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A Method for Assessing Costs Associated with Conversion/Reconversion of Low-Volume Roadways

Cade Humphries[1], Evan Humphries[1], Soon-Jae Lee[1+], and Kyu-Dong Jeong[2]

Abstract: This paper presents an explanation of the methods used to evaluate the costs associated with the conversion of low-volume roads to gravel and asphalt, as well as the potential reconversion to the original surface type, for the purpose of maintenance cost savings. Across the country, agencies are converting lesser-used surfaced roads into un-surfaced (gravel-type) roads in order to curtail present maintenance spending. But the conversion costs money, and there is the possibility that growth may occur that would necessitate the reconversion of the roadway, an expensive task that could negate any potential savings from the initial conversion. The conversion and maintenance costs are dependent on local material costs and road standards. The feasibility of this practice requires a more in-depth look at the costs involved with both conversion and maintenance of both surface types, as well as potential for growth in the area. This paper presents the minimum costs associated with conversion and reconversion of low-volume roads in Texas as an example of one way to assess costs for decision-making purposes.

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Key words*: Average daily traffic; Conversion; Low-volume road; Maintenance; Reconversion; Surfaced; Un-surfaced.*

Introduction

In 2010, high profile publications such as the Washington Post and USA Today reported that a growing number of states are looking at the option, or are already practicing the process, of converting deteriorating low-volume asphalt roads to gravel to cut maintenance costs [1, 2]. Counties in Michigan, Indiana, Maine, South Dakota, Alabama, and Pennsylvania have already converted miles of asphalt roadways into gravel in an effort to save money on frequent, costly repairs. Roads that have been replaced by newer, more efficient routes are falling into disrepair so badly it is more expensive to maintain or resurface them than it is to convert it to gravel and maintain it as such [1].

There has been some research done in Minnesota and South Dakota regarding conversion. In Minnesota, Jahren et al. [3] examined the economics of upgrading a gravel road to a paved road. In South Dakota, Zimmerman and Wolters [4] looked at the optimum surface type for a given situation, including upgrading a gravel road to a paved road. However, a major area where research is lacking is in the examination of the whole picture, including: maintenance costs of the existing roadway, the cost to convert the surface type, the cost to maintain the new surface, and the cost to reconvert to the original surface type if the situation calls for it.

The Texas Department of Transportation (TxDOT) recently completed a project that attempts to frame the situation in a general way in order to gain an understanding of costs associated with this process; Project 0-6677, "Economic Analysis of Low-Volume Road Surfacing Alternatives". This paper describes the process used to determine and assign costs, the software and methods used in the assessment process, and how conclusions were drawn from the results. The conclusions as they are specific to Texas and TxDOT project 0-6677 are presented as an example of how the results can be interpreted.

Survey of County Personnel

Before costs could be assigned, they had to be accounted for. Therefore, an attempt was made to build the most realistic schedule of costs for maintaining un-surfaced roads. Depending on their classification, low-volume roads may be built and maintained by the state, county, or other agency. TxDOT provided all the information needed for the maintenance of paved roads, but as the State does not operate any unpaved roads and therefore could not provide data on them, it was decided that information for building and maintaining unpaved roads should come from maintenance officials at the county level.

A survey was created based upon the one used by Zimmerman and Wolters [4] in which they polled South Dakota officials regarding maintenance costs of low-volume roads. The survey generated was distributed to 674 officials in Texas. This included 32 County Engineers, 26 County Road and Bridge Superintendents, 596 County Commissioners and 20 various personnel that were referred to us by other survey contacts. The contact information for those included in the survey was taken from the Texas County Directory 2011. It was the intention of the survey to gather information the frequency, costs, and types of work performed on gravel roads. Respondents were asked to give information on condition, ADT, maintenance practices, aggregate type, and many other things for both paved and unpaved roads.

By the end of the three weeks following distribution and follow-up, only 13 people had completed it. The data that was collected varied significantly. For example, the price of seal coat ranged from $12,000 per mile to $33,000 per mile in different

[1] Department of Engineering Technology, Texas State University, San Marcos, TX 78666, USA.

[2] Korea Institute of Construction Technology, 2311, Daehwa-dong, Ilsan-gu, Goyang-si, Gyeonggi-do, Korea, 411-712.

[+] Corresponding Author: E-mail soonjae93@gmail.com

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counties. The research team received 38 emails and 19 phone calls from those who received the survey, and there were two consistent responses from these direct contacts:

- First, most expressed how unpopular "unpaving" a road would be with residents. Additionally, very few respondents thought it would save money.
- The second was an explanation of why we were receiving low response rates, poor data, and why people began the survey but did not finish: Counties in Texas with un-surfaced roads did not have the resources to track cost data. As one respondent said, "Due to the fact that we are such a small county it is impossible for me to keep up with the costs on a road by road basis."

It was determined that a new approach to generating cost data was needed.

Work Plan Models

It was determined that the best way to estimate the costs for comparison was to build hypothetical conversion and maintenance models in a workbook so that all costs could be calculated with their district specific modifications accounted for. Costs could then be gathered from TxDOT as well as other published sources. For this particular task, the source chosen was *RS Means Heavy Construction Cost Data* [5]. Additional information, such as production rates of the equipment, were obtained from the *Caterpillar Performance Handbook* [6]. The authors worked with TxDOT to establish a realistic construction plan, including a schedule, equipment list, and a general maintenance plan for one lane-mile. For consistency in calculating quantities, one lane-mile was defined as one section of an asphaltic surfaced roadway 24' wide and 5280' long. All calculations for quantities were based on this theoretical model. At this point, the workbook contained a sheet for each of the following:

- A crew and equipment list, and a list of districts – Contained the estimated crew needed to perform each task included in the schedule for each element of the model. Also assigned an hourly rate to each worker or piece of equipment. Each TxDOT district was hyperlinked back to the txdot.gov webpage for quick access to general information.
- A sheet for the RS Means multipliers (City Cost Index) – Each district was assigned a cost multiplier from *RS Means Heavy Construction Cost Data* [5] to more accurately reflect pricing in that particular location. This sheet defined those multipliers for both labor and equipment for each district.
- Surfaced to un-surfaced schedule – Accounted for all equipment and personnel needed to convert a roadway from surfaced to un-surfaced, as well as the daily schedule and production for the entire length of the model.
- Surfaced to un-surfaced conversion – Assigned costs to the needs in the schedule, which established the equipment and labor costs for the entire model.
- Maintain un-surfaced logic – Set a goal of one mile per day and broke down each maintenance item so that costs could be assigned. This sheet was specifically to see if maintenance of one mile of unsurfaced road could be completed in one day.
- Maintain un-surfaced breakdown – Listed the state as a whole, each climatic zone, and each TxDOT district, as well as their climate type, geographic region, equipment and labor multipliers (as defined by *RS Means Heavy Construction Cost Data* [5]), as well as the total equipment, material, and labor costs for each (multipliers applied).
- Un-surfaced to surface schedule – Accounted for all equipment and personnel needed to convert a roadway from un-surfaced to surfaced as well as the daily schedule and production for the entire length of the model.
- Un-surfaced to surfaced conversion – Assigned costs to the needs in the schedule, which established equipment and labor costs for the entire model.
- Maintain surfaced breakdown – This sheet integrated conversion costs and maintenance costs, as maintenance activities were less than (but comprised of the same types involved in) conversion. In addition to listing the districts and corresponding information about region and climate, it defined each maintenance activity. Material rates and costs are given for each, and the total cost to maintain one mile of surfaced roadway in the state, each climatic zone, and each district are established.

Once the work plans, schedules, and initial costs were gathered, TxDOT reviewed them for approval so that the model accurately reflected the conversion and maintenance activities typical of this type of project.

Work Plans

All work plans developed used the same one lane-mile definition given above.

Conversion Process – Surfaced to Un-surfaced.

A hypothetical conversion process for surfaced to un-surfaced roads was developed. All costs (including labor, equipment, and material) and the calculations are included in the workbook, as is the schedule for all work. This situation was defined as "A surfaced roadway has reached its maximum sustainable lifetime and due to the low capacity of traffic volume the roadway must be converted to an un-surfaced roadway." Assumptions were made for standardization purposes:

- Thickness of existing roadway surface is two (2) inches of chip sealed asphaltic roadway.
- Under the pavement layer will be at least eight (8) inches of Type 1 Flexible base material, however this process will affect ONLY the top four (4) inches of Flexible base.
- The surface area for the roadway was determined as 126,720 ft^2/mi.

Once all of this was established, the process for un-surfacing was established:

1. The roadway shall be ripped with a motor grader to a depth no greater than (0.5) feet.
2. The roadway shall then be watered thoroughly (for amount needed see below at Water per Cubic Yard).
3. The roadway shall then be processed with a mixer or soil stabilization machine at a depth no greater than (0.5) feet.

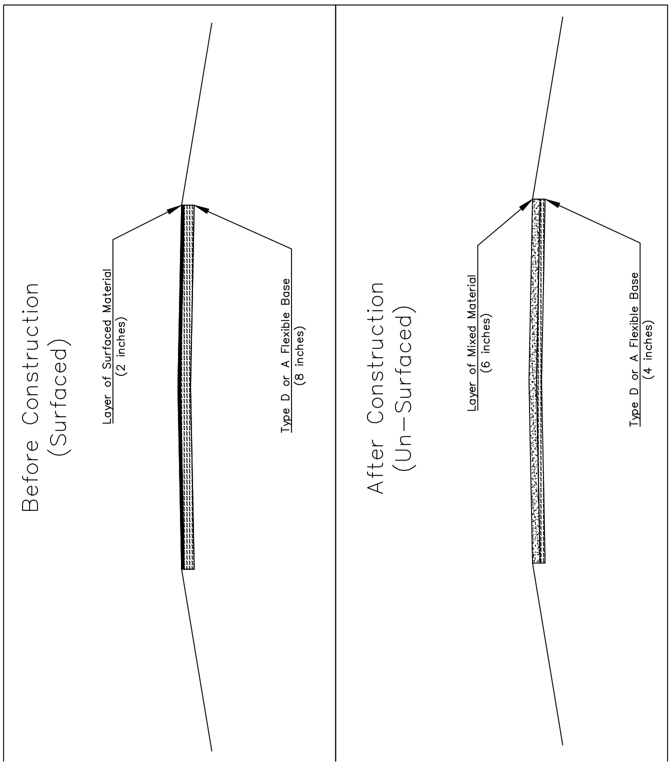

Fig. 1. Surfaced to Un-surfaced Visual Description.

4. The roadway shall then be leveled off by a motor grader in order to disperse the processed material to near final grade (± 0.1 ft.) of the designed final surface.
5. The roadway shall then be compacted to recommended compaction levels as set by appropriate engineer by district.
6. The roadway shall then be finished by motor grader to an accuracy of (± 0.05 ft) of the designed final surface.

After defining the size and scope of the conversion process, materials were included to ensure all cost factors were considered. For an un-surfaced road, the materials needed for conversion were determined to be water and aggregate, for which quantities were established: Aggregates ≈ 2350 yd^3/mi; and Water = 35,250 gal/mi.

The price of water was found to be highly variable based on the location of the project. The closer to a city or main water supply the project is located, the lower the cost. However, in Texas, extreme environmental fluctuations and water availability can have a great impact on the price of water. It was found that in the broad scheme, water did not have a great impact on the overall cost of the project, however, it is understood that in certain extreme circumstances it can be an important factor.

Lastly, equipment pricing was gathered for all equipment needed to perform the conversion of a road from surfaced to un-surfaced. The production data was gathered from the *Caterpillar Performance Handbook* [6]. Costs were gathered from RS Means 2012 [5] and calculated for each piece of equipment according to the work plan and schedule, specific to each district. These costs are detailed in the workbook for TxDOT project 0-6677. Fig. 1 shows surfaced to un-surfaced visual description.

Maintenance Process – Un-surfaced

For estimation purposes, a maintenance schedule was established. The maintenance process takes into account the equipment, labor, and materials costs to maintain an un-surfaced road on a bi-monthly basis. Based on information gathered, the assumption was made that on an un-surfaced road with an ADT of 250 cars per day, maintenance would need to be performed every 60 days, or 15,000 cars. The equipment needed is a motor grader and an operator, so production and cost data was easy to obtain.

Using individual data for each district, a maintenance schedule was developed that included both routine blading and gravel resurfacing. This yielded the maintenance cost of un-surfaced road per mile per year for each district. It should be noted that since only one type of gravel was used for evaluating every district (which may not be the preferred or most cost effective material in every district), there could be variations in the estimated and actual un-surfaced road maintenance costs of individual districts. It is possible that each district has a preferred aggregate, which may have an impact on the overall cost and performance of an un-surfaced road.

Conversion Process – Un-surfaced to Surfaced

A realistic conversion process had to be developed for turning an un-surfaced road into a surfaced road. The schedule and its elements are detailed in the workbook. The process is a basic prepare-and-pave, but requires more equipment, materials, labor, and planning than the surfaced to un-surfaced conversion. Again, a situation was defined, “An un-surfaced roadway has reached its maximum sustainable capacity of traffic volume and must be converted to an asphalt surfaced roadway.” The assumptions made were as follows:

- Thickness of existing un-surfaced roadway surface is at least (8) inches in total depth and is to be treated as compacted Type 1 Flex Base.
- There will be residual amounts of Recycled Asphalt Pavement in the existing roadway due to gravel loss effects, the effect of the RAP in the composition of the aggregate will not be considered.
- A nominal (2) inches of Type 1 Flex Base will be used as level up material.
- The surface area for the roadway was determined to be 126,720 ft^2/mi.

Once all of this was established, the process for surfacing was established:

1. The roadway shall be ripped and processed according to TxDOT Spec 247.4 A Preparation of Subgrade or Existing Base.

"When new base is required to be mixed with existing base, deliver, place, and spread the new flexible base in the required amount per station. Manipulate and thoroughly mix the new base with existing material to provide a uniform mixture to the specified depth before shaping."

2. The roadway shall then be watered thoroughly.
3. The roadway shall then be processed with a mixer or soil stabilization machine at a depth no greater than (0.5) feet.
4. The roadway shall then be leveled off by a motor grader in order to disperse the processed material to near final grade (± 0.1 ft) of the designed final surface.

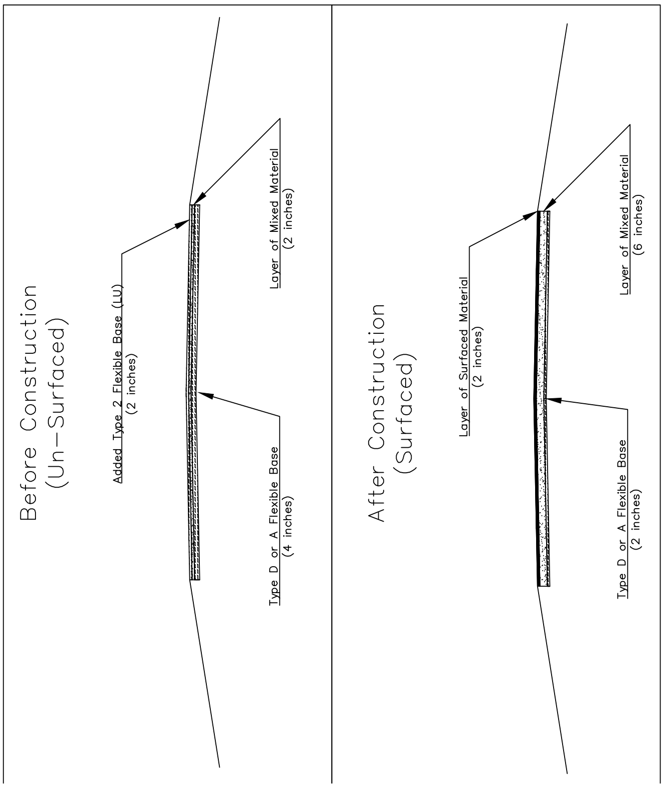

Fig. 2. Un-Surfaced to Surfaced Visual Description.

5. The roadway shall then be compacted to recommended compaction levels as set by appropriate engineer of district according to regional material characteristics.
6. The roadway shall then be finished according to TxDOT Spec 247.5 D. Finishing.

After completing compaction, clip, skin, or tight-blade the surface with a maintainer or subgrade trimmer to a depth of approximately 1/4 in. Remove loosened material and dispose of it at an approved location. Seal the clipped surface immediately by rolling with a pneumatic tire roller until a smooth surface is attained. Add small increments of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines, and grades as shown on the plans or as directed. In areas where surfacing is to be placed, correct grade deviations greater than 1/4 in. in 16 ft. measured longitudinally or greater than 1/4 in. over the entire width of the cross-section. Correct by loosening, adding, or removing material. Reshape and recompact in accordance with Section 247.4.C, “Compaction.”

7. The additional layers of the surface shall be designed according to a State of Texas Professional Engineer and is considered beyond the scope of this project.

After defining size and scope, materials needed for the conversion were determined:

Base Aggregate

- The ratio of thickness of loose gravel to compacted gravel is 1.28:1; therefore, a 2-inch compacted gravel lift requires placement of 2.56 inches of loose gravel.
- 6" of Existing Materials to be blended with additional material ≈ 2,350 yd^3/mi.
- Add 2" Flexible Base ≈ 783 yd^3/mi.
- 2" Flexible Base Volume with swell multiplier ≈ 1,000 yd^3/mi.
- Total Cubic Yards to be mixed per mile ≈ 3,350 yd^3/mi.

It was also calculated that for this process, there would be: 63,650 gal/mi of water needed; 4,928 gal/mi of Prime Coat; and 4,928 gal/mi of Seal Coat. The cost of Prime and Seal Coat varies by district. TxDOT provided the average bid prices for most districts, but the individual costs for each district are listed in the workbook for project 0-6677 and will be specific to each district.

Also needed was 128 yd^3/mi of Grade 4 rock. The cost of Grade 4 rock varies by district. TxDOT provided the average bid prices for most districts, but the individual Grade 4 rock costs for each district are listed in the workbook for project 0-6677 and will be specific to each district. All average bid prices provided by TxDOT are “in-place” pricing, in that they include all costs such as overhead, transportation, installation, etc.

Lastly, equipment pricing was gathered for all equipment needed to perform the conversion of a road from un-surfaced to surfaced. As with the surfaced to un-surfaced conversion, the production data was gathered from the *Caterpillar Performance Handbook* [6]. Costs were gathered from RS Means 2012 [5] and calculated for each piece of equipment according to the work plan, including the schedule. Fig. 2 shows un-surfaced to surfaced visual description.

Maintenance Process – Surfaced

The maintenance procedure for surfaced roads was defined using state standards and common practices. The maintenance procedure for surfaced roads was defined using state standards and common practices, specifically, the Seal Coat and Surface Treatment Manual [7]. The maintenance plan included adding one layer each of Seal Coat and of Grade 4 Rock every 7 years. Per TxDOT, an average level-up of 20% per one mile was factored in, as well as the cost of materials and equipment, including centerline striping. The price for surface treatments was taken from TxDOT Bid Item 316, and was provided by TxDOT.

To this point, the workbook established the baseline conversion and maintenance net present cost for the agency. However, when planning for the long term, it is imperative to perform an analysis that can project costs out for years in order to determine which surface type will be more cost-effective in the long run. For this part of the analysis, HDM-III, a road-deterioration modeling program created by the World Bank, was utilized.

HDM-III Software

The World Bank developed the Highway Design and Maintenance Standards Model (HDM) as a software tool for use by agencies around the world, especially developing countries, as a tool to help assist in infrastructure management. Because it is directed towards developing countries, it is designed to assess both asphaltic roads and gravel roads. HDM-III can analyze out to 30 years, and allows road managers to evaluate multiple options quickly, to see what the most cost-effective, long-term solution might be. Overall, the model is to assess costs as compared to performance, and offers the results

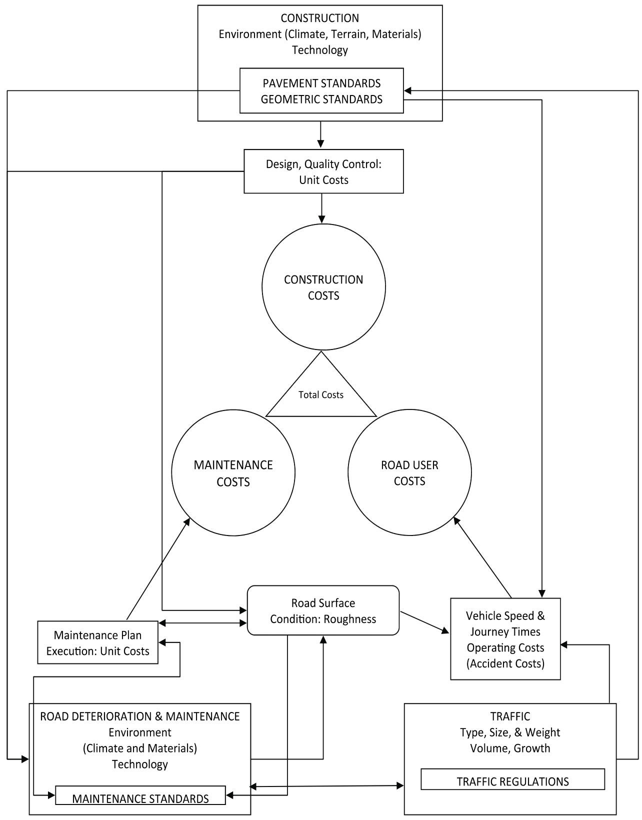

Fig. 3. The HDM Model: Interaction of Costs and Road Construction Maintenance and Use (taken from Haas et al. [8]).

so that road managers can make the best decisions for a given project, whether it is new construction or current and future maintenance and rehabilitation [8]. Fig. 3 gives an overview of how the program assesses these costs.

Due to the nature of the program, it is highly adaptable to be used for this research. The user can analyze different maintenance strategies by cost, available materials, environmental impacts (such as topography), etc., over time in order to determine the annual maintenance cost for a given road. It can be used to analyze paved roads of various surface types, according to each agency's own known costs and procedures. Since the program is held to international specifications, all data, information, reports, etc., should be input as, and are given in, metric.

Sensitivity Analysis of HDM-III

There were a potential 106 inputs concerning surfaced road, and 90 concerning un-surfaced. It was beyond the scope of this project to gather accurate data for every possible input, and verifying all data to the same level of assurance would be difficult, given the time frame and scope of the project. Examples of such inputs included specific gradation sizes for aggregate, curvature of the road, and other highly specialized engineered aspects of the roadway construction. In order to determine the most critical inputs for the final simulations, a sensitivity analysis of the HDM-III program was needed to identify the variables that had the greatest effect.

To find and focus on the inputs with the most impact, the research team created a separate workbook to measure the weight of the impact of each variable on a baseline output figure developed as a control variable ("ceteris paribus" method). Hundreds of variables such as environmental conditions, material conditions, frequency of work done, cost factors, material specifications, material properties, and many more were defined and given ranges. The workbook was designed to test each input from the lowest-possible to the highest-reasonable range of each variable to indicate the influence on the results given by HDM-III by defining one set of data that would act as the constant. Each input was assigned a range (n = 5). The research team then ran an analysis at each interval for each input (more than 300 simulations). In order to determine the impact of each variable within each range, and using the results of these simulations, we used a comparative analysis to determine which variables had impact at the traffic level being evaluated. For each variable that was altered and a simulation run, the simulation was compared to the baseline constant to see where and by how much it differed (see example, Table 1).

The sensitivity analysis confirmed that data based on cost had the most impact on the result. Maintenance intervals and material cost were found to have the greatest impact. Environmental condition variables (such as climate and in situ soil condition), material condition, and other non-cost related variables had no relevant impact on the overall cost evaluation of either surface. This was not surprising, as the goal of the program is to estimate costs, but did help to confirm which major costs needed to be most accurate to provide the most realistic results.

HDM-III Simulations for Cost Over Time

All cost data for each district and region was converted into metric and loaded into the program. Simulations were run for each district, climate region, and the state as a whole as the independent variables. Because the sensitivity analysis ruled out plasticity index and climate as long-term contributing factors to cost, and due to it's predominant use in prior research, ADT was used as the dependent variable. Each of these simulations generated a 25-year economic analysis by forecasting the annual maintenance cost of a road based on the inputs provided.

Table 2 presents the results of the HDM-III simulations run by zone, with the average cost for all ADT's of un-surfaced used as a comparison. It is easy to see from this example that costs vary widely by zone, and so simulations were run for each individual district to obtain an understanding of the whole picture.

A control simulation was run using the actual costs in order to identify costs without any effect of ADT. In total, there were 187 simulations run: there were thirty-one (31), one for each of the twenty-five (25) TxDOT districts, five (5) climate regions, and one (1) for Texas as a whole; for unpaved, each was run six (6) times, with levels of ADT at 0 (control), 100, 200, 300, 400, and 500. Additionally, one simulation for a paved road was run, but more were not necessary due to the lack of impact of ADT on surfaced roadways, thus ADT was only relevant to cost over time for un-surfaced roads, which is likely due to the low-volume of traffic required by the study. The control was run to find the baseline and to make sure no unseen variables were affecting the outcome. The results of these simulations, or the annual maintenance cost for one

Table 1. Example of HDM-III Sensitivity Analysis Results.

Screen	Page	Category	Input Description	Optional Input	Current Input Value	Constant Input	Zero Range	Low Range	Medium Range	High Range	Unit
Analysis Control	1		Discount Rate		12	12	0	6	12	18	%
Analysis Control	1		Analysis Period		20	20	0	10	20	30	Year
Road Characteristics	1		Descript.	Name		Sensitivity A					
Road Characteristics	1		Paved or Unpaved	P or U		P	U		P		P or U
Road Characteristics	1	Geo.	Road Length		10	66	0	33	66	99	km
Road Characteristics	1	Environ.	Altitude		518	500	0	250	500	750	m
Road Characteristics	1	Environ.	Rainfall		0.06	0.0635	0	0.031	0.063	0.09	m/month
Road Characteristics Paved	2	Surface	Surface Type		1	1	4	5	1	2	Table
Road Characteristics Paved	2	Cond.	Roughness		6	3	0	3	6	9	IRI
Road Characteristics Paved	2	Cond.	Construction Fault Code		0	0	1		0		
Road Characteristics Unpaved	2	Cond.	Gravel Thickness		152		0	75	150	225	mm
Road Characteristics Unpaved	2	Cond.	Gravel Age		0		0	2.5	5	7.5	y

Table 2. Example of HDM-III Simulation Results Comparison.

Location	Un-Surfaced Annual Cost	Surfaced Annual Cost	Difference
	Average for All ADTs	~	
Zone 6 - Texas	$6,920.18	$6,276.44	($643.74)
Zone 1	$7,435.17	$6,437.38	($997.79)
Zone 2	$4,988.97	$6,115.51	$1,126.54
Zone 3	$5,858.01	$6,115.51	$257.50
Zone 4	$6,791.43	$5,954.57	($836.86)
Zone 5	$9,334.20	$6,276.44	($3,057.75)

mile of a road with the characteristics given in the inputs, were then entered into a new sheet in the workbook so that they could be compared to find the point at which it is the same cost to maintain both an un-surfaced and a surfaced road, which is referred to as the "break-even" point. This necessitated a new sheet in the workbook:

- Simulations – This sheet lists the climate and geographic information for the state as a whole, the climatic zones, and each of the TxDOT districts. The cost per mile of each maintenance activity as calculated before the simulations (or the baseline costs) is presented, followed by the results of the simulations in order of ADT for the state, each climatic zone, and each district. Finally, the difference between the estimated baseline cost and the simulated costs are presented, which showed how much of an impact ADT actually had on the maintenance costs.

Based on the differences in the estimated costs and the projected costs, it is possible to gauge which surface type is the most cost effective to maintain at a given ADT. However, the purpose of all of this was to determine, based on maintenance AND conversion costs, which surface type is most economical for a given road. To do this, the ADT at which it is the same cost to maintain both an un-surfaced and a surfaced road was needed for the state, climate zones, and districts. In order to establish the break-even point, one more analysis needed to be performed.

ADT Analysis

It was known from research into this subject that other states established an ADT break-even point to consider when evaluating roads for conversion. For example, South Dakota established ranges for different types of roads [4], notably gravel was for ADT's of 0-150. Minnesota found that roads with an ADT of 150+ per day were more economically viable if paved [3].

In order to determine the break-even ADT, first, all data was converted from metric back into standard. The results of each simulation were entered for each district, zone, and the state as a whole, for each ADT. Using linear interpolation, the break-even point was calculated for each district, climatic region, and the state as a whole. The break-even point for the state as a whole was found to be approximately 150 ADT, though it ranges from less than 100 to more than 500 depending on the district. It is based on the cost to maintain an un-surfaced roadway as it compares to a surfaced roadway. The break-even ADT by zones was determined through the analysis named above using the costs generated by HDM-III and presented in Table 3. For example, for Zone 6 (state as a whole), the Surfaced Annual Cost falls between the Un-surfaced Annual Cost for simulations run at ADT of 100 and 200, which supports the average break-even falling around ~150 ADT.

Fig. 4 is a visual representation of the ADT break-even point by district and zone. Red represents where the ADT break-even point was found to be above 500, meaning that district where it would be economically viable for the agency to have un-surfaced roads with an ADT above 500. Dark blue represents districts with an ADT break-even point of less than 0 ADT. In those districts, based on the costs used and the simulations run, there is no cost benefit to having

Table 3. Example of Effect of ADT on Annual Maintenance Cost for a Surfaced and Un-Surfaced Roadway.

Location	Un-Surfaced Annual Cost					Surfaced Annual Cost
	ADT @ 100	ADT @ 200	ADT @ 300	ADT @ 400	ADT @ 500	~
Zone 6 - Texas	$6,115.51	$6,437.38	$6,920.18	$7,402.98	$7,724.85	$6,276.44
Zone 1	$6,598.31	$7,081.11	$7,402.98	$7,885.79	$8,207.65	$6,437.38
Zone 2	$4,184.29	$4,506.16	$4,988.97	$5,471.77	$5,793.64	$6,115.51
Zone 3	$4,988.97	$5,471.77	$5,793.64	$6,276.44	$6,759.24	$6,115.51
Zone 4	$5,954.57	$6,437.38	$6,759.24	$7,242.05	$7,563.92	$5,954.57
Zone 5	$8,529.52	$8,851.39	$9,334.20	$9,817.00	$10,138.87	$6,276.44

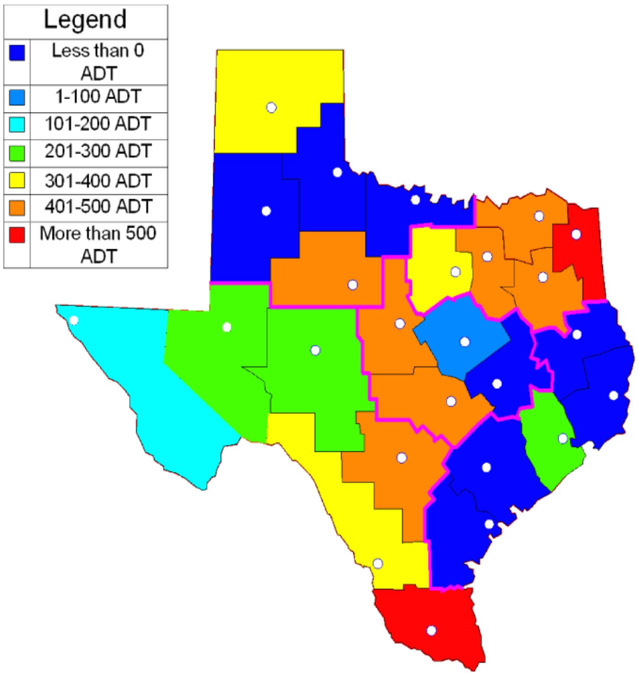

Fig. 4. Break-Even Point by District in Texas.

an un-surfaced road over a surfaced road. The heavy pink lines distinguish the climate zones.

The last sheet created in the workbook was for the ADT analysis:

- ADT Analysis – Lists the state, climate zones, and each district, as well as all relevant information for maintenance and conversion. Using the calculated break-even points, and ADT information provided by TxDOT, the research was able to determine how many miles are eligible for conversion (based on those break-even points) in Texas. Additionally, the costs to maintain un-surfaced at 0-100, 101-200, 201-300, 301-400, and 401-500 are given for the state, climate zones, and each district, as well as maintenance cost information for a surfaced road. After the calculated maintenance costs are given, the conversion costs as calculated for the state, climate zones, and districts are given for both surfaced to un-surfaced and un-surfaced to surfaced conversion.

This provides for cost information for each individual activity, but the purpose of gathering the data is to evaluate the big picture. One situation is given below, with many more potential situations able to be addressed because the data has been gathered and is in one place.

Situational Example

The goal of this project was to establish a methodology for examining the costs to convert, maintain, reconvert, and maintain a section of roadway. That goal was met, as conversion and maintenance costs were established. However the costs alone do not provide the whole picture, so the costs gathered were applied to a situation in order to examine their meaning.

The Situation

One surfaced lane mile in Texas, at ADT 100 (below the break even ADT 150), is under consideration for conversion to un-surfaced roadway. (All maintenance costs used are based on the HDM-III simulations).

Scenario 1

The roadway is converted. The cost to convert from surfaced to un-surfaced is $7,649. The annual cost to maintain one mile of un-surfaced roadway is $6,116. The annual cost to maintain one mile of surfaced roadway is $6,276, which is a savings of $161 per year per mile in maintenance with un-surfaced. When the cost to convert is divided by the savings per year resulting from the conversion, it would take 48 years for the conversion to pay for itself.

Scenario 2

The roadway is converted, and then needs reconversion at some point. The initial cost to convert one mile from surfaced to un-surfaced is $7,649. The cost to reconvert one mile from un-surfaced to surfaced is $106,771. Together, that is a total conversion cost of $114,420. Just like in Scenario 1, the difference of the two annual maintenance costs per mile is $161. To break-even on the un-surfacing then reconversion of one lane mile in Texas, that reconversion would have to take place at least 711 years after the initial conversion to un-surfaced. In other words, it takes 711 years of saving $161 per year to pay for the reconversion from un-surfaced to surfaced.

Scenario 3

The roadway is left as is. No conversion takes place, and the cost to maintain one mile of surfaced roadway is $6,276 per year. The savings in this scenario is in the money not spent on conversion, especially reconversion (a total of $114,420 per mile).

The scenarios above illustrate the need to examine the long-term situation of the road and area under consideration, and draw attention to the importance of the consideration of the high conversion rates. It also demonstrates how growth, or a rise in ADT, can have a dramatic impact on the ultimate savings goals of un-surfacing a roadway. These numbers seem extreme, which underscores the need to examine these situations with real material costs and projections.

Conclusions

The break-even point for the state of Texas as a whole is ~150 ADT. Beyond 150 ADT, it is more cost effective to maintain a surfaced road than an un-surfaced road. However this number can be deceptive, as it varies greatly by district, and each district needs to be looked at on an individual basis for decision-making purposes. Additionally, further analysis should be done which takes into account the higher impact of heavy-truck traffic on both types of roads.

The ADT break-even point for maintenance costs is driven mostly by material costs. This is not surprising, as labor and equipment should be relatively similar across districts. Further, it is recognized that each district likely has a preferred engineered specification for both types of roadway. In order to fully understand how much of an impact the materials cost has on each district, individual analyses of each district would need to be done that take into account the normal engineered specification for un-surfaced roads, including the correct quantities of the preferred materials for each separate district. Due to time and access constraints, this project utilized one particular material for each maintenance and conversion activity for all districts, as opposed to the preferred or normal material for each district. The methodology presented here can be used by any agency in any location as a basis for evaluating any low-volume roads under their control. Even though the average break-even ADT for the state is ~150, in the Atlanta and Pharr districts, it was much higher. Individual districts, as well as small towns, counties, and others responsible for low-volume roads know their growth projections, areas where that growth will occur, and preferred materials, actual local pricing, equipment, and labor rates. Knowing this information and their options allows road agencies to make the best decisions regarding the assets they are managing, and could eventually save everyone money, from the agency itself to the travelling public who use the roads.

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