Final Report

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

Including Maintenance & Rehabilitation Schedules and Life Cycle Cost Analysis

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GLOSSARY OF ABBREVIATIONS

AADT - average annual daily traffic
AADTT - average annual daily truck traffic
ESALs - equivalent single axle loads
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
PCC - Portland cement concrete
PG - Performance grading
PW - present worth
SHRP - strategic highway research program

1. Introduction

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 Maintenance and Rehabilitation plans that are appropriate for use by Nova Scotia municipalities.

Both rigid and flexible pavements are used in Nova Scotia for both provincial highways and municipal streets, flexible pavement being the most common option. Each pavement type is designed and constructed based on local traffic and site conditions.

Rigid pavements in Nova Scotia typically consist of a Jointed Plain Concrete Pavement (JPCP) over a base which provides uniform support for the concrete slabs. The concrete pavement is placed over a Type 1 granular base. 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 primarily for 100 series highways by Nova Scotia Transportation and Public Works.

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 Nova Scotia typically consist of C-HF and B-HF asphalt surface and binder courses over Type 1 base and Type 2 subbase. Asphalt cement typically follows the Strategic Highway Research Program (SHRP) Performance Grading (PG) specifications.

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 Analysis (LCCA) as part of the tender process for pavement choice evaluation is fairly new. This process has been evolving in Canada since the first Ministry of Transportation Ontario (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.

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 the municipalities of Nova Scotia. 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 with climate regions reflective of Halifax.

2. 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).

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 Nova Scotia are discussed in this report.

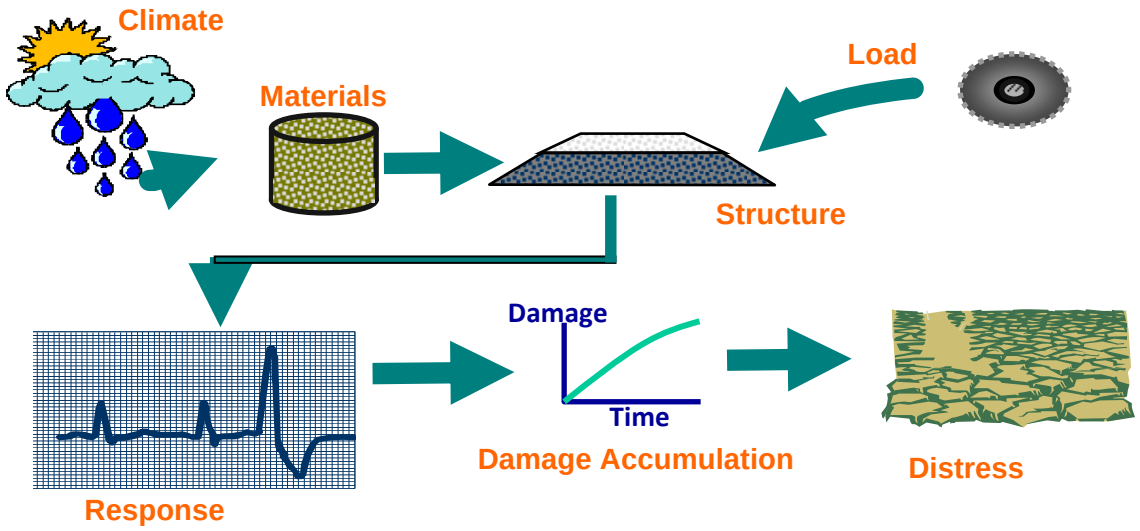


Figure 2.1 General Pavement Design Procedure and Analysis

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 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 two 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

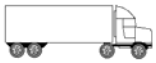
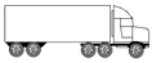
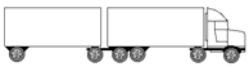
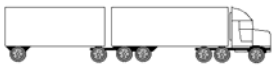
The MEPDG uses a rigorous process to estimate the traffic loads on a roadway. To complete this part of the process, the traffic volume for each month, is divided into the 13 vehicle classes as established by the US Federal Highway Administration (FHWA). Light vehicles, class 1 through 3 (motorcycles 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.

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

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

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 %

2.2 Climate Condition

A significant factor influencing the performance of pavements is climate. Major Climate region, Halifax was selected for this study. Extreme temperatures located in other locations are often accounted for by adjusting materials such as the asphalt binder type, base and sub base. The annual climate statistics of the regional municipality of Halifax are shown in Table 2.2.

Table 2.2 Annual Climate Statistics of a Major Climate Region of Nova Scotia - Halifax

Parameters	Halifax
Mean annual air temperature (°C)	7.6
Mean annual precipitation (mm)	1283.4
Freezing index (°C - days)	660.2
Average annual number of freeze/thaw cycles	54

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)

PCC used across Nova Scotia is primarily based on Standard Specification, Highway Construction and Maintenance (Nova Scotia Transportation and Public Works, 1997 - Revision 2011). Based on the specification, the concrete properties in Table 2.3 were used in the analysis.

Table 2.3 Portland Cement Concrete Properties

Property	**Value**
Concrete Strength	4.85 MPa - 28-day Modulus of Rupture 33.2 GPa - 28-day Elastic Modulus
Binder types	GU
Unit Weight	2350 kg/m^3
Water to cementing materials Ratio	0.45
Air content	6.5 ± 1%
Minimum cementing material content	360 kg/m^3
Sealant type	Rubberized Asphalt Sealant

Concrete pavements of thickness less than 200 mm are not dowelled in this analysis. Concrete pavements of thickness greater than 200mm are dowelled with 32 mm dowel bars. Dowels bars are placed at 300 mm intervals across the transverse joints. The slabs length for collector roads, minor and major arterial roads is 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 shoulder 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 Nova Scotia is primarily based on the Standard Specification for Hot Mix Asphalt Concrete, Section S-1 (January 2012); and Performance Graded Asphalt Binder, Section S-2 (January 2010). This specification provides guidance on the mix design and placement of the different types of mixes commonly used for municipal roadways. In this analysis, C-HF mix is used as a surface course for collector and arterial roadways. And B-HF is used for the base course asphalt. The properties of the HMA materials used in the analysis are shown in Table 2.4.

Table 2.4 Hot Mix Asphalt Properties

Property	C-HF (Surface Course)	B-HF (Base Course)
Asphalt Cement Type	Variable with traffic	Variable with traffic
Unit weight	2,402 kg/m^3	2,402 kg/m^3
Effective Binder Content (Percent by Volume)	5.0-5.5 %	4.5-5.0 %
Air Voids	3.0-5.0%	3.0-5.0 %
Gradation Passing 19 mm	100 %	95-100 %
Gradation Passing 9.5 mm	75-90 %	68-80 %
Gradation Passing 4.75 mm	52-68 %	47-63 %
Gradation Passing 75 mm	3.0-6.5 %	3.0-6.5 %

Table 2.5 PG Grade for Pavement Design Matrix

Province	Bitumen Type	Collector (250 to 500)	Minor Arterial (1000 to 1500)	Major Arterial (2500)	Major Arterial (7500 to 10,000)
Nova Scotia	C-HF (Surface)	58-28	58-28	58-28	58-28
	B-HF (Binder)	58-28	58-28	58-28	58-28

2.3.3 Granular Base and Subbase

The most commonly available aggregates used in pavement construction in Nova Scotia consist of Type 1 base and Type 2 subbase. These materials, described in Nova Scotia Transportation and Public Works Standard specification, can be both used beneath the flexible and rigid pavement structures (Table 2.6).

Table 2.6 Granular Base and Subbase Properties

Property	Sieve Size	Type 1 (Base)		Type 2 (Subbase)	
Aggregate Gradation (min. and max. percent passing)	80 mm	N/A	N/A	100	100
	56 mm	N/A	N/A	70	100
	28 mm	N/A	N/A	50	80
	20 mm	100	100	N/A	N/A
	14 mm	50	85	35	65
	5 mm	20	50	20	50
	1.25 mm	N/A	N/A	N/A	N/A
	1.6 mm	5	12	3	10
	0.8 mm	3	8	0	7
Plasticity Index		3		3	
Modulus		200 MPa		100 MPa	
Poisson's Ratio		0.35		0.35	

These materials are commonly available and widely used across Nova Scotia. 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 Nova Scotia. To characterize the sensitivity of this parameter and to describe the range of potential conditions across the province, the subgrade parameters shown in Table 2.7 were used in the analysis.

Table 2.7 Subgrade Properties

Soil Properties	Low Plasticity Clay	Inorganic Silt	Sandy Silt
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	57	32	18
Plasticity Index	24	18	4

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 2.8. 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 2.8 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. 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 the province of Nova Scotia, the materials chosen as well as many of the design features were established based on current Nova Scotia 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 MEPDG. 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.

The pavement designs presented ensure that they have sufficient structural capacity to accommodate the anticipated design loadings. It should be recognized that environmental effects such as freezing and thawing can significantly impact the performance of the pavement. In areas of highly frost susceptible soils such as very fine sands and silts, consideration should be given to the incorporation of frost mitigation actions. These could include removal and replacement of the frost susceptible soils within the local frost depth with a non-frost susceptible material, deepening ditches, including subdrains to rapidly remove water from the pavement structure and subsoils, installation of frost tapers, stabilization of subgrade soils to reduce permeability or the use of insulation to limit the penetration of frost into the subgrade.

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 review was completed to ensure that the cross-sections matched conditions and municipal performance expectations in Nova Scotia.

The resulting pavement designs are shown inTable 3.1 Representative Equivalent Pavement Designs for Nova Scotia. These designs are considered to be typical for municipal pavements across the province of Nova Scotia. 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 Equivalent Pavement Designs for Nova Scotia

			Average Annual Daily Truck Traffic (AADTT) - 25 Year Pavement Design-Nova Scotia							
			Collector (one lane in each direction)		Minor Arterial (one lane in each direction)		Major Arterial (two lanes in each direction)			
			250	500	1,000	1,500	2,500	5,000	7,500	10,000
Subgrade Strength	30 MPa (CBR=3)	PCC	175 mm PCC 200 mm Granular Base	180 mm PCC 200 mm Granular Base	190 mm PCC 200 mm Granular Base	200 mm PCC 200 mm Granular Base	210 mm PCC 200 mm Granular Base	215 mm PCC 200 mm Granular Base	210 mm PCC 200 mm Granular Base	210 mm PCC 200 mm Granular Base
		HMA	50 mm C-HF 50 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 50 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 70 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 80 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 110 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 120 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 140 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 150 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2
	40 MPa (CBR=4)	PCC	175 mm PCC 200 mm Granular Base	180 mm PCC 200 mm Granular Base	190 mm PCC 200 mm Granular Base	200 mm PCC 200 mm Granular Base	200 mm PCC 200 mm Granular Base	210 mm PCC 200 mm Granular Base	200 mm PCC 200 mm Granular Base	210 mm PCC 200 mm Granular Base
		HMA	50 mm C-HF 50 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 50 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 60 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 70 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 110 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 120 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 140 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2	50 mm C-HF 150 mm B-HF 150 mm Base Type 1 400 mm Subbase Type 2
	50 MPa (CBR=5)	PCC	175 mm PCC 200 mm Granular Base	175 mm PCC 200 mm Granular Base	190 mm PCC 200 mm Granular Base	200 mm PCC 200 mm Granular Base	200 mm PCC 200 mm Granular Base	210 mm PCC 200 mm Granular Base	200 mm PCC 200 mm Granular Base	200 mm PCC 200 mm Granular Base
		HMA	50 mm C-HF 50 mm B-HF 150 mm Base Type 1 300 mm Subbase Type 2	50 mm C-HF 50 mm B-HF 150 mm Base Type 1 300 mm Subbase Type 2	50 mm C-HF 60 mm B-HF 150 mm Base Type 1 300 mm Subbase Type 2	50 mm C-HF 70 mm B-HF 150 mm Base Type 1 300 mm Subbase Type 2	50 mm C-HF 100 mm B-HF 150 mm Base Type 1 300 mm Subbase Type 2	50 mm C-HF 120 mm B-HF 150 mm Base Type 1 300 mm Subbase Type 2	50 mm C-HF 140 mm B-HF 150 mm Base Type 1 300 mm Subbase Type 2	50 mm C-HF 150 mm B-HF 150 mm Base Type 1 300 mm Subbase Type 2
Concrete Slab and Joint Properties			No dowels Slab length = 4.5 m Tied shoulder/curb *		No dowels Slab length = 4.5 m Tied shoulder/curb *	32 mm Dowel bars, 300 mm spacing Slab length = 4.5 m Tied shoulder/curb *	32 mm Dowel bars, 300 mm spacing Slab length = 4.5 m Tied shoulder/curb *	32 mm Dowel bars, 300 mm spacing Slab length = 4.5 m Tied shoulder/curb *	32 mm 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 Nova Scotia Specifications
- Subgrade levels are based on three common subgrade materials in Nova Scotia.
  - 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 constructability reasons, a minimum concrete pavement thickness of 175 mm is recommended for slipform paving
- 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. 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 primarily used for high level asset management decision making in the Province.

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 design 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 design 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. As there is only limited information on the long-term performance of rigid pavements in Nova Scotia, the maintenance and rehabilitation plans were based on performance information developed in Ontario and Québec. 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 2.7.

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 1 km 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 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 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 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 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 municipalities in Nova Scotia 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 recommended 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 1 km 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 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 C-HF	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 C-HF	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 C-HF	40 mm

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

Expected Year	Activity Description	Quantity (per 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 C-HF	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 C-HF	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 B-HF	50 mm
48	Resurface with C-HF	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 C-HF	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 B-HF	50 mm
35	Resurface with C-HF	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 C-HF	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 C-HF	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 B-HF	50 mm
32	Resurface with C-HF	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 C-HF	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 Nova Scotia.

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	C-HF, mm (t) 58-28	$121.90
	B-HF, mm (t) 58-28	$101.76
PCC	175 mm PCC pavement, no dowels (m^2)	$48.63
	180 mm PCC pavement, no dowels (m^2)	$49.50
	190 mm PCC pavement, no dowels (m^2)	$51.25
	200 mm PCC pavement, 32 mm dowels (m^2)	$58.50
	210 mm PCC pavement, 32 mm dowels (m^2)	$60.25
	215 mm PCC pavement, 32 mm dowels (m^2)	$61.13
	PCC pavement placement/crew costs (m^2)	$18.00
Base	Type 1, mm (t)	$15.00
Subbase	Type 2, mm (t)	$12.00
Excavation	Earth excavation (m^3)	$10.00
	Rock excavation (m^3)	$45.00
	Hot mix asphalt pavement excavation (m^3)	$40.00
	Concrete pavement excavation(m^3)	$75.00
	Contaminated material excavation(m^3)	$125.00

Table 4.10 Unit Costs for Maintenance and Rehabilitation Activities

Description of Maintenance and Rehabilitation Treatments	Unit Costs
Rout and seal (m)	$1.75
Spot repairs, mill and patch (m^2)	$12.00
Asphalt base repair (m^2)	$40.00
Mill HMA (t)	$10.00
Resurface with C-HF, mm (t)	$121.90
Resurface with B-HF, mm (t)	$101.76
Reseal joints (m)	$10.00
Partial depth PCC repair (m^2)	$150.00
Full depth PCC repair (m^2)	$125.00
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 where 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 discount rate used for the life-cycle cost analysis 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 =7,500) on the low strength subgrade for Nova Scotia is shown in Table 4.11 through Table 4.14. 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 from Nova Scotia can be found in

Table 4.15 through Table 4.17 along with all results in Appendix B.

Table 4.11 Initial Pavement Structure Major Arterial Concrete Pavement

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	210 mm PCC pavement, 32 mm dowels (m^2)	210	16000	$ 60.25	$ 964,000
Base	Type 1, mm (t)	200	7680	$ 15.00	$ 115,200
Excavation	Earth excavation (m^3)	410	6560	$ 10.00	$ 65,600
	Total Initial Cost				$1,144,800

Table 4.12 Pavement Maintenance and Rehabilitation Action Plan Major Arterial Concrete Pavement

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	320	$ 150.00	$ 48,000	$ 26,728
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 35,436
25	Full depth PCC repair, % area (m^2)	10	1600	$ 125.00	$ 200,000	$ 59,061
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m^2)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 17,045
40	Full depth PCC repair, % area (m^2)	15	2400	$ 125.00	$ 300,000	$ 42,614
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m^2)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 172,593	$ 15,051
	Total M&R Cost				$ 779,852	$ 201,734

Table 4.13 Initial Pavement Structure Major Arterial Flexible Pavement

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	C-HF, mm (t) 58-28	50	2,016	$ 121.90	$ 245,750
Binder	B-HF, mm (t) 58-28	140	5,510	$ 101.76	$ 560,738
Base	Type 1, mm (t)	150	5,760	$ 15.00	$ 86,400
Subbase	Type 2, mm (t)	400	12,800	$ 12.00	$ 153,600
Excavation	Earth excavation (m^3)	740	11,840	$ 10.00	$ 118,400
	Total Initial Cost				$1,164,889

Table 4.14 Pavement Maintenance and Rehabilitation Action Plan Major Arterial Flexible Pavement

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	$ 1.75	$ 350	$ 237
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	5	800	$ 12.00	$ 9,600	$ 6,498
13	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 928
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	15	2400	$ 12.00	$ 28,800	$ 15,273
18	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 8,310
18	Full depth asphalt base repair, % area (m²)	10	1600	$ 40.00	$ 64,000	$ 26,593
18	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 102,114
23	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 285
28	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 670
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	10	1600	$ 12.00	$ 19,200	$ 4,898
32	Mill HMA, mm (t)	90	3600	$ 10.00	$ 36,000	$ 7,555
32	Resurface with B-HF, mm (t)	50	1968	$ 101.76	$ 200,264	$ 42,029
32	Resurface with C-HF, mm (t)	40	1613	$ 121.90	$ 196,600	$ 41,260
37	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 432
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m²)	10	1600	$ 12.00	$ 19,200	$ 2,727
45	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 2,226
45	Full depth asphalt base repair, % area (m²)	10	1600	$ 40.00	$ 64,000	$ 7,123
45	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 27,351
48	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 252
50	Residual value				$ 192,354	$ 16,774
	Total M&R Cost				$ 987,660	$ 279,987

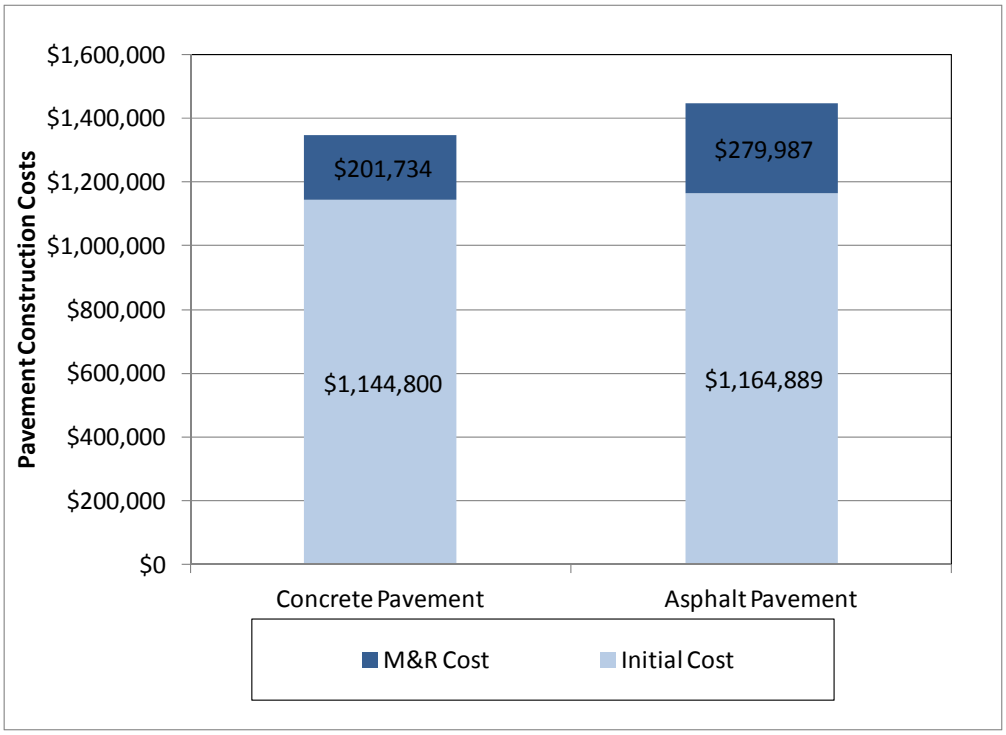


Figure 4.1 Example LCCA Comparison of Costs for a Major Arterial Pavement (AADTT =7,500)

Table 4.15 Summary of LCCA Results for Low Subgrade Strength- Nova Scotia

Typical Municipal Pavement for Nova Scotia

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	$ 446,813	$ 370,319	$ 453,750	$ 370,319
M&R Cost (Discounted)	$ 39,722	$ 64,034	$ 39,722	$ 64,034
Total Cost	$ 486,535	$ 434,353	$ 493,472	$ 434,353
LCC Difference	11%		12%	

Item	Minor Arterial			
	1,000 PCC	1,000 HMA	1,500 PCC	1,500 HMA
Initial Cost	$ 467,625	$ 409,369	$ 522,750	$ 428,893
M&R Cost (Discounted)	$ 70,095	$ 73,506	$ 70,095	$ 73,506
Total Cost	$ 537,720	$ 482,875	$ 592,845	$ 502,400
LCC Difference	10%		15%	

Item	Major Arterial			
	2,500 PCC	2,500 HMA	5,000 PCC	5,000 HMA
Initial Cost	$ 1,073,250	$ 974,935	$ 1,087,125	$ 1,013,984
M&R Cost (Discounted)	$ 166,176	$ 167,465	$ 166,176	$ 167,465
Total Cost	$ 1,239,426	$ 1,142,400	$ 1,253,301	$ 1,181,450
LCC Difference	8%		6%	

Item	Major Arterial			
	7,500 PCC	7,500 HMA	10,000 PCC	10,000 HMA
Initial Cost	$ 1,144,800	$ 1,164,889	$ 1,144,800	$ 1,206,541
M&R Cost (Discounted)	$ 201,734	$ 279,987	$ 201,734	$ 279,987
Total Cost	$ 1,346,534	$ 1,444,876	$ 1,346,534	$ 1,486,529
LCC Difference	-7%		-10%	

Table 4.16 Summary of LCCA Results for Medium Subgrade Strength- Nova Scotia

Typical Municipal Pavement for Nova Scotia

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	$ 446,813	$ 370,319	$ 453,750	$ 370,319
M&R Cost (Discounted)	$ 39,722	$ 64,034	$ 39,722	$ 64,034
Total Cost	$ 486,535	$ 434,353	$ 493,472	$ 434,353
LCC Difference	11%		12%	

Item	Minor Arterial			
	1,000 PCC	1,000 HMA	1,500 PCC	1,500 HMA
Initial Cost	$ 467,625	$ 389,844	$ 522,750	$ 409,369
M&R Cost (Discounted)	$ 70,095	$ 73,506	$ 70,095	$ 73,506
Total Cost	$ 537,720	$ 463,350	$ 592,845	$ 482,875
LCC Difference	14%		19%	

Item	Major Arterial			
	2,500 PCC	2,500 HMA	5,000 PCC	5,000 HMA
Initial Cost	$ 1,045,500	$ 974,935	$ 1,073,250	$ 1,013,984
M&R Cost (Discounted)	$ 166,176	$ 167,465	$ 166,176	$ 167,465
Total Cost	$ 1,211,676	$ 1,142,400	$ 1,239,426	$ 1,181,450
LCC Difference	6%		5%	

Item	Major Arterial			
	7,500 PCC	7,500 HMA	10,000 PCC	10,000 HMA
Initial Cost	$ 1,115,200	$ 1,164,889	$ 1,144,800	$ 1,206,541
M&R Cost (Discounted)	$ 201,734	$ 279,987	$ 201,734	$ 279,987
Total Cost	$ 1,316,934	$ 1,444,876	$ 1,346,534	$ 1,486,529
LCC Difference	-10%		-10%	

Table 4.17 Summary of LCCA Results for High Subgrade Strength- Nova Scotia

Typical Municipal Pavement for Nova Scotia

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	$ 446,813	$ 344,819	$ 446,813	$ 344,819
M&R Cost (Discounted)	$ 39,722	$ 64,034	$ 39,722	$ 64,034
Total Cost	$ 486,535	$ 408,853	$ 486,535	$ 408,853
LCC Difference	16%		16%	

Item	Minor Arterial			
	1,000 PCC	1,000 HMA	1,500 PCC	1,500 HMA
Initial Cost	$ 467,625	$ 364,344	$ 522,750	$ 383,869
M&R Cost (Discounted)	$ 70,095	$ 73,506	$ 70,095	$ 73,506
Total Cost	$ 537,720	$ 437,850	$ 592,845	$ 457,375
LCC Difference	19%		23%	

Item	Major Arterial			
	2,500 PCC	2,500 HMA	5,000 PCC	5,000 HMA
Initial Cost	$ 1,045,500	$ 884,885	$ 1,073,250	$ 962,984
M&R Cost (Discounted)	$ 166,176	$ 167,465	$ 166,176	$ 167,465
Total Cost	$ 1,211,676	$ 1,052,351	$ 1,239,426	$ 1,130,450
LCC Difference	13%		9%	

Item	Major Arterial			
	7,500 PCC	7,500 HMA	10,000 PCC	10,000 HMA
Initial Cost	$ 1,115,200	$ 1,110,489	$ 1,115,200	$ 1,152,141
M&R Cost (Discounted)	$ 201,734	$ 279,987	$ 201,734	$ 279,987
Total Cost	$ 1,316,934	$ 1,390,476	$ 1,316,934	$ 1,432,129
LCC Difference	-6%		-9%	

5. Closure

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 in Nova Scotia.

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 Nova Scotia.

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 Nova Scotia 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

Nova Scotia Roadway Design Matrix

Typical Pavement Designs for Nova Scotia

			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	175 mm PCC	180 mm PCC	190 mm PCC	200 mm PCC	210 mm PCC	215 mm PCC	210 mm PCC	210 mm PCC
			200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1
		HMA	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF
			50 mm B-HF	50 mm B-HF	70 mm B-HF	80 mm B-HF	110 mm B-HF	120 mm B-HF	140 mm B-HF	150 mm B-HF
			150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1
			400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2
	40 MPa (CBR=4)	PCC	175 mm PCC	180 mm PCC	190 mm PCC	200 mm PCC	200 mm PCC	210 mm PCC	200 mm PCC	210 mm PCC
			200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1
		HMA	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF
			50 mm B-HF	50 mm B-HF	60 mm B-HF	70 mm B-HF	110 mm B-HF	120 mm B-HF	140 mm B-HF	150 mm B-HF
			150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1
			400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2	400 mm Subbase Type 2
	50 MPa (CBR=5)	PCC	175 mm PCC	175 mm PCC	190 mm PCC	200 mm PCC	200 mm PCC	210 mm PCC	200 mm PCC	200 mm PCC
			200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1	200 mm Base Type 1
		HMA	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF	50 mm C-HF
			50 mm B-HF	50 mm B-HF	60 mm B-HF	70 mm B-HF	100 mm B-HF	120 mm B-HF	140 mm B-HF	150 mm B-HF
			150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1	150 mm Base Type 1
			300 mm Subbase Type 2	300 mm Subbase Type 2	300 mm Subbase Type 2	300 mm Subbase Type 2	300 mm Subbase Type 2	300 mm Subbase Type 2	300 mm Subbase Type 2	300 mm Subbase Type 2
			No Dowels	No Dowels	No mm Dowels	32 mm Dowels	32 mm Dowels	32 mm Dowels	32 mm Dowels	32 mm Dowels
			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	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 Nova Scotia Specifications
- Subgrade levels are based on three common subgrade materials in Québec.
  - Low Strength (30 MPa) - Low Plasticity Clay Subgrade
  - Medium Strength (40 MPa) - Low Plasticity Silt Subgrade
  - High Strength (50 MPa) - Sandy Silt Subgrade
- For urban sections, a tied concrete curb or a monolithic slab and curb can be used as a tied shoulder or widened slab respectively.

Appendix B

Life-Cycle Cost Analysis Results

Typical Municipal Pavement for Nova Scotia

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	$ 446,813	$ 370,319	$ 453,750	$ 370,319
M&R Cost (Discounted)	$ 39,722	$ 64,034	$ 39,722	$ 64,034
Total Cost	$ 486,535	$ 434,353	$ 493,472	$ 434,353
LCC Difference	11%		12%	

Item	Minor Arterial			
	1,000 PCC	1,000 HMA	1,500 PCC	1,500 HMA
Initial Cost	$ 467,625	$ 409,369	$ 522,750	$ 428,893
M&R Cost (Discounted)	$ 70,095	$ 73,506	$ 70,095	$ 73,506
Total Cost	$ 537,720	$ 482,875	$ 592,845	$ 502,400
LCC Difference	10%		15%	

Item	Major Arterial			
	2,500 PCC	2,500 HMA	5,000 PCC	5,000 HMA
Initial Cost	$ 1,073,250	$ 974,935	$ 1,087,125	$ 1,013,984
M&R Cost (Discounted)	$ 166,176	$ 167,465	$ 166,176	$ 167,465
Total Cost	$ 1,239,426	$ 1,142,400	$ 1,253,301	$ 1,181,450
LCC Difference	8%		6%	

Item	Major Arterial			
	7,500 PCC	7,500 HMA	10,000 PCC	10,000 HMA
Initial Cost	$ 1,144,800	$ 1,164,889	$ 1,144,800	$ 1,206,541
M&R Cost (Discounted)	$ 201,734	$ 279,987	$ 201,734	$ 279,987
Total Cost	$ 1,346,534	$ 1,444,876	$ 1,346,534	$ 1,486,529
LCC Difference	-7%		-10%	

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	
175	mm PCC
200	mm Base Type 1
No	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	175 mm PCC pavement, no dowels (m^2)	175	7500	$ 48.63	$ 364,688
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	375	2813	$ 10.00	$ 28,125
	Total Initial Cost				$ 446,813

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	167	$ 10.00	$ 1,667	$ 928
25	Partial depth PCC repair, % area (m^2)	2	150	$ 150.00	$ 22,500	$ 6,644
25	Full depth PCC repair, % area (m^2)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 984
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 13,317
40	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 473
50	Residual Value				$ 51,111	$ 4,457
	Total M&R Cost				$ 176,597	$ 39,722

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	
50	mm C-HF
50	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	50	923	$ 101.76	$ 93,874
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	400	6,000	$ 12.00	$ 72,000
Excavation	Earth excavation (m^3)	650	4,875	$ 10.00	$ 48,750
	Total Initial Cost				$ 370,319

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	5	375	$ 40.00	$ 15,000	$ 2,719
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 721
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 83,047	$ 7,242
	Total M&R Cost				$ 243,910	$ 64,034

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	
180	mm PCC
200	mm Base Type 1
No	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, m	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 (m^2)	180	7500	$ 49.50	$ 371,250
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	380	2850	$ 10.00	$ 28,500
	Total Initial Cost				$ 453,750

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	167	$ 10.00	$ 1,667	$ 928
25	Partial depth PCC repair, % area (m^2)	2	150	$ 150.00	$ 22,500	$ 6,644
25	Full depth PCC repair, % area (m^2)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 984
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 13,317
40	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 473
50	Residual Value				$ 51,111	$ 4,457
	Total M&R Cost				$ 176,597	$ 39,722

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	
50	mm C-HF
50	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	50	923	$ 101.76	$ 93,874
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	400	6,000	$ 12.00	$ 72,000
Excavation	Earth excavation (m^3)	650	4,875	$ 10.00	$ 48,750
	Total Initial Cost				$ 370,319

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	5	375	$ 40.00	$ 15,000	$ 2,719
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 721
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 83,047	$ 7,242
	Total M&R Cost				$ 243,910	$ 64,034

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	
190	mm PCC
200	mm Base Type 1
No	mm 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	190 mm PCC pavement, no dowels (m^2)	190	7500	$ 51.25	$ 384,375
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	390	2925	$ 10.00	$ 29,250
	Total Initial Cost				$ 467,625

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 (m^2)	5	375	$ 150.00	$ 56,250	$ 16,611
25	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 27,685
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	15	1125	$ 125.00	$ 140,625	$ 19,975
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 67,014	$ 5,844
	Total M&R Cost				$ 291,528	$ 70,095

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	
50	mm C-HF
70	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	70	1,292	$ 101.76	$ 131,423
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	400	6,000	$ 12.00	$ 72,000
Excavation	Earth excavation (m^3)	670	5,025	$ 10.00	$ 50,250
	Total Initial Cost				$ 409,369

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
15	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 12.00	$ 9,000	$ 4,329
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 40.00	$ 30,000	$ 5,439
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	90	1688	$ 10.00	$ 16,875	$ 1,622
48	Resurface with B-HF, mm (t)	50	923	$ 101.76	$ 93,874	$ 9,025
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 169,088	$ 14,745
	Total M&R Cost				$ 285,118	$ 73,506

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 Base Type 1
32	mm 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, 32 mm dowels (m^2)	200	7500	$ 58.50	$ 438,750
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	400	3000	$ 10.00	$ 30,000
	Total Initial Cost				$ 522,750

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 (m^2)	5	375	$ 150.00	$ 56,250	$ 16,611
25	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 27,685
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	15	1125	$ 125.00	$ 140,625	$ 19,975
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 67,014	$ 5,844
	Total M&R Cost				$ 291,528	$ 70,095

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	
50	mm C-HF
80	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	80	1,476	$ 101.76	$ 150,198
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	400	6,000	$ 12.00	$ 72,000
Excavation	Earth excavation (m^3)	680	5,100	$ 10.00	$ 51,000
	Total Initial Cost				$ 428,893

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
15	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 12.00	$ 9,000	$ 4,329
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 40.00	$ 30,000	$ 5,439
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	90	1688	$ 10.00	$ 16,875	$ 1,622
48	Resurface with B-HF, mm (t)	50	923	$ 101.76	$ 93,874	$ 9,025
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 169,088	$ 14,745
	Total M&R Cost				$ 285,118	$ 73,506

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	
210	mm PCC
200	mm Base Type 1
32	mm 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	210 mm PCC pavement, 32 mm dowels (m^2)	210	15000	$ 60.25	$ 903,750
Base	Type 1, mm (t)	200	7200	$ 15.00	$ 108,000
Excavation	Earth excavation (m^3)	410	6150	$ 10.00	$ 61,500
	Total Initial Cost				$ 1,073,250

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	$ 150.00	$ 45,000	$ 25,058
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 33,222
25	Full depth PCC repair, % area (m^2)	10	1500	$ 125.00	$ 187,500	$ 55,369
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 15,980
40	Full depth PCC repair, % area (m^2)	15	2250	$ 125.00	$ 281,250	$ 39,950
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 134,028	$ 11,688
	Total M&R Cost				$ 629,722	$ 166,176

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	
50	mm C-HF
110	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	1,890	$ 121.90	$ 230,391
Binder	B-HF, mm (t) 58-28	110	4,059	$ 101.76	$ 413,044
Base	Type 1, mm (t)	150	5,400	$ 15.00	$ 81,000
Subbase	Type 2, mm (t)	400	12,000	$ 12.00	$ 144,000
Excavation	Earth excavation (m^3)	710	10,650	$ 10.00	$ 106,500
	Total Initial Cost				$ 974,935

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	$ 1.75	$ 350	$ 274
10	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 537
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 12.00	$ 9,000	$ 5,525
20	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 5,653
20	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 69,466
25	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 517
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 4,165
35	Mill HMA, mm (t)	90	3375	$ 10.00	$ 33,750	$ 6,119
35	Resurface with B-HF, mm (t)	50	1845	$ 101.76	$ 187,747	$ 34,037
35	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 33,414
40	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 373
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 2,003
48	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 1,442
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 40.00	$ 30,000	$ 2,884
48	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 17,720
50	Residual value				$ 191,094	$ 16,664
	Total M&R Cost				$ 693,942	$ 167,465

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	
215	mm PCC
200	mm Base Type 1
32	mm 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	215 mm PCC pavement, 32 mm dowels (m^2)	215	15000	$ 61.13	$ 916,875
Base	Type 1, mm (t)	200	7200	$ 15.00	$ 108,000
Excavation	Earth excavation (m^3)	415	6225	$ 10.00	$ 62,250
	Total Initial Cost				$ 1,087,125

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
12	Partial depth PCC repair, % area (m^2)	2	300	$ 150.00	$ 45,000	$ 25,058
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 33,222
25	Full depth PCC repair, % area (m^2)	10	1500	$ 125.00	$ 187,500	$ 55,369
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 15,980
40	Full depth PCC repair, % area (m^2)	15	2250	$ 125.00	$ 281,250	$ 39,950
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 134,028	$ 11,688
	Total M&R Cost				$ 629,722	$ 166,176

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	
50	mm C-HF
120	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	1,890	$ 121.90	$ 230,391
Binder	B-HF, mm (t) 58-28	120	4,428	$ 101.76	$ 450,593
Base	Type 1, mm (t)	150	5,400	$ 15.00	$ 81,000
Subbase	Type 2, mm (t)	400	12,000	$ 12.00	$ 144,000
Excavation	Earth excavation (m^3)	720	10,800	$ 10.00	$ 108,000
	Total Initial Cost				$ 1,013,984

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	$ 1.75	$ 350	$ 274
10	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 537
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 12.00	$ 9,000	$ 5,525
20	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 5,653
20	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 69,466
25	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 517
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 4,165
35	Mill HMA, mm (t)	90	3375	$ 10.00	$ 33,750	$ 6,119
35	Resurface with B-HF, mm (t)	50	1845	$ 101.76	$ 187,747	$ 34,037
35	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 33,414
40	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 373
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 2,003
48	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 1,442
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 40.00	$ 30,000	$ 2,884
48	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 17,720
50	Residual value				$ 191,094	$ 16,664
	Total M&R Cost				$ 693,942	$ 167,465

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 Base Type 1
32	mm 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, 32 mm dowels (m^2)	210	16000	$ 60.25	$ 964,000
Base	Type 1, mm (t)	200	7680	$ 15.00	$ 115,200
Excavation	Earth excavation (m^3)	410	6560	$ 10.00	$ 65,600
	Total Initial Cost				$ 1,144,800

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	320	$ 150.00	$ 48,000	$ 26,728
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 35,436
25	Full depth PCC repair, % area (m^2)	10	1600	$ 125.00	$ 200,000	$ 59,061
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m^2)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 17,045
40	Full depth PCC repair, % area (m^2)	15	2400	$ 125.00	$ 300,000	$ 42,614
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m^2)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 172,593	$ 15,051
	Total M&R Cost				$ 779,852	$ 201,734

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	
50	mm C-HF
140	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	2,016	$ 121.90	$ 245,750
Binder	B-HF, mm (t) 58-28	140	5,510	$ 101.76	$ 560,738
Base	Type 1, mm (t)	150	5,760	$ 15.00	$ 86,400
Subbase	Type 2, mm (t)	400	12,800	$ 12.00	$ 153,600
Excavation	Earth excavation (m^3)	740	11,840	$ 10.00	$ 118,400
	Total Initial Cost				$ 1,164,889

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	$ 1.75	$ 350	$ 237
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 12.00	$ 9,600	$ 6,498
13	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 928
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 12.00	$ 28,800	$ 15,273
18	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 8,310
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 26,593
18	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 102,114
23	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 285
28	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 670
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 4,898
32	Mill HMA, mm (t)	90	3600	$ 10.00	$ 36,000	$ 7,555
32	Resurface with B-HF, mm (t)	50	1968	$ 101.76	$ 200,264	$ 42,029
32	Resurface with C-HF, mm (t)	40	1613	$ 121.90	$ 196,600	$ 41,260
37	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 432
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 2,727
45	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 2,226
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 7,123
45	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 27,351
48	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 252
50	Residual value				$ 192,354	$ 16,774
	Total M&R Cost				$ 987,660	$ 279,987

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	
210	mm PCC
200	mm Base Type 1
32	mm 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, 32 mm dowels (m^2)	210	16000	$ 60.25	$ 964,000
Base	Type 1, mm (t)	200	7680	$ 15.00	$ 115,200
Excavation	Earth excavation (m^3)	410	6560	$ 10.00	$ 65,600
	Total Initial Cost				$ 1,144,800

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	320	$ 150.00	$ 48,000	$ 26,728
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 35,436
25	Full depth PCC repair, % area (m^2)	10	1600	$ 125.00	$ 200,000	$ 59,061
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m^2)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 17,045
40	Full depth PCC repair, % area (m^2)	15	2400	$ 125.00	$ 300,000	$ 42,614
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m^2)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 172,593	$ 15,051
	Total M&R Cost				$ 779,852	$ 201,734

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	
50	mm C-HF
150	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	2,016	$ 121.90	$ 245,750
Binder	B-HF, mm (t) 58-28	150	5,904	$ 101.76	$ 600,791
Base	Type 1, mm (t)	150	5,760	$ 15.00	$ 86,400
Subbase	Type 2, mm (t)	400	12,800	$ 12.00	$ 153,600
Excavation	Earth excavation (m^3)	750	12,000	$ 10.00	$ 120,000
	Total Initial Cost				$ 1,206,541

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	$ 1.75	$ 350	$ 237
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 12.00	$ 9,600	$ 6,498
13	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 928
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 12.00	$ 28,800	$ 15,273
18	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 8,310
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 26,593
18	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 102,114
23	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 285
28	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 670
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 4,898
32	Mill HMA, mm (t)	90	3600	$ 10.00	$ 36,000	$ 7,555
32	Resurface with B-HF, mm (t)	50	1968	$ 101.76	$ 200,264	$ 42,029
32	Resurface with C-HF, mm (t)	40	1613	$ 121.90	$ 196,600	$ 41,260
37	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 432
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 2,727
45	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 2,226
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 7,123
45	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 27,351
48	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 252
50	Residual value				$ 192,354	$ 16,774
	Total M&R Cost				$ 987,660	$ 279,987

Typical Municipal Pavement for Nova Scotia

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	$ 446,813	$ 370,319	$ 453,750	$ 370,319
M&R Cost (Discounted)	$ 39,722	$ 64,034	$ 39,722	$ 64,034
Total Cost	$ 486,535	$ 434,353	$ 493,472	$ 434,353
LCC Difference	11%		12%	

Item	Minor Arterial			
	1,000 PCC	1,000 HMA	1,500 PCC	1,500 HMA
Initial Cost	$ 467,625	$ 389,844	$ 522,750	$ 409,369
M&R Cost (Discounted)	$ 70,095	$ 73,506	$ 70,095	$ 73,506
Total Cost	$ 537,720	$ 463,350	$ 592,845	$ 482,875
LCC Difference	14%		19%	

Item	Major Arterial			
	2,500 PCC	2,500 HMA	5,000 PCC	5,000 HMA
Initial Cost	$ 1,045,500	$ 974,935	$ 1,073,250	$ 1,013,984
M&R Cost (Discounted)	$ 166,176	$ 167,465	$ 166,176	$ 167,465
Total Cost	$ 1,211,676	$ 1,142,400	$ 1,239,426	$ 1,181,450
LCC Difference	6%		5%	

Item	Major Arterial			
	7,500 PCC	7,500 HMA	10,000 PCC	10,000 HMA
Initial Cost	$ 1,115,200	$ 1,164,889	$ 1,144,800	$ 1,206,541
M&R Cost (Discounted)	$ 201,734	$ 279,987	$ 201,734	$ 279,987
Total Cost	$ 1,316,934	$ 1,444,876	$ 1,346,534	$ 1,486,529
LCC Difference	-10%		-10%	

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	
175	mm PCC
200	mm Base Type 1
No	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	175 mm PCC pavement, no dowels (m^2)	175	7500	$ 48.63	$ 364,688
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	375	2813	$ 10.00	$ 28,125
	Total Initial Cost				$ 446,813

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	167	$ 10.00	$ 1,667	$ 928
25	Partial depth PCC repair, % area (m^2)	2	150	$ 150.00	$ 22,500	$ 6,644
25	Full depth PCC repair, % area (m^2)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 984
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 13,317
40	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 473
50	Residual Value				$ 51,111	$ 4,457
	Total M&R Cost				$ 176,597	$ 39,722

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	
50	mm C-HF
50	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	50	923	$ 101.76	$ 93,874
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	400	6,000	$ 12.00	$ 72,000
Excavation	Earth excavation (m^3)	650	4,875	$ 10.00	$ 48,750
	Total Initial Cost				$ 370,319

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	5	375	$ 40.00	$ 15,000	$ 2,719
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 721
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 83,047	$ 7,242
	Total M&R Cost				$ 243,910	$ 64,034

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	
180	mm PCC
200	mm Base Type 1
No	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, m	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 (m^2)	180	7500	$ 49.50	$ 371,250
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	380	2850	$ 10.00	$ 28,500
	Total Initial Cost				$ 453,750

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	167	$ 10.00	$ 1,667	$ 928
25	Partial depth PCC repair, % area (m^2)	2	150	$ 150.00	$ 22,500	$ 6,644
25	Full depth PCC repair, % area (m^2)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 984
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 13,317
40	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 473
50	Residual Value				$ 51,111	$ 4,457
	Total M&R Cost				$ 176,597	$ 39,722

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	
50	mm C-HF
50	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	50	923	$ 101.76	$ 93,874
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	400	6,000	$ 12.00	$ 72,000
Excavation	Earth excavation (m^3)	650	4,875	$ 10.00	$ 48,750
	Total Initial Cost				$ 370,319

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	5	375	$ 40.00	$ 15,000	$ 2,719
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 721
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 83,047	$ 7,242
	Total M&R Cost				$ 243,910	$ 64,034

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	
190	mm PCC
200	mm Base Type 1
No	mm 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	190 mm PCC pavement, no dowels (m^2)	190	7500	$ 51.25	$ 384,375
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	390	2925	$ 10.00	$ 29,250
	Total Initial Cost				$ 467,625

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 (m^2)	5	375	$ 150.00	$ 56,250	$ 16,611
25	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 27,685
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	15	1125	$ 125.00	$ 140,625	$ 19,975
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 67,014	$ 5,844
	Total M&R Cost				$ 291,528	$ 70,095

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	
50	mm C-HF
60	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	60	1,107	$ 101.76	$ 112,648
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	400	6,000	$ 12.00	$ 72,000
Excavation	Earth excavation (m^3)	660	4,950	$ 10.00	$ 49,500
	Total Initial Cost				$ 389,844

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
15	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 12.00	$ 9,000	$ 4,329
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 40.00	$ 30,000	$ 5,439
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	90	1688	$ 10.00	$ 16,875	$ 1,622
48	Resurface with B-HF, mm (t)	50	923	$ 101.76	$ 93,874	$ 9,025
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 169,088	$ 14,745
	Total M&R Cost				$ 285,118	$ 73,506

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 Base Type 1
32	mm 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, 32 mm dowels (m^2)	200	7500	$ 58.50	$ 438,750
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	400	3000	$ 10.00	$ 30,000
	Total Initial Cost				$ 522,750

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 (m^2)	5	375	$ 150.00	$ 56,250	$ 16,611
25	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 27,685
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	15	1125	$ 125.00	$ 140,625	$ 19,975
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 67,014	$ 5,844
	Total M&R Cost				$ 291,528	$ 70,095

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	
50	mm C-HF
70	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	70	1,292	$ 101.76	$ 131,423
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	400	6,000	$ 12.00	$ 72,000
Excavation	Earth excavation (m^3)	670	5,025	$ 10.00	$ 50,250
	Total Initial Cost				$ 409,369

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
15	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 12.00	$ 9,000	$ 4,329
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 40.00	$ 30,000	$ 5,439
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	90	1688	$ 10.00	$ 16,875	$ 1,622
48	Resurface with B-HF, mm (t)	50	923	$ 101.76	$ 93,874	$ 9,025
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 169,088	$ 14,745
	Total M&R Cost				$ 285,118	$ 73,506

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 Base Type 1
32	mm 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, 32 mm dowels (m^2)	200	15000	$ 58.50	$ 877,500
Base	Type 1, mm (t)	200	7200	$ 15.00	$ 108,000
Excavation	Earth excavation (m^3)	400	6000	$ 10.00	$ 60,000
	Total Initial Cost				$ 1,045,500

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	$ 150.00	$ 45,000	$ 25,058
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 33,222
25	Full depth PCC repair, % area (m^2)	10	1500	$ 125.00	$ 187,500	$ 55,369
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 15,980
40	Full depth PCC repair, % area (m^2)	15	2250	$ 125.00	$ 281,250	$ 39,950
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 134,028	$ 11,688
	Total M&R Cost				$ 629,722	$ 166,176

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	
50	mm C-HF
110	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	1,890	$ 121.90	$ 230,391
Binder	B-HF, mm (t) 58-28	110	4,059	$ 101.76	$ 413,044
Base	Type 1, mm (t)	150	5,400	$ 15.00	$ 81,000
Subbase	Type 2, mm (t)	400	12,000	$ 12.00	$ 144,000
Excavation	Earth excavation (m^3)	710	10,650	$ 10.00	$ 106,500
	Total Initial Cost				$ 974,935

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	$ 1.75	$ 350	$ 274
10	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 537
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 12.00	$ 9,000	$ 5,525
20	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 5,653
20	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 69,466
25	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 517
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 4,165
35	Mill HMA, mm (t)	90	3375	$ 10.00	$ 33,750	$ 6,119
35	Resurface with B-HF, mm (t)	50	1845	$ 101.76	$ 187,747	$ 34,037
35	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 33,414
40	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 373
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 2,003
48	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 1,442
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 40.00	$ 30,000	$ 2,884
48	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 17,720
50	Residual value				$ 191,094	$ 16,664
	Total M&R Cost				$ 693,942	$ 167,465

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	
210	mm PCC
200	mm Base Type 1
32	mm 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	210 mm PCC pavement, 32 mm dowels (m^2)	210	15000	$ 60.25	$ 903,750
Base	Type 1, mm (t)	200	7200	$ 15.00	$ 108,000
Excavation	Earth excavation (m^3)	410	6150	$ 10.00	$ 61,500
	Total Initial Cost				$ 1,073,250

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	$ 150.00	$ 45,000	$ 25,058
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 33,222
25	Full depth PCC repair, % area (m^2)	10	1500	$ 125.00	$ 187,500	$ 55,369
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 15,980
40	Full depth PCC repair, % area (m^2)	15	2250	$ 125.00	$ 281,250	$ 39,950
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 134,028	$ 11,688
	Total M&R Cost				$ 629,722	$ 166,176

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	
50	mm C-HF
120	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	1,890	$ 121.90	$ 230,391
Binder	B-HF, mm (t) 58-28	120	4,428	$ 101.76	$ 450,593
Base	Type 1, mm (t)	150	5,400	$ 15.00	$ 81,000
Subbase	Type 2, mm (t)	400	12,000	$ 12.00	$ 144,000
Excavation	Earth excavation (m^3)	720	10,800	$ 10.00	$ 108,000
	Total Initial Cost				$ 1,013,984

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	$ 1.75	$ 350	$ 274
10	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 537
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 12.00	$ 9,000	$ 5,525
20	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 5,653
20	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 69,466
25	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 517
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 4,165
35	Mill HMA, mm (t)	90	3375	$ 10.00	$ 33,750	$ 6,119
35	Resurface with B-HF, mm (t)	50	1845	$ 101.76	$ 187,747	$ 34,037
35	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 33,414
40	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 373
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 2,003
48	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 1,442
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 40.00	$ 30,000	$ 2,884
48	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 17,720
50	Residual value				$ 191,094	$ 16,664
	Total M&R Cost				$ 693,942	$ 167,465

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 Base Type 1
32	mm 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, 32 mm dowels (m^2)	200	16000	$ 58.50	$ 936,000
Base	Type 1, mm (t)	200	7680	$ 15.00	$ 115,200
Excavation	Earth excavation (m^3)	400	6400	$ 10.00	$ 64,000
	Total Initial Cost				$ 1,115,200

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	320	$ 150.00	$ 48,000	$ 26,728
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 35,436
25	Full depth PCC repair, % area (m^2)	10	1600	$ 125.00	$ 200,000	$ 59,061
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m^2)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 17,045
40	Full depth PCC repair, % area (m^2)	15	2400	$ 125.00	$ 300,000	$ 42,614
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m^2)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 172,593	$ 15,051
	Total M&R Cost				$ 779,852	$ 201,734

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	
50	mm C-HF
140	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	2,016	$ 121.90	$ 245,750
Binder	B-HF, mm (t) 58-28	140	5,510	$ 101.76	$ 560,738
Base	Type 1, mm (t)	150	5,760	$ 15.00	$ 86,400
Subbase	Type 2, mm (t)	400	12,800	$ 12.00	$ 153,600
Excavation	Earth excavation (m^3)	740	11,840	$ 10.00	$ 118,400
	Total Initial Cost				$ 1,164,889

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	$ 1.75	$ 350	$ 237
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 12.00	$ 9,600	$ 6,498
13	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 928
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 12.00	$ 28,800	$ 15,273
18	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 8,310
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 26,593
18	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 102,114
23	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 285
28	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 670
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 4,898
32	Mill HMA, mm (t)	90	3600	$ 10.00	$ 36,000	$ 7,555
32	Resurface with B-HF, mm (t)	50	1968	$ 101.76	$ 200,264	$ 42,029
32	Resurface with C-HF, mm (t)	40	1613	$ 121.90	$ 196,600	$ 41,260
37	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 432
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 2,727
45	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 2,226
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 7,123
45	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 27,351
48	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 252
50	Residual value				$ 192,354	$ 16,774
	Total M&R Cost				$ 987,660	$ 279,987

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 Base Type 1
32	mm 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, 32 mm dowels (m^2)	210	16000	$ 60.25	$ 964,000
Base	Type 1, mm (t)	200	7680	$ 15.00	$ 115,200
Excavation	Earth excavation (m^3)	410	6560	$ 10.00	$ 65,600
	Total Initial Cost				$ 1,144,800

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	320	$ 150.00	$ 48,000	$ 26,728
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 35,436
25	Full depth PCC repair, % area (m^2)	10	1600	$ 125.00	$ 200,000	$ 59,061
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m^2)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 17,045
40	Full depth PCC repair, % area (m^2)	15	2400	$ 125.00	$ 300,000	$ 42,614
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m^2)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 172,593	$ 15,051
	Total M&R Cost				$ 779,852	$ 201,734

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	
50	mm C-HF
150	mm B-HF
150	mm Base Type 1
400	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	2,016	$ 121.90	$ 245,750
Binder	B-HF, mm (t) 58-28	150	5,904	$ 101.76	$ 600,791
Base	Type 1, mm (t)	150	5,760	$ 15.00	$ 86,400
Subbase	Type 2, mm (t)	400	12,800	$ 12.00	$ 153,600
Excavation	Earth excavation (m^3)	750	12,000	$ 10.00	$ 120,000
	Total Initial Cost				$ 1,206,541

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	$ 1.75	$ 350	$ 237
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 12.00	$ 9,600	$ 6,498
13	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 928
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 12.00	$ 28,800	$ 15,273
18	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 8,310
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 26,593
18	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 102,114
23	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 285
28	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 670
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 4,898
32	Mill HMA, mm (t)	90	3600	$ 10.00	$ 36,000	$ 7,555
32	Resurface with B-HF, mm (t)	50	1968	$ 101.76	$ 200,264	$ 42,029
32	Resurface with C-HF, mm (t)	40	1613	$ 121.90	$ 196,600	$ 41,260
37	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 432
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 2,727
45	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 2,226
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 7,123
45	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 27,351
48	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 252
50	Residual value				$ 192,354	$ 16,774
	Total M&R Cost				$ 987,660	$ 279,987

Typical Municipal Pavement for Nova Scotia

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	$ 446,813	$ 344,819	$ 446,813	$ 344,819
M&R Cost (Discounted)	$ 39,722	$ 64,034	$ 39,722	$ 64,034
Total Cost	$ 486,535	$ 408,853	$ 486,535	$ 408,853
LCC Difference	16%		16%	

Item	Minor Arterial			
	1,000 PCC	1,000 HMA	1,500 PCC	1,500 HMA
Initial Cost	$ 467,625	$ 364,344	$ 522,750	$ 383,869
M&R Cost (Discounted)	$ 70,095	$ 73,506	$ 70,095	$ 73,506
Total Cost	$ 537,720	$ 437,850	$ 592,845	$ 457,375
LCC Difference	19%		23%	

Item	Major Arterial			
	2,500 PCC	2,500 HMA	5,000 PCC	5,000 HMA
Initial Cost	$ 1,045,500	$ 884,885	$ 1,073,250	$ 962,984
M&R Cost (Discounted)	$ 166,176	$ 167,465	$ 166,176	$ 167,465
Total Cost	$ 1,211,676	$ 1,052,351	$ 1,239,426	$ 1,130,450
LCC Difference	13%		9%	

Item	Major Arterial			
	7,500 PCC	7,500 HMA	10,000 PCC	10,000 HMA
Initial Cost	$ 1,115,200	$ 1,110,489	$ 1,115,200	$ 1,152,141
M&R Cost (Discounted)	$ 201,734	$ 279,987	$ 201,734	$ 279,987
Total Cost	$ 1,316,934	$ 1,390,476	$ 1,316,934	$ 1,432,129
LCC Difference	-6%		-9%	

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	
175	mm PCC
200	mm Base Type 1
No	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	175 mm PCC pavement, no dowels (m^2)	175	7500	$ 48.63	$ 364,688
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	375	2813	$ 10.00	$ 28,125
	Total Initial Cost				$ 446,813

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	167	$ 10.00	$ 1,667	$ 928
25	Partial depth PCC repair, % area (m^2)	2	150	$ 150.00	$ 22,500	$ 6,644
25	Full depth PCC repair, % area (m^2)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 984
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 13,317
40	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 473
50	Residual Value				$ 51,111	$ 4,457
	Total M&R Cost				$ 176,597	$ 39,722

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	
50	mm C-HF
50	mm B-HF
150	mm Base Type 1
300	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	50	923	$ 101.76	$ 93,874
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	300	4,500	$ 12.00	$ 54,000
Excavation	Earth excavation (m^3)	550	4,125	$ 10.00	$ 41,250
	Total Initial Cost				$ 344,819

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	5	375	$ 40.00	$ 15,000	$ 2,719
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 721
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 83,047	$ 7,242
	Total M&R Cost				$ 243,910	$ 64,034

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	
175	mm PCC
200	mm Base Type 1
No	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, m	1000

Initial Pavement Structure

Pavement layer	Description of pavement layer, Amount (Quantity)	Amount	Quantity per km	Price per unit of quantity	Cost
Surface	175 mm PCC pavement, no dowels (m^2)	175	7500	$ 48.63	$ 364,688
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	375	2813	$ 10.00	$ 28,125
	Total Initial Cost				$ 446,813

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	167	$ 10.00	$ 1,667	$ 928
25	Partial depth PCC repair, % area (m^2)	2	150	$ 150.00	$ 22,500	$ 6,644
25	Full depth PCC repair, % area (m^2)	5	375	$ 125.00	$ 46,875	$ 13,842
25	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 984
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 13,317
40	Reseal joints, % Length (m)	20	333	$ 10.00	$ 3,333	$ 473
50	Residual Value				$ 51,111	$ 4,457
	Total M&R Cost				$ 176,597	$ 39,722

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	
50	mm C-HF
50	mm B-HF
150	mm Base Type 1
300	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	50	923	$ 101.76	$ 93,874
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	300	4,500	$ 12.00	$ 54,000
Excavation	Earth excavation (m^3)	550	4,125	$ 10.00	$ 41,250
	Total Initial Cost				$ 344,819

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	5	375	$ 40.00	$ 15,000	$ 2,719
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 721
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 83,047	$ 7,242
	Total M&R Cost				$ 243,910	$ 64,034

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	
190	mm PCC
200	mm Base Type 1
No	mm 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	190 mm PCC pavement, no dowels (m^2)	190	7500	$ 51.25	$ 384,375
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	390	2925	$ 10.00	$ 29,250
	Total Initial Cost				$ 467,625

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 (m^2)	5	375	$ 150.00	$ 56,250	$ 16,611
25	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 27,685
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	15	1125	$ 125.00	$ 140,625	$ 19,975
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 67,014	$ 5,844
	Total M&R Cost				$ 291,528	$ 70,095

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	
50	mm C-HF
60	mm B-HF
150	mm Base Type 1
300	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	60	1,107	$ 101.76	$ 112,648
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	300	4,500	$ 12.00	$ 54,000
Excavation	Earth excavation (m^3)	560	4,200	$ 10.00	$ 42,000
	Total Initial Cost				$ 364,344

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
15	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 12.00	$ 9,000	$ 4,329
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 40.00	$ 30,000	$ 5,439
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	90	1688	$ 10.00	$ 16,875	$ 1,622
48	Resurface with B-HF, mm (t)	50	923	$ 101.76	$ 93,874	$ 9,025
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 169,088	$ 14,745
	Total M&R Cost				$ 285,118	$ 73,506

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 Base Type 1
32	mm 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, 32 mm dowels (m^2)	200	7500	$ 58.50	$ 438,750
Base	Type 1, mm (t)	200	3600	$ 15.00	$ 54,000
Excavation	Earth excavation (m^3)	400	3000	$ 10.00	$ 30,000
	Total Initial Cost				$ 522,750

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 (m^2)	5	375	$ 150.00	$ 56,250	$ 16,611
25	Full depth PCC repair, % area (m^2)	10	750	$ 125.00	$ 93,750	$ 27,685
25	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 1,230
40	Partial depth PCC repair, % area (m^2)	5	375	$ 150.00	$ 56,250	$ 7,990
40	Full depth PCC repair, % area (m^2)	15	1125	$ 125.00	$ 140,625	$ 19,975
40	Reseal joints, % Length (m)	25	417	$ 10.00	$ 4,167	$ 592
50	Residual Value				$ 67,014	$ 5,844
	Total M&R Cost				$ 291,528	$ 70,095

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	
50	mm C-HF
70	mm B-HF
150	mm Base Type 1
300	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	945	$ 121.90	$ 115,196
Binder	B-HF, mm (t) 58-28	70	1,292	$ 101.76	$ 131,423
Base	Type 1, mm (t)	150	2,700	$ 15.00	$ 40,500
Subbase	Type 2, mm (t)	300	4,500	$ 12.00	$ 54,000
Excavation	Earth excavation (m^3)	570	4,275	$ 10.00	$ 42,750
	Total Initial Cost				$ 383,869

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	$ 1.75	$ 438	$ 269
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	2	150	$ 12.00	$ 1,800	$ 1,105
15	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	750	$ 12.00	$ 9,000	$ 4,329
20	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 2,827
20	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 34,733
25	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 258
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 1,041
35	Mill HMA, mm (t)	40	750	$ 10.00	$ 7,500	$ 1,360
35	Full depth asphalt base repair, % area (m^2)	10	750	$ 40.00	$ 30,000	$ 5,439
35	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 16,707
40	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 124
43	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	375	$ 12.00	$ 4,500	$ 552
48	Mill HMA, mm (t)	90	1688	$ 10.00	$ 16,875	$ 1,622
48	Resurface with B-HF, mm (t)	50	923	$ 101.76	$ 93,874	$ 9,025
48	Resurface with C-HF, mm (t)	40	756	$ 121.90	$ 92,156	$ 8,860
50	Residual value				$ 169,088	$ 14,745
	Total M&R Cost				$ 285,118	$ 73,506

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 Base Type 1
32	mm 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, 32 mm dowels (m^2)	200	15000	$ 58.50	$ 877,500
Base	Type 1, mm (t)	200	7200	$ 15.00	$ 108,000
Excavation	Earth excavation (m^3)	400	6000	$ 10.00	$ 60,000
	Total Initial Cost				$ 1,045,500

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	$ 150.00	$ 45,000	$ 25,058
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 33,222
25	Full depth PCC repair, % area (m^2)	10	1500	$ 125.00	$ 187,500	$ 55,369
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 15,980
40	Full depth PCC repair, % area (m^2)	15	2250	$ 125.00	$ 281,250	$ 39,950
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 134,028	$ 11,688
	Total M&R Cost				$ 629,722	$ 166,176

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	
50	mm C-HF
100	mm B-HF
150	mm Base Type 1
300	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	1,890	$ 121.90	$ 230,391
Binder	B-HF, mm (t) 58-28	100	3,690	$ 101.76	$ 375,494
Base	Type 1, mm (t)	150	5,400	$ 15.00	$ 81,000
Subbase	Type 2, mm (t)	300	9,000	$ 12.00	$ 108,000
Excavation	Earth excavation (m^3)	600	9,000	$ 10.00	$ 90,000
	Total Initial Cost				$ 884,885

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	$ 1.75	$ 350	$ 274
10	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 537
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 12.00	$ 9,000	$ 5,525
20	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 5,653
20	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 69,466
25	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 517
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 4,165
35	Mill HMA, mm (t)	90	3375	$ 10.00	$ 33,750	$ 6,119
35	Resurface with B-HF, mm (t)	50	1845	$ 101.76	$ 187,747	$ 34,037
35	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 33,414
40	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 373
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 2,003
48	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 1,442
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 40.00	$ 30,000	$ 2,884
48	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 17,720
50	Residual value				$ 191,094	$ 16,664
	Total M&R Cost				$ 693,942	$ 167,465

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	
210	mm PCC
200	mm Base Type 1
32	mm 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	210 mm PCC pavement, 32 mm dowels (m^2)	210	15000	$ 60.25	$ 903,750
Base	Type 1, mm (t)	200	7200	$ 15.00	$ 108,000
Excavation	Earth excavation (m^3)	410	6150	$ 10.00	$ 61,500
	Total Initial Cost				$ 1,073,250

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	$ 150.00	$ 45,000	$ 25,058
12	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 4,640
25	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 33,222
25	Full depth PCC repair, % area (m^2)	10	1500	$ 125.00	$ 187,500	$ 55,369
25	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 2,461
40	Partial depth PCC repair, % area (m^2)	5	750	$ 150.00	$ 112,500	$ 15,980
40	Full depth PCC repair, % area (m^2)	15	2250	$ 125.00	$ 281,250	$ 39,950
40	Reseal joints, % Length (m)	25	833	$ 10.00	$ 8,333	$ 1,184
50	Residual Value				$ 134,028	$ 11,688
	Total M&R Cost				$ 629,722	$ 166,176

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	
50	mm C-HF
120	mm B-HF
150	mm Base Type 1
300	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	1,890	$ 121.90	$ 230,391
Binder	B-HF, mm (t) 58-28	120	4,428	$ 101.76	$ 450,593
Base	Type 1, mm (t)	150	5,400	$ 15.00	$ 81,000
Subbase	Type 2, mm (t)	300	9,000	$ 12.00	$ 108,000
Excavation	Earth excavation (m^3)	620	9,300	$ 10.00	$ 93,000
	Total Initial Cost				$ 962,984

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	$ 1.75	$ 350	$ 274
10	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 537
10	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	750	$ 12.00	$ 9,000	$ 5,525
20	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 5,653
20	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 69,466
25	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 517
30	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 4,165
35	Mill HMA, mm (t)	90	3375	$ 10.00	$ 33,750	$ 6,119
35	Resurface with B-HF, mm (t)	50	1845	$ 101.76	$ 187,747	$ 34,037
35	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 33,414
40	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 373
45	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1500	$ 12.00	$ 18,000	$ 2,003
48	Mill HMA, mm (t)	40	1500	$ 10.00	$ 15,000	$ 1,442
48	Full depth asphalt base repair, % area (m^2)	5	750	$ 40.00	$ 30,000	$ 2,884
48	Resurface with C-HF, mm (t)	40	1512	$ 121.90	$ 184,313	$ 17,720
50	Residual value				$ 191,094	$ 16,664
	Total M&R Cost				$ 693,942	$ 167,465

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 Base Type 1
32	mm Dowels
4.5	m Slab Length
0.5	m Widened Slab

Geometric Design	
Design feature	Dimension
Width of the traffic lanes, m	16.0
Total width of paved shoulders, m	N/A
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, 32 mm dowels (m^2)	200	16000	$ 58.50	$ 936,000
Base	Type 1, mm (t)	200	7680	$ 15.00	$ 115,200
Excavation	Earth excavation (m^3)	400	6400	$ 10.00	$ 64,000
	Total Initial Cost				$ 1,115,200

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	320	$ 150.00	$ 48,000	$ 26,728
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 35,436
25	Full depth PCC repair, % area (m^2)	10	1600	$ 125.00	$ 200,000	$ 59,061
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m^2)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 17,045
40	Full depth PCC repair, % area (m^2)	15	2400	$ 125.00	$ 300,000	$ 42,614
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m^2)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 172,593	$ 15,051
	Total M&R Cost				$ 779,852	$ 201,734

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	
50	mm C-HF
140	mm B-HF
150	mm Base Type 1
300	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	2,016	$ 121.90	$ 245,750
Binder	B-HF, mm (t) 58-28	140	5,510	$ 101.76	$ 560,738
Base	Type 1, mm (t)	150	5,760	$ 15.00	$ 86,400
Subbase	Type 2, mm (t)	300	9,600	$ 12.00	$ 115,200
Excavation	Earth excavation (m^3)	640	10,240	$ 10.00	$ 102,400
	Total Initial Cost				$ 1,110,489

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	$ 1.75	$ 350	$ 237
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 12.00	$ 9,600	$ 6,498
13	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 928
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 12.00	$ 28,800	$ 15,273
18	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 8,310
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 26,593
18	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 102,114
23	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 285
28	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 670
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 4,898
32	Mill HMA, mm (t)	90	3600	$ 10.00	$ 36,000	$ 7,555
32	Resurface with B-HF, mm (t)	50	1968	$ 101.76	$ 200,264	$ 42,029
32	Resurface with C-HF, mm (t)	40	1613	$ 121.90	$ 196,600	$ 41,260
37	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 432
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 2,727
45	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 2,226
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 7,123
45	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 27,351
48	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 252
50	Residual value				$ 192,354	$ 16,774
	Total M&R Cost				$ 987,660	$ 279,987

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 Base Type 1
32	mm 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, 32 mm dowels (m^2)	200	16000	$ 58.50	$ 936,000
Base	Type 1, mm (t)	200	7680	$ 15.00	$ 115,200
Excavation	Earth excavation (m^3)	400	6400	$ 10.00	$ 64,000
	Total Initial Cost				$ 1,115,200

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	320	$ 150.00	$ 48,000	$ 26,728
12	Reseal joints, % Length (m)	25	889	$ 10.00	$ 8,889	$ 4,950
25	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 35,436
25	Full depth PCC repair, % area (m^2)	10	1600	$ 125.00	$ 200,000	$ 59,061
25	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 5,250
25	Texturize, % area (m^2)	25	4000	$ 10.00	$ 40,000	$ 11,812
40	Partial depth PCC repair, % area (m^2)	5	800	$ 150.00	$ 120,000	$ 17,045
40	Full depth PCC repair, % area (m^2)	15	2400	$ 125.00	$ 300,000	$ 42,614
40	Reseal joints, % Length (m)	50	1778	$ 10.00	$ 17,778	$ 2,525
40	Texturize, % area (m^2)	50	8000	$ 10.00	$ 80,000	$ 11,364
50	Residual Value				$ 172,593	$ 15,051
	Total M&R Cost				$ 779,852	$ 201,734

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	
50	mm C-HF
150	mm B-HF
150	mm Base Type 1
300	mm Subbase Type 2

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	C-HF, mm (t) 58-28	50	2,016	$ 121.90	$ 245,750
Binder	B-HF, mm (t) 58-28	150	5,904	$ 101.76	$ 600,791
Base	Type 1, mm (t)	150	5,760	$ 15.00	$ 86,400
Subbase	Type 2, mm (t)	300	9,600	$ 12.00	$ 115,200
Excavation	Earth excavation (m^3)	650	10,400	$ 10.00	$ 104,000
	Total Initial Cost				$ 1,152,141

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	$ 1.75	$ 350	$ 237
8	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	5	800	$ 12.00	$ 9,600	$ 6,498
13	Rout and seal, m/km (m)	1000	1000	$ 1.75	$ 1,750	$ 928
13	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	15	2400	$ 12.00	$ 28,800	$ 15,273
18	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 8,310
18	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 26,593
18	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 102,114
23	Rout and seal, m/km (m)	500	500	$ 1.75	$ 875	$ 285
28	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 670
28	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 4,898
32	Mill HMA, mm (t)	90	3600	$ 10.00	$ 36,000	$ 7,555
32	Resurface with B-HF, mm (t)	50	1968	$ 101.76	$ 200,264	$ 42,029
32	Resurface with C-HF, mm (t)	40	1613	$ 121.90	$ 196,600	$ 41,260
37	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 432
40	Spot repairs, mill 40 mm/patch 40 mm, % area (m^2)	10	1600	$ 12.00	$ 19,200	$ 2,727
45	Mill HMA, mm (t)	50	2000	$ 10.00	$ 20,000	$ 2,226
45	Full depth asphalt base repair, % area (m^2)	10	1600	$ 40.00	$ 64,000	$ 7,123
45	Resurface with C-HF, mm (t)	50	2016	$ 121.90	$ 245,750	$ 27,351
48	Rout and seal, m/km (m)	1500	1500	$ 1.75	$ 2,625	$ 252
50	Residual value				$ 192,354	$ 16,774
	Total M&R Cost				$ 987,660	$ 279,987