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Tight Budgets and Roadway Maintenance: The Need for Further Study of the Conversion/Reconversion Scenario for Low-Volume Roadways

예산 및 도로 유지관리 : 저교통량 도로의 포장 변경을 위한 추가연구의 필요성

Kim, Hyun Hwan 김현환 | Texas State University · Graduate Research Assistant (E-mail : k_h82@txstate.edu)
Evan Humphries | Texas State University · Research Associate (E-mail : ec1149@txstate.edu)
Jiong Hu | Texas State University · Associate Professor (E-mail : Jiong.Hu@txstate.edu)
Lee, Soon Jae 이순제 | Member · Texas State University · Associate Professor (E-mail : SL31@txstate.edu)
Lee, Moon Sup 이문섭 | Member · Korea Institute of Civil Engineering and Building Technology · Senior Researcher
Corresponding Author (E-mail : truepath@kict.re.kr)

ABSTRACT

PURPOSES : This paper presents a description of the current issues facing road managers regarding the surface-type conversion of low-volume roads for cost savings.

METHODS : The paper reviews previous works conducted toward this end, acknowledges gaps in the current research, and lays out what information is needed for further studies.

RESULTS : If the cost to maintain an unsurfaced road is less than the cost of maintaining a surfaced road, then there is potential for cost savings for the management agency. However, the problem is bigger than simply maintaining the roads that already exist. If unsurfaced roads prove to be more economical than surfaced roads, then the cost to convert from a surfaced to an unsurfaced roadway, and vice versa, when necessary, must also be examined.

CONCLUSIONS : No other studies have addressed the un-surfacing of a road for cost savings, and it is therefore unknown whether substantial savings can be realistically obtained by converting from a surfaced to an unsurfaced road. To determine whether a conversion policy would be a viable option, additional data and research are needed.

Keywords
Low-volume road, Surfaced, Unsurfaced, Conversion, Reconversion, Maintenance, Average daily traffic

Corresponding Author : Lee, Moon Sup, Senior Researcher
Korea Institute of Civil Engineering and Building Technology,
283, Goyangdae-ro, Ilsanseo-gu, Goyang-si, Gyeonggi-do, 411-712, Korea
Tel : +82.31.9100.690 Fax : +82.31.9100.161
E-mail : truepath@kict.re.kr

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1. 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 (Etter, 2010; Rajala, 2010). 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 (Etter, 2010).

Part of the issue can be explained by the continued migration of people to urban areas (Smadi, Hough, Schultz, & Birst, 1999). Roadways are paved based on several factors, and the amount of average daily traffic (ADT) is one of them. Users prefer paved roads, they are more comfortable to drive on. They are also more expensive to maintain. Around the country, the conversion of paved to un-paved roads is based on the theory that different types of road surfaces can be used effectively based on the specific scenario to save cost over time in maintenance. The Context Sensitive Roadway Surfacing Selection Guide (Maher, Marshall, Harrison, & Baumgaertner, 2005) was developed by the Federal Lands - Highway Division of the Federal Highway Administration (FHWA), and gives a comprehensive overview of road surfacing options. The goal is "to present the widest possible range of surfacing alternatives, including those which are not commonly used, to maximize the effectiveness of the selection process as a tool for identifying the optimum surfacing for a particular project, based on the specific project's conditions and needs" (p. 2).

Much more known in the transportation field, the opposite is also happening: roads are being upgraded to surfaced from gravel (Jahren, Smith, Thorius, Rukashaza-Mukome, White, & Johnson, 2005). As populations shift and grow in certain areas, roads that once were sufficient for their level of use need to be upgraded to accommodate additional traffic. In this case, the savings in maintenance may be in having paved roads. However, it is important to keep in mind the potential maintenance cost savings must be balanced with the cost to convert. These costs are different for every state, county, and region.

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" describes the current interest from TxDOT in improving their maintenance policies, specifically those that pertain to surfaced roads. It then develops hypothetical conversion and maintenance plans for a given situation and applies real costs to estimate base-line costs. Road deterioration modeling program HDM-III is used to evaluate the maintenance costs over a 25-year analysis period and generate yearly maintenance costs based on real data. ADT was identified as the most important factor. Conversion was found to be a viable option in some places, but due to high reconversion costs presents risks that must be examined thoroughly before action is taken. More information and some of the results are presented as a case study.

2. METHODOLOGIES

2.1. HDM-Ⅲ

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. There are currently two versions of the HDM program, HDM-III and HDM-4. These models are the most widely used deterioration models for unsealed roads as well as for sealed roads internationally. While the HDM-4 model is the most recent, it is also more detailed than the previous version, HDM-III. This study will utilize HDM-III, as it is available for free download (and thus available to any agency, regardless of budget) from the World Bank website at:

http://www.worldbank.org/transport/roads/rd_tools/hdm3.htm

HDM-III is a road deterioration-modeling program based on costs:

"Three interacting sets of costs are added together over time and discounted to present values. Costs are determined by first predicting physical quantities of resource consumption which are then multiplied by unit costs or prices. The cost factors considered in the model are highway construction and maintenance costs and road user costs" (Haas, Hudson, & Zaniewski, 1994, p. 495-496). This program was initially developed based off on the results of four studies, conducted between 1973 and 1982 and included:

- Kenya study (Abaynayaka et. al., 1977): Develop relationships for road deterioration and road user costs
- Caribbean study (Morosiuk & Abaynayaka, 1982): Compared road geometry effect on vehicle operating costs
- India study (CRRI, 1982): Investigated operational concerns on Indian roads.
- Brazil study (GEIPOT, 1982): Validated previous model relationships.

In order to assist in the appraisal of road investments, the World Bank initiated these four studies specifically to develop road deterioration models to evaluate what effect construction and maintenance activities had on road user costs on LVRs. Drawing on the above research, the World Bank developed a comprehensive deterioration model in 1987 and adapted it for use with the personal computer in 1995. This model, known as HDM-III, was the primary model until 2000. In 2000, the World Bank updated the model to reflect state of the art practice to the HDM-4 model with additions and updates. This model is not necessary for the assessments required by this study. HDM-III can analyze up to 30 years, and allows road managers to evaluate multiple options quickly, to see what the

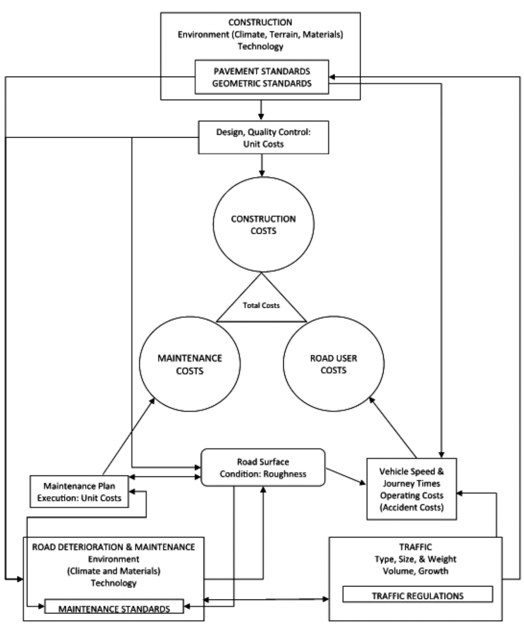

Fig. 1 The HDM model : Interaction of costs and road construction maintenance and use (Watanatada, Harral, Paterson, Dhareshwar, Bhandari, & Tsunokawa, 1987)

most cost-effective, long-term solution might be. Overall, the model is to assess costs as compared to performance, and offers the results 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 (Haas et al, 1994). Figure 1 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.

Previous studies have examined when it is cost effective to convert a road from gravel to paved, and others have examined when it is cost effective to convert a road from paved to gravel. However, no study was located that examines the conversion-reconversion scenario.

2.2. Low-Volume Roads

Definition and Uses. Behrens (1999) defines a low-volume road as those in a rural environment that enable automobile operation and account for less than 500 vehicles per day. Other studies that have addressed the issues involved with LVRs consistently place the high-end ADT for a low-volume road at somewhere around 400-500 ADT (Jahren, et al, 2005; Maher et al, 2005). TxDOT defines "low volume" as 0-500 (TxDOT, 2011). For the purposes of comparative research, it will be important to have an agreed upon definition of a LVR. LVRs are often rural roads with sporadic residences or large agricultural businesses (dairy, beef, etc.), who are the only groups needing access to the roads. Unless the residents are vocal enough, or the business important enough, these roads generally receive only minimum maintenance (Smadi et al, 1999). With agencies looking to save every penny they can, it is worth it to ask what surface type is the most cost effective for a low-volume road.

There is a relationship between road deterioration and the ADT of that road. As traffic goes up, the road will deteriorate more quickly. One study found that as ADT goes up, higher standards become more cost-effective (Memmot & Hanks, 1992). Paved roads have higher standards for construction, as they are intended for higher levels of traffic. Gravel roads typically have lower standards than paved roads, in terms of design and materials. This indicates that at low ADT, gravel may be a cost-effective option, which is consistent with what has been observed nationally. Other options addressed in literature include paving gravel roads with high ADT, use of chemical additives to improve gravel performance, reduction of maintenance of low-volume gravel roads, and closing of unnecessary gravel roads (Smadi et al, 1999).

Surfaced Type Roads. There are many types of agencies involved in maintaining bituminous pavements. For comparative research purposes, "surfaced" will require definition, as it can be defined by different agencies different ways. However, when LVRs are paved, the bituminous surface is usually less than 40 mm and does not contribute significantly to the structural capacity of the pavement (Pidwerbesky, Steven, & Arnold, 1997). This is in contrast to paved roads in which the asphalt acts as a structural agent of the road, or compromises a significant portion of the roadway surface.

Typically, surfaced low-volume roads do not benefit from the advanced pavement design afforded to high volume roadways. One study elaborates, "Long-life pavements are often associated with high traffic volume facilities, and in such situations, perpetual pavements make good engineering and economic sense" (Timm, Newcomb, & Selvarai, 2006). Zimmerman & Wolters (2002) reinforce this concept: "On higher volume paved roads…decision-making has evolved into a fairly sophisticated process done under the framework of a pavement management system (PMS)", but that for LVRs "the decision making process is very different. Most local governmental units do not use the same decision tools to help them with the maintenance and rehabilitation decisions made in conjunction with a PMS."

Maintenance of Surfaced Type Roads. In Texas, surfaced roads are maintained according to the Texas Department of Transportation Seal Coat and Surface Treatment Manual (2010). Based on this manual, typical maintenance of a surfaced road consists of the application of a seal coat (specifically chip seal) every seven years on average. The cost to perform this maintenance is rising, and every year, agencies are doing less with the same amount of money (Farkas, 2010). The typical maintenance for a surfaced type road involves one layer of seal coat and one layer of aggregate (a chip seal), and pothole patching as necessary (Webb, 2010). Currently, Texas uses chip seals as a maintenance method for surfaced roads experiencing superheavy load moves, but has had problems with the treatment failing. A study in 2011 found that it could take weeks for a seal coat applied as maintenance to be ready for heavy traffic loads, heavy traffic before the seal coat had completely cured could cause failure (Oh, Chen, Walubita, & Wimsatt, 2011). TxDOT and other agencies do not have the ability to shut down entire roads for weeks at a time.

TxDOT is doing what they can to accommodate the changes, but still, "The statewide percentage of lane miles in "Good" or better condition dropped slightly from 86.97 in FY 2010 to 86.66 in FY 2011. Most of the statewide drop is mainly because of the ongoing extreme drought condition and increased oilfield development traffic" (TxDOT, 2011, p. iv). This is further supported by the PMIS conclusions that "Overall Pavement condition in Texas got slightly worse in FY 2011 because of decreased ride quality and increased distress on asphalt pavements… FM roads got worse in all categories…[and] Asphalt Concrete Pavement (ACP) got worse in all categories" (TxDOT, 2011, p. ii). If a surfaced roadway is under continual low volume conditions, it may be more cost effective to use an unsurfaced road instead.

Un-Surfaced Type Roads. For the purposes of comparative research, "un-surfaced" will need to be defined. For TxDOT project 0-6677, it was defined as a road with a surface course consisting of aggregate not held together with any binder (such as tar or bitumen), or chemical additives (such as lime or cement). Gravel roads are generally the lowest service provided to the traveling public and are widely regarded by the public as inferior to paved roads (Etter, 2010; Farkas, 2010; Rajala, 2010). It should be noted here that TxDOT does not control any mileage that is unpaved, all low-volume roadways managed by the agency are surfaced. Generally, unpaved roads are managed at the county level.

Un-surfaced roads have several issues associated with them. If placed on slopes, or near water, erosion can be a big problem with maintaining the surface. Additionally, un-surfaced roads create dust that can suffocate crops planted close to the roadway. If that dust or aggregate makes its way down slope or into waterways, it can become sediment in the water. If that sediment builds up over time, it can block or redirect those waterways (Gesford & Anderson, 2006).

Maintenance of Un-Surfaced Type Roads. The major maintenance activities of a gravel or un-surfaced road are typically regular blading. Worldwide, after construction, LVRs are typically selected for maintenance utilizing a "worst-first policy," (Veeraragavan & Krishna, 2011). This results in only the very worst roads being repaired, while allowing other roads to deteriorate to that point by ignoring them. It is a cycle of disrepair which does little to actually decrease the problem. Despite this continuing practice, attempts to decrease the costs of maintaining LVRs and to increase the sophistication by which such roads are managed have been ongoing for more than 20 years. In 1991, Anderson & Session developed a mathematical formulation for management of intermittent roads, which are roads that experience short periods of use and long periods of little or no use. Skorseth & Selim (2000) produced Gravel Roads: Maintenance and Design Manual that provides design and maintenance guidelines for gravel roads in a frequently referenced document. More and more studies aimed at improving decision-making and maintenance practices find treatment in the literature (Veeraragavan & Krishna, 2011; Huntington & Ksaibati, 2011; Douglas, 2011; Kivilands & Strezs, 2011; Mladenovic, Cirilovic, & Queiroz, 2011; Chamorro & Tighe, 2011; Reddy & Veeraragavan, 2011). Of particular importance to anyone involved in the maintenance of un-surfaced roads are four manuals listed below (in chronological order):

- Gravel Roads Maintenance and Design Manual: geared toward maintenance officials. (Skorseth & Selim, 2000).
- Low-volume Roads Engineering: Best Management Practices Field Guide: geared toward constructors and designers. (Kellar & Sherar, 2003).
- Environmentally Sensitive Maintenance for Dirt and Gravel Roads: geared toward constructors and designers. (Gesford & Anderson, 2006).
- Unsealed Roads Manual: Guidelines to Good Practice: geared toward network managers (Giumarra, ed., 2009).

Blading is the most common maintenance activity for use on un-surfaced roads. The timing and frequency of blading is the most important aspect of un-surfaced road maintenance and as such many strategies have been considered and many attempts to model the practice have been undertaken. Authors have attempted to establish general guidelines for gravel road maintenance. However, in one study, it was concluded that due to the complexity and numerous variables involved in maintenance needs of un-surfaced roads, the generalizations required for an optimization model are not as effective as a process that utilizes the local knowledge of maintenance professionals (Burger, Henderson, & Van Rooyen, 2007). However county officials were not found to maintain good records, a situation that is reinforced elsewhere (Rukashaza-Mukome, Thorius, Jahren, Johnson, & White, 2003). It is understood that each agency will have their own process regarding the maintenance of un-surfaced roads.

2.3. Conversion

Definition. As the name would suggest, conversion is the changing from one surface type to another. However, the process will be different for the conversion due to both deteriorating road conditions and lack of funding sources to rehabilitate those roads. Benzie County, in Michigan, converted several road segments to gravel in the past few years. Only roads that were considered failed and unsafe to drive on were candidates for conversion. Other factors included cost savings as a result of the conversion and the very low vehicle per day counts on sections of the road (CTC & Associates, 2010). The cost of road maintenance and the cost of the upgrade are necessary inputs for the decision. It is generally understood that the cost of maintaining a gravel road increases with the traffic volume. As traffic volume increases, the road becomes rougher more quickly and this necessitates more frequent surface smoothing with road graders. Also, more gravel is thrown off the road or blown away as dust, necessitating more gravel replacement (Jahren, 2005).

The ultimate goals of conversion one way or the other are cost savings and usability. The challenge is that the usability of the road needs to be better after the conversion, with less money spent to maintain it that way. Over time, roads that were built to standards of the time have become deficient, and need to be redesigned and brought up to current standards. This creates a funding issue, and if the goal of the conversion is to save money, how is an agency to know of the conversion is worth it? In examining upgrades to standards requirements for FM Highways in Texas, one study found that for roads with less than 750 ADT, the cost involved with redesigning the road meant upgrading was not a cost-effective option (Memmot & Hanks, 1992).

Converting from Un-Surfaced to Surfaced. Agencies experientially determined that at certain traffic volumes, un-surfaced roads will deteriorate at a pace that makes maintenance cost prohibitive. Therefore, studies were commissioned beginning in the late 1970's to determine the optimal time to upgrade an un-surfaced road to surfaced (Bhander, 1979; Reckard, 1983; Luhr & McCollough, 1983; Kentucky Transportation Center, 1988).

More recently, Departments of Transportation in South Dakota (Zimmerman & Wolters, 2002) and Minnesota (Jahren et al., 2005) have examined the economics of surface upgrades. Despite extensive literature review and interviews of national stakeholders in un-surfaced roads, no studies examining the reversion of surfaced roads to un-surfaced roads has been found. From the literature, the conversion threshold whereby it becomes more economical to pave an un-surfaced road will occur between 100 and 200 vehicles per day.

Clemmons & Saager's 2011 study found that the break-even point for upgrading from an un-surfaced road to a chip sealed road occurs at just under 200 vehicles per day but recommends that chip sealing any road with more than 145 vehicles per day as the most cost-effective practice. These results look at agency costs as well as user costs, which they place at $0.10 per mile per car savings on a surfaced road over an un-surfaced road.

The conversion of un-surfaced low-volume roads to surfaced has been a topic of research for some time. The first study that could be found on this topic was a 1979 report by Bhander that evaluated the effect of timing and opportunity costs of paving a road. In 1983, an FHWA Report by Reckard concluded that there are some gravel roads that should never be upgraded to a surfaced road. In 1988 the Kentucky Transportation Center developed 10 questions to guide decision makers through the consideration of paving an un-surfaced road. This study also summarized the purpose fueling such considerations:

"The decision to pave is a matter of trade-offs. Paving helps to seal the surface from rainfall, and thus protects the base and subgrade material. It eliminates dust problems, has high user acceptance because of increased smoothness, and can accommodate many types of vehicles such as tractor-trailers that do not operate as effectively on un-surfaced roads. In spite of the benefits of paved roads, well-maintained gravel roads are an effective alternative. In fact, some local agencies are reverting to gravel roads.

Gravel roads have the advantage of lower construction and sometimes lower maintenance costs. They may be easier to maintain, requiring less equipment and possibly lower operator skill levels. Potholes can be patched more effectively. Gravel roads generate lower speeds than paved surfaces. Another advantage of the unpaved road is its forgiveness of external forces. For example, today vehicles with gross weights of 100,000 pounds or more operate on Kentucky's local roads. Such vehicles would damage a lightly paved road so as to require resealing, or even reconstruction. The damage on a gravel road would be much easier and less expensive to correct.

There is nothing wrong with a good gravel road. Properly maintained, a gravel road can serve general traffic adequately for many years.”

In 1983 Luhr & McCullough used a design and management program to predict the appropriate timing for conversion. After these studies, Zimmerman and Wolters were the next to tackle the question in 2002. In lieu of these aforementioned studies, Zimmerman and Wolters (2002) concluded that, “while there is substantial documentation on decision making for paved roads, there is a lack of guidance on maintaining, rehabilitating and determining appropriate surface types for low-volume roads.” After the 2002 study, several more studies, including those listed above, have increased the available documentation on the decision of surface conversion yet a hesitancy to generalize findings to local conditions have resulted in continued interest in funding studies of this nature. Additionally, most of these studies have looked at the economics of upgrading an un-surfaced road to a surfaced road.

Alternatives to the costly asphalt cement materials conventionally used in HMA have been sought as surfacing options. One of these alternatives is asphalt-treated mixtures (ATM). These mixtures consist of crushed rock or natural gravel mixed with low percentages (2.5% - 4.5%) of paving-grade asphalt cement (Rostron et al., 1971). Often, substandard materials that would not be acceptable for use on higher volume roads are considered for use in LVR. Bhusal, Li, and Wen (2011) found that using recycled-concrete aggregate (RCA), being a low quality aggregate, may be a good option for constructing LVR because LVR experience fewer equivalent single-axle loads as compared with interstates or highways.

The methodology differs, but TxDOT provides general guidelines regarding what an upgrade might look like: “A surface treatment is placed on a crushed stone base to provide a roadway with the least expensive permanent type of bituminous surface. It seals and protects the base and provides strength at the road surface so that the base can resist the abrasive and disruptive forces of traffic” (Webb, 2010). Other states have reported similar processes when converting a gravel road to a surfaced road for residential areas (Etter, 2010; Rajala, 2010).

Converting from Surfaced to Un-Surfaced. A newer consideration is the conversion of a surfaced road to an un-surfaced road. Clemmons & Saager (2011) discuss a situation in which inadequate funding necessitated the reversion of 10 miles of LVR from chip seal to gravel roads that was supported by local officials and transportation plans. Despite the fact that the sealed road was in terrible condition, the conversion to gravel was “very unpopular” with residents. This sentiment is echoed throughout the literature.

The methodology for converting a surfaced road to an un-surfaced road typically involves the use of a rotary mixer to grind up the top layer of asphalt, followed by a roller to compact it down to the driving surface (Etter, 2010; Shearer & Scheetz, 2011). Additives can be used when needed, though the necessity depends on the conditions of the material and environmental factors of the individual roadways. In a 2011 case study, conversion via full depth reclamation of asphalt pavement using a mixer, utilizing additives, and shaped by a motorgrader followed by compacting roller was the preferred method for improvements to a road in Pennsylvania (Shearer & Scheetz). Full depth reclamation “is a pavement rehabilitation technique in which the full flexible pavement section and a predetermined portion of the underlying materials are uniformly crushed, pulverized, or blended, so that a stabilized base course results; further stabilization may be obtained through the use of available additives” (Full Depth Reclamation Technical Subcommittee of the Committee on Recycling Education, 2011). However, upon evaluation of the roadway in the case study above, it was determined that due to the instability of the substructure of the road, for additional stability, the project would utilize geotextile fabric (Shearer & Scheetz, 2011). The use of geotextiles, additives, and added recycled materials are all available options when planning conversion (Johnson, 2008). This illustrates both the numerous options available in conversion, as well as the unexpected issues that may arise during the planning and construction process.

Evaluation of Conversion Options. Previous studies have addressed converting from surfaced to un-surfaced, and from un-surfaced to surfaced, and there is a general indication that ADT is a large contributing factor to maintenance costs, due to it being a major deterioration factor on low-volume roadways

(Gupta, Kumar, & Rastogi, 2011; Jahren et al, 2005; Smadi et al, 1999). Other deleterious factors include weather, in situ soil conditions, and other environmental impacts. The external factors that have an impact on the life of the roadway, combined with the issues related to design/materials/construction, mean that in order to evaluate the most cost-effective surface choice for a given project, the life-cycle cost of the surface should be examined.

Jahren et al (2005) and Zimmerman and Wolters (2004) both developed models that took life-cycle cost into consideration when determining if conversion was a viable option. In his study of Saudi Arabian low-volume urban roads, Mubaraki (2012) uses a pavement deterioration modeling (PDM) program to analyze the roadways, recommending maintenance for surfaced roads as opposed to conversion. The general nature of this research lends itself to utilizing an already existing program, rather than creating a new one to evaluate only Texas roads. One popular program being used is HDM-III.

3. RESULTS and DISCUSSION

3.1. Texas Roadways: An Example

In Texas, there is always a Pavement Management Plan (PMP) in place to manage the pavements under TxDOT's purview. The goal is to increase all pavements in the state to an average of 90% or better by 2012 (TxDOT, 2011). To accomplish this, they utilize a Pavement Management Information System (PMIS) into which scores for various categories are entered. These scores are for things such as distresses (ruts, cracks, potholes, failures, etc), ride quality (smoothness), and condition (a mathematical combination of distress and ride quality), as well as the various types of roads. This includes interstate highway (IH), state highway (SH), and farm-to-market (FM) highways with asphalt concrete pavement (ACP), continuously reinforced concrete pavement (CRCP), and jointed concrete pavement (JCP) type pavements.

In FY 2008, for flexible pavements in Texas, overall seven of the eight ACP distresses got worse, and three of the four "deep" distresses got worse. TxDOT states, "Continued increases in pavement material costs also affected flexible (asphalt) pavements by reducing the amount of mileage that could be resurfaced with existing maintenance and rehabilitation budgets…" (TxDOT, 2008, p. 119). This prompted a new urgency, and starting in 2008, TxDOT required each district to come up with a four-year pavement plan. For FY 2011, four years after the maintenance plan implementation, FM roads (the most likely to be low-volume) got worse in all categories, and ACP surfaced type roads got worse in all categories. However, one of the interesting tables is presented near the beginning of the report.

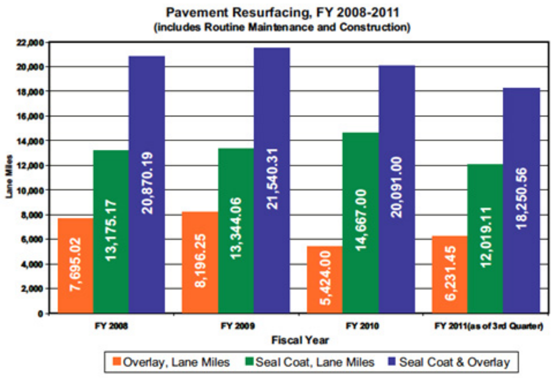

Fig. 2 Pavement Resurfacing, FY 2008-2011 (TxDOT, 2011)

Figure 2 shows the number of miles that were treated for routine maintenance and construction. In FY 2010, where 14,667 miles were seal coated, noticeably more than in FY 2008 (13,175.17) or FY 2009 (13,344.06), and certainly more than in FY 2011 (12,019.11). This is explained by TxDOT, "Additional savings were achieved in summer 2010 from lower unit bid prices and innovative processes. These savings allowed TxDOT to treat more mileage with the same amount of money, which helped reduce the amount of observed pavement deterioration" (TxDOT, 2011, p. V). Money is very much an issue when it comes to treating flexible pavements in Texas.

Texas' population is expected to increase to 17 million by 2030, and an increase in population means an increase in transportation needs, and thus an increase in transportation related costs. Some areas will experience heavy growth, while others will continue to dwindle in population. Also of interest to TxDOT and other agencies that maintain the roads is how industry growth effects road planning. The energy industry is causing growth in rural areas while developing natural energy resources, causing towns to develop over very short periods of time. This necessitates road conversion to handle the influx of traffic, or increased maintenance to keep surfaced roads not designed for high traffic loads from falling into disrepair. It begs the question: can these agencies transportation dollars be better spent?

A study recently conducted in Texas (TxDOT Project No. 0-6677) attempts to answer this question (Humphries et al, 2014). Maintenance and conversion costs were determined with the assistance of the agency, and a hypothetical scenario was developed. Data included below is pulled from that study.

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 computer simulations run in this project.

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, 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).

Based on the results of that study, it was determined that the issue of conversion based on a given road's ADT was not a sufficient criteria for deciding if conversion was a viable option. The location of the road, material costs, and growth predictions all need to be considered. With energy resource management (including operations involving natural gas and oil) underway in so many states, the possibility that a road may be converted for one reason, then need to be reconverted, is very real.

Visual description from surfaced to un-surfaced roadways can be found in Figure 3.

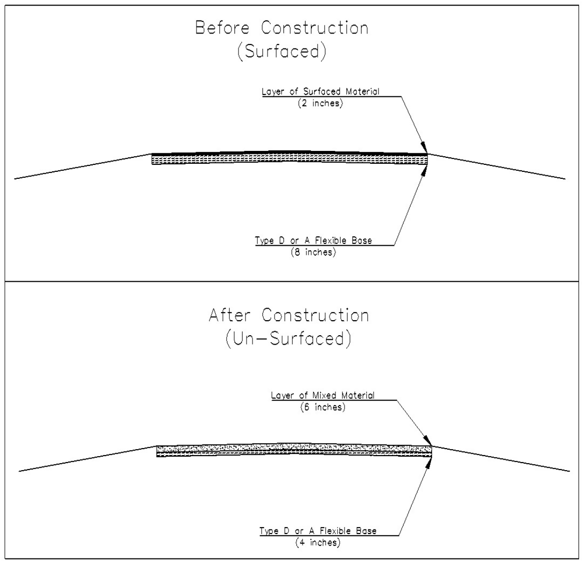

Fig. 3 Surfaced to Un-surfaced Visual Description (Humphries et al., 2014)

3.2. National Need for Examination

The FHWA reported that 70% of the roads in the United States, a full 3 million miles, are low-volume roadways, yet they carry only 15% of the nation's traffic (FHWA, 1992). With such a large number of lane miles serving such a small percentage of the nation's traffic, it is critical to implement the most efficient maintenance strategies available and to seek out even more efficient strategies for these roads.

In 2007, 36% of the publicly owned roads in the United States were classified as unpaved roads (FHWA, 2008). That statistic would mean that of the 70% of the roads in the United States that are classified as LVR, just over half of them are un-surfaced roads. The even division of surfaced and un-surfaced roads among LVRs means that agencies in charge of maintaining these roads must have in depth knowledge of two quite different surface types in order to adequately maintain their full network.

4. CONCLUSIONS and RECOMMENDATIONS

If the cost to maintain an unsurfaced road is less than the cost of maintaining a surfaced roadway, then there is potential for agency cost savings. However, the problem is bigger than just maintaining what already exists. If unsurfaced proves to be a more economical surface type, then the cost to convert a roadway from surfaced to unsurfaced, and back when necessary, must also be examined.

Before it can be determined if surfaced or un-surfaced is a more economical option, the ADT "break-even" point for a low volume road (the level at which it costs the same amount to maintain a surfaced and an unsurfaced road) must be determined. This can be found by examining the average daily traffic and its impact on road maintenance costs. It is important to keep in mind that maintenance is only half of the picture. Before a road can be maintained at it's optimum surface type, conversion may be necessary to change the surface. This process will have agency cost associated with it.

It is widely known that costs across different regions of Texas can vary greatly when it comes to transportation construction needs. This will hold true throughout the nation as well. Proximity to resources, as well as the availability of equipment and labor, all have an impact on conversion construction costs and maintenance costs. It is important that research looks at the whole picture, and so conversion from surfaced to un-surfaced should be examined, as well as conversion from un-surfaced to surfaced. The maintenance costs for both types of roadways will also need to be analyzed.

Since no other studies have addressed the un-surfacing of a road for cost savings, it is unknown if substantial savings can realistically be obtained by converting a road from surfaced to un-surfaced. In order to determine if a conversion policy is a viable option, more data and more research is needed.

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