City of Saskatoon

Design and Development Standards Manual

Section Nine

Surface Infrastructure

Version 16

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1 Purpose

The purpose of the City of Saskatoon Roadway Pavement Structure Design Guide (Design Guide) is to define the pavement design methodology and procedures to be used for new flexible pavement design within the City of Saskatoon. The Design Guide is based on the design procedures outlined in the American Association of State Highway and Transportation Officials (AASHTO) 1993 Guide for Design of New Pavement Structures modified for the City of Saskatoon's conditions.

2 Pavement Design

This Design Guide focuses on addressing components concerning the design of new flexible pavement structures:

- Drainage Condition Evaluation
- Evaluation and Classification of Subgrade Support Conditions
- Estimation of Design Traffic and Loadings (ESALs)
- AASHTO Design Inputs for Serviceability, Reliability and Overall Standard Deviation
- Material Characterization
- Pavement Design Structural Number
- Deferred Top Lift Construction
- Minimum Pavement Layer Thicknesses

Design methodology has been provided for both rural and urban roadway cross-sections. For the purpose of this Design Guide, urban and rural cross sections can be defined as follows:

- Urban cross-section – roadway with surface drainage controlled with curb and gutter, catch basins and a storm sewer system, and
- Rural cross-section – roadway with surface drainage directed to ditches on both sides of the road, with a minimum of 1 m from ditch bottom to the top of subgrade and with lateral drainage of the granular material extended through the shoulder to drain out onto the side slope.

The design methodology presented in this Design Guide addresses the various design steps and inputs the Pavement Designer must consider when completing a new flexible pavement design. These steps are presented in the Pavement Design Flow Chart located in Appendix A of this Design Guide.

2.1 Drainage Condition Evaluation

Geometric aspects are important influences in pavement drainage. Adequate surface drainage is important and minimum cross-slopes and longitudinal grades are required to be of sufficient grade at the top of the subgrade to promote water being evacuated as quickly as possible along the granular base-subgrade interface. These influencing geometric factors apply to both urban and rural cross-sections.

2.1.1 Urban Cross-section

Guidelines for the pavement design drainage for urban cross sections are presented in the following sections. In the absence of hydrogeological information for the study area, a hydrogeological study is required for areas incorporating new or reconstructed roadways. Refer to the City of Saskatoon Standard Construction Drawings for examples of urban cross-sections.

Note that "seasonal groundwater" represents the most shallow groundwater condition anticipated, based on the hydrogeological study for the area. For the purposes of the roadway design, the seasonal groundwater level shall be defined as one (1.0) metre above the maximum observed level in the hydrogeological study. Where a hydrogeological study/information is not available, it shall be assumed that the seasonal groundwater is less than one (1.0) metre below subgrade elevation.

Condition 1: Seasonal Groundwater Greater than 1.0 metre below Subgrade Elevation (Good Drainage)

Edge Drain System:

Where the seasonal groundwater is located one (1.0) metre or greater below the anticipated subgrade elevation, longitudinal edge subdrains are required. For crowned roads a subdrain is required on both sides of the structure. If super elevated, the subdrain is only required on the low side.

Back lanes will have the same subdrainage system as the adjacent road it intersects. The difference would be that only one weeping tile subdrain shall be set in a trench that runs down the centreline of the back lane.

Condition 2: Groundwater Less than 1.0 metre below Subgrade Elevation (Poor Drainage)

Drainage Layer System:

Where the seasonal groundwater is located less than one (1.0) metre below the anticipated subgrade elevation or a hydrogeological study is not available, a minimum 200 millimetre thick drainage layer shall be provided. To evacuate the collected water the same subdrain configuration as described for the "groundwater greater than 1.0 metre" condition should be installed. The subdrain should be located within the drainage layer material and geotextile with positive outfall towards the catchbasin locations.

Back lanes will have the same subdrainage system as the adjacent road it intersects. The difference would be that only one weeping tile drain shall run down the centreline of the back lane.

2.1.2 Rural Cross-section

Guidelines for the pavement design drainage for rural cross sections are presented in the following sections. A hydrogeological study is required for areas incorporating new or reconstructed roadways. In the case of rural cross sections, the drainage design is based on the distance from the top of subgrade to the ditch invert. Refer to the City of Saskatoon Standard Construction Drawings for examples of rural cross-sections.

Condition 1: Ditch Invert 1.0 metre or Greater below Subgrade Elevation (Good Condition)

Where the ditch invert is located at one (1.0) metre or more below the subgrade, the pavement drainage condition is considered as good. In this case the granular materials, base and sub-base, should extend to the road side-slope to enable water to escape. No other drainage detail is necessary.

Condition 2: Ditch Invert between 0.5 metre to < 1.0 metre below Subgrade Elevation (Marginal Condition)

Where the ditch invert is located less than one (1.0) metre below subgrade, but greater than 0.5 metre, the pavement drainage condition is considered marginal. Project and location specific conditions should be considered that would influence the potential depth of water that may be held in the ditch. This would include the longitudinal ditch grade, side-slope angle, width of ditch, surface drainage pattern from surrounding area, etc.

Marginal Good Drainage Condition:

If the potential for standing water is greater than 200 millimetres in depth is considered unlikely, the rural "good condition" detail of daylighting the granular materials to the side-slope is considered appropriate. Daylighting from road structure to ditch and capping side-slopes.

Marginal Poor Drainage Condition:

If the potential for standing water greater than 200 millimetres in depth is considered likely, the pavement structure is required to be designed as an urban section with the same details for either a shallow or deep groundwater condition (but not a curb and gutter). The material outside of the roadway footprint (i.e. the material forming the side-slope) shall be constructed with fine-grained low permeable material to act as a "plug" preventing water from entering the pavement structure from the ditch.

***Condition 3: Ditch Invert less than 0.5 metre** below Subgrade Elevation (Poor Condition)*

Where the ditch invert is located less than 0.5 metre below subgrade, the pavement drainage condition is considered poor. The pavement structure is required to be designed as for an urban section with the same details for either a shallow or deep groundwater condition (but not a curb and gutter). The material outside of the roadway footprint (i.e. the material forming the side-slope) shall be constructed with fine-grained low permeable material. A subdrain is required to evacuate the collected water. The subdrain shall be extended to the ditch at all low points and at maximum intervals of 200 metres.

2.2 Evaluation and Classification of Subgrade Support Conditions

Subgrade support is to be expressed in terms of resilient modulus (M_R). Two acceptable methods for classifying subgrade support are as follows:

1. Estimating the Subgrade Resilient Modulus from California Bearing Ratio (CBR); and/or
2. Determining the Resilient Modulus from Non-Destructive Testing of Prototype Pavements.

Subgrade preparation is required at the bottom layer of all roadway structures and shall be in accordance to the City of Saskatoon Standard Construction Specifications.

2.2.1 Estimating the Resilient Modulus from CBR

Correlations have been established by researchers that allow the resilient modulus to be estimated from other soil properties. The correlation for fine grained soils with a soaked CBR to be used is:

Equation 1

$$M_R\ (MPa) = 17.6 \times CBR^{0.64}$$

OR

$$M_R\ (psi) = 2555 \times CBR^{0.64}$$

Where:

M_R = Resilient modulus

CBR = California Bearing Ratio

An appropriate number of geotechnical tests shall be performed to reflect the test repeatability, the range of soil types expected to be encountered on the project, and the size of the project. Geotechnical testing, including determination of CBR values, shall be completed once every 3000 square metres of roadway area but not less than 1 test per street block.

With the permission of the Technical Services Department CBR values may be obtained from the soils Group Index (GI) value. A combination of CBR values determined from CBR laboratory tests and derived from GI tests is acceptable in situations where more than one CBR value is required for design.

Determining the Resilient Modulus from Non-Destructive Testing of Prototype Pavements

The resilient modulus may be determined by testing a prototype pavement structure with a Falling Weight Deflectometer (FWD) and the deflection data analysed to determine the back-calculated subgrade modulus. For the design of new construction pavement structures, the subgrade modulus can be estimated using an existing representative roadway located near the new project, with similar subgrade soils and drainage conditions, as a prototype. The prototype should preferably meet the following criteria:

- be a minimum of three (3) years old;
- be a minimum of 0.5 km in length;
- be free of structural distress;
- be slightly under-design for the loading condition on the new project being designed; and
- have the same pavement structure type as proposed for the new project being designed.

Alternatively, for a roadway that is being reconstructed to increase capacity or improve geometrics, the existing road can be tested with an FWD prior to reconstruction.

The recommended method for determining design M_R from FWD testing requires an adjustment factor (C) to adjust the value used to represent subgrade conditions consistent with the AASHO road test and to account for regional climate effects. The intent of this adjustment is to ensure the design M_R is representative of the aggregate “year-round” subgrade support condition. The Effective Roadbed Resilient Modulus for design purposes can be determined by the following equation:

Equation 2

$$Design\ M_R = C \times (Back\ calculated\ M_R)$$

Where:

Design M_R = Design Resilient Modulus (MPa)

C = adjustment factor of 0.36

Back calculated M_R = Resilient Modulus based on FWD Testing

This combined adjustment factor would apply to pavement tested by the FWD during the mid-summer through early fall months when the subgrade is in a relatively stable and unfrozen condition. Unusual spring conditions (earlier or later than normal) may affect this period of stability and should be considered when interpreting the results.

The City of Saskatoon must approve the use of this method to determine the resilient modulus for pavement design purposes on a project-by-project basis.

2.2.2 Selection of the Resilient Modulus Value for Design

The design of a pavement structure following the 1993 AASHTO Guide is based on the average M_R value for a representative soil type. The designer must not select a design M_R value based on some minimum or conservative criteria as this will introduce increased conservatism in design beyond that provided in the reliability factor.

2.3 Estimation of Design Traffic and Loadings (ESALs)

Design Traffic is defined in terms of Equivalent Single Axle Loadings (ESALs). Based on the information provided in this section of the Design Guide, the new Roadway Design ESALs can be determined using the following procedure:

Step 1: Determine the Roadway Classification (from an approved Transportation Study).

Step 2: Determine the required Design Period based on roadway classification and roadway cross section type (urban or rural) using Table 2.3.1**.**

Table 2.3.1: Design Periods

Roadway Group	Road Class	Design Cross Section Type	
		Rural (years)	Urban (years)
Residential	Locals	15	20
	Collectors	20	20
	Arterials	20	20
Commercial	Locals	15	20
	Collectors	20	20
	Arterials	20	20
Industrial	Locals	20	20
	Collectors	20	20
	Arterials	20	20
Freeways and Ramps		30	30
Boundary Roads		15	15

Step 3: Determine the new roadway AADT, % Commercial and Number of Buses as part of the required Transportation Study submittal.

The Transportation Study determines the Annual Average Daily Traffic (AADT), Traffic Growth Rate, Percent Commercial, Percent Single Axle Trucks (SUT), Percent Semi-Trailer Combination (TTC), and Number of Buses per day.

When the Transportation Report indicates there is a bus route or there is a bus route anticipated or the bus traffic assessment is omitted for the new road, and does not indicate the number of buses, for buildout period and established period, the number of buses per route, per day and per direction shall be as outlined in the following Table 2.3.2.

Table 2.3.2: Assumed Bus Volumes

Roadway Group	Road Class	# of Routes	# of Buses
Residential	Locals*	0*	0*
	Collectors	1	32
	Arterials	1	32
Commercial	Locals	1	32
	Collectors	2	64
	Arterials	2	64
Industrial	Locals	1	32
	Collectors	1	32
	Arterials	2	64
Freeways and Ramps		2	64
Boundary Roads		1	32

***For curvilinear style neighbourhood layouts, there shall be zero bus routes on the Residential Local roadways. For grid style neighbourhood layout Residential Local Roads, there shall be 1 bus route with 32 buses needing to be accommodated.**

The Percent Commercial is shown in Equation 3.

Equation 3

$$\%\,Commercial = \%SUT + \%\,TTC$$

Where

%SUT = percent of AADT that are Single Axle Unit Trucks.

%TTC = percent of AADT that are Semi-Tractor Trailer Combination

Step 4: Determine the Direction Split for two-way roads.

Instances where vehicle loadings may not be equally distributed between travel directions should be considered.

Step 5: Determine the Lane Distribution Factor (LDF) for multi-lane roadways using Table 2.3.3**.**

The roadway structure to be based on the highest ESAL count as determined through the Lane Distributions as shown in Table 2.3.3.

Table 2.3.3: Lane Distribution Factors

Roadway Cross-Section	LDF		
	1 Lane per Direction	2 Lanes per Direction	3 or more Lanes per Direction
Urban	Design ESALs to account for 100% Commercial Traffic and Buses	Design ESALs to account for 70% Commercial Traffic Design ESALs to account for 100% buses	Design ESALs to account for 70% Commercial Traffic Design ESALs to account for 100% buses
Rural	Design ESALs to account for 100% Commercial Traffic and Buses	Design ESALs to account for 85% Commercial Traffic Design ESALs to account for 100% buses	Design ESALs to account for 70% Commercial Traffic Design ESALS to account for 100% buses

For freeways of three (3) or more lanes, a traffic study may be warranted to determine project specific LDF values.

Step 6: Determine the Load Equivalency Factor (LEF) for the expected axle classifications/loadings.

Ideally a blended LEF is determined from detailed axle spectra, which would include the anticipated range of axle classifications and weights. It is understood however that this information is not always available, and therefore a blended LEF must be estimated by other means.

Traffic loading is expressed in terms of percentage Single Unit Trucks, Tractor Trailer Combinations, and Buses. The following LEFs are to be utilized for each commercial and bus traffic classification as shown in Table 2.3.4.

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Table 2.3.4: Commercial and Bus Traffic Load Equivalency Factors

Load Vehicle	Load Equivalency Factor
Single Unit Trucks (SUT)	1.2 ESALs
Tractor Semi- Trailer Combination (TTC)	2.0 ESALs
Buses (Bus)	3.0 ESALs

A blended LEF can be determined from the estimated proportion of each commercial traffic type using Equation 4. Buses are not part of the blended LEF with the commercial traffic.

Equation 4

$$Load\ Equivalency\ Factor\ (LEF_{Commercial}) = \frac{[(\#SUT) \times SUT_{LEF} + (\#TTC) \times TTC_{LEF}]}{(\#SUT) + (\#TTC)}$$

Where:

#SUT = number of Single Axle Unit Trucks per day

#TTC = number of Semi-Tractor Trailer Combination per day

SUT_{LEF} = Single Unit Trucks Load Equivalency Factors from Table 2.3.3

TTC_{LEF} = Semi-Tractor Trailer Combination Load Equivalency Factors from Table 2.3.3

Step 7: Determine the Traffic Growth Factor (TGF)

Determine the Traffic Growth Factor (TGF) for the corresponding Design Period from Step 2. The TGF can be determined using Equation 5.

Equation 5

$$Traffic\ Growth\ Factor\ (TGF) = \frac{[(1+g)^n - 1]}{g}$$

Where:

g = growth rate (expressed as a decimal, e.g. 3% = 0.03)

n = design period in years.

Step 8: Determine the Commercial Design ESALs as per Equation 6

Equation 6

$$\mathit{Commercial\ Design}\frac{ESALs}{lane} =$$

$$(\mathrm{AADT}) \times (\%\ \mathrm{Commercial}) \times (\mathrm{Direction\ Split}) \times (\mathrm{LDF}_{COM}) \times (\mathrm{LEF}_{COM}) \times (\mathrm{TGF}) \times (365\,\frac{\mathrm{days}}{\mathrm{year}})$$

Where:

AADT = Average Annual Daily Traffic (#/day)

% Commercial = percent of AADT that are SUT and TTC

Directional Split = Distribution of the volume between travel directions

$\mathrm{LDF}_{\mathrm{COM}}$ = Lane Distribution Factor

$\mathrm{LEF}_{\mathrm{COM}}$ = Load Equivalency Factor

TGF = Traffic Growth Factor

Step 9: Determine the Bus Design ESALs as per Equation 7

Equation 7

$$\mathit{Bus\ Design\ ESALs/lane} = (\#\mathrm{BUS}) \times (\mathrm{LDF}_{BUS}) \times (\mathrm{LEF}_{BUS}) \times (\mathrm{TGF}) \times (365\,\frac{\mathrm{days}}{\mathrm{year}})$$

Where:

#BUS = number of buses per day per direction

Directional Split = Distribution of the volume between travel directions

$\mathrm{LDF}_{\mathrm{BUS}}$ = Lane Distribution Factor

$\mathrm{LEF}_{\mathrm{BUS}}$ = Load Equivalency Factor

TGF = Traffic Growth Factor

Step 10: Determine the new roadway Design ESALs as per Equation 8

Equation 8

$$Design\frac{ESALs}{lane} = Commercial\ Design\frac{ESALs}{lane} + Bus\ Design\frac{ESALs}{Lane}$$

Where:

Commercial Design ESALs/lane = the commercial traffic loading from Equation 6.

Bus Design ESALs/lane = the Bus traffic loading from Equation 7.

2.4 AASHTO Design Inputs for Serviceability, Reliability and Overall Standard Deviation

The Design Inputs recommended for completing new flexible pavement designs are presented in Table 2.4.1:

Table 2.4.1: AASHTO Pavement Design Inputs

AASHTO Design Input		Value	
Design ESALs		As Determined in Section 2.3	
Reliability (Function of ESALs)			
	Design ESALs Range	R (%)	Z_R
	< 100,000	75	-0.674
	> 100,000 – 1,000,000	80	-0.841
	> 1,000,000 – 5,000,000	85	-1.037
	> 5,000,000 – 10,000,000	85	-1.037
	> 10,000,000	90	-1.282
Serviceability			
	Initial Serviceability Index (p_i)	4.2	
	Terminal Serviceability Index (p_t)	2.5	
	Serviceability Loss (ΔPSI)	1.7	
Overall Standard Deviation (S_o)		0.45	
Subgrade Resilient Modulus (M_R)		As Determined in Section 2.2	

2.5 Material Characterization

The material layer properties and corresponding AASHTO layer coefficients for use in the design of new pavement structures are presented in Table 2.5.1. The material properties for Granular Base, Granular Sub-base and Drainage Layers are based on material specifications as described in the City of Saskatoon Standard Construction Specifications.

Table 2.5.1: AASHTO Layer Coefficients

Material Type	Material Properties	AASHTO Layer Coefficient
ACP	n/a	0.4
ACP - Polymer Modified	n/a	0.42
Cold In-place Recycled Asphalt Concrete	n/a	0.3
Full Depth Reclamation with Stabilization	n/a	0.3
Granular Base Course	CBR 65	0.13
Granular Sub-base Course	CBR 25	0.1
Drainage Rock	n/a	0.1
Drainage Recycled Concrete	n/a	0.1
Drainage Sand	n/a	0.05

The following table provides the Asphalt Concrete Pavement (ACP) type for each road class to be based on the City of Saskatoon Standard Construction Specifications

Table 2.5.2: Pavement Types

Roadway Group	Road Class	Asphalt Type	
		Bottom Lift	Top Lift
Residential	Locals	T2	A9 – PMA
	Collectors	T2	T2 – PMA
	Arterials	T2-PMA	T2 – PMA
Commercial	Locals	T2	T2 – PMA
	Collectors	T2	T2 – PMA
	Arterials	T2-PMA	T2 – PMA
Industrial	Locals	A2	T2 – PMA
	Collectors	A2-PMA	T2 – PMA
	Arterials	A2-PMA	T2 – PMA
Freeways and Ramps		A2-PMA	T2 – PMA
Boundary Roads		T2-PMA	T2 – PMA
Back Lanes		T2	A9 – PMA

AASHTO 1993 also provides guidelines for addressing the expected drainage conditions of the pavement structure through the use of modified layer coefficients. The factor for modifying the layer coefficient has been integrated into the structural number equation as a drainage coefficient for each pavement layer. Drainage considerations pertaining to pavement design have been addressed in detail in Section 2.1 of this Design Guide.

The drainage coefficients for use in the design of new pavement structures are presented in Table 2.5.3.

Table 2.5.3: AASHTO Drainage Coefficients

Material Type	Urban and Rural	Rural
	Drainage Coefficient for Good Drainage	Drainage Coefficient for Poor Drainage
ACP	n/a	n/a
ACP - Polymer Modified	n/a	n/a
Granular Base Course	1	0.8
Granular Sub-base Course	1	0.8
Drainage Rock	1	1
Drainage Recycled Concrete	1	1
Drainage Sand	1	1

2.6 Pavement Design Structural Number

A Design Structural Number (SN) is determined from design ESALs, subgrade resilient modulus, and design inputs. Solve for the Design Structural Number based on using the AASHTO Equation below:

Equation 9

$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

Note: inputs are in Imperial units (i.e. inches, psi etc.).

Where:

W_{18} = Design ESALs/Lane from Equation 8.

Z_r = Standard normal deviate from Table 2.4.1.

S_o = Standard error of the traffic prediction and performance prediction from Table 2.4.1.

SN = Design Structural Number (inches).

ΔPSI = the difference between the initial design serviceability index, p_o, and the design terminal serviceability index, p_t, from Table 2.4.1.

M_r = Resilient Modulus from Equation 1 or 2 (psi)

Once the design SN has been determined, it is necessary to identify a set of pavement layer thicknesses which, when combined, will provide the load-carrying capacity corresponding to the design SN. Equation 10 provides the basis for converting SN into actual thickness of Asphalt Concrete Pavement (ACP), granular base course, granular sub-base course and drainage layer material:

Equation 10

$$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3 + \cdots a_nD_nm_n$$

Where:

a_1, a_2, a_3, a_n = layer coefficient for each pavement layer (a_1 is the asphalt concrete layer)

D_1, D_2, D_3 , D_n = actual pavement layer thickness (mm) (D_1 is the asphalt concrete layer)

m_2, m_3, m_n = drainage layer coefficients for each corresponding pavement layer.

The SN equation does not have a single unique solution, and there are many combinations of layer thicknesses that provide satisfactory thickness design solutions.

2.7 Deferred Top Lift Construction

A mandatory deferred top lift will be required on all local roadways, all collector roadways and select arterial roadways with substantial utility installations. The deferred top-lift asphalt process will provide staged construction to help deal with short-term settlements from utility installations and provides a new driving surface close to substantial neighbourhood build out once construction traffic has been removed from the area and damage to the roadways can be minimized.

Deferred top lift construction includes the application of a first stage ACP layer with deferment of two years at which point a final stage ACP layer is required. Deferring the final stage ACP layer provides two major benefits:

1) Staged construction provides an opportunity for any corrections to the roadway profile due to settlement, additional utility installation, or initial pavement deficiencies/defects; and

2) Staged construction provides a final surfacing to the roadway following the majority of the heavy vehicle loading (construction traffic), and restores the roadways serviceability.

The Designer is responsible to ensure all ACP layers conform to the design ACP thickness as well as the minimum ACP layer thicknesses. The final stage lift is to be constructed upon two years of final acceptance of the initial stage.

2.8 Minimum Pavement Layer Thicknesses

Minimum thicknesses have been established due to the following reasons:

1) Material properties (i.e. aggregate top size and gradation) dictate the minimum constructible layer thickness;

2) Minimum pavement layer for the purpose of sufficiently limiting the stresses and strains at pavement layer boundaries as to prevent permanent deformation for the design traffic loading (ESALs);

3) Back lanes to comprise of the same structure as the Local Roadway Classification within the Road Group

The minimum layer thicknesses for each roadway classification as well as minimum ACP thicknesses for first and final stage construction for each roadway classification are presented in Table 2.8.1.

Table 2.8.1: Minimum Pavement Layer Thicknesses

Road Group	Roadway Classification	First Stage Minimum ACP Thickness (mm)	Final Stage Minimum ACP Thickness (mm)	Minimum Granular Base Course Thickness - if Used (mm)	Minimum Granular Sub-base Course Thickness - if Used (mm)	Minimum Drainage Layer Thickness (mm)
Residential	Local	50	35	150	150	200
	Collector	60	35	150	150	200
	Arterial	80	80	150	150	200
Commercial	Local	60	35	150	150	200
	Collector	60	35	150	150	200
	Arterial	80	80	150	150	200
Industrial	Local	60	50	150	150	200
	Collector	60	50	150	150	200
	Arterial	80	80	150	150	200
Freeways and Ramps			175	150	150	200
Boundary Roads			160	150	150	200

There may be instances where the Designer may elect to design the pavement structure granular layers entirely out of granular base course, or a combination of base course and drainage layer. In these instanced the following minimum granular base course layers are required:

Case 1: Granular Base Course over Drainage layer

If the design pavement structure granular layers is made entirely out of granular base course and a drainage layer is required, then the granular base course over the drainage layer will have a minimum base thickness of 200 mm.

Case 2: Granular Base Course over Subgrade Layer

If the design pavement structure granular layer is made entirely out of granular base course and a drainage layer is not required, then the granular base course over the subgrade layer will have a minimum base thickness of 300 mm over prepared subgrade with edge drains.

Case 3: Granular Base Course and Sub-Base over Drainage Layer

If the design pavement structure is made with granular base and sub-base layers, and a drainage layer is required, then the granular base and sub-base course over the drainage layer will each have a minimum thickness of 150 mm each resulting in a combined thickness of 300 mm over the 200mm drainage layer.

Case 4: Granular Base Course and Sub-Base over Subgrade Layer

If the design pavement structure is made with granular base and sub-base layers, and a drainage layer is not required, then the granular base and sub-base course over prepared subgrade will each have a minimum thickness of 150 mm each resulting in a combined thickness of 300 mm over prepared subgrade with edge drains

If found that field conditions differ from geotechnical report determination of subgrade conditions, alternative designs may be required to accommodate. These alternative designs will need to be submitted for acceptance. These alternative designs may be submitted as part of the initial design report to account for potentially poor subgrade conditions due to excess moisture or cooler temperatures at time of excavation and subgrade preparation.

The Designer is responsible to ensure the AASHTO layer design conforms to the pavement layer minimums.

3 Sidewalk, Pathway and Curb Crossing Design

Sidewalk, pathway and curbs shall be functionally designed as outlined in Section 8 of the City of Saskatoon's 'Design and Development Standards Manual' and constructed as outlined in the City of Saskatoon's 'Standard Specifications and Drawings'.

As of January 1, 2021, granular base is required for all newly developed sidewalks and curbs.

4 Submittal Requirements

4.1 Submission to the City

The Pavement Design Report and supporting information to be submitted to:

City of Saskatoon
Land Development Manager
Construction and Design Department
222 3rd Avenue North
Saskatoon SK S7K 0J5

The pavement design submission requires a letter of submittal indicating the development agreement date, description of the project, and recommended pavement design. Attached to the pavement design submission will be all supporting information which provides the basis for the pavement design, including, but not limited to:

- Pavement Design Values Table (in Appendix C)
- Area drawing identifying roadway layouts and design centerline elevations, geotechnical subgrade properties, seasonal water tables, traffic flows including percent commercial as well as identifying roadway structural cross sections; and ,
- Relevant sections of the following reports contributing to the design:
  - Geotechnical
  - Hydro-geological
  - Traffic/Truck Traffic Forecasts

The pavement design is required to be signed and stamped by a Professional Engineer with permission to consult in the province of Saskatchewan.

4.2 Submissions and Approvals

The Designer is responsible for being aware of the regulatory requirements governing roadway construction, and for compliance with these requirements.

Regulatory and supporting documents that shall be referenced for the design and installation of the surface infrastructure include the following:

- *Standard Construction Specifications and Drawings: Roadways, Water, and Sewer*, City of Saskatoon; and

- AASHTO (1993) Guide for Design of New Pavement Structures and the supplements to this guide.

4.3 As-Built Drawings

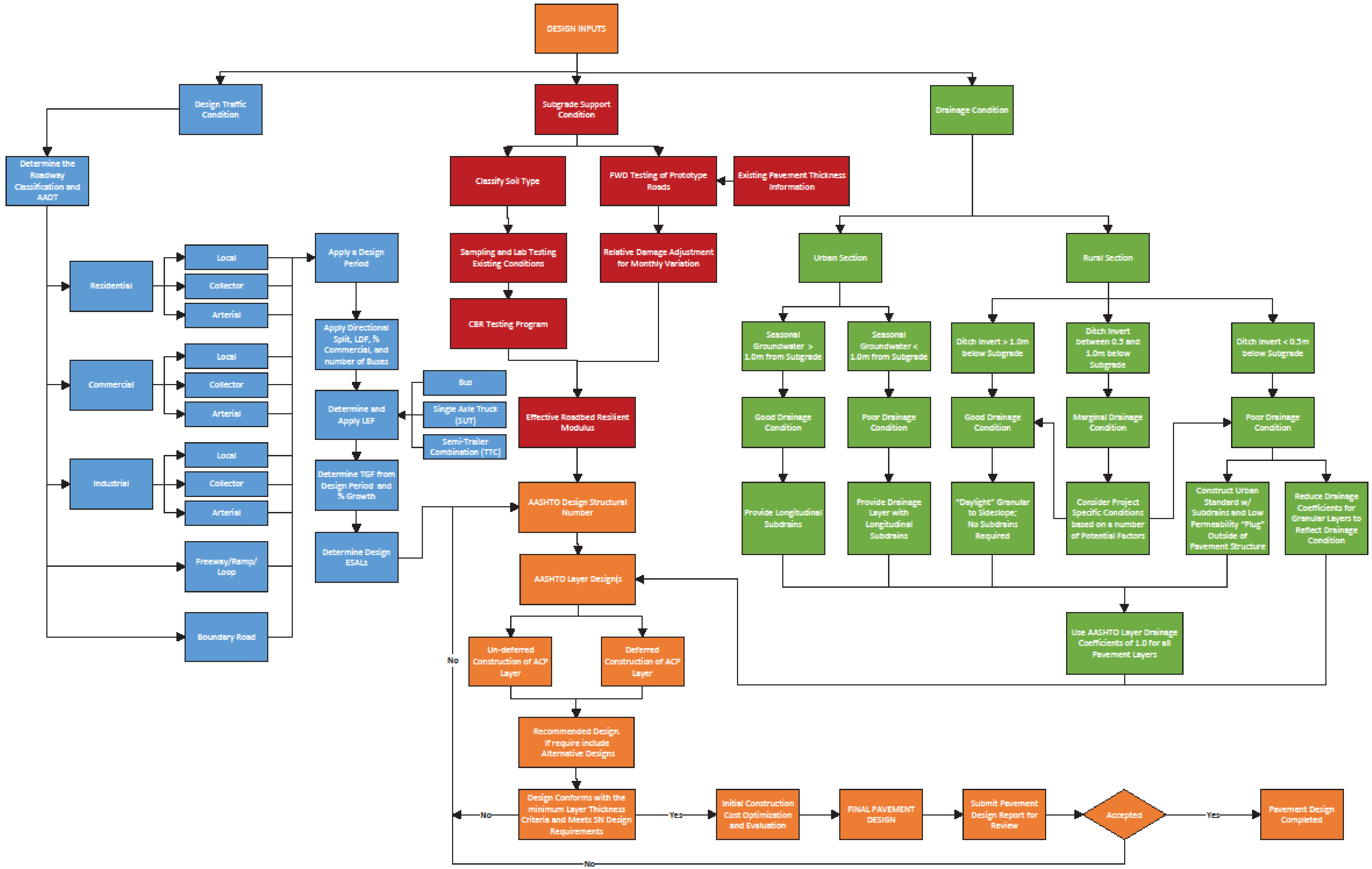
Proponents shall provide the Technical Services Department with Figure(s) that illustrate the roadways, access points, curbs, sidewalks, medians, and islands that were constructed. As-built drawings are required for final acceptance of roadway construction.

The As-Built Drawings shall include the following:

- Location and test results of all saturated CBR samples.
- Any reports or testing related to the pavement design.
- Thickness of Asphalt, Base, and Sub Base and type and location of and additional materials such as geogrid, woven and non-woven geotextiles, and weeping tile.
- Detailed plans illustrating the staged installation of the surface infrastructure.
- Figure(s) scaled to 1:200 that illustrate intersections for the following roadway types:
    - Freeway/freeway;
    - Freeway/arterial;
    - Arterial/arterial; and
    - Arterial/collector.
- Figure(s) scaled to 1:2000 that illustrate the following:
    - The proposed roadway/lane layout;
    - Proposed access points;
    - Existing and proposed utilities, perforated pipes shall be illustrated in the plan view drawings;
    - Rights of way, easement, and roadway widths;
    - Land use/zoning;
    - Buffers; and
    - One metre contours.

Appendix A Pavement Design Flow Chart

City of Saskatoon



Appendix B Sample Pavement Design

City of Saskatoon

B1.0 Sample Pavement Design

The following is an example of a new flexible pavement design using the design procedure.

Sample Project Description:

The City of Saskatoon would like to complete a new pavement design for a 4-lane (2-lane per travel direction) Urban Commercial - Arterial Roadway with and estimated AADT of 7000 vehicles/day and Total Percent Commercial = 6% with 3 bus routes.

Note: The example shows typical comments to support assumptions or facts. There are no attached sample reports. However, all design submitted shall include submittal requirement as per Section 4.0.

B1.1 Drainage Condition Considerations

Step 1: Record Geotechnical Report

From the Hydrogeological report, record the values for subgrade elevation and water table into the Pavement Design Values. For example:

Drainage Considerations	Value	Unit	Comments
Subgrade Elevation:	512.155	m	As shown in the attached Report
Water Table Elevation:	511.3	m	As shown in the attached Report

Step 2: Determine the Difference from Water Table to Subgrade Elevation

Calculate the difference from the water table to subgrade elevation as shown below:

$$\Delta WT = Water\ Table\ Elevation - Subgrade\ Elevation$$

Using the values listed in the above table:

$$\Delta WT = 511.3\ m - 512.155m = -0.855m$$

The difference from the water table to subgrade elevation is less than one (1) metre. The drainage is considered Poor. Record the value into the Pavement Design Values table.

Step 3: Determine Sub-Drainage System

Proposed roadway geometric, geotechnical and subsurface drainage conditions indicate that this Urban Section of pavement will be subjected to groundwater conditions less than 1.0 metre from the top of subgrade elevation. Therefore, a drainage layer with longitudinal sub drains is selected for this pavement structure and drainage coefficients of 1.0 are to be used for each pavement layer material. Record the required Sub-Drainage System into the Pavement Design Values table.

Sub-Drainage System	Value	Unit	Comments
Edge Drain:	Yes		Based on the Design Guide
Drainage Layer:	Yes		The drainage is Poor; the water table is less than 1m from subgrade.

B1.2 Evaluation and Classification of Subgrade Support Conditions

Step 1: Determine Subgrade Support Condition

Laboratory testing of the subgrade materials indicated an expected bearing capacity equivalent to a soaked CBR = 3.0% for the soil type of ML – Silt.

From Equation 1:

$$M_R\ (MPa) = 17.6 \times (CBR)^{0.64} = 17.6 \times (3.0)^{0.64} = 35.5\ MPa$$

$$M_R\ (psi) = 2555 \times (CBR)^{0.64} = 2555 \times (3.0)^{0.64} = 5161.17 psi$$

FWD testing was not required, for this design as laboratory testing determined the CBR was 3.0%. However, this design M_R was confirmed from FWD testing of prototype roadways in the vicinity with showed seasonally adjusted resilient moduli ranging between 25 and 35 MPa.

Record the values into the Pavement Design Values table

Subgrade Support Conditions	Value	Unit	Comments
Soil Type:	ML - Silt		As shown in the attached Report
Design CBR:	3	%	As shown in the attached Report
Subgrade grade Resilient Modulus (Mr):	36	MPa	As calculated

B1.3 Estimation of Design Traffic (ESALs)

Step 1: Determine the Roadway Classification

From the transportation study, record the Cross Section, Roadway Group and Classification into the Pavement Design Values table.

Step 2: Determine the Design Period

Use the Design Period based on the roadway group and classification from Table 2.3.1.

Roadway Classification	Value	Unit	Comments
Cross Section:	Urban		Roadway cross sectional area will have a curb.
Road Group - Classification:	Commercial - Arterial		Based on the City's zoning bylaw and estimate traffic demands.
Design Period:	20	years	Based on the prescribe Design Period from the Design Guide for Road Group and Classification.

Step 3: Transportation Study

From the Transportation Study, record the Annual Average Daily Traffic (AADT), Traffic Growth Rate, Percent Commercial, Percent Single Axle Trucks (SUT), Percent Semi-Trailer Combination (TTC), Number of Buses per day per direction.

a) Determine the Annual Average Daily Traffic

The Transportation Study must state the Annual Average Daily Traffic. The ADDT is 7,000 vehicles/day.

b) Determine the Traffic Growth Rate

The Traffic/Truck Traffic Forecast report must state the projected traffic growth rate for the road over the design period of the road. The Designer should assume that a developing neighbourhood will have a higher traffic growth rate than established neighbourhood. For this example the traffic growth rate is 3%.

c) Determine Single Axle Unit Trucks & Semi- Tractor Trailer Combination Percentages

The Traffic/Truck Traffic Forecast report should state the percent SUT and percent TTC. The percent SUT is 4%. The percent TTC is 2%.

d) Determine the % Commercial

The percent commercial is composed of Single Axle Unit Trucks (%SUT) and Semi-Tractor Trailer Combination (%TTC). The percent commercial is the sum of percent SUT and percent TTC, which is 6%.

e) Determine Number of Buses per day

The Traffic/Truck Traffic Forecast report should state the number of buses per day. When the Transportation Report indicates there is a bus route but does not indicate the number of buses, it is assumed there are 32 buses per route, per day and per direction. The sample project description indicated there are 3 routes resulting in 96 buses per day per direction.

f) Record Transportation Study

Record the values into the Pavement Design Values table.

Design Traffic	Value	Unit	Comments
Annual Average Daily Traffic (AADT):	7000	Vehicles/day	As shown in the attached Report
Traffic Growth Rate:	3	%	Statistical average of traffic growth
Percent Commercial:	6	%	As shown in the attached Report
Percent Single Axle Trucks (SUT):	4	%	As shown in the attached Report
Percent Semi-Trailer Combination (TTC):	2	%	As shown in the attached Report
Number of Buses/Day:	96	buses/day	3 bus routes

Step 4: Estimate the Direction Split for two way roads

For this example, commercial vehicle loading is equally distributed between travel directions. Record the value into the Pavement Design Values table.

Design Traffic	Value	Unit	Comments
Direction Split:	50	%	Equal commercial traffic loading on each direction

Step 5: Estimate the Lane Distribution Factor

For this example there are 2 lanes in each travel direction. Use the Lane Distribution Factors (LDF) based on **Table 2.3.2**. Record the values into the Pavement Design Values table.

Design Traffic	Value	Unit	Comments
Number of Lanes in each Direction:	2	lane	
Commercial Lane Distribution Factors (LDF):	70	%	Based on the LDF from the Design Guide for cross section
Bus Lane Distribution Factors (LDF):	100	%	Based on the LDF from the Design Guide for cross section

Step 6: Determine the Load Equivalency Factors

Use the Load Equivalency Factors for SUT, TTC and Bus from Table 2.3.3 as shown below:

Design Traffic	LEF	Unit	Comments
Single Unit Trucks (SUT)	1.2	ESALs	Fixed
Tractor Semi- Trailer Combination (TTC)	2	ESALs	Fixed
Transit Buses (Bus)	3	ESALs	Fixed

Calculate the Commercial Load Equivalency Factor (LEF) using Equation 4.

From Equation 4:

$$Load\ Equivalency\ Factor\ (LEF) = \frac{[(\#SUT) \times SUT_{LEF} + (\#TTC) \times TTC_{LEF}]}{(\#SUT) + (\#TTC)}$$

$$\#SUT = \%SUT \ \times AADT = 4\% \times 7000 = 280\ vehicles$$

$$\#TTC = \%TTC \times AADT = 2\% \ \times 7000 = 140\ vehicles$$

$$LEF = \frac{[(280\ vehicles)(1.2) + (140\ vehicles)(2)]}{(280\ vehicles) + (140\ vehicles)} = 1.47\ ESALs\ per\ Commercial\ Vehicle$$

Record the value into the Pavement Design Values table.

Design Traffic	Value	Unit	Comments
Commercial Load Equivalency Factor (LEF)	1.47	ESALs/ vehicle	Refer to Calculation
Bus Load Equivalency Factor (LEF)	3	ESALs/ vehicle	Based on the Design Guide value for Bus LDF

Step 7: Determine the Traffic Growth Factor

The Design Period for a Commercial - Urban Arterial is 20 years, and the traffic growth rate is 3%. Calculate the Traffic Growth Factor using Equation 5.

From Equation 5:

$$Traffic\ Growth\ Factor\ (TGF) = \frac{[(1+g)^n - 1]}{g}$$

$$TGF = \frac{[(1+0.03)^{20} - 1]}{0.03} = 26.9\ years$$

Record the value into the Pavement Design Values.

Design Traffic	Value	Unit	Comments
Traffic Growth Factor:	26.9	years	Refer to Calculation

Step 8: Determine the Commercial Design ESALs per lane

Calculate the Commercial Design ESALs using Equation 6.

From Equation 6:

$$\begin{aligned} &Commercial\ Design\ ESALs/lane \\ &\quad = (\mathrm{AADT}) \times (\%\ \mathrm{Commercial}) \times (\mathrm{Direction\ Split}) \times (\mathrm{LDF}_{COM}) \times (\mathrm{LEF}_{COM}) \\ &\quad \times (\mathrm{TGF}) \times (365\frac{\mathrm{days}}{\mathrm{year}}) \end{aligned}$$

$$\begin{aligned} &Commerical\ Design\frac{ESALs}{lane} \\ &\quad = \left(7{,}000\frac{\mathrm{vehicles}}{\mathrm{day}}\right) \times (0.06) \times (0.5) \times (0.7) \times (1.47) \times (26.9\ \mathrm{years}) \\ &\quad \times \left(365\frac{\mathrm{days}}{\mathrm{year}}\right) = 2.12x10^6 ESALs/lane \end{aligned}$$

Record the value into the Pavement Design Values table.

Design Traffic	Value	Unit	Comments
Commercial Design ESALS	2.12x10^6	ESALs/lane	Refer to Calculation

Step 9: Determine the Bus Design ESALs per lane

Calculate the Bus Design ESALs using Equation 7.

From Equation 7:

$$Bus\ Design\ ESALs/lane = (\#\mathrm{BUS}) \times (\mathrm{LDF}_{BUS}) \times (\mathrm{LEF}_{BUS}) \times (\mathrm{TGF}) \times (365\,\frac{\mathrm{days}}{\mathrm{year}})$$

$$Bus\ Design\,\frac{ESALs}{lane} = \left(96\,\frac{\mathrm{bus}}{\mathrm{day}}\right) \times (1) \times (3) \times (26.9\ \mathrm{year}) \times \left(365\,\frac{\mathrm{days}}{\mathrm{year}}\right)$$

$$= 2.83\ x\ 10^{6}\ ESALs/lane$$

Record the value into the Pavement Design Values table.

Design Traffic	Value	Unit	Comments
Bus Design ESALS	2.83x10^6	ESALs/lane	Refer to Calculation

Step 10: Determine the new roadway Design ESALs per lane

Calculate the new roadway Design ESALs using Equation 8.

From Equation 8:

$$Design\,\frac{ESALs}{lane} = Commercial\ Design\,\frac{ESALs}{lane} + Bus\ Design\,\frac{ESALs}{Lane}$$

$$= 2.12x10^{6}\,\frac{ESALs}{lane} \times 2.83x10^{6}\ M\,\frac{ESALs}{lane} = 4.95x10^{6}\,\frac{ESALs}{lane}$$

Record the value into the Pavement Design Values table.

Design Traffic	Value	Unit	Comments
Design ESALs (W_{18})	4.95x10^6	ESALs/lane	Refer to Calculation

B1.4 AASHTO Design Inputs for Serviceability, Reliability and Overall Standard Deviation

Step 1: Determine the Serviceability

Use the Serviceability Loss Factor (ΔPSI) from Table 2.4.1. Record the value into the Pavement Design Values table.

Step 2: Determine the Reliability

Use the Reliability (R) based on the design ESALs of 4.95x10^6 ESALs/lane from Table 2.4.1. The Reliability is 85%, which corresponds with a standard normal deviate (Z_r) of -1.037. Record the values into the Pavement Design Values table.

Step 3: Determine the Overall Standard Deviation

Use the Overall Standard Deviation (S_o) from Table 2.4.1. Record the value into the Pavement Design Values table.

AASHTO Design Inputs	Value	Unit	Comments
Reliability (R):	85	%	Based on the R from the Design Guide
Standard Normal Deviate (Zr):	-1.037		Based on the Zr from the Design Guide
Standard Error (So):	0.45		Fixed
Initial Serviceability (pi):	4.2		Fixed
Final Serviceability (pt):	2.5		Fixed
ΔPSI	1.7		Fixed

B1.5 Material Characterization

The pavement design for a Commercial – Arterial with poor drainage conditions requires the following materials layer and drainage coefficients from Table 2.5.1 and Table 2.5.3:

Pavement Layer	Type	Design Layer Coefficient	Drainage Coefficient
ACP Thickness (mm)	ACP – Modified	0.42	n/a
Granular Base Course Thickness (mm)	Granular Base	0.13	1
Granular Sub-base Course Thickness (mm)	Granular Sub-Base	0.1	1
Drainage Layer Thickness (mm)	Drainage Rock	0.1	1
Geotextile	Combigrid	Varies depending on CBR	1

B1.6 Pavement Design Structural Number

Step 1: Determine the Pavement Design Structural Number

Calculate the Structural Number (SN) using Equation 9.

From Equation 9:

$$\log_{10}(W_{18}) = Z_r \times S_o + 9.36 \times \log_{10}(SN+1) - 0.2 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

SN = 4.90 in = 124.4mm

Note: inputs are in Imperial units (i.e. inches, psi etc.).

Step 2: Determine the Layer Thickness

Calculate layer thickness for designs using Equation 10.

From Equation 10:

$$SN = a_1 D_1 + a_2 D_2 m_2 g + a_3 D_3 m_3 g + \cdots a_n D_n m_n g$$

For example, using Option 2:

$$SN = (160mm)(0.42) + (150mm)(0.13)(1)(1) + (175mm)(0.1)(1)(1) + (200mm)(0.1)(1)(1) = 124.2mm$$

Using Option 1 (for cbr=3, the layer coefficient of combigrid (g) is 1.36:

$$SN = (160mm)(0.42) + (150mm)(0.13)(1)(1.36) + (150mm)(0.1)(1)(1.36) + (200mm)(0.1)(1)(1.36) = 141.4mm$$

The SN is 141.4mm

Pavement Layer	Design Layer Coefficient	Drainage Coefficient	Minimum Layer (mm)	OPT 1 (mm)	OPT 2 (mm)	OPT 3 (mm)
ACP Thickness (mm)	0.42	n/a	160	160	160	170
Granular Base Course Thickness (mm)	0.13	1	150	150	150	150
Granular Sub-Base Couse Thickness (mm)	0.1	1	150	150	175	150
Drainage Layer (drainage Rock) Thickness (mm)	0.1	1	200	200	200	200
Combi-Grid	1.36	N/A	No	Yes	No	No
Total SN Provided	**-**	**-**	**121.7**	141.4	124.2	125.9

B2.0 Recommended Pavement Design

Based on an economical evaluation of each Design Option (including constructability, construction costs, material availability, etc.), Option 1 is recommended for as the Final Pavement Design.

Pavement Layer	Material	Layer Coefficient	Drainage Coefficient	Recommended
ACP Thickness	ACP - Polymer Modified	0.4	n/a	160
Granular Base	Granular Base	0.13	1	150
Granular Sub-Base	Granular Sub-Base	0.1	1	150
Drainage Layer:	Drainage Rock	0.1	1	200
Combigrid	40/40	1.36	1	Yes
Total SN Provided		-	-	141.4

Record the values into the Pavement Design Values table. A sample of a completed Pavement Design Values table is shown below.

BUILDING BETTER ROADS
SASKATOON'S ROAD PLAN

Pavement Design Values

Project Title City of Saskatoon New Neighbourhood Design and Standard Development Manual Example

Company Project #: 19-XXXX

Developer Project #: 19-XXXX

Design Company: ABC Road Engineers

Developer Company: ABC Developer

Designer: Designer Name

Submittal Date: dd/mm/YYYY

Developer Agreement Date: dd/mm/YYYY

Input Form

Calculate SN

Don't forget to calculate

****If only using one phase use the Full/Remaining Phase Column****

	Build-Out Phase Value	Intermediate Phase Value	Full/Remaining Phase Value	Units	Comments
1. Drainage Considerations					
a. Subgrade Elevation:	512.155	512.155	512.155	m	
b. Water Table Elevation:	511.3	511.3	511.3	m	
c. Difference of Water Table Elevation to Subgrade Elevation:	0.855	0.855	0.855	m	
2. Sub-Drainage System					
a. Edge Drain:	Yes	Yes	Yes		
b. Drainage Layer:	Yes	Yes	Yes		
3. Subgrade Support Conditions					
a. Soil Type:	ML	ML	ML		
b. Design CBR:	3	3	3		
c. Subgrade Resilient Modulus (Mr):	36	36	36	Mpa	
4. Roadway Classification					
a. Cross Section:	Urban	Urban	Urban		
b. Road Group:	Commercial - Arterials	Commercial - Arterials	Commercial - Arterials		
c. Design Period:	0	0	20		
5. Transportation Report					
a. Annual Average Daily Traffic (AADT):	0	0	7000	Vehicles/day	
b. Traffic Growth Rate:	0	0	3	%	
c. Percent Commercial:	0	0	6	%	
d. Percent Single Axle Trucks (SUT):	0	0	4	%	
e. Percent Semi-Trailer Combination (TTC):	0	0	2	%	
f. Number of Buses/Day:	0	0	96	Busses/Day	
h. Direction Split:	50	50	50	%	
i. Number of Lanes in each Direction:			2 Lane		
j. Commercial Lane Distribution Factors (LDF):	0.0	0.0	0.7		
k. Bus Lane Distribution Factors (LDF):	1	1	1		
l. Load Equivalency Factors SUT:	1.2	1.2	1.2	Fixed	Based on the Design Guide
m. Load Equivalency Factors TTC:	2	2	2	Fixed	Based on the Design Guide
n. Load Equivalency Factors BUS:	3	3	3	Fixed	Based on the Design Guide
o. Commercial Load Equivalency Factor (LEF)			1.47		
p. Bus Load Equivalency Factor (LEF)	3	3	3	ESALs/vehicle	Based on the Design Guide value for Bus LDF
q. Traffic Growth Factor:	0.00	0.00	26.90		
r. Commercial Design ESALs			2116869	ESALS	
s. Bus Design ESALs	0	0	2827728	ESALS	
t. Sub Total Design ESALs:	0	0	4944597	ESALS	
r. Total ESALs			4944597	ESALS	TRUE * If FALSE, review design ESALs range
5. Serviceability					
a. Reliability (R):	75	75	85		
b. Standard Normal Deviate (Zr):	-0.674	-0.674	-1.037		
c. Standard Error (So):	0.45	0.45	0.45		Fixed
d. Initial Serviceability (pi):	4.2	4.2	4.2		Fixed
e. Final Serviceability (pt):	2.5	2.5	2.5		Fixed
f. ΔPSI	1.7	1.7	1.7		Fixed
6. Structure Layers					
b. Total Design SN			**124.4**		mm

*Use Selection Boxes to autofill information

b.	Pavement Layer	Material	Layer Coefficient	Drainage Coefficient	Minimum Layer (if required)	Option 1 - Recommended	Option 2	Option 3
	ACP Thickness (mm)	ACP - Polymer Modified	0.42	N/A	80	80	80	80
	ACP Thickness (mm)	ACP - Polymer Modified	0.42	N/A	80	80	80	90
	Granular Base Course Thickness (mm)	Granular Base Course	0.13	1	150	150	150	150
	Granular Sub-Base Course Thickness (mm)	Granular Sub-Base Course	0.1	1	150	150	175	150
	Geo-textile/membrane	None	1.00 Review Combi Grid Chart	N/A	N/A	No	No	No
	Drainage Layer Thickness (mm)	Drainage Rock	0.1	1	200	200	200	200
	Geo-textile/membrane	Combi-Grid	1.36 Review Combi Grid Chart	N/A	N/A	Yes	No	No
				SN Provided by the Pavement Structure:	121.7	141.4	124.2	125.9
				Total Thickness of the Pavement Structure (mm):	660	660	685	670

Appendix C Table of Pavement Design Values Template

Pavement Design Values

BUILDING BETTER ROADS
SASKATOON'S ROAD PLAN

Project Title: ______________________

Company Project #: ______________ Developer Project #: ______________

Design Company: ______________ Developer Company: ______________

Designer: ______________

Submittal Date: ______________ Developer Agreement Date: ______________

Input Form

Calculate SN

Don't forget to calculate

If only using one phase use the Full/Remaining Phase Column

	Build-Out Phase	Intermediate Phase	Full/Remaining Phase		
	Value	Value	Value	Units	Comments
1. Drainage Considerations					
a. Subgrade Elevation:	0	0	0	m	
b. Water Table Elevation:	0	0	0	m	
c. Difference of Water Table Elevation to Subgrade Elevation:	0	0	0	m	
2. Sub-Drainage System					
a. Edge Drain:					
b. Drainage Layer:					
3. Subgrade Support Conditions					
a. Soil Type:					
b. Design CBR:	0	0	0		
c. Subgrade Resilient Modulus (Mr):	0	0	0	Mpa	
4. Roadway Classification					
a. Cross Section:					
b. Road Group:					
c. Design Period:	0	0	0		
5. Transportation Report					
a. Annual Average Daily Traffic (AADT):	0	0	0	Vehicles/day	
b. Traffic Growth Rate:	0	0	0	%	
c. Percent Commercial:	0	0	0	%	
d. Percent Single Axle Trucks (SUT):	0	0	0	%	
e. Percent Semi-Trailer Combination (TTC):	0	0	0	%	
f. Number of Buses/Day:	0	0	0	Busses/Day	
h. Direction Split:	50	50	50	%	
i. Number of Lanes in each Direction:					
j. Commercial Lane Distribution Factors (LDF):	FALSE	FALSE	FALSE		
k. Bus Lane Distribution Factors (LDF):	1	1	1		
l. Load Equivalency Factors SUT:	1.2	1.2	1.2	Fixed	Based on the Design Guide
m. Load Equivalency Factors TTC:	2	2	2	Fixed	Based on the Design Guide
n. Load Equivalency Factors BUS:	3	3	3	Fixed	Based on the Design Guide
o. Commercial Load Equivalency Factor (LEF)					
p. Bus Load Equivalency Factor (LEF)	3	3	3	ESALs/vehicle	Based on the Design Guide value for Bus LDF
q. Traffic Growth Factor:	0.00	0.00	0.00		
r. Commercial Design ESALs				ESALS	
s. Bus Design ESALs	0	0	0	ESALS	
t. Sub Total Design ESALs:	0	0	0	ESALS	
r. Total ESALs			0	ESALS	FALSE * If FALSE, review design ESALs range
5. Serviceability					
a. Reliability (R):	75	75	75		
b. Standard Normal Deviate (Zr):	-0.674	-0.674	-0.674		
c. Standard Error (So):	0.45	0.45	0.45		Fixed
d. Initial Serviceability (pi):	4.2	4.2	4.2		Fixed
e. Final Serviceability (pt):	2.5	2.5	2.5		Fixed
f. ΔPSI	1.7	1.7	1.7		Fixed
6. Structure Layers					
b. Total Design SN			**0.0**	mm	

*Use Selection Boxes to autofill information

b. Pavement Layer	Material	Layer Coefficient	Drainage Coefficient	Minimum Layer (if required)	Option 1 - Recommended	Option 2	Option 3
ACP Thickness (mm)	ACP - Polymer Modified	0.42	N/A	0	0	0	0
ACP Thickness (mm)	ACP	0.4	N/A	0	0	0	0
Granular Base Course Thickness (mm)	Granular Base Course	0.13	1	0	0	0	0
Granular Sub-Base Course Thickness (mm)	Granular Sub-Base Course	0.1	1	0	0	0	0
Geo-textile/membrane	None	1.00 Review Combi Grid Chart	N/A	N/A	No	No	No
Drainage Layer Thickness (mm)	Drainage Rock	0.1	1	0	0	0	0
Geo-textile/membrane	None	1.00 Review Combi Grid Chart	N/A	N/A	No	No	No
			SN Provided by the Pavement Structure:	0.0	0.0	0.0	0.0
			Total Thickness of the Pavement Structure (mm):	0	0	0	0