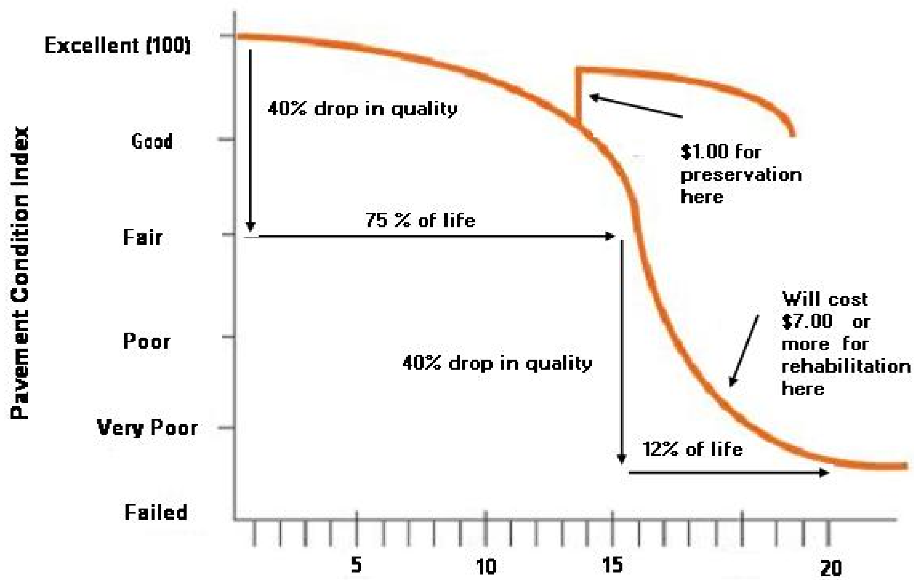
Utah Department of Transportation

PAVEMENT PRESERVATION MANUAL – Part 4

Pavement Condition Modeling with dTIMS



Office of Asset Management

2009

Forward

This manual is a part of a series of documents being prepared to compile information being used in our Pavement Management program. These documents will replace our 1998 Pavement Management and Pavement Design manual. Separate design manuals are being prepared to replace that section and provide guidance on the mechanistic design method.

The focus for this manual will be information about our dTIMS modeling process. The other manuals will describe our pavement management program, the types of distress seen in our pavements, and the treatment strategies being used to most efficiently remedy these.

Pavement Preservation Manuals:
Part 1 – Pavement Preservation and Rehabilitation Program
Part 2 – Pavement Condition Data
Part 3 – Preservation Treatments
Part 4 – Pavement Condition Modeling with dTIMS

Many factors influence the decisions being made on when and how to best maintain our pavements. The recent trend of increased costs and reduced funding has affected both the condition of our pavements and the strategic direction being used to manage these pavements.

Our pavements are aging, and are being subjected to continuously increasing levels of traffic. Our challenge as the stewards of our State's pavements is to select the right treatment at the right time, within our available funding limits, to maximize our pavement life. It has been well established that taking care of our pavements with well timed preservation treatments, i.e. "Good Roads Cost Less" (GRCL) strategy, is more efficient than being in a reactive repair mode of maintenance or reconstruction.

Constantly rising construction costs and the reduction of available funding has forced us to adjust our pavement management strategy by prioritizing our state highway system. The Department formed a Pavement Management Quality Improvement Team (PMQIT) to address the challenge and formulate a new pavement management strategy. The PMQIT established a 3 level priority system with different treatment strategies for each. Our Interstate strategy will be to maintain the system at the current condition levels using strict GRCL guidelines. Our high volume, non-interstate, Level 1 system, will be maintained using a GRCL philosophy, as funding allows. Our low volume, Level 2 System, will be maintained with chip seal projects and reactive maintenance as funding permits. It is worth noting that our revised strategy still specifies GRCL best practices on roads carrying 95% of the VMT in the state of Utah.

See our UDOT Pavement Management web page for additional information about our Pavement Management program.

See our UDOT Pavement Design and Materials Manuals for mix design and other material specifications.

Table of Contents

Introduction

Our modeling process is an integrated approach with multiple inputs and a series of complex trade off decisions to optimize the overall system condition with the available funding. The dTIMS software application provides the flexibility to continuously make adjustments to the process to respond to changes in how the department wants to do business. This document will include the latest changes to the model, reflecting the changes in our pavement management strategy.

The Department has contracted with Deighton Associates Limited, of Ontario Canada, for many years to support and develop the dTIMS modeling software being used. The dTIMS stands for their Deighton Total Infrastructure Management System. Separate user manuals are available for specific information about how the software works. This manual will discuss the separate elements, how they work together, our strategy, and the setup values being used.

The model is primarily used to forecast the future condition with a given funding scenario, and suggest the set of treatment strategies that will provide the highest overall benefit to the system condition. This can be done for the full statewide system, or for a Region level sub system. This can be done with multiple funding scenarios and multiple condition level goals, for different analysis periods.

The model uses the most current traffic volumes, the most current pavement condition, the most current route system, the most current construction history, the most current project costs, the most current pavement management strategy, and the most current funding scenarios to recommend projects for our preservation and rehabilitation programs.

The model is configured at several levels to reflect our pavement management strategy. This is done by the types of pavement being modeled, the deterioration rates used, the condition data being used, the condition level at which different treatments are recommended, the types of treatments being recommended, the costs of the treatments, and the resulting change in condition from the selected treatments. These elements of the modeling process all have an effect on how complicated the model is and how well it works. Our approach has been to keep the model as simple as possible, while being as sophisticated as practical. Our measure for how well it works is based on how well the recommended projects match with what our Region Engineers think needs to be done based on their daily observations of the pavements.

Separate sections will address each of these areas with our approach and how the model is configured.

Our pavement network data is stored in a program called the Plan for Every Section (PFES). The network is stored as sections of pavement based on historical construction or maintenance activities. Each Region manages this sectioning information and the model is set up to work with the same sectioning.

Pavement Families

Pavement families are our way of grouping pavements that perform in a similar fashion and have treatments that are triggered at similar condition levels. This has evolved along with the development of the model. Each pavement section is classified as one of the pavement families.

The initial model was set up with six families, which was expanded to nine, and now is back to six. Our current Families are base on pavement type, and our Maintenance Management Levels – based on traffic volumes. These are:

0.	Gravel	15 miles
1.	Interstate Concrete	225miles
2.	Level 1 Concrete (AADT > 2,000)	90 miles
3.	N/A	
4.	N/A	
5.	Interstate Asphalt	710 miles
6.	Level 1 Asphalt (AADT > 2,000 or > 500 trucks)	2,075 miles
7.	Level 2 Asphalt (AADT < 2,000)	2,720 miles
8.	N/A	

This strategy allows the model to work with different funding strategies for these families, different treatment strategies for these families, and different performance goals for these families.

The gravel sections are not included in the modeling. The State highway system includes a number of institutional roads that are also not included in the modeling.

There has been some thought about getting more detailed and using families for our older Marshal design pavements and our newer Superpave design pavements. This is on hold while we evaluate how well the recent changes for the Level 1 and Level 2 families work for us. This is expected to have the same effect, as the Level 2 system roads are older low volume Marshal design pavements. The Level 1 roads are a combination with all of the recent rehab work being built with the polymer modified binders.

Performance Curves

Performance curves are curves/equations that predict how various pavements will perform over time based upon certain pavement characteristics and due to certain pavement distresses. These curves assume a “do nothing” strategy, meaning that only routine maintenance activities will occur over the pavement’s lifetime. Two basic “do nothing” performance curves were chosen for our pavement management model, one for asphalt and one for concrete.

For the highest level of condition modeling, separate curves would be developed for each pavement family, for each measure of condition being used. These detailed curves would be based on measured changes in condition over the life of the pavement. Understanding that this would require a level of data collection and analysis beyond our resources, we chose to keep this part of the model as simple as reasonable.

We chose to use the method of Dr. Gilbert Baladi from the Department of Civil Engineering at Michigan State University for representing pavement condition using Condition Indices. The condition is converted to a 0 to 100 scale. Then the condition index of 50 has been chosen to represent the point at which the Maximum Allowable Extent (MAE) for each condition has been reached (meaning that the pavement *for that distress* is in poor condition). This concept will be further discussed in the section for “Condition Indices”.

The performance curves are quadratic curves based upon the performance life of the pavement, using a 0 to 100 scales to represent condition. For example if the performance life of the pavement is chosen to be 30 years, the initial points of (0 years,100 condition) (representing a brand new pavement) and (30 years, 50 condition) (representing the effective life) are known. The curve is defined to be quadratic in shape, and the equation can then be calculated as follows:

Present Condition Index = $100 – x (\text{age})^2$
With Present Condition Index = 50, then $x = (100-50) / (\text{performance life})^2$
With performance life = 30, then $50 = 100 – x (30)^2$, so $x = (100-50) / (30)^2 = 0.0556$

For a performance curve formula: Present Condition Index = $100 – 0.0556 (\text{age})^2$

The chosen curves for our model are based upon performance lives of 30 and 40 years, for asphalt and concrete respectively. We have chosen to deteriorate the pavement at a rate of either 2:1 or 1.5:1, once the effective performance life has been reached.

After an analysis of the Ride data for a number of years it was observed that the ride condition deteriorates at a slower rate for asphalt pavements, and a more rapid rate on concrete pavements, than the other conditions being used. This lead to the addition of two additional curves being used for the Ride condition. We added a 45 year curve for asphalt ride, and a 35 year curve for concrete ride.

It should be noted that these curves begin at “perfect” condition levels. We know that even brand new rehabs sometimes don’t achieve smoothness levels that would correspond with our

100 Index for Ride. This is addressed with condition "Resets", which will be discussed in a separate section.

One of our concerns is that many of our pavement ages are well beyond the performance life period of these curves. They're somewhere along the side of the curve more than along the flatter top part of the curve. We also have older Marshal design pavements that we know perform differently from our newer Superpave pavements. The model is set up to work with average performance, some pavements perform better – some deteriorate quicker. We account for this is with our pavement families, allowing different levels of measured distress to relate to the same condition index value, and using different treatments.

One of the first questions that comes up when looking at these curves used to express condition performance is how can our asphalt curve be 30 years long, when we use a 20 year design life for our asphalt pavements. The answer is because it seems to work for these conditions. Based on observed performance the pavements have been lasting longer than the 20 year design life.

This is an even more urgent concern with the plans to change our design methods to the more accurate Mechanistic performance based method. If these new designs perform as predicted they will fail much sooner than our older pavements and we'll need to develop some additional curves.

30-Year Design Life
This is the standard performance curve for our asphalt pavements. We use this curve to model environmental cracking, rutting and wheel-path (fatigue) cracking. The equation is:

For years 0-30 = $100 - (50 / 30^2)(\text{age})^2$ and for years 30+ = $49.96 - 2(\text{age}-30)$

35-Year Design Life
This is the performance curve that is used to model the pavement deterioration of roughness on concrete pavements. The equation is:

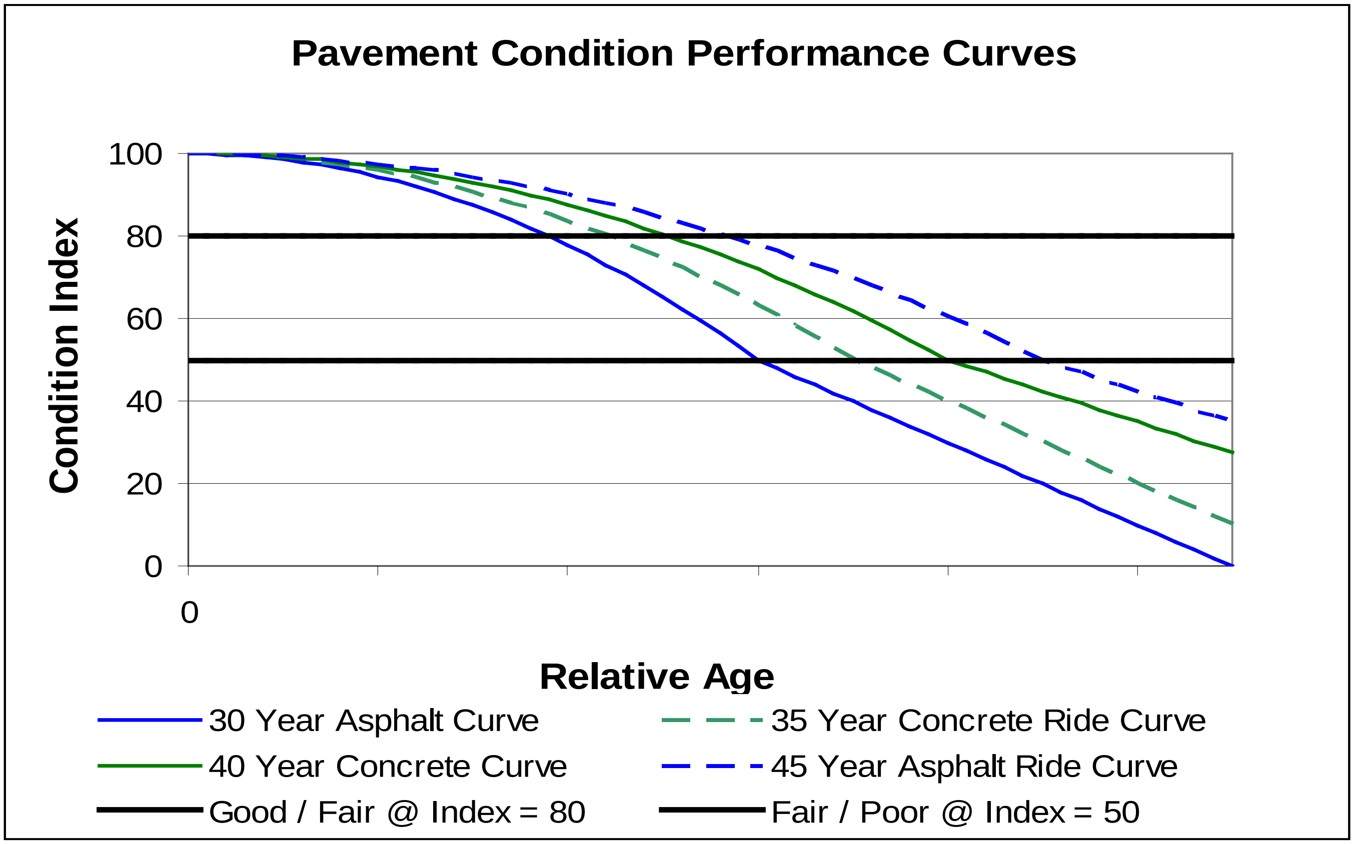
For years 0-35 = $100 - (50 / 35^2)(\text{age})^2$ and for years 35+ = $50.02 - 2(\text{age}-35)$

40-Year Design Life
This is the standard performance curve for our concrete pavements. We use this curve to model slab cracking, faulting and joint condition. The equation is:

For years 0-40 = $100 - (50 / 40^2)(\text{age})^2$ and for years 40+ = $49.92 - 1.5(\text{age}-40)$

45-Year Design Life
This is the performance curve that is used to model the pavement deterioration of roughness on asphalt pavements. The equation is:

For years 0-45 = $100 - (50 / 45^2)(\text{age})^2$ and for years 45+ = $49.98 - 1.5(\text{age}-45)$



There is another performance curve we have thought about using that should be discussed. Our curves start with new pavement age. Many of our pavements were built quite a while ago and have been maintained with a variety of rehabilitation and preservative treatments. These follow up treatments on older pavement don't perform as well as the initial treatments on newer pavement. Until we have the condition history and performance analysis to develop these we will account for this with the Index resets.

The treatment most affected by the pavement age is our functional repair. This is the treatment we use for seals and thin overlays placed on pavements with a little bit of distress. These treatments usually include some lane leveling, rut filling or patching work before the seal is placed. The condition after the treatment is usually just as good as when we place a similar seal on a pavement without distress, but we know the treatment won't perform as well. We account for this with our Index reset being a little bit lower, so it effectively provides a shorter life.

Condition Indices

As briefly explained above, UDOT chose to model the deterioration of its pavements using condition indices according to the "Baladi Method". This method is based on the idea of Threshold Values and a Maximum Allowable Extent (MAE) that allow you to represent the condition of a pavement on a 0 to100 scale. It was decided to use a threshold value of 80 to represent the boundary between good and fair condition, and a value of 50 to represent the boundary between fair and poor condition.

For each measure of condition Threshold values are selected for the 100 Index. These are usually 0, for no distress. This is followed with selecting threshold values for the MAE with an Index value of 50. We then create a formula to calculate the Index for all of the measured values. Our condition index formulas are all linear.

We also developed a composite Overall Condition Index (OCI). This was created within the model for two main purposes. This is to allow the model to optimize the system level performance based on all the indices combined, rather than on one individual index. The second purpose was to provide a way to compare any section of pavement with any other section, and to monitor the overall system year to year.

The measured condition data in mile or tenth of mile intervals is converted to an Index value for the entire pavement section. Every pavement section then has a set or 4 condition indices plus the overall condition index.

Concrete Indices

The following indices were developed for concrete pavements: (these are in 4 letter computer programming code)

RIDE: Roughness based on IRI
CONK: Structural cracking from corner breaks and cracked slabs
FALT: Faulting (difference in slab elevation)
JONT: Joint index from spalling and asphalt patching

Our data collection is now collecting this in tenth mile intervals – so the maximum number of slabs for 100% is 35. We are basing this on an average joint spacing ~15'

RIDE (Roughness) – This is a measure of the driver's comfort when traveling down the road. It is collected using a profiler to measure the surface roughness and reported as IRI (International Roughness Index). The IRI is an average of the left and right wheel path in inches per mile. Higher values indicate a rougher road. Ride is the only condition that has a 100 index that doesn't equate to a measured value of 0. For Ride we use an IRI value of 65 in/mi for our 100 index.

MAE for IRI = 190 in/mile (condition level where Index = 50)

<u>RIDE Index:</u> RIDE = 100 + (50 * 65) / (190-65) – (50 * IRI) / (190-65) = 126 – 0.4 (IRI)

CONK (Concrete Cracking) – This is a combined index made up of three separately calculated indices for corner breaks (CBRK), shattered slabs (SHSL) and cracked slabs (CRKS). 100% = 35 slabs

Corner breaks are diagonal cracks in the concrete slabs, where the severity of the distress is determined by the faulting or spalling along the crack (i.e. no spalling or faulting = low severity & spalling or faulting greater than ½ inch = high severity).

Shattered slabs are those broken with cracking into three or more pieces.

Cracked slabs are those with either Longitudinal or Transverse cracks.

MAEs are in terms of the number of broken/shattered slabs per tenth mile

MAE for Corner Breaks = 25% (8.75)

<u>Corner Break Index:</u> CBRK = 100 – ((50 / 8.75) * Sum Low, Med, High Corner Breaks)

MAE for Shattered Slabs = 25% (8.75)

<u>Shattered Slab Index:</u> SHSL = 100 – ((50 / 8.75) * Sum Low, Med, High Shattered Slabs)

MAE for Cracked Slabs = 30% (10.5)

<u>Cracked Slab Index:</u> CRKS = 100 – ((50 / 10.5) * Sum Low, Med, High Cracked Slabs)

<u>Cracking Index</u>: **CONK** = 100 – ((50 / 8.75) * Sum Low, Med, High Corner Breaks) – ((50 / 8.75) * Sum Low, Med, High Shattered Slabs) – ((50 / 10.5) * Sum Low, Med, High Cracked Slabs)

FALT (Faulting) – Faulting is a measure of the difference in slab elevations recorded as number of faults per tenth mile. Severity is determined by the height of the fault (< 0.3 inch = low severity and > 0.5 inch = high severity). Only faults > 0.1 inch are recorded.

MAE for low severity = 100% (35)
MAE for medium severity = 25% (8.75)
MAE for high severity = 10% (3.5)

<u>Faulting Index</u>: **FALT** = 100 – ((50 / 35) * Low + (50 / 8.75) * Med + (50 / 3.5) * High)

JONT (Joint Index) – This is a combined index made up of joint spalling (JTSP) and asphalt patching (PTCH).

Joint spalling is a measure of the number of transverse joints with spalls (surface defects). The severity is determined by the size of the spalls (< 3 inches = low severity and > 6 inches = high severity). 100% = 35

MAE for Joint Spalling = 25% (8.75)

Joint Spall Index: JTSP = 100 – ((50 / 8.75) * Sum Low, Med, High Joint Spalling)

Asphalt patching is a measure of the number of slabs with an asphalt patch. These are typically found as temporary spall repairs. 100% = 35

MAE for Patching = 35% (12.25)

Patching Index: PTCH = 100 – (50 / 12.25) * Patching

Joint Index: **JONT** = 100 – ((50 / 8.75) * Sum Low, Med, High Joint Spalling) – (50 / 12.25) * Patching

Asphalt Indices

The following indices were developed for asphalt pavements:

RIDE: Roughness based on IRI
RUT: Rutting (longitudinal depressions in the wheel path)
ENVCK: Environmental cracking (transverse, longitudinal and block cracking)
WPCK: Wheel-path cracking (cracking due to fatigue)

RIDE (Roughness) – This is measured in the same manner as for concrete pavements. The IRI value of 45 in/mi is being used for the 100 index.

MAE for IRI =170 in/mile

RIDE index: **RIDE** = 100 + (50 * 45) / (170-45) – (50 * IRI) / (170-45) = 118 – 0.4 (IRI)

RUT (Rutting) – Rutting is a measure of the longitudinal depressions (ruts) that develop in the wheel paths, usually due to heavy truck loading. Rutting is collected with a transverse laser system every 20', which measures changes in elevation across the wheel paths. The rut depth used is the higher of the two wheel paths, measured in inches. These values are then averaged and reported every 0.1 mile.

RUT MAE = 0.5 inches

RUT Index: **RUT** = 100 – (50 / 0.5) * Rut Depth

ENVCK (Environmental Cracking) – This is a measure of the cracks in the road due to environmental (non-structural) conditions. This is a combined index made up of transverse cracking, longitudinal cracking and block cracking or skin patching.

The severity for cracking is too involved to include here. See Appendix B and the Part 3 manual for Distress for the differences between Low, Medium & High severity cracking.

Transverse cracking is primarily across the pavement due to thermal stresses in pavement that has lost some of it's resiliency due to aging. The number of cracks at each severity level is counted. 100% = 52.8, or cracking every 10'.

Longitudinal cracking is along the pavement, primarily due to separation along construction seams. The length of cracking at each severity level is measured. 100% = 528'.

Block cracking is a combination of transverse and longitudinal cracking usually covering the entire surface. The length of cracking at each severity level is measured. 100% = 528'.

Different MAEs are used for Low, Medium and High severity cracking.

MAE for Low Severity = 100% (528)
MAE for Medium Severity = 75% (396)
MAE for High Severity = 50% (264)

Environmental Cracking Index: ENV = 100 – ((50 / 52.8) * Low Trans + (50 / 39.6) * Med Trans + (50 / 26.4) * High Trans + (50 / 528) * Low Long + (50 / 396) * Med Long + (50 / 264) * High Long + (50 / 528) * Low Block + (50 / 396) * Med Block + (50 / 264) * High Block)

Skin patching is where a thin overlay has been placed over a localized area of heavy distress. The square feet of area are measured. 100% = 6,336 sf

MAE for Skin Patching = 25 % (1,584 sf)

Skin Patch Index: = 100 – (50 / 1,584) * square feet of Skin Patch

Environmental Cracking Index **ENVCK** = Minimum Value Environmental Cracking or Skin Patch Index

WPCK (Wheel-Path Cracking) – This is a measure of the cracks that occur directly in the wheel path. Cracks directly in the wheel path are an indication of failure due to vehicle loading (fatigue). The square feet of wheel path area at each severity level is measured. For measuring wheel path cracking a 2.5' wide area is used. For figuring 100% cracking for failure a 1.5' wide area is going to be used. This provides the automated software a wider area to identify the wheel path cracking, but a more typical area that gets cracked to compare the % of the area with cracking. 100% = 1,584 sf

Different MAEs are used for Low, Medium and High severity cracking.

MAE for Low Severity = 40% (633.6)
MAE for Medium Severity = 20% (316.8)
MAE for High Severity = 10% (158.4)

Wheel Path cracking index: **WPCK** = 100 – ((50 / 633.6) * Low WP + (50 / 316.8) * Med WP + (50 / 158.4) * High WP)

OCI (Overall Condition Index) – Within the dTIMS pavement management model there is the overall condition index. The purpose of the index is twofold. The first is to allow the dTIMS model to maximize the benefit to the entire pavement network based upon multiple indices instead of only a single index. This allows the model to compare every section of pavement on a similar scale regardless of pavement type or individual characteristics. The second reason for having a combined index is to give an indication of the "overall health/condition" of the pavement section.

For UDOT, the primary purpose of the OCI is to allow the model to compare pavement sections and maximize the benefit to the network (optimize the pavement condition).

Overall Condition Index: OCI = average of Asphalt or Concrete Indices

This is a source of confusion when interpreted as a measure of actual condition. A measure for actual condition would need to have the individual indices combined differently. Actual condition should include additional measures as well, like age and structural adequacy.

Refer to Appendix A for the listing of measured condition levels for the Good, Fair & Poor condition levels.

Treatments

The following is a list of treatments that are used in the model, with examples. Though somewhat specific in nature, they are meant to represent categories of similar types of treatments with similar costs that would provide similar benefits. The actual treatment is determined by the Region pavement engineer.

The Part 2 manual has more detail about each treatment and why it would be used.

Concrete Grinding: Joint sealing & Diamond grinding

Concrete Minor Rehab: Slab jacking, partial & full depth slab repair, slab replacements

We are currently looking into another minor rehab that includes dowel bar work, but need to include the load transfer data and trigger decisions to use this.

Concrete Major Rehab: Crack & seat, Rubblization, Replacement

Low Seal: Chip seal, Slurry seal

Medium Seal: Micro-surface, hot applied chip

High Seal:[1] Open graded seal, HMA, SMA or Bonded wearing course

Functional Repair: Lane Leveling, Patching or Rut filling, with a seal or thin overlay

Asphalt Minor Rehab: Rotomilling & replace, Cold in place, thin overlay less than 4"

Asphalt Major Rehab: Rotomilling & overlay, thick overlay, full depth reclamation

The model doesn't currently include treatments for reconstruction. We felt that we didn't have sufficient condition data to forecast drainage issues, or subgrade and base course deterioration.

[1] The PMQIT recommended that the use of open graded seals be restricted to existing locations in good condition.

Preferred Seal Type

To provide consistency in the modeling and across the state, we developed the following criteria for categorizing the types of seal coats being used. These categories were selected to provide similar benefits and similar costs.

Rural:
Interstate – Medium Seal
Non Interstate with > 15,000 AADT – High Seal
Non Interstate with < 15,000 & > 7,500 AADT – Medium Seal
Non Interstate with < 7,500 AADT – Low Seal

Urban:
Interstate & Principal Arterials – High Seal
Minor Arterials & Collectors with > 10,000 AADT – High Seal
Minor Arterials & Collectors with < 10,000 & > 2,000 AADT and > 1,000 Trucks – High Seal
Minor Arterials & Collectors with < 10,000 & > 2,000 AADT and < 1,000 Trucks – Medium Seal
Minor Arterials & Collectors with < 2,000 AADT – Low Seal

High Seals include the Hot Mix Asphalt surfacing with Dense or Open Grades Seal Coats, Stone Matrix Asphalt surfacing, or the Bonded Wearing Courses

Medium Seals include the Micro Surfacing treatments

Low Seals include the Chip seals, Scrub seals, or Slurry seals

Treatment Costs

Listed below are the current costs that are used for each treatment.

These are based on typical project cost from awarded projects. Seal projects typically include mobilization, traffic control, striping, and materials. As the treatments get more involved, the projects typically get more involved with additional work. These project costs include the typical extra work for items like curb & gutter, driveways, adjusting utilities, dealing with drainage needs, signs, etc. Project costs not included in our pavement projects include items such as widening, the ITS and signal work, major culverts, bridges and other structures.

Each treatment is multiplied by a factor of 1.20 to account for the additional design and construction engineering, plus other contingency costs typically included in cost estimates for project overruns.

Inflation costs are also accounted for within the model for future cost increases. This is set at a 4% increase per year. It should be noted that this can become substantial over a 20 year analysis period.

All costs are in dollars per square yard. (7,040 SY / lane mile)

Concrete Grinding - $8.50 urban and $6.50 rural

Concrete Minor Rehab[2] - $15 urban and $12 rural

Concrete Major Rehab - $100 urban and $70 rural

Low Seal - $2.50 urban and rural

Medium Seal - $5 urban and $3.50 rural

High Seal - $11 urban and $8 rural

Functional Repair - $14 urban and $11 rural

Asphalt Minor Rehab - $23 urban and $20 rural

Asphalt Major Rehab - $35 urban and $32 rural

[2] Costs used for minor rehab without dowel bar retrofit work

Treatment Triggers

Treatments are triggered when certain condition levels are met. These are expressed in ranges, rather than at specific values. The triggered treatments are then recommended and optimized according to the overall benefit / cost analysis and the budget available.

In general, UDOT's recommended strategy is to treat a section of pavement no sooner than 6 years for asphalt and 10 years for concrete, due to limited funding constraints.

The following is a list of the various treatments and their triggers within the pavement management model.

Concrete Grinding:
RIDE or FALT <= 75 **and** CONK >= 80 **and** FALT >= 50

Concrete Minor Rehab:
RIDE, FALT, CONK or JTSP <= 75 **and** CONC >= 60

Concrete Major Rehab:
CONK <= 50

Seal: Low, Medium or High
RIDE, RUT & ENVCK >= 70 **and** WPCK >= 75

Functional Repair- Interstate & Level 1:
RIDE, RUT or ENVCK < 70 **and** RIDE, RUT & ENVCK > 50 **and** WPCK >= 70

Functional Repair- Level 2:[3]
RIDE, RUT or ENVCK < 70 **and** RIDE, RUT & ENVCK > 50

Asphalt Minor Rehab:
RIDE, RUT or ENVCK < 60 or WPCK < 75 **and** WPCK >= 60

Asphalt Major Rehab
WPCK <= 55

[3] Level 2 roads are allowed to have more wheel path distress and still trigger a functional repair. Higher level treatments are typically not funded for these roads. Our current modeling is being done without the level 2 system, as our funding isn't sufficient to maintain these routes with the same strategy as the Interstate and Level 1 routes.

Treatment Resets

When a treatment is applied to a section of road, the index values assigned to the section are increased to represent the change in condition that will be gained by performing the treatment. This increase in the index value is known as a treatment reset. The treatments will affect each of the condition measure differently.

Even though all of the apparent distress might be repaired from a treatment – the pavement is still older than it was when built, so it will deteriorate at a different rate than when it was new, and some of the distresses will develop sooner – most indices won't get reset to 100 unless it's a major rehabilitation project.

The applied treatments also have the effect of adding additional life to the pavement. The following section talks about remaining service life (RSL) and how this is used.

Concrete Grinding

Ride	+ 55% or a minimum of 90
Faulting	+ 55% or a minimum of 90
RSL	+ 15 years

Concrete Minor Rehab

Ride	+ 55% or a minimum of 90
Faulting	+ 55% or a minimum of 90
Joint Spalling	+ 35% or a minimum of 80
Concrete Cracking	+ 35% or a minimum of 80
RSL	+ 15 years

Concrete Major Rehab

Reset all indices to 100	
RSL	+ 40 years

Low Seal

Ride	+ 10%
Rutting	+ 10%
Env. Cracking	Reset to 100
Wheel-path Cracking	+ 2.5%
RSL	+ 5 years

Medium Seal

Ride	+ 20%
Rutting	+ 20%
Env. Cracking	Reset to 100
Wheel-path Cracking	+ 3.5%
RSL	+ 7 years

High Seal

Ride	+ 30% or a maximum of 95
Rutting	+ 30% or a maximum of 95

Env. Cracking	Reset to 100
Wheel-path Cracking	+ 5%
RSL	+ 9 years

Functional Repair

Ride	+ 25% or a minimum of 80
Rutting	+ 25% or a minimum of 80
Env. Cracking	+ 60% or a minimum of 85
Wheel-path Cracking	+ 5%
RSL	+ 8 years

Asphalt Minor Rehab

Ride	+ 50% or a maximum of 90
Rutting	+ 50% or a maximum of 95
Env. Cracking	Reset to 100
Wheel-path Cracking	+ 10%
RSL	+ 15 years

Asphalt Major Rehab

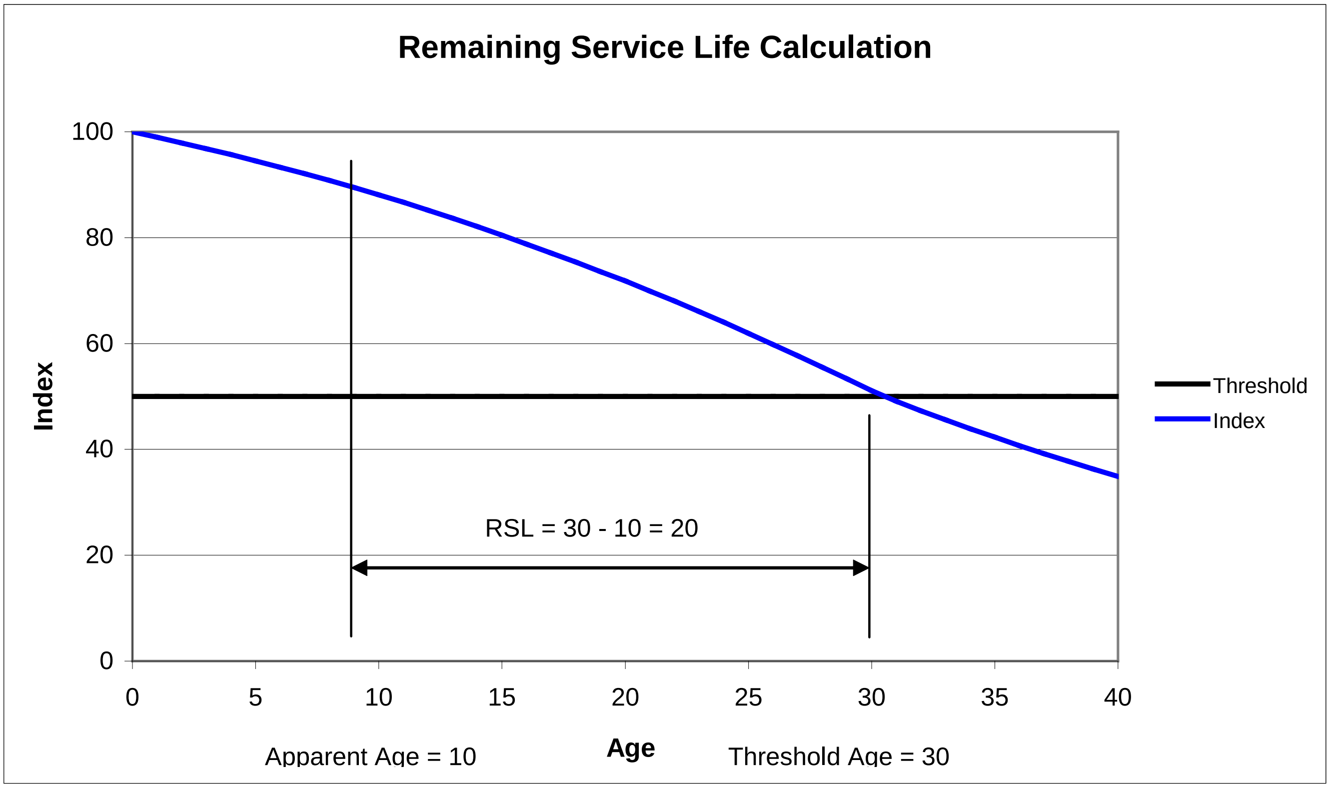
Reset all indices to 100

RSL	+ 30 years

Remaining Service Life (RSL):

By monitoring the pavement condition, we can estimate the time until the deterioration reaches an unacceptable operating condition. This requires the use of the deterioration curve, the current condition index, and the threshold index. This applies to each measure of condition.

Example RSL Calculation: given Condition Index at 90

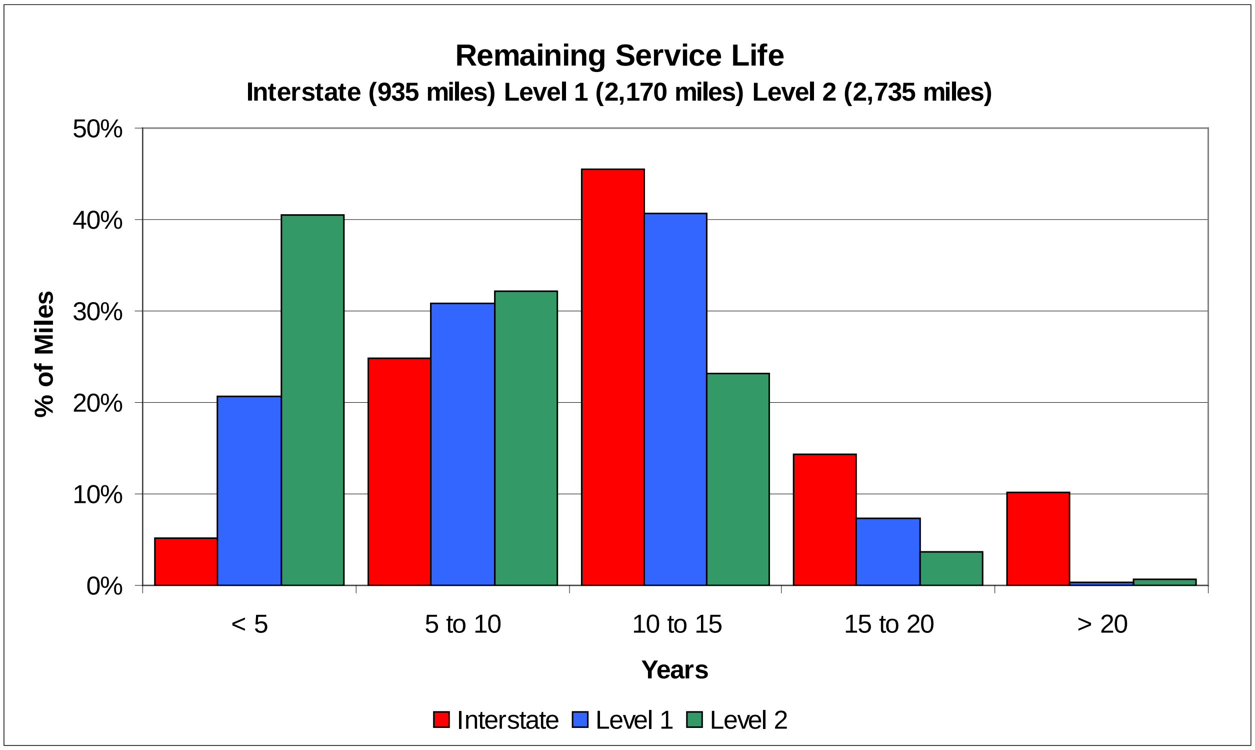


By definition, the RSL = 0 for a pavement section when the only cost effective treatment is a major rehabilitation or reconstruction. This would suggest that the condition index used is based on the "structural" life of the pavement. It needs to be understood that even when the RSL reaches 0, there could still be many years of useful life in the pavement – it would just be in an unacceptable condition.

In our current model we consider all of the condition measures, and allow the worse measure of condition to control. The appropriate treatment and cost would be different for a pavement with RSL = 0 for fatigue cracking, compared to a pavement with RSL = 0 for rutting, or environmental cracking.

This way of using RSL is used to report the current condition of the system in terms of years of remaining life.

Remaining Service Life chart using 2009 condition data, based on lowest Index:



Another way to use RSL is by the definition that for each calendar year the pavement looses one year of remaining service life. This definition doesn't consider the actual condition or the change in the rate of deterioration over time. But this is still a useful pavement management tool to compare the amount of work being recommended (or performed) each year to the amount of life being lost.

Each of the treatments effectively extends the pavement life a number of years before it returns to the same condition level that it was at before the treatment. This additional life ranges from 5 to 7 years for a chip seal treatment to 30 years for a reconstruction.

By summarizing the miles of work recommended each year * the additional life, we can see if we're doing enough work to balance with the amount of life being lost each year. Our 5,835 mile system would loose 5,835 mile years of life each year – suggesting we should be doing at least 5,835 mile years of work to maintain the system condition.

By using a long-term statewide pavement management strategy, we can apply a combination of routine maintenance, preventive maintenance, minor and major rehabilitation, and reconstruction projects to improve our pavement performance, extend the pavement life, and address structural deficiencies. With our focus to keep our good roads in good condition, and our mix of rehabilitation and preservation projects, we can maintain a balance of roads in good condition, fair condition & poor condition.

Benefits and Optimization (under development)

Area between curves
AADT factor
Safety index

Model Inputs (under development)

Explain funding
Section information from PFES
Age
PCS
AADT

Model Results (under development)

Include something about the first year including STIP projects as well as ongoing projects not yet completed.
Explain FY

Timeline (under development)

Tim’s timeline chart

Appendix A:

The following table has the measured condition values for the principal Index values of Good (>80), Fair and Poor (<50) for each distress, for 0.1 mile sections.

Condition	Measure	Good	Fair	Poor
Index		> 80	80 to 50	< 50
Concrete Ride (Index = 100 @ 65)	IRI	< 115	115 to 190	> 190
Corner Breaks	# slabs	< 3.5 (10%)	10% to 25%	> 8.75 (25%)
Cracked Slabs - Trans + Long	# slabs	< 4.2 (12%)	12% to 30%	> 10.5 (30%)
Shattered Slabs	# slabs	< 3.5 (10%)	10% to 25%	> 8.75 (25%)
Cracking Index = Corner Breaks + Cracked Slabs + Shattered Slabs				
Joint Spalling	% slabs	< 3.5 (10%)	10% to 25%	> 10.5 (25%)
Asphalt Patching	% slabs	< 4.9 (14%)	14% to 35%	> 12.25 (35%)
Joint Condition Index = Joint Spalling + Patching				
Faulting < 0.3" (low severity)	# of joints	< 14 (40%)	40% to 100%	35 (100%)
Faulting 0.3" to 0.5" (med severity)	# of joints	< 3.5 (10%)	10% to 25%	> 8.75 (25%)
Faulting > 0.5" (high severity)	# of joints	0	0 to 10%	> 3.5 (10%)
Faulting Index = Sum Low + Medium + High				
Overall Condition Index Concrete = Average of Ride, Cracking, Joint Condition & Faulting				
Asphalt Ride (Index = 100 @ 45)	IRI	< 95	95 to 170	> 170
Asphalt Rut	inches	< 0.2	0.2 to 0.5	> 0.5
Transverse Cracking Low	# of cracks	< 21.1 (40%)	21.1 to 52.8	> 52.8 (100%)
Transverse Cracking Medium	# of cracks	< 15.8 (30%)	15.8 to 39.6	> 39.6 (75%)
Transverse Cracking High	# of cracks	< 10.6 (20%)	10.6 to 26.4	> 26.4 (50%)
Transverse Cracking Index = Sum of Low, Medium or High				
Longitudinal Cracking Low	Feet of cracks	< 211.2 (40%)	211.2 to 528	> 528 (100%)
Longitudinal Cracking Medium	Feet of cracks	< 158.4 (30%)	158.4 to 396	> 396 (75%)
Longitudinal Cracking High	Feet of cracks	< 105.6 (20%)	105.6 to 264	> 264 (50%)
Longitudinal Cracking Index = Sum of Low, Medium or High				
Block Cracking Low	Feet of cracks	< 211.2 (40%)	211.2 to 528	> 528 (100%)
Block Cracking Medium	Feet of cracks	< 158.4 (30%)	158.4 to 396	> 396 (75%)
Block Cracking High	Feet of cracks	< 105.6 (20%)	105.6 to 264	> 264 (50%)
Block Cracking Index = Sum of Low, Medium or High				
Skin Patching	Sq Ft of Patching	< 633.6 (10%)	633 to 1,584	> 1,584 (25%)
Environmental Cracking Index = (Transverse + Longitudinal + Block) or Skin Patching				

Wheel Path Cracking Low	Sq Ft of cracks	< 253.4 (16%)	253 to 633	> 633.6 (40%)
Wheel Path Cracking Medium	Sq Ft of cracks	< 126.7 (8%)	126 to 316	> 316.8 (20%)
Wheel Path Cracking High	Sq Ft of cracks	< 63.3 (4%)	63 to 158	> 158.4 (10%)

Wheel Path Cracking Index = Sum of Low, Medium or High
use 3' wide area for both wheel paths: 100% = 1,584

Overall Condition Index Asphalt = Average of Ride, Rutting, Environmental Cracking & Wheel Path Cracking

Appendix B:

The following table has the condition data collected in 2009. This data was collected in the Negative direction and both directions for the Interstate. This data is available in 0.1 mile intervals. dTIMS converts the measured 0.1 mile values to section level Index values.

Field Name	Definition	Units
Route	Route name	N/A
Direction	Direction of ARAN collection	N/A
From_MP	Milepoint at start of segment to 3 decimals.	Miles
To_MP	Milepoint at end of segment to 3 decimals.	Miles
Pavement_Type	Pavement type	N/A
Conc_Shattered_Low	Slab broken into 3 pieces	# of Slabs
Conc_Shattered_Med	Slab broken into 4 pieces	
Conc_Shattered_High	Slab broken into 5 or more pieces	
Conc_Long_Low	Crack widths < 1/8" and crack lengths >= 2 feet	# of Slabs
Conc_Long_Med	Crack widths 1/8" to 1/2" and crack lengths >= 2 feet	
Conc_Long_High	Crack widths > 1/2" and crack lengths >= 2 feet	
Conc_Trans_Low	Crack widths < 1/8" and crack lengths >= 2 feet	# of Slabs
Conc_Trans_Med	Crack widths 1/8" to 1/4" and crack lengths >= 2 feet	
Conc_Trans_High	Crack widths > 1/4" and crack lengths >= 2 feet	
Conc_CrnBrk_Low	One Corner Break with no Spalling or Faulting	# of Slabs
Conc_CrnBrk_Med	One Corner Break AND Spalling < 3" OR Faulting < 1/2"	
Conc_CrnBrk_High	Two or more Corner Breaks OR One Corner Break along with either Spalling > 3" or Faulting > 1/2"	
Conc_JntSpl_Low	Spalling < 3" wide	# of Transverse Joints Affected
Conc_JntSpl_Med	Spalling 3" to 6" wide	
Conc_JntSpl_High	Spalling > 6" wide	
Conc_Asphalt_Patch	Count # of slabs with asphalt patches	# of Slabs
Conc_Faulting_Low	Faults 0.1" to 0.3"	# of Faults
Conc_Faulting_Med	Faults 0.3" to 0.5"	
Conc_Faulting_High	Faults > 0.5"	
Conc_Faulting_Total	Total number of faults	
Asph_WhlPath_Low	Longitudinal cracks with no or only a few secondary cracks. No spalling.	Square Feet
Asph_WhlPath_Med	Interconnected cracks starting to form an alligator pattern, dimensions generally > 12" length	
Asph_WhlPath_High	Alligator pattern with dimensions < 12" length or pieces missing	
Asph_Block_Low	Unsealed cracks < 1/4" wide or sealed cracks	Feet
Asph_Block_Med	Widths 1/4" to 3/4" or secondary crack widths < 1/4"	
Asph_Block_High	Widths > 3/4" or secondary cracks widths >= 1/4"	
Asph_Long_Low	Sealed cracks or unsealed cracks < 1/4" wide	Feet (Note:

Asph_Long_Med	Unsealed or poorly sealed cracks with widths > 1/4" and < 3/4" or secondary crack widths < 1/4"	Max can be > 528')
Asph_Long_High	Widths > 3/4" or secondary cracks widths > 1/4", unsealed or poorly sealed.	
Asph_Trans_Low	Unsealed cracks < 1/4" wide or sealed cracks	Count (Number of cracks)
Asph_Trans_Med	Unsealed or poorly sealed cracks with widths > 1/4" and < 3/4" or secondary crack widths < 1/4"	
Asph_Trans_High	Widths > 3/4" or secondary cracks widths > 1/4", unsealed or poorly sealed.	
Asph_Bleed_High	Shiny appearance due to excess asphalt. Aggregate obscured by excess asphalt.	Feet
Asph_Patch	Area of patching and utility cuts over one square foot in size.	Square Feet
IRI_Left	IRI in left wheelpath	in / mile
IRI_Right	IRI in right wheelpath	
IRI_Average	Average of left and right IRI	
Rut_Left	Rutting in left wheelpath	inches
Rut_Right	Rutting in right wheelpath	