project depending on conditions, specific project requirements, equipment availability, and location of the project. The unit costs used for the LCCA are considered typical for municipal roadways in Southern and Eastern Ontario.

The unit prices used for the LCCA are shown in Table 4.9 and Table 4.10. While these values are considered reasonable at the time of this report, it is important to note that prices will fluctuate with time and can vary dramatically depending on the location and size of the project. Review and updating of these unit costs is a critical component of any evaluation.

Table 4.9 Unit Costs for Initial Pavement Construction

Pavement Layer	Description of Pavement Layer	Unit Cost
HMA	Superpave 12.5FC2 (t)	$120.00
	Superpave 12.5FC1 (t)	$115.00
	Superpave 12.5 (t)	$105.00
	Superpave 19 (t)	$96.00
PCC	180 mm PCC pavement, no dowels (m^2)	$41.20
	190 mm PCC pavement, no dowels (m^2)	$42.60
	200 mm PCC pavement, 32M dowels (m^2)	$49.50
	210 mm PCC pavement, 32M dowels (m^2)	$50.90
	230 mm PCC pavement, 32M dowels (m^2)	$53.70
Base	Granular A (t)	$18.00
Subbase	Granular B (t)	$15.00
Excavation	Earth excavation (m^3)	$18.00
	Rock excavation (m^3)	$150.00
	Hot mix asphalt pavement excavation (m^3)	$65.00
	Concrete pavement excavation(m^3)	$82.00
	Contaminated material excavation(m^3)	$80.00

Table 4.10 Unit Costs for Maintenance and Rehabilitation Activities

Description of Maintenance and Rehabilitation Treatments	Unit Costs
Rout and seal (m)	$5.00
Spot repairs, mill and patch (m^2)	$35.00
Asphalt base repair (m^2)	$45.00
Mill HMA (t)	$15.00
Resurface with Superpave 12.5FC2 (t)	$120.00
Resurface with Superpave 12.5FC1 (t)	$115.00
Resurface with Superpave 12.5 (t)	$105.00
Resurface with Superpave 19 (t)	$96.00
Reseal joints (m)	$10.00
Partial depth PCC repair (m^2)	$125.00
Full depth PCC repair (m^2)	$100.00
Texturize (m^2)	$10.00

4.4 Excavation Costs

The costs of excavation are not always necessary to include in an LCCA. They are not applicable to many sites were the pavement geometry is adjusted and the final road grade can be adjusted. Depending

on the longitudinal profile and the existing grade of new construction projects, the extent of excavation required may be reduced during the geometric design process.

Due to the difference in the material strength, the total thickness required for PCC pavements is less than that of HMA pavements. When a pavement is being placed to match an existing grade, excavation of existing materials is required. For thicker pavement structures this can add cost for more earth movement and for any haulage and disposal of material that cannot be used on site. The excavation costs, where appropriate, can be a substantial project cost. The typical pavement sections provided have been designed to include excavation costs when necessary. The thinner pavement structure required by concrete pavements can make this a definitive cost advantage.

In the case of pavement reconstruction, the grade of the pavement surface is typically maintained and materials must be excavated to a depth where the new cross-section can be placed. Since the vast majority of pavement works completed by municipalities are for existing roadways and not green field construction, it has been assumed that excavation needs to be accounted for and has been included in the examples provided.

4.5 Estimating Life-Cycle Costs

To ensure a fair comparison of different options, life cycle costs are typically evaluated in terms of their Net Present Worth (NPW). The present worth represents the cost of a future activity in terms of today's dollars. The initial costs and on-going costs are then combined to evaluate the total project present worth.

The future costs are discounted to adjust for inflation and interest rates. The discount rate used to adjust the future costs is typically set at an agency level. The current discount rate used by the Province of Ontario is 5.0%.

When evaluating the life-cycle cost, it is typically understood that there is a margin of error due to possible differences in quantities, unit costs, and pavement performance over the service life. Comparisons with marginal differences in cost may require further investigation into other factors to determine the optimal pavement type.

An example LCCA for a major arterial roadway (AADTT = 2,500) on the low strength subgrade is shown in Table 4.11 and Table 4.12. This example shows the reduced cost of activities due to discounting, as well as the relatively low cost of the maintenance and rehabilitation compared to the initial construction. The comparison of the costs shown in Figure 4.1 illustrates the relative difference between the two pavement types. For this example, the concrete pavement option has an 11 % lower cost over the pavement life-cycle.

The LCCA process has also been followed and cost comparisons have been generated for other conditions. Full costs comparisons have been developed for all combinations of pavement type, traffic level, and subgrade material. Summaries of the LCCA results can be found in Table 4.13 through Table 4.15 along with all results in Appendix B.

Table 4.11 Example LCCA for a Major Arterial Concrete Pavement (AADTT = 2,500)

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m^2)	200	7500	$ 49.50	$ 742,500
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 129,600
Excavation	Earth Excavation, mm (m^3)	400	3000	$ 18.00	$ 108,000
	Total Initial Cost				**$ 980,100**

Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m^2)	2	300	$ 125.00	$ 37,500	$ 20,881
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m^2)	5	750	$ 125.00	$ 93,750	$ 27,685
25	Full depth PCC repair, % area (m^2)	10	1500	$ 100.00	$ 150,000	$ 44,295
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m^2)	5	750	$ 125.00	$ 93,750	$ 13,317
40	Full depth PCC repair, % area (m^2)	15	2250	$ 100.00	$ 225,000	$ 31,960
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 109,028	$ 9,508
	Total M&R Cost				**$ 515,972**	**$ 136,916**

Table 4.12 Example LCCA for a Major Arterial Asphalt Pavement (AADTT = 2,500)

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	1,512	$ 115.00	$ 173,880
Binder	Superpave 19, mm (t)	110	4,059	$ 96.00	$ 389,664
Base	Granular A, mm (t)	150	5,400	$ 18.00	$ 97,200
Subbase	Granular B, mm (t)	450	13,500	$ 15.00	$ 202,500
Excavation	Earth excavation (m^3)	750	11,250	$ 18.00	$ 202,500
	Total Initial Cost				**$ 1,065,744**

Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost	Net present worth
5	Rout and seal, m (m)	200	200	$ 5.00	$ 1,000	$ 784
10	Rout and seal, m (m)	500	500	$ 5.00	$ 2,500	$ 1,535
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 35.00	$ 26,250	$ 16,115
20	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 8,480
20	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 65,534
25	Rout and seal, m (m)	1000	1000	$ 5.00	$ 5,000	$ 1,477
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 35.00	$ 52,500	$ 12,147
35	Mill HMA, mm (t)	90	3375	$ 15.00	$ 50,625	$ 9,178
35	Resurface with Superpave 19, mm (t)	50	1845	$ 96.00	$ 177,120	$ 32,110
35	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 31,523
40	Rout and seal, m (m)	1500	1500	$ 5.00	$ 7,500	$ 1,065
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 35.00	$ 52,500	$ 5,843
48	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 2,163
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 45.00	$ 33,750	$ 3,245
48	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 16,717
50	Residual value				$ 191,775	$ 16,723
	Total M&R Cost				**$ 553,480**	**$ 191,192**

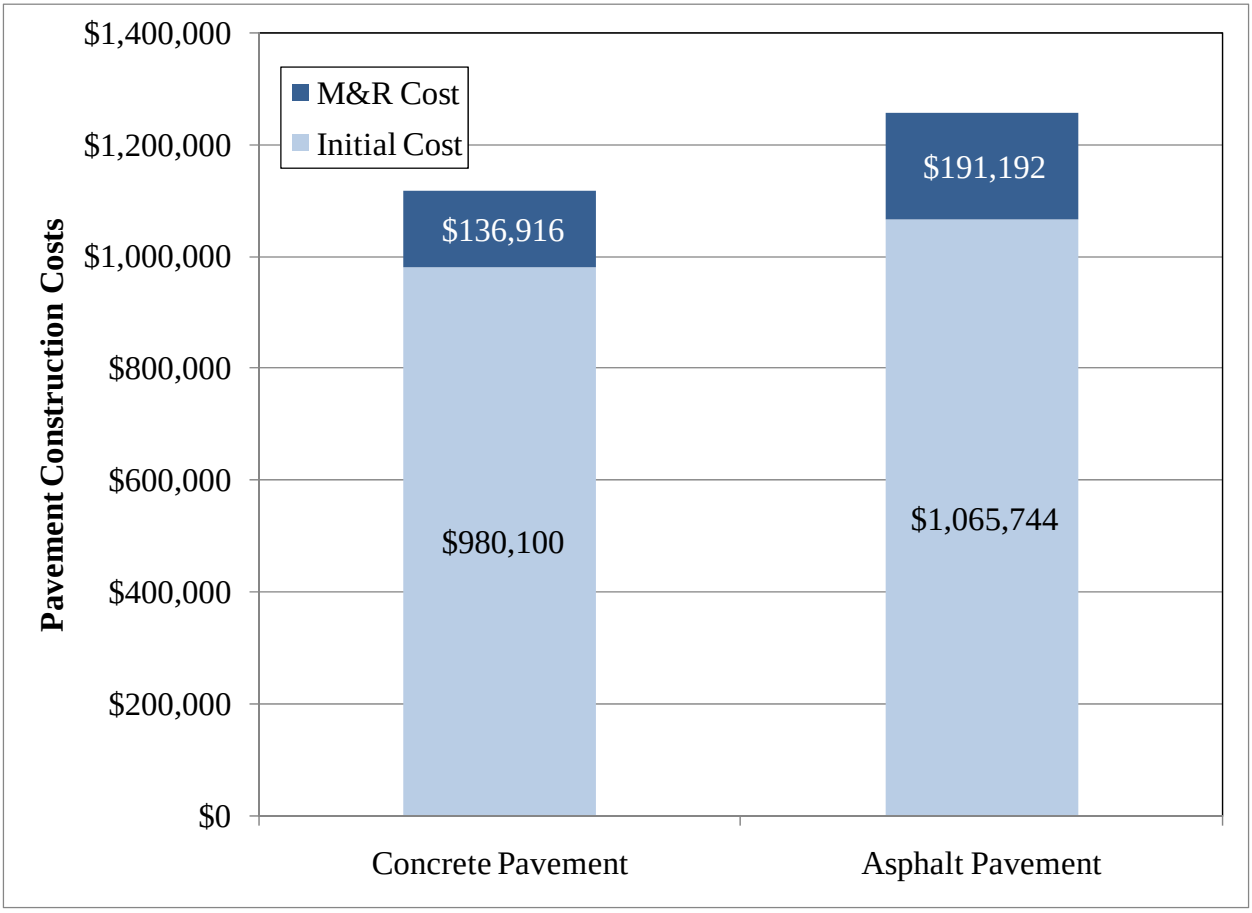


Figure 4.1. Example LCCA Comparison of Costs for a Major Arterial Pavement (AADTT = 2,500)

Table 4.13 Summary of LCCA Results for Low Subgrade Strength

Typical Ontario Municipal Pavements

LIFE CYCLE COST ANALYSIS SUMMARY

Listed by 25 Year AADTT and Pavement Type for Low Strength Subgrade

Item	Collector			
	250 PCC	**250 HMA**	**500 PCC**	**500 HMA**
Initial Cost	$ 425,100	$ 430,236	$ 436,950	$ 448,236
M&R Cost (Discounted)	$ 32,955	$ 64,406	$ 32,955	$ 64,406
Total Cost	$ 458,055	$ 494,642	$ 469,905	$ 512,642
LCC Difference	**7%**		**8%**	

Item	Minor Arterial			
	1,000 PCC	**1,000 HMA**	**1,500 PCC**	**1,500 HMA**
Initial Cost	$ 490,050	$ 494,748	$ 490,050	$ 513,810
M&R Cost (Discounted)	$ 57,553	$ 87,998	$ 57,553	$ 86,278
Total Cost	$ 547,603	$ 582,746	$ 547,603	$ 600,088
LCC Difference	**6%**		**9%**	

Item	Major Arterial			
	2,500 PCC	**2,500 HMA**	**5,000 PCC**	**5,000 HMA**
Initial Cost	$ 980,100	$ 1,065,744	$ 980,100	$ 1,211,868
M&R Cost (Discounted)	$ 136,916	$ 191,192	$ 136,916	$ 191,192
Total Cost	$ 1,117,016	$ 1,256,936	$ 1,117,016	$ 1,403,060
LCC Difference	**11%**		**20%**	

Item	Major Arterial			
	7,500 PCC	**7,500 HMA**	**10,000 PCC**	**10,000 HMA**
Initial Cost	$ 1,070,720	$ 1,333,325	$ 1,121,280	$ 1,382,054
M&R Cost (Discounted)	$ 170,523	$ 342,478	$ 170,523	$ 349,035
Total Cost	$ 1,241,243	$ 1,675,803	$ 1,291,803	$ 1,731,090
LCC Difference	**26%**		**25%**	

Table 4.14 Summary of LCCA Results for Medium Subgrade Strength

Typical Ontario Municipal Pavements

LIFE CYCLE COST ANALYSIS SUMMARY

Listed by 25 Year AADTT and Pavement Type for Medium Strength Subgrade

Item	Collector			
	250 PCC	**250 HMA**	**500 PCC**	**500 HMA**
Initial Cost	$ 425,100	$ 412,236	$ 436,950	$ 430,236
M&R Cost (Discounted)	$ 32,955	$ 64,406	$ 32,955	$ 64,406
Total Cost	$ 458,055	$ 476,642	$ 469,905	$ 494,642
LCC Difference	**4%**		**5%**	

Item	Minor Arterial			
	1,000 PCC	**1,000 HMA**	**1,500 PCC**	**1,500 HMA**
Initial Cost	$ 490,050	$ 439,686	$ 490,050	$ 477,810
M&R Cost (Discounted)	$ 57,553	$ 87,998	$ 57,553	$ 86,278
Total Cost	$ 547,603	$ 527,684	$ 547,603	$ 564,088
LCC Difference	**4%**		**3%**	

Item	Major Arterial			
	2,500 PCC	**2,500 HMA**	**5,000 PCC**	**5,000 HMA**
Initial Cost	$ 980,100	$ 991,620	$ 980,100	$ 1,103,868
M&R Cost (Discounted)	$ 136,916	$ 200,051	$ 136,916	$ 191,192
Total Cost	$ 1,117,016	$ 1,191,671	$ 1,117,016	$ 1,295,060
LCC Difference	**6%**		**14%**	

Item	Major Arterial			
	7,500 PCC	**7,500 HMA**	**10,000 PCC**	**10,000 HMA**
Initial Cost	$ 1,045,440	$ 1,256,525	$ 1,070,720	$ 1,343,654
M&R Cost (Discounted)	$ 170,523	$ 342,478	$ 170,523	$ 349,035
Total Cost	$ 1,215,963	$ 1,599,003	$ 1,241,243	$ 1,692,690
LCC Difference	**24%**		**27%**	

Table 4.15 Summary of LCCA Results for High Subgrade Strength

Typical Ontario Municipal Pavements

LIFE CYCLE COST ANALYSIS SUMMARY

Listed by 25 Year AADTT and Pavement Type for High Strength Subgrade

Item	Collector			
	250 PCC	**250 HMA**	**500 PCC**	**500 HMA**
Initial Cost	$ 425,100	$ 412,236	$ 436,950	$ 412,236
M&R Cost (Discounted)	$ 32,955	$ 64,406	$ 32,955	$ 64,406
Total Cost	$ 458,055	$ 476,642	$ 469,905	$ 476,642
LCC Difference	**4%**		**1%**	

Item	Minor Arterial			
	1,000 PCC	**1,000 HMA**	**1,500 PCC**	**1,500 HMA**
Initial Cost	$ 490,050	$ 421,686	$ 490,050	$ 459,810
M&R Cost (Discounted)	$ 57,553	$ 87,998	$ 57,553	$ 86,278
Total Cost	$ 547,603	$ 509,684	$ 547,603	$ 546,088
LCC Difference	**7%**		**0%**	

Item	Major Arterial			
	2,500 PCC	**2,500 HMA**	**5,000 PCC**	**5,000 HMA**
Initial Cost	$ 980,100	$ 955,620	$ 980,100	$ 1,029,744
M&R Cost (Discounted)	$ 136,916	$ 191,192	$ 136,916	$ 191,192
Total Cost	$ 1,117,016	$ 1,146,812	$ 1,117,016	$ 1,220,936
LCC Difference	**3%**		**9%**	

Item	Major Arterial			
	7,500 PCC	**7,500 HMA**	**10,000 PCC**	**10,000 HMA**
Initial Cost	$ 1,045,440	$ 1,218,125	$ 1,045,440	$ 1,305,254
M&R Cost (Discounted)	$ 170,523	$ 342,478	$ 170,523	$ 349,035
Total Cost	$ 1,215,963	$ 1,560,603	$ 1,215,963	$ 1,654,290
LCC Difference	**22%**		**26%**	

5.0 CONCLUSIONS

Municipalities are always looking for opportunities to improve the performance of their roadways and more efficiently spend their available budgets. While there are many pavement types available to municipalities, the most common alternatives have historically been asphalt and concrete pavements. Both of these pavement types have been used throughout Ontario.

The MEPDG process has many advantages over historic pavement design procedures. More robust design inputs have led to improvements in the design of both asphalt and concrete pavements based on long term pavement performance. The designs developed will meet the needs of municipalities. These designs have been evaluated to ensure that they are consistent with municipal practices across Ontario.

Pavement type selection is one of the more challenging engineering decisions facing roadway administrators. The process includes a variety of engineering factors such as materials and structural performance which must be weighed against the initial and life-cycle costs, as well as, sustainable benefits. The technical part of the evaluation includes an analysis of pavement life-cycle strategies including initial and future costs for construction and maintenance, supplemental costs for engineering and contract administration and traffic control/protection and societal costs such as user delay and environmental impact. Non-economic factors such as roadway geometry, availability of local materials, qualified contractors and construction experience, conservation of materials/energy, stimulation of competition, impact on winter maintenance, light reflectance, safety and comfort can also be factored into the decision process. The evaluation helps to select an alternative that is consistent with the agency's financial goals, policy decisions, and experience.

The pavement design and life-cycle cost analysis presented in this report is considered to be typical for Southern and Eastern Ontario municipal pavements. While every attempt has been made to ensure that both PCC and asphalt pavements were treated equally, it should be recognized that specific local factors such as project timing and local experience will often influence the choice of a particular pavement type.

The decision to use life-cycle cost analysis and evaluate sustainable benefits including non-economic factors as part of the pavement type selection process provides government agencies with better knowledge of the true cost of a roadway rather than just considering the initial cost of the pavement. As this report shows, concrete pavements can offer both attractive initial construction costs and favourable life cycle costs when compared to asphalt.

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APPENDIX A

SOUTHERN AND EASTERN ONTARIO MUNICIPAL ROADWAY DESIGN MATRIX

Typical Pavement Designs for Ontario Municipal Roadways

			Average Annual Daily Truck Traffic (AADTT) - 25 Year Pavement Design							
			Collector		Minor Arterial		Major Arterial			
			250	500	1,000	1,500	2,500	5,000	7,500	10,000
Subgrade Strength	30 MPa (CBR=3)	PCC	180 mm PCC	190 mm PCC	200 mm PCC	200 mm PCC	200 mm PCC	200 mm PCC	210 mm PCC	230 mm PCC
			200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A
		HMA	40 mm SP 12.5	40 mm SP 12.5	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC2
			80 mm SP 19	80 mm SP 19	90 mm SP 19	100 mm SP 19	110 mm SP 19	120 mm SP 19	130 mm SP 19	140 mm SP 19
			150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A
			350 mm Granular B	400 mm Granular B	450 mm Granular B	450 mm Granular B	450 mm Granular B	600 mm Granular B	600 mm Granular B	600 mm Granular B
	40 MPa (CBR=4)	PCC	180 mm PCC	190 mm PCC	200 mm PCC	200 mm PCC	200 mm PCC	200 mm PCC	200 mm PCC	210 mm PCC
			200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A
		HMA	40 mm SP 12.5	40 mm SP 12.5	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC2
			80 mm SP 19	80 mm SP 19	80 mm SP 19	100 mm SP 19	100 mm SP 19	120 mm SP 19	130 mm SP 19	140 mm SP 19
			150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A
			300 mm Granular B	350 mm Granular B	350 mm Granular B	350 mm Granular B	400 mm Granular B	450 mm Granular B	500 mm Granular B	550 mm Granular B
	50 MPa (CBR=5)	PCC	180 mm PCC	190 mm PCC	200 mm PCC	200 mm PCC	200 mm PCC	200 mm PCC	200 mm PCC	200 mm PCC
			200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A	200 mm Granular A
		HMA	40 mm SP 12.5	40 mm SP 12.5	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC1	40 mm SP 12.5 FC2
			80 mm SP 19	80 mm SP 19	80 mm SP 19	100 mm SP 19	100 mm SP 19	110 mm SP 19	130 mm SP 19	140 mm SP 19
			150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A	150 mm Granular A
			300 mm Granular B	300 mm Granular B	300 mm Granular B	300 mm Granular B	350 mm Granular B	400 mm Granular B	450 mm Granular B	500 mm Granular B
			No Dowels	No Dowels	32 M Dowels	32 M Dowels	32 M Dowels	32 M Dowels	32 M Dowels	32 M Dowels
			4 m Slab Length	4 m Slab Length	4.5 m Slab Length	4.5 m Slab Length	4.5 m Slab Length	4.5 m Slab Length	4.5 m Slab Length	4.5 m Slab Length
			Tied Shoulder/Curb	Tied Shoulder/Curb	Tied Shoulder/Curb	Tied Shoulder/Curb	Tied Shoulder/Curb	Tied Shoulder/Curb	0.5 m Widened Slab	0.5 m Widened Slab

Notes:

- All materials are based on current MTO OPS Specifications
- Subgrade levels are based on three common subgrade materials in Ontario
  - Low Strength (30 MPa) - Low Plasticity Clay Subgrade
  - Medium Strength (40 MPa) - Low Plasticity Silt Subgrade
  - High Strength (50 MPa) - Sandy Silt Subgrade
- Climate conditions are represented by Mt. Forest, ON

APPENDIX B

LIFE-CYCLE COST ANALYSIS RESULTS

Unit Costs

Discount Rate (%)	5.0
Analysis Period (years)	50

Initial pavement structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Unit costs	Conversion Factor	Unit
HMA	Superpave 12.5FC2, mm (t)	$120.00	2.520	kg/m²/mm
	Superpave 12.5FC1, mm (t)	$115.00	2.520	kg/m²/mm
	Superpave 12.5, mm (t)	$105.00	2.460	kg/m²/mm
	Superpave 19, mm (t)	$96.00	2.460	kg/m²/mm
PCC	180 mm PCC pavement, no dowels (m²)	$41.20	-	-
	190 mm PCC pavement, no dowels (m²)	$42.60	-	-
	200 mm PCC pavement, 32M dowels (m²)	$49.50	-	-
	210 mm PCC pavement, 32M dowels (m²)	$50.90	-	-
	230 mm PCC pavement, 32M dowels (m²)	$53.70	-	-
Base	Granular A, mm (t)	$18.00	2.400	kg/m²/mm
Subbase	Granular B, mm (t)	$15.00	2.000	kg/m²/mm
Excavation	Earth excavation (m³)	$18.00	-	-
	Rock excavation (m³)	$150.00	-	-
	Hot mix asphalt pavement excavation (m³)	$65.00	-	-
	Concrete pavement excavation(m³)	$82.00	-	-
	Contaminated material excavation(m³)	$80.00	-	-

Pavement preservation treatments

Description of maintenance and rehabilitation treatments	Unit costs	Conversion Factor	Unit
Rout and seal, m/km (m)	$5.00	-	-
Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	$35.00	-	-
Full depth asphalt base repair, % area (m²)	$45.00	-	-
Mill HMA, mm (t)	$15.00	2.500	kg/m²/mm
Resurface with Superpave 12.5FC2, mm (t)	$120.00	2.520	kg/m²/mm
Resurface with Superpave 12.5FC1, mm (t)	$115.00	2.520	kg/m²/mm
Resurface with Superpave 12.5, mm (t)	$105.00	2.460	kg/m²/mm
Resurface with Superpave 19, mm (t)	$96.00	2.460	kg/m²/mm
Reseal joints, % length (m)	$10.00	-	-
Partial depth PCC repair, % area (m²)	$125.00	-	-
Full depth PCC repair, % area (m²)	$100.00	-	-
Texturize, % area (m²)	$10.00	-	-

Typical Ontario Municipal Pavements

LIFE CYCLE COST ANALYSIS SUMMARY

Listed by 25 Year AADTT and Pavement Type for Low Strength Subgrade

Item	Collector			
	250 PCC	250 HMA	500 PCC	500 HMA
Initial Cost	$ 425,100	$ 430,236	$ 436,950	$ 448,236
M&R Cost (Discounted)	$ 32,955	$ 64,406	$ 32,955	$ 64,406
Total Cost	$ 458,055	$ 494,642	$ 469,905	$ 512,642
LCC Difference	7%		8%	

Item	Minor Arterial			
	1,000 PCC	1,000 HMA	1,500 PCC	1,500 HMA
Initial Cost	$ 490,050	$ 494,748	$ 490,050	$ 513,810
M&R Cost (Discounted)	$ 57,553	$ 87,998	$ 57,553	$ 86,278
Total Cost	$ 547,603	$ 582,746	$ 547,603	$ 600,088
LCC Difference	6%		9%	

Item	Major Arterial			
	2,500 PCC	2,500 HMA	5,000 PCC	5,000 HMA
Initial Cost	$ 980,100	$ 1,065,744	$ 980,100	$ 1,211,868
M&R Cost (Discounted)	$ 136,916	$ 191,192	$ 136,916	$ 191,192
Total Cost	$ 1,117,016	$ 1,256,936	$ 1,117,016	$ 1,403,060
LCC Difference	11%		20%	

Item	Major Arterial			
	7,500 PCC	7,500 HMA	10,000 PCC	10,000 HMA
Initial Cost	$ 1,070,720	$ 1,333,325	$ 1,121,280	$ 1,382,054
M&R Cost (Discounted)	$ 170,523	$ 342,478	$ 170,523	$ 349,035
Total Cost	$ 1,241,243	$ 1,675,803	$ 1,291,803	$ 1,731,090
LCC Difference	26%		25%	

Road Class **Municipal Collector PCC**
AADTT **250**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design	
180	mm PCC
200	mm Granular A
No	Dowels
4	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	180 mm PCC pavement, no dowels (m²)	180	7500	$ 41.20	$ 309,000
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	380	2850	$ 18.00	$ 51,300
	Total Initial Cost				**$ 425,100**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	10	188	$ 10.00	$ 1,875	$ 1,044
25	Partial depth PCC repair, % area (m²)	2	150	$ 125.00	$ 18,750	$ 5,537
25	Full depth PCC repair, % area (m²)	5	375	$ 100.00	$ 37,500	$ 11,074
25	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 1,107
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 10,653
40	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 533
50	Residual Value				$ 41,875	$ 3,652
	Total M&R Cost				**$ 145,625**	**$ 32,955**

Road Class **Municipal Collector HMA**
AADTT **250**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5
80 mm SP 19
150 mm Granular A
350 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490
Binder	Superpave 19, mm (t)	80	1,476	$ 96.00	$ 141,696
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	350	5,250	$ 15.00	$ 78,750
Excavation	Earth excavation (m³)	620	4,650	$ 18.00	$ 83,700
	Total Initial Cost				**$ 430,236**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	2	150	$ 35.00	$ 5,250	$ 3,223
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 29,205
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m²)	5	375	$ 45.00	$ 16,875	$ 3,059
35	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 14,048
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 1,082
48	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 7,450
50	Residual value				$ 73,950	$ 6,449
	Total M&R Cost				**$ 246,895**	**$ 64,406**

Road Class **Municipal Collector PCC**
AADTT **500**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design	
190	mm PCC
200	mm Granular A
No	Dowels
4	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section, m	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	190 mm PCC pavement, no dowels (m²)	190	7500	$ 42.60	$ 319,500
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	390	2925	$ 18.00	$ 52,650
	Total Initial Cost				**$ 436,950**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	10	188	$ 10.00	$ 1,875	$ 1,044
25	Partial depth PCC repair, % area (m²)	2	150	$ 125.00	$ 18,750	$ 5,537
25	Full depth PCC repair, % area (m²)	5	375	$ 100.00	$ 37,500	$ 11,074
25	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 1,107
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 10,653
40	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 533
50	Residual Value				$ 41,875	$ 3,652
	Total M&R Cost				**$ 145,625**	**$ 32,955**

Road Class **Municipal Collector HMA**
AADTT **500**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5
80 mm SP 19
150 mm Granular A
400 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490
Binder	Superpave 19, mm (t)	80	1,476	$ 96.00	$ 141,696
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	400	6,000	$ 15.00	$ 90,000
Excavation	Earth excavation (m^3)	670	5,025	$ 18.00	$ 90,450
	Total Initial Cost				**$ 448,236**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 35.00	$ 5,250	$ 3,223
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 29,205
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m^2)	5	375	$ 45.00	$ 16,875	$ 3,059
35	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 14,048
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 1,082
48	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 7,450
50	Residual value				$ 73,950	$ 6,449
	Total M&R Cost				**$ 246,895**	**$ 64,406**

Road Class **Municipal Minor Arterial PCC**
AADTT **1000**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	7500	$ 49.50	$ 371,250
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	400	3000	$ 18.00	$ 54,000
	Total Initial Cost				**$ 490,050**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 1,856
25	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 22,148
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	15	1125	$ 100.00	$ 112,500	$ 15,980
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 54,514	$ 4,754
	Total M&R Cost				**$ 238,403**	**$ 57,553**

Road Class **Municipal Minor Arterial HMA**
AADTT **1000**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5 FC1
90 mm SP 19
150 mm Granular A
450 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940
Binder	Superpave 19, mm (t)	90	1,661	$ 96.00	$ 159,408
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	450	6,750	$ 15.00	$ 101,250
Excavation	Earth excavation (m^3)	730	5,475	$ 18.00	$ 98,550
	Total Initial Cost				**$ 494,748**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 35.00	$ 5,250	$ 3,223
15	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 35.00	$ 26,250	$ 12,627
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 32,767
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 45.00	$ 33,750	$ 6,119
35	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 15,761
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	90	1688	$ 15.00	$ 25,313	$ 2,434
48	Resurface with Superpave 19, mm (t)	50	923	$ 96.00	$ 88,560	$ 8,514
48	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 8,359
50	Residual value				$ 167,344	$ 14,593
	Total M&R Cost				**$ 327,599**	**$ 87,998**

Road Class **Municipal Minor Arterial PCC**
AADTT **1500**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	7500	$ 49.50	$ 371,250
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	400	3000	$ 18.00	$ 54,000
	Total Initial Cost				**$ 490,050**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 1,856
25	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 22,148
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	15	1125	$ 100.00	$ 112,500	$ 15,980
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 54,514	$ 4,754
	Total M&R Cost				**$ 238,403**	**$ 57,553**

Road Class **Municipal Minor Arterial HMA**
AADTT **1500**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5 FC1
100 mm SP 19
150 mm Granular A
450 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940
Binder	Superpave 19, mm (t)	100	1,845	$ 96.00	$ 177,120
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	450	6,750	$ 15.00	$ 101,250
Excavation	Earth excavation (m^3)	740	5,550	$ 18.00	$ 99,900
	Total Initial Cost				**$ 513,810**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 35.00	$ 5,250	$ 3,223
18	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 35.00	$ 26,250	$ 10,907
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 32,767
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 45.00	$ 33,750	$ 6,119
35	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 15,761
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	90	1688	$ 15.00	$ 25,313	$ 2,434
48	Resurface with Superpave 19, mm (t)	50	923	$ 96.00	$ 88,560	$ 8,514
48	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 8,359
50	Residual value				$ 167,344	$ 14,593
	Total M&R Cost				**$ 327,599**	**$ 86,278**

Road Class **Municipal Major Arterial PCC**
AADTT **2,500**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road, m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	15000	$ 49.50	$ 742,500
Base	Granular A, mm (t)	200	7200	$ 18.00	$ 129,600
Excavation	Earth excavation (m³)	400	6000	$ 18.00	$ 108,000
	Total Initial Cost				**$ 980,100**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m²)	2	300	$ 125.00	$ 37,500	$ 20,881
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m²)	5	750	$ 125.00	$ 93,750	$ 27,685
25	Full depth PCC repair, % area (m²)	10	1500	$ 100.00	$ 150,000	$ 44,295
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m²)	5	750	$ 125.00	$ 93,750	$ 13,317
40	Full depth PCC repair, % area (m²)	15	2250	$ 100.00	$ 225,000	$ 31,960
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 109,028	$ 9,508
	Total M&R Cost				**$ 515,972**	**$ 136,916**

Road Class **Municipal Major Arterial HMA**
AADTT **2,500**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC1
110 mm SP 19
150 mm Granular A
450 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	1,512	$ 115.00	$ 173,880
Binder	Superpave 19, mm (t)	110	4,059	$ 96.00	$ 389,664
Base	Granular A, mm (t)	150	5,400	$ 18.00	$ 97,200
Subbase	Granular B, mm (t)	450	13,500	$ 15.00	$ 202,500
Excavation	Earth excavation (m^3)	750	11,250	$ 18.00	$ 202,500
	Total Initial Cost				**$ 1,065,744**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
5	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 784
10	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 1,535
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 35.00	$ 26,250	$ 16,115
20	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 8,480
20	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 65,534
25	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 1,477
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 35.00	$ 52,500	$ 12,147
35	Mill HMA, mm (t)	90	3375	$ 15.00	$ 50,625	$ 9,178
35	Resurface with Superpave 19, mm (t)	50	1845	$ 96.00	$ 177,120	$ 32,110
35	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 31,523
40	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,065
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 35.00	$ 52,500	$ 5,843
48	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 2,163
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 45.00	$ 33,750	$ 3,245
48	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 16,717
50	Residual value				$ 191,775	$ 16,723
	Total M&R Cost				**$ 783,610**	**$ 191,192**

Road Class **Municipal Major Arterial PCC**
AADTT **5,000**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road, m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	15000	$ 49.50	$ 742,500
Base	Granular A, mm (t)	200	7200	$ 18.00	$ 129,600
Excavation	Earth excavation (m³)	400	6000	$ 18.00	$ 108,000
	Total Initial Cost				**$ 980,100**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m²)	2	300	$ 125.00	$ 37,500	$ 20,881
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m²)	5	750	$ 125.00	$ 93,750	$ 27,685
25	Full depth PCC repair, % area (m²)	10	1500	$ 100.00	$ 150,000	$ 44,295
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m²)	5	750	$ 125.00	$ 93,750	$ 13,317
40	Full depth PCC repair, % area (m²)	15	2250	$ 100.00	$ 225,000	$ 31,960
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 109,028	$ 9,508
	Total M&R Cost				**$ 515,972**	**$ 136,916**

Road Class **Municipal Major Arterial HMA**
AADTT **5,000**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC1
120 mm SP 19
150 mm Granular A
600 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	1,512	$ 115.00	$ 173,880
Binder	Superpave 19, mm (t)	120	4,428	$ 96.00	$ 425,088
Base	Granular A, mm (t)	150	5,400	$ 18.00	$ 97,200
Subbase	Granular B, mm (t)	600	18,000	$ 15.00	$ 270,000
Excavation	Earth excavation (m^3)	910	13,650	$ 18.00	$ 245,700
	Total Initial Cost				**$ 1,211,868**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
5	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 784
10	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 1,535
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 35.00	$ 26,250	$ 16,115
20	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 8,480
20	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 65,534
25	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 1,477
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 35.00	$ 52,500	$ 12,147
35	Mill HMA, mm (t)	90	3375	$ 15.00	$ 50,625	$ 9,178
35	Resurface with Superpave 19, mm (t)	50	1845	$ 96.00	$ 177,120	$ 32,110
35	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 31,523
40	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,065
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 35.00	$ 52,500	$ 5,843
48	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 2,163
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 45.00	$ 33,750	$ 3,245
48	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 16,717
50	Residual value				$ 191,775	$ 16,723
	Total M&R Cost				**$ 783,610**	**$ 191,192**

Road Class **Municipal Major Arterial PCC**
AADTT **7,500**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
210	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
0.5	m Widened Slab

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	210 mm PCC pavement, 32M dowels (m²)	210	16000	$ 50.90	$ 814,400
Base	Granular A, mm (t)	200	7680	$ 18.00	$ 138,240
Excavation	Earth excavation (m³)	410	6560	$ 18.00	$ 118,080
	Total Initial Cost				**$ 1,070,720**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m²)	2	320	$ 125.00	$ 40,000	$ 22,273
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 29,530
25	Full depth PCC repair, % area (m²)	10	1600	$ 100.00	$ 160,000	$ 47,248
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m²)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 14,205
40	Full depth PCC repair, % area (m²)	15	2400	$ 100.00	$ 240,000	$ 34,091
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m²)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 145,926	$ 12,725
	Total M&R Cost				**$ 658,519**	**$ 170,523**

Road Class **Municipal Major Arterial HMA**
AADTT **7,500**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC1
130 mm SP 19
150 mm Granular A
600 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	1,613	$ 115.00	$ 185,472
Binder	Superpave 19, mm (t)	130	5,117	$ 96.00	$ 491,213
Base	Granular A, mm (t)	150	5,760	$ 18.00	$ 103,680
Subbase	Granular B, mm (t)	600	19,200	$ 15.00	$ 288,000
Excavation	Earth excavation (m^3)	920	14,720	$ 18.00	$ 264,960
	Total Initial Cost				**$ 1,333,325**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
8	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 677
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 35.00	$ 28,000	$ 18,952
13	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 2,652
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 35.00	$ 84,000	$ 44,547
18	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 12,466
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 29,917
18	Resurface with Superpave 12.5FC1, mm (t)	50	2016	$ 115.00	$ 231,840	$ 96,334
23	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 814
28	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,913
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 14,285
32	Mill HMA, mm (t)	90	3600	$ 15.00	$ 54,000	$ 11,333
32	Resurface with Superpave 19, mm (t)	50	1968	$ 96.00	$ 188,928	$ 39,650
32	Resurface with Superpave 12.5FC1, mm (t)	40	1613	$ 115.00	$ 185,472	$ 38,924
37	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,233
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 7,955
45	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 3,339
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 8,013
45	Resurface with Superpave 12.5FC1, mm (t)	50	2016	$ 115.00	$ 231,840	$ 25,803
50	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 654
50	Residual value				$ 194,740	$ 16,982
	Total M&R Cost				**$ 1,156,340**	**$ 342,478**

Road Class **Municipal Major Arterial PCC**
AADTT **10,000**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
230	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
0.5	m Widened Slab

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	230 mm PCC pavement, 32M dowels (m²)	230	16000	$ 53.70	$ 859,200
Base	Granular A, mm (t)	200	7680	$ 18.00	$ 138,240
Excavation	Earth excavation (m³)	430	6880	$ 18.00	$ 123,840
	Total Initial Cost				**$ 1,121,280**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m²)	2	320	$ 125.00	$ 40,000	$ 22,273
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 29,530
25	Full depth PCC repair, % area (m²)	10	1600	$ 100.00	$ 160,000	$ 47,248
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m²)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 14,205
40	Full depth PCC repair, % area (m²)	15	2400	$ 100.00	$ 240,000	$ 34,091
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m²)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 145,926	$ 12,725
	Total M&R Cost				**$ 658,519**	**$ 170,523**

Road Class **Municipal Major Arterial HMA**
AADTT **10,000**
Subgrade **30 MPa (CBR=3)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC2
140 mm SP 19
150 mm Granular A
600 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC2, mm (t)	40	1,613	$ 120.00	$ 193,536
Binder	Superpave 19, mm (t)	140	5,510	$ 96.00	$ 528,998
Base	Granular A, mm (t)	150	5,760	$ 18.00	$ 103,680
Subbase	Granular B, mm (t)	600	19,200	$ 15.00	$ 288,000
Excavation	Earth excavation (m^3)	930	14,880	$ 18.00	$ 267,840
	Total Initial Cost				**$ 1,382,054**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
8	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 677
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 35.00	$ 28,000	$ 18,952
13	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 2,652
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 35.00	$ 84,000	$ 44,547
18	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 12,466
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 29,917
18	Resurface with Superpave 12.5FC2, mm (t)	50	2016	$ 120.00	$ 241,920	$ 100,523
23	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 814
28	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,913
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 14,285
32	Mill HMA, mm (t)	90	3600	$ 15.00	$ 54,000	$ 11,333
32	Resurface with Superpave 19, mm (t)	50	1968	$ 96.00	$ 188,928	$ 39,650
32	Resurface with Superpave 12.5FC2, mm (t)	40	1613	$ 120.00	$ 193,536	$ 40,617
37	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,233
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 7,955
45	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 3,339
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 8,013
45	Resurface with Superpave 12.5FC2, mm (t)	50	2016	$ 120.00	$ 241,920	$ 26,925
48	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 721
50	Residual value				$ 200,620	$ 17,495
	Total M&R Cost				**$ 1,178,684**	**$ 349,035**

Typical Ontario Municipal Pavements

LIFE CYCLE COST ANALYSIS SUMMARY

Listed by 25 Year AADTT and Pavement Type for Medium Strength Subgrade

Item	Collector			
	250 PCC	250 HMA	500 PCC	500 HMA
Initial Cost	$ 425,100	$ 412,236	$ 436,950	$ 430,236
M&R Cost (Discounted)	$ 32,955	$ 64,406	$ 32,955	$ 64,406
Total Cost	$ 458,055	$ 476,642	$ 469,905	$ 494,642
LCC Difference	4%		5%	

Item	Minor Arterial			
	1,000 PCC	1,000 HMA	1,500 PCC	1,500 HMA
Initial Cost	$ 490,050	$ 439,686	$ 490,050	$ 477,810
M&R Cost (Discounted)	$ 57,553	$ 87,998	$ 57,553	$ 86,278
Total Cost	$ 547,603	$ 527,684	$ 547,603	$ 564,088
LCC Difference	4%		3%	

Item	Major Arterial			
	2,500 PCC	2,500 HMA	5,000 PCC	5,000 HMA
Initial Cost	$ 980,100	$ 991,620	$ 980,100	$ 1,103,868
M&R Cost (Discounted)	$ 136,916	$ 200,051	$ 136,916	$ 191,192
Total Cost	$ 1,117,016	$ 1,191,671	$ 1,117,016	$ 1,295,060
LCC Difference	6%		14%	

Item	Major Arterial			
	7,500 PCC	7,500 HMA	10,000 PCC	10,000 HMA
Initial Cost	$ 1,045,440	$ 1,256,525	$ 1,070,720	$ 1,343,654
M&R Cost (Discounted)	$ 170,523	$ 342,478	$ 170,523	$ 349,035
Total Cost	$ 1,215,963	$ 1,599,003	$ 1,241,243	$ 1,692,690
LCC Difference	24%		27%	

Road Class	**Municipal Collector PCC**
AADTT	**250**
Subgrade	**40 MPa (CBR=4)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design	
180	mm PCC
200	mm Granular A
No	Dowels
4	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	180 mm PCC pavement, no dowels (m²)	180	7500	$ 41.20	$ 309,000
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	380	2850	$ 18.00	$ 51,300
	Total Initial Cost				**$ 425,100**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	10	188	$ 10.00	$ 1,875	$ 1,044
25	Partial depth PCC repair, % area (m²)	2	150	$ 125.00	$ 18,750	$ 5,537
25	Full depth PCC repair, % area (m²)	5	375	$ 100.00	$ 37,500	$ 11,074
25	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 1,107
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 10,653
40	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 533
50	Residual Value				$ 41,875	$ 3,652
	Total M&R Cost				**$ 145,625**	**$ 32,955**

Road Class **Municipal Collector HMA**
AADTT **250**
Subgrade **40 MPa (CBR=4)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5
80 mm SP 19
150 mm Granular A
300 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490
Binder	Superpave 19, mm (t)	80	1,476	$ 96.00	$ 141,696
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	300	4,500	$ 15.00	$ 67,500
Excavation	Earth excavation (m^3)	570	4,275	$ 18.00	$ 76,950
	Total Initial Cost				**$ 412,236**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 35.00	$ 5,250	$ 3,223
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 29,205
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m^2)	5	375	$ 45.00	$ 16,875	$ 3,059
35	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 14,048
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 1,082
48	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 7,450
50	Residual value				$ 73,950	$ 6,449
	Total M&R Cost				**$ 246,895**	**$ 64,406**

Road Class **Municipal Collector PCC**
AADTT **500**
Subgrade **40 MPa (CBR=4)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design	
190	mm PCC
200	mm Granular A
No	Dowels
4	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section, m	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	190 mm PCC pavement, no dowels (m²)	190	7500	$ 42.60	$ 319,500
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	390	2925	$ 18.00	$ 52,650
	Total Initial Cost				**$ 436,950**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	10	188	$ 10.00	$ 1,875	$ 1,044
25	Partial depth PCC repair, % area (m²)	2	150	$ 125.00	$ 18,750	$ 5,537
25	Full depth PCC repair, % area (m²)	5	375	$ 100.00	$ 37,500	$ 11,074
25	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 1,107
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 10,653
40	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 533
50	Residual Value				$ 41,875	$ 3,652
	Total M&R Cost				**$ 145,625**	**$ 32,955**

Road Class **Municipal Collector HMA**
AADTT **500**
Subgrade **40 MPa (CBR=4)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5
80 mm SP 19
150 mm Granular A
350 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490
Binder	Superpave 19, mm (t)	80	1,476	$ 96.00	$ 141,696
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	350	5,250	$ 15.00	$ 78,750
Excavation	Earth excavation (m^3)	620	4,650	$ 18.00	$ 83,700
	Total Initial Cost				**$ 430,236**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 35.00	$ 5,250	$ 3,223
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 29,205
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m^2)	5	375	$ 45.00	$ 16,875	$ 3,059
35	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 14,048
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 1,082
48	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 7,450
50	Residual value				$ 73,950	$ 6,449
	Total M&R Cost				**$ 246,895**	**$ 64,406**

Road Class **Municipal Minor Arterial PCC**
AADTT **1000**
Subgrade **40 MPa (CBR=4)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
200 mm PCC
200 mm Granular A
32 M Dowels
4.5 m Slab Length
Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	7500	$ 49.50	$ 371,250
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	400	3000	$ 18.00	$ 54,000
	Total Initial Cost				**$ 490,050**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 1,856
25	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 22,148
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	15	1125	$ 100.00	$ 112,500	$ 15,980
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 54,514	$ 4,754
	Total M&R Cost				**$ 238,403**	**$ 57,553**

Road Class **Municipal Minor Arterial HMA**
AADTT **1000**
Subgrade **40 MPa (CBR=4)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5 FC1
80 mm SP 19
150 mm Granular A
350 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940
Binder	Superpave 19, mm (t)	80	1,476	$ 96.00	$ 141,696
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	350	5,250	$ 15.00	$ 78,750
Excavation	Earth excavation (m^3)	620	4,650	$ 18.00	$ 83,700
	Total Initial Cost				**$ 439,686**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 35.00	$ 5,250	$ 3,223
15	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 35.00	$ 26,250	$ 12,627
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 32,767
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 45.00	$ 33,750	$ 6,119
35	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 15,761
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	90	1688	$ 15.00	$ 25,313	$ 2,434
48	Resurface with Superpave 19, mm (t)	50	923	$ 96.00	$ 88,560	$ 8,514
48	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 8,359
50	Residual value				$ 167,344	$ 14,593
	Total M&R Cost				**$ 327,599**	**$ 87,998**

Road Class	**Municipal Minor Arterial PCC**
AADTT	**1500**
Subgrade	**40 MPa (CBR=4)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	7500	$ 49.50	$ 371,250
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	400	3000	$ 18.00	$ 54,000
	Total Initial Cost				**$ 490,050**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 1,856
25	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 22,148
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	15	1125	$ 100.00	$ 112,500	$ 15,980
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 54,514	$ 4,754
	Total M&R Cost				**$ 238,403**	**$ 57,553**

Road Class **Municipal Minor Arterial HMA**
AADTT **1500**
Subgrade **40 MPa (CBR=4)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5 FC1
100 mm SP 19
150 mm Granular A
350 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940
Binder	Superpave 19, mm (t)	100	1,845	$ 96.00	$ 177,120
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	350	5,250	$ 15.00	$ 78,750
Excavation	Earth excavation (m^3)	640	4,800	$ 18.00	$ 86,400
	Total Initial Cost				**$ 477,810**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 35.00	$ 5,250	$ 3,223
18	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 35.00	$ 26,250	$ 10,907
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 32,767
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 45.00	$ 33,750	$ 6,119
35	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 15,761
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	90	1688	$ 15.00	$ 25,313	$ 2,434
48	Resurface with Superpave 19, mm (t)	50	923	$ 96.00	$ 88,560	$ 8,514
48	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 8,359
50	Residual value				$ 167,344	$ 14,593
	Total M&R Cost				**$ 327,599**	**$ 86,278**

Road Class	**Municipal Major Arterial PCC**
AADTT	**2,500**
Subgrade	**40 MPa (CBR=4)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road, m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m^2)	200	15000	$ 49.50	$ 742,500
Base	Granular A, mm (t)	200	7200	$ 18.00	$ 129,600
Excavation	Earth excavation (m^3)	400	6000	$ 18.00	$ 108,000
	Total Initial Cost				**$ 980,100**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m^2)	2	300	$ 125.00	$ 37,500	$ 20,881
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m^2)	5	750	$ 125.00	$ 93,750	$ 27,685
25	Full depth PCC repair, % area (m^2)	10	1500	$ 100.00	$ 150,000	$ 44,295
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m^2)	5	750	$ 125.00	$ 93,750	$ 13,317
40	Full depth PCC repair, % area (m^2)	15	2250	$ 100.00	$ 225,000	$ 31,960
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 109,028	$ 9,508
	Total M&R Cost				**$ 515,972**	**$ 136,916**

Road Class **Municipal Major Arterial HMA**
AADTT **2,500**
Subgrade **40 MPa (CBR=4)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC1
100 mm SP 19
150 mm Granular A
400 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	1,512	$ 115.00	$ 173,880
Binder	Superpave 19, mm (t)	100	3,690	$ 96.00	$ 354,240
Base	Granular A, mm (t)	150	5,400	$ 18.00	$ 97,200
Subbase	Granular B, mm (t)	400	12,000	$ 15.00	$ 180,000
Excavation	Earth excavation (m^3)	690	10,350	$ 18.00	$ 186,300
	Total Initial Cost				**$ 991,620**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
5	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 784
10	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 1,535
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 35.00	$ 26,250	$ 16,115
20	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 8,480
20	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 65,534
25	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	1000	1000	$ 35.00	$ 35,000	$ 10,336
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 35.00	$ 52,500	$ 12,147
35	Mill HMA, mm (t)	90	3375	$ 15.00	$ 50,625	$ 9,178
35	Resurface with Superpave 19, mm (t)	50	1845	$ 96.00	$ 177,120	$ 32,110
35	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 31,523
40	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,065
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 35.00	$ 52,500	$ 5,843
48	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 2,163
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 45.00	$ 33,750	$ 3,245
48	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 16,717
50	Residual value				$ 191,775	$ 16,723
	Total M&R Cost				**$ 813,610**	**$ 200,051**

Road Class	**Municipal Major Arterial PCC**
AADTT	**5,000**
Subgrade	**40 MPa (CBR=4)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road, m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m^2)	200	15000	$ 49.50	$ 742,500
Base	Granular A, mm (t)	200	7200	$ 18.00	$ 129,600
Excavation	Earth excavation (m^3)	400	6000	$ 18.00	$ 108,000
	Total Initial Cost				**$ 980,100**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m^2)	2	300	$ 125.00	$ 37,500	$ 20,881
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m^2)	5	750	$ 125.00	$ 93,750	$ 27,685
25	Full depth PCC repair, % area (m^2)	10	1500	$ 100.00	$ 150,000	$ 44,295
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m^2)	5	750	$ 125.00	$ 93,750	$ 13,317
40	Full depth PCC repair, % area (m^2)	15	2250	$ 100.00	$ 225,000	$ 31,960
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 109,028	$ 9,508
	Total M&R Cost				**$ 515,972**	**$ 136,916**

Road Class **Municipal Major Arterial HMA**
AADTT **5,000**
Subgrade **40 MPa (CBR=4)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC1
120 mm SP 19
150 mm Granular A
450 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	1,512	$ 115.00	$ 173,880
Binder	Superpave 19, mm (t)	120	4,428	$ 96.00	$ 425,088
Base	Granular A, mm (t)	150	5,400	$ 18.00	$ 97,200
Subbase	Granular B, mm (t)	450	13,500	$ 15.00	$ 202,500
Excavation	Earth excavation (m^3)	760	11,400	$ 18.00	$ 205,200
	Total Initial Cost				**$ 1,103,868**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
5	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 784
10	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 1,535
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 35.00	$ 26,250	$ 16,115
20	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 8,480
20	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 65,534
25	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 1,477
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 35.00	$ 52,500	$ 12,147
35	Mill HMA, mm (t)	90	3375	$ 15.00	$ 50,625	$ 9,178
35	Resurface with Superpave 19, mm (t)	50	1845	$ 96.00	$ 177,120	$ 32,110
35	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 31,523
40	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,065
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 35.00	$ 52,500	$ 5,843
48	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 2,163
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 45.00	$ 33,750	$ 3,245
48	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 16,717
50	Residual value				$ 191,775	$ 16,723
	Total M&R Cost				**$ 783,610**	**$ 191,192**

Road Class	**Municipal Major Arterial PCC**
AADTT	**7,500**
Subgrade	**40 MPa (CBR=4)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
0.5	m Widened Slab

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	16000	$ 49.50	$ 792,000
Base	Granular A, mm (t)	200	7680	$ 18.00	$ 138,240
Excavation	Earth excavation (m³)	400	6400	$ 18.00	$ 115,200
	Total Initial Cost				**$ 1,045,440**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m²)	2	320	$ 125.00	$ 40,000	$ 22,273
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 29,530
25	Full depth PCC repair, % area (m²)	10	1600	$ 100.00	$ 160,000	$ 47,248
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m²)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 14,205
40	Full depth PCC repair, % area (m²)	15	2400	$ 100.00	$ 240,000	$ 34,091
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m²)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 145,926	$ 12,725
	Total M&R Cost				**$ 658,519**	**$ 170,523**

Road Class **Municipal Major Arterial HMA**
AADTT **7,500**
Subgrade **40 MPa (CBR=4)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC1
130 mm SP 19
150 mm Granular A
500 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	1,613	$ 115.00	$ 185,472
Binder	Superpave 19, mm (t)	130	5,117	$ 96.00	$ 491,213
Base	Granular A, mm (t)	150	5,760	$ 18.00	$ 103,680
Subbase	Granular B, mm (t)	500	16,000	$ 15.00	$ 240,000
Excavation	Earth excavation (m^3)	820	13,120	$ 18.00	$ 236,160
	Total Initial Cost				**$ 1,256,525**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
8	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 677
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 35.00	$ 28,000	$ 18,952
13	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 2,652
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 35.00	$ 84,000	$ 44,547
18	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 12,466
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 29,917
18	Resurface with Superpave 12.5FC1, mm (t)	50	2016	$ 115.00	$ 231,840	$ 96,334
23	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 814
28	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,913
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 14,285
32	Mill HMA, mm (t)	90	3600	$ 15.00	$ 54,000	$ 11,333
32	Resurface with Superpave 19, mm (t)	50	1968	$ 96.00	$ 188,928	$ 39,650
32	Resurface with Superpave 12.5FC1, mm (t)	40	1613	$ 115.00	$ 185,472	$ 38,924
37	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,233
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 7,955
45	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 3,339
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 8,013
45	Resurface with Superpave 12.5FC1, mm (t)	50	2016	$ 115.00	$ 231,840	$ 25,803
50	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 654
50	Residual value				$ 194,740	$ 16,982
	Total M&R Cost				**$ 1,156,340**	**$ 342,478**

Road Class	**Municipal Major Arterial PCC**
AADTT	**10,000**
Subgrade	**40 MPa (CBR=4)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
210	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
0.5	m Widened Slab

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	210 mm PCC pavement, 32M dowels (m²)	210	16000	$ 50.90	$ 814,400
Base	Granular A, mm (t)	200	7680	$ 18.00	$ 138,240
Excavation	Earth excavation (m³)	410	6560	$ 18.00	$ 118,080
	Total Initial Cost				**$ 1,070,720**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m²)	2	320	$ 125.00	$ 40,000	$ 22,273
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 29,530
25	Full depth PCC repair, % area (m²)	10	1600	$ 100.00	$ 160,000	$ 47,248
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m²)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 14,205
40	Full depth PCC repair, % area (m²)	15	2400	$ 100.00	$ 240,000	$ 34,091
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m²)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 145,926	$ 12,725
	Total M&R Cost				**$ 658,519**	**$ 170,523**

Road Class **Municipal Major Arterial HMA**
AADTT **10,000**
Subgrade **40 MPa (CBR=4)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC2
140 mm SP 19
150 mm Granular A
550 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC2, mm (t)	40	1,613	$ 120.00	$ 193,536
Binder	Superpave 19, mm (t)	140	5,510	$ 96.00	$ 528,998
Base	Granular A, mm (t)	150	5,760	$ 18.00	$ 103,680
Subbase	Granular B, mm (t)	550	17,600	$ 15.00	$ 264,000
Excavation	Earth excavation (m^3)	880	14,080	$ 18.00	$ 253,440
	Total Initial Cost				**$ 1,343,654**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
8	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 677
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 35.00	$ 28,000	$ 18,952
13	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 2,652
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 35.00	$ 84,000	$ 44,547
18	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 12,466
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 29,917
18	Resurface with Superpave 12.5FC2, mm (t)	50	2016	$ 120.00	$ 241,920	$ 100,523
23	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 814
28	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,913
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 14,285
32	Mill HMA, mm (t)	90	3600	$ 15.00	$ 54,000	$ 11,333
32	Resurface with Superpave 19, mm (t)	50	1968	$ 96.00	$ 188,928	$ 39,650
32	Resurface with Superpave 12.5FC2, mm (t)	40	1613	$ 120.00	$ 193,536	$ 40,617
37	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,233
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 7,955
45	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 3,339
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 8,013
45	Resurface with Superpave 12.5FC2, mm (t)	50	2016	$ 120.00	$ 241,920	$ 26,925
48	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 721
50	Residual value				$ 200,620	$ 17,495
	Total M&R Cost				**$ 1,178,684**	**$ 349,035**

Typical Ontario Municipal Pavements

LIFE CYCLE COST ANALYSIS SUMMARY

Listed by 25 Year AADTT and Pavement Type for High Strength Subgrade

Item	Collector			
	250 PCC	250 HMA	500 PCC	500 HMA
Initial Cost	$ 425,100	$ 412,236	$ 436,950	$ 412,236
M&R Cost (Discounted)	$ 32,955	$ 64,406	$ 32,955	$ 64,406
Total Cost	$ 458,055	$ 476,642	$ 469,905	$ 476,642
LCC Difference	4%		1%	

Item	Minor Arterial			
	1,000 PCC	1,000 HMA	1,500 PCC	1,500 HMA
Initial Cost	$ 490,050	$ 421,686	$ 490,050	$ 459,810
M&R Cost (Discounted)	$ 57,553	$ 87,998	$ 57,553	$ 86,278
Total Cost	$ 547,603	$ 509,684	$ 547,603	$ 546,088
LCC Difference	7%		0%	

Item	Major Arterial			
	2,500 PCC	2,500 HMA	5,000 PCC	5,000 HMA
Initial Cost	$ 980,100	$ 955,620	$ 980,100	$ 1,029,744
M&R Cost (Discounted)	$ 136,916	$ 191,192	$ 136,916	$ 191,192
Total Cost	$ 1,117,016	$ 1,146,812	$ 1,117,016	$ 1,220,936
LCC Difference	3%		9%	

Item	Major Arterial			
	7,500 PCC	7,500 HMA	10,000 PCC	10,000 HMA
Initial Cost	$ 1,045,440	$ 1,218,125	$ 1,045,440	$ 1,305,254
M&R Cost (Discounted)	$ 170,523	$ 342,478	$ 170,523	$ 349,035
Total Cost	$ 1,215,963	$ 1,560,603	$ 1,215,963	$ 1,654,290
LCC Difference	22%		26%	

Road Class **Municipal Collector PCC**
AADTT **250**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design	
180	mm PCC
200	mm Granular A
No	Dowels
4	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	180 mm PCC pavement, no dowels (m²)	180	7500	$ 41.20	$ 309,000
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	380	2850	$ 18.00	$ 51,300
	Total Initial Cost				**$ 425,100**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	10	188	$ 10.00	$ 1,875	$ 1,044
25	Partial depth PCC repair, % area (m²)	2	150	$ 125.00	$ 18,750	$ 5,537
25	Full depth PCC repair, % area (m²)	5	375	$ 100.00	$ 37,500	$ 11,074
25	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 1,107
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 10,653
40	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 533
50	Residual Value				$ 41,875	$ 3,652
	Total M&R Cost				**$ 145,625**	**$ 32,955**

Road Class **Municipal Collector HMA**
AADTT **250**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5
80 mm SP 19
150 mm Granular A
300 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490
Binder	Superpave 19, mm (t)	80	1,476	$ 96.00	$ 141,696
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	300	4,500	$ 15.00	$ 67,500
Excavation	Earth excavation (m³)	570	4,275	$ 18.00	$ 76,950
	Total Initial Cost				**$ 412,236**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	2	150	$ 35.00	$ 5,250	$ 3,223
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 29,205
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m²)	5	375	$ 45.00	$ 16,875	$ 3,059
35	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 14,048
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 1,082
48	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 7,450
50	Residual value				$ 73,950	$ 6,449
	Total M&R Cost				**$ 246,895**	**$ 64,406**

Road Class **Municipal Collector PCC**
AADTT **500**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design	
190	mm PCC
200	mm Granular A
No	Dowels
4	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section, m	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	190 mm PCC pavement, no dowels (m²)	190	7500	$ 42.60	$ 319,500
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	390	2925	$ 18.00	$ 52,650
	Total Initial Cost				**$ 436,950**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	10	188	$ 10.00	$ 1,875	$ 1,044
25	Partial depth PCC repair, % area (m²)	2	150	$ 125.00	$ 18,750	$ 5,537
25	Full depth PCC repair, % area (m²)	5	375	$ 100.00	$ 37,500	$ 11,074
25	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 1,107
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 10,653
40	Reseal joints, % Length (m)	20	375	$ 10.00	$ 3,750	$ 533
50	Residual Value				$ 41,875	$ 3,652
	Total M&R Cost				**$ 145,625**	**$ 32,955**

Road Class **Municipal Collector HMA**
AADTT **500**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5
80 mm SP 19
150 mm Granular A
300 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490
Binder	Superpave 19, mm (t)	80	1,476	$ 96.00	$ 141,696
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	300	4,500	$ 15.00	$ 67,500
Excavation	Earth excavation (m³)	570	4,275	$ 18.00	$ 76,950
	Total Initial Cost				**$ 412,236**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	2	150	$ 35.00	$ 5,250	$ 3,223
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 29,205
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m²)	5	375	$ 45.00	$ 16,875	$ 3,059
35	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 14,048
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 1,082
48	Resurface with Superpave 12.5, mm (t)	40	738	$ 105.00	$ 77,490	$ 7,450
50	Residual value				$ 73,950	$ 6,449
	Total M&R Cost				**$ 246,895**	**$ 64,406**

Road Class **Municipal Minor Arterial PCC**
AADTT **1000**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
200 mm PCC
200 mm Granular A
32 M Dowels
4.5 m Slab Length
Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	7500	$ 49.50	$ 371,250
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	400	3000	$ 18.00	$ 54,000
	Total Initial Cost				**$ 490,050**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 1,856
25	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 22,148
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	15	1125	$ 100.00	$ 112,500	$ 15,980
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 54,514	$ 4,754
	Total M&R Cost				**$ 238,403**	**$ 57,553**

Road Class **Municipal Minor Arterial HMA**
AADTT **1000**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5 FC1
80 mm SP 19
150 mm Granular A
300 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940
Binder	Superpave 19, mm (t)	80	1,476	$ 96.00	$ 141,696
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	300	4,500	$ 15.00	$ 67,500
Excavation	Earth excavation (m^3)	570	4,275	$ 18.00	$ 76,950
	Total Initial Cost				**$ 421,686**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 35.00	$ 5,250	$ 3,223
15	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 35.00	$ 26,250	$ 12,627
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 32,767
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 45.00	$ 33,750	$ 6,119
35	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 15,761
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	90	1688	$ 15.00	$ 25,313	$ 2,434
48	Resurface with Superpave 19, mm (t)	50	923	$ 96.00	$ 88,560	$ 8,514
48	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 8,359
50	Residual value				$ 167,344	$ 14,593
	Total M&R Cost				**$ 327,599**	**$ 87,998**

Road Class **Municipal Minor Arterial PCC**
AADTT **1500**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
200 mm PCC
200 mm Granular A
32 M Dowels
4.5 m Slab Length
Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	7500	$ 49.50	$ 371,250
Base	Granular A, mm (t)	200	3600	$ 18.00	$ 64,800
Excavation	Earth excavation (m³)	400	3000	$ 18.00	$ 54,000
	Total Initial Cost				**$ 490,050**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 1,856
25	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Full depth PCC repair, % area (m²)	10	750	$ 100.00	$ 75,000	$ 22,148
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m²)	5	375	$ 125.00	$ 46,875	$ 6,658
40	Full depth PCC repair, % area (m²)	15	1125	$ 100.00	$ 112,500	$ 15,980
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 54,514	$ 4,754
	Total M&R Cost				**$ 238,403**	**$ 57,553**

Road Class **Municipal Minor Arterial HMA**
AADTT **1500**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 2-lane roadway

Pavement Design
40 mm SP 12.5 FC1
100 mm SP 19
150 mm Granular A
300 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	7.5
Total width of paved shoulders, m	N/A
Total width of subject road, m	7.5
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940
Binder	Superpave 19, mm (t)	100	1,845	$ 96.00	$ 177,120
Base	Granular A, mm (t)	150	2,700	$ 18.00	$ 48,600
Subbase	Granular B, mm (t)	300	4,500	$ 15.00	$ 67,500
Excavation	Earth excavation (m^3)	590	4,425	$ 18.00	$ 79,650
	Total Initial Cost				**$ 459,810**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, m/km (m)	250	250	$ 5.00	$ 1,250	$ 767
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 35.00	$ 5,250	$ 3,223
18	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 35.00	$ 26,250	$ 10,907
20	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 4,240
20	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 32,767
25	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 738
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 3,037
35	Mill HMA, mm (t)	40	750	$ 15.00	$ 11,250	$ 2,040
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 45.00	$ 33,750	$ 6,119
35	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 15,761
40	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 355
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 35.00	$ 13,125	$ 1,610
48	Mill HMA, mm (t)	90	1688	$ 15.00	$ 25,313	$ 2,434
48	Resurface with Superpave 19, mm (t)	50	923	$ 96.00	$ 88,560	$ 8,514
48	Resurface with Superpave 12.5FC1, mm (t)	40	756	$ 115.00	$ 86,940	$ 8,359
50	Residual value				$ 167,344	$ 14,593
	Total M&R Cost				**$ 327,599**	**$ 86,278**

Road Class **Municipal Major Arterial PCC**
AADTT **2,500**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
200 mm PCC
200 mm Granular A
32 M Dowels
4.5 m Slab Length
Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road, m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	15000	$ 49.50	$ 742,500
Base	Granular A, mm (t)	200	7200	$ 18.00	$ 129,600
Excavation	Earth excavation (m³)	400	6000	$ 18.00	$ 108,000
	Total Initial Cost				**$ 980,100**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m²)	2	300	$ 125.00	$ 37,500	$ 20,881
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m²)	5	750	$ 125.00	$ 93,750	$ 27,685
25	Full depth PCC repair, % area (m²)	10	1500	$ 100.00	$ 150,000	$ 44,295
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m²)	5	750	$ 125.00	$ 93,750	$ 13,317
40	Full depth PCC repair, % area (m²)	15	2250	$ 100.00	$ 225,000	$ 31,960
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 109,028	$ 9,508
	Total M&R Cost				**$ 515,972**	**$ 136,916**

Road Class **Municipal Major Arterial HMA**
AADTT **2,500**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC1
100 mm SP 19
150 mm Granular A
350 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	1,512	$ 115.00	$ 173,880
Binder	Superpave 19, mm (t)	100	3,690	$ 96.00	$ 354,240
Base	Granular A, mm (t)	150	5,400	$ 18.00	$ 97,200
Subbase	Granular B, mm (t)	350	10,500	$ 15.00	$ 157,500
Excavation	Earth excavation (m³)	640	9,600	$ 18.00	$ 172,800
	Total Initial Cost				**$ 955,620**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
5	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 784
10	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 1,535
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	5	750	$ 35.00	$ 26,250	$ 16,115
20	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 8,480
20	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 65,534
25	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 1,477
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	10	1500	$ 35.00	$ 52,500	$ 12,147
35	Mill HMA, mm (t)	90	3375	$ 15.00	$ 50,625	$ 9,178
35	Resurface with Superpave 19, mm (t)	50	1845	$ 96.00	$ 177,120	$ 32,110
35	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 31,523
40	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,065
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	10	1500	$ 35.00	$ 52,500	$ 5,843
48	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 2,163
48	Full depth asphalt base repair, % area (m²)	5	750	$ 45.00	$ 33,750	$ 3,245
48	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 16,717
50	Residual value				$ 191,775	$ 16,723
	Total M&R Cost				**$ 783,610**	**$ 191,192**

Road Class **Municipal Major Arterial PCC**
AADTT **5,000**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
	Tied Shoulder/Curb

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road, m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	15000	$ 49.50	$ 742,500
Base	Granular A, mm (t)	200	7200	$ 18.00	$ 129,600
Excavation	Earth excavation (m³)	400	6000	$ 18.00	$ 108,000
	Total Initial Cost				**$ 980,100**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m²)	2	300	$ 125.00	$ 37,500	$ 20,881
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m²)	5	750	$ 125.00	$ 93,750	$ 27,685
25	Full depth PCC repair, % area (m²)	10	1500	$ 100.00	$ 150,000	$ 44,295
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m²)	5	750	$ 125.00	$ 93,750	$ 13,317
40	Full depth PCC repair, % area (m²)	15	2250	$ 100.00	$ 225,000	$ 31,960
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 109,028	$ 9,508
	Total M&R Cost				**$ 515,972**	**$ 136,916**

Road Class **Municipal Major Arterial HMA**
AADTT **5,000**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC1
110 mm SP 19
150 mm Granular A
400 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	N/A
Total width of subject road m	15.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	1,512	$ 115.00	$ 173,880
Binder	Superpave 19, mm (t)	110	4,059	$ 96.00	$ 389,664
Base	Granular A, mm (t)	150	5,400	$ 18.00	$ 97,200
Subbase	Granular B, mm (t)	400	12,000	$ 15.00	$ 180,000
Excavation	Earth excavation (m³)	700	10,500	$ 18.00	$ 189,000
	Total Initial Cost				**$ 1,029,744**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
5	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 784
10	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 1,535
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	5	750	$ 35.00	$ 26,250	$ 16,115
20	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 8,480
20	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 65,534
25	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 1,477
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	10	1500	$ 35.00	$ 52,500	$ 12,147
35	Mill HMA, mm (t)	90	3375	$ 15.00	$ 50,625	$ 9,178
35	Resurface with Superpave 19, mm (t)	50	1845	$ 96.00	$ 177,120	$ 32,110
35	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 31,523
40	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,065
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	10	1500	$ 35.00	$ 52,500	$ 5,843
48	Mill HMA, mm (t)	40	1500	$ 15.00	$ 22,500	$ 2,163
48	Full depth asphalt base repair, % area (m²)	5	750	$ 45.00	$ 33,750	$ 3,245
48	Resurface with Superpave 12.5FC1, mm (t)	40	1512	$ 115.00	$ 173,880	$ 16,717
50	Residual value				$ 191,775	$ 16,723
	Total M&R Cost				**$ 783,610**	**$ 191,192**

Road Class **Municipal Major Arterial PCC**
AADTT **7,500**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
0.5	m Widened Slab

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	16000	$ 49.50	$ 792,000
Base	Granular A, mm (t)	200	7680	$ 18.00	$ 138,240
Excavation	Earth excavation (m³)	400	6400	$ 18.00	$ 115,200
	Total Initial Cost				**$ 1,045,440**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m²)	2	320	$ 125.00	$ 40,000	$ 22,273
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 29,530
25	Full depth PCC repair, % area (m²)	10	1600	$ 100.00	$ 160,000	$ 47,248
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m²)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 14,205
40	Full depth PCC repair, % area (m²)	15	2400	$ 100.00	$ 240,000	$ 34,091
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m²)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 145,926	$ 12,725
	Total M&R Cost				**$ 658,519**	**$ 170,523**

Road Class **Municipal Major Arterial HMA**
AADTT **7,500**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC1
130 mm SP 19
150 mm Granular A
450 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC1, mm (t)	40	1,613	$ 115.00	$ 185,472
Binder	Superpave 19, mm (t)	130	5,117	$ 96.00	$ 491,213
Base	Granular A, mm (t)	150	5,760	$ 18.00	$ 103,680
Subbase	Granular B, mm (t)	450	14,400	$ 15.00	$ 216,000
Excavation	Earth excavation (m^3)	770	12,320	$ 18.00	$ 221,760
	Total Initial Cost				**$ 1,218,125**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
8	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 677
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 35.00	$ 28,000	$ 18,952
13	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 2,652
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 35.00	$ 84,000	$ 44,547
18	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 12,466
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 29,917
18	Resurface with Superpave 12.5FC1, mm (t)	50	2016	$ 115.00	$ 231,840	$ 96,334
23	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 814
28	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,913
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 14,285
32	Mill HMA, mm (t)	90	3600	$ 15.00	$ 54,000	$ 11,333
32	Resurface with Superpave 19, mm (t)	50	1968	$ 96.00	$ 188,928	$ 39,650
32	Resurface with Superpave 12.5FC1, mm (t)	40	1613	$ 115.00	$ 185,472	$ 38,924
37	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,233
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 7,955
45	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 3,339
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 8,013
45	Resurface with Superpave 12.5FC1, mm (t)	50	2016	$ 115.00	$ 231,840	$ 25,803
50	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 654
50	Residual value				$ 194,740	$ 16,982
	Total M&R Cost				**$ 1,156,340**	**$ 342,478**

Road Class **Municipal Major Arterial PCC**
AADTT **10,000**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design	
200	mm PCC
200	mm Granular A
32	M Dowels
4.5	m Slab Length
0.5	m Widened Slab

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	200 mm PCC pavement, 32M dowels (m²)	200	16000	$ 49.50	$ 792,000
Base	Granular A, mm (t)	200	7680	$ 18.00	$ 138,240
Excavation	Earth excavation (m³)	400	6400	$ 18.00	$ 115,200
	Total Initial Cost				**$ 1,045,440**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
12	Partial depth PCC repair, % area (m²)	2	320	$ 125.00	$ 40,000	$ 22,273
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 29,530
25	Full depth PCC repair, % area (m²)	10	1600	$ 100.00	$ 160,000	$ 47,248
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m²)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m²)	5	800	$ 125.00	$ 100,000	$ 14,205
40	Full depth PCC repair, % area (m²)	15	2400	$ 100.00	$ 240,000	$ 34,091
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m²)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 145,926	$ 12,725
	Total M&R Cost				**$ 658,519**	**$ 170,523**

Road Class **Municipal Major Arterial HMA**
AADTT **10,000**
Subgrade **50 MPa (CBR=5)**

All quantities and costs are for one km of 4-lane roadway

Pavement Design
40 mm SP 12.5 FC2
140 mm SP 19
150 mm Granular A
500 mm Granular B

Geometric Design	
Design feature	**Dimension**
Width of the traffic lanes, m	15.0
Total width of paved shoulders, m	1.00
Total width of subject road, m	16.0
Length of section	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	Superpave 12.5FC2, mm (t)	40	1,613	$ 120.00	$ 193,536
Binder	Superpave 19, mm (t)	140	5,510	$ 96.00	$ 528,998
Base	Granular A, mm (t)	150	5,760	$ 18.00	$ 103,680
Subbase	Granular B, mm (t)	500	16,000	$ 15.00	$ 240,000
Excavation	Earth excavation (m^3)	830	13,280	$ 18.00	$ 239,040
	Total Initial Cost				**$ 1,305,254**

Urban Pavement Maintenance and Rehabilitation Action Plan

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity	Price per unit of quantity	Cost	Net present worth
8	Rout and seal, m/km (m)	200	200	$ 5.00	$ 1,000	$ 677
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 35.00	$ 28,000	$ 18,952
13	Rout and seal, m/km (m)	1000	1000	$ 5.00	$ 5,000	$ 2,652
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 35.00	$ 84,000	$ 44,547
18	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 12,466
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 29,917
18	Resurface with Superpave 12.5FC2, mm (t)	50	2016	$ 120.00	$ 241,920	$ 100,523
23	Rout and seal, m/km (m)	500	500	$ 5.00	$ 2,500	$ 814
28	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,913
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 14,285
32	Mill HMA, mm (t)	90	3600	$ 15.00	$ 54,000	$ 11,333
32	Resurface with Superpave 19, mm (t)	50	1968	$ 96.00	$ 188,928	$ 39,650
32	Resurface with Superpave 12.5FC2, mm (t)	40	1613	$ 120.00	$ 193,536	$ 40,617
37	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 1,233
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 35.00	$ 56,000	$ 7,955
45	Mill HMA, mm (t)	50	2000	$ 15.00	$ 30,000	$ 3,339
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 45.00	$ 72,000	$ 8,013
45	Resurface with Superpave 12.5FC2, mm (t)	50	2016	$ 120.00	$ 241,920	$ 26,925
48	Rout and seal, m/km (m)	1500	1500	$ 5.00	$ 7,500	$ 721
50	Residual value				$ 200,620	$ 17,495
	Total M&R Cost				**$ 1,178,684**	**$ 349,035**