

Improving Network Investment Results by Implementing Competition and Asset Management in the Pavement Type Selection Process

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Abstract

The US spends an estimated \$91 billion on US highways every year, with most pavement expenditures going to maintenance of the existing system. However, congestion is a major issue. It is estimated that congestion leads to 5.5 billion wasted hours and 2.9 billion gallons of wasted gas, costing \$121 billion annually. Expansion of the system is needed, but current funding streams are not even able to keep up with maintenance needs. The primary approach to address this challenge has been to increase funding. While this is needed, agencies also need to improve the efficiency of their roadway investments to get more out of their pavements. This can be accomplished in two ways. First, agencies can increase competition in the pavement bidding process. Basic economics confirms that when there is competition among many contractors and across paving industries, the average unit prices for pavements are lowered significantly. The second way is to improve the management of the pavement assets to increase the average life of the network. A longer life network, though it may initially cost more, has a larger return to both the agency and the driving public in reduced expenditures and congestion. This paper will show how agencies can improve the pavement network investment efficiency using these two items.

Introduction

Roadways and pavements play a vital, but underappreciated role in our nation's economic competitiveness. According to the US Department of Transportation (USDOT), outlays from the highway trust fund in the last 10 years amount to roughly \$360 billion (FHWA, 2012). This excludes the roughly \$27.5 billion provided in the American Recovery and Reinvestment Act of 2009. The current U.S. surface transportation authorization law (Moving Ahead for Progress in the 21st Century, or MAP-21), authorized almost \$41 billion in fiscal year 2014 for highway and bridge improvements. Still, federal investment only accounts for about 45% of total highway investments – state and local investments account for the other 55%. This means that the US spends roughly \$91 billion on highway improvements every year, or nearly a TRILLION dollars every decade.

Despite these enormous outlays, the needs of our aging highway network are rapidly outpacing the available resources. Most pavement expenditures go to

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maintenance of the existing system, but even this is not enough. According the USDOT's 2013 Report to Congress on Condition and Performance of the Nation's Highways, Bridges and Transit (FHWA, 2013), the federal government needs to invest between 20-25% more just to maintain the current conditions and would have to double the investment to make any meaningful improvements in the highway network condition and performance.

All this has led to major congestion on the system. It is estimated that congestion leads to 5.5 billion wasted hours and an additional 2.9 billion gallons of gas of wasted gas, costing \$121 billion annually (Schrank, Eisele, & Lomax, 2012). Expansion of the system is needed, but current funding is not even able to keep up with maintenance & rehabilitation needs. This has put agencies in an untenable position.

Most reports on improving our nation's transportation system focus on increasing the revenues for the current system and improving the maintenance activities to lower expenditures. While this is definitely needed, agencies need to recognize that expansion and new construction is needed to improve capacity of the system to address the issue of congestion. The question is how do we expand? We believe that this can be accomplished in two ways:

1. Introduce more competition into the pavement bidding process. Most paving projects are bid with one material only. Basic economics tells us and analysis confirms that when there is competition among many contractors and across paving industries, the average unit prices for pavements are lowered significantly. This brings value to the agency, allowing more miles of pavement to be paved for the same investment.
2. Improve the management of the pavement assets in order to increase the average "Remaining Service Interval" (i.e. the time to next rehabilitation) of the pavement network. A longer life network, though it may initially cost more, will have a much larger return to both the agency and the driving public in reduced expenditures and reduced congestion. Such a network also frees up needed money, currently used for maintenance / rehabilitation for expansion of the road network, which further improves the competitiveness of the local, state, and national economies.

The Role of Competitions

Now more than ever, given the significant economic restraints, growing infrastructure needs and increased public scrutiny; roadway agencies cannot afford to forgo any opportunity to make infrastructure dollars go farther. As recognized and documented in pavement type selection guidance over the last 50 years, ensuring competition between pavement industries can be a significant contributor in this regard. (AASHTO, 1960; FHWA, 2012) However, an analysis of Bid Data from 2019-2014 shows that currently, well over 90% of all paving projects are bid with one material only (Oman). Competition between industries in the transportation-construction marketplace can help assure the highest return on investment of taxpayer dollars by driving down costs and fostering innovation because it brings additional contractors and suppliers to the market (Figure 1). While competition among contractors that construct a single pavement type does provide some of these benefits; there is an additional level of competition when there is

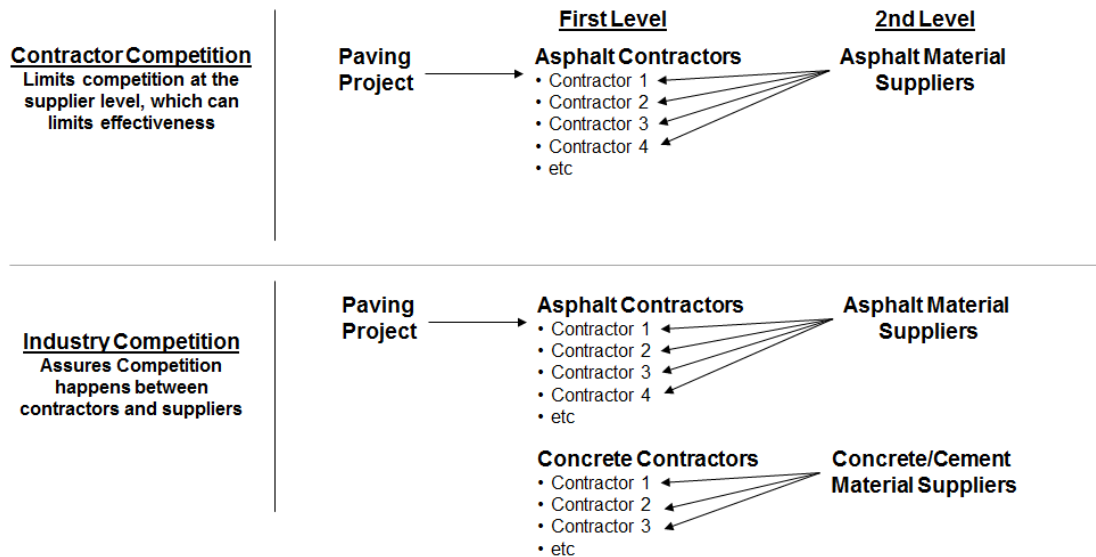
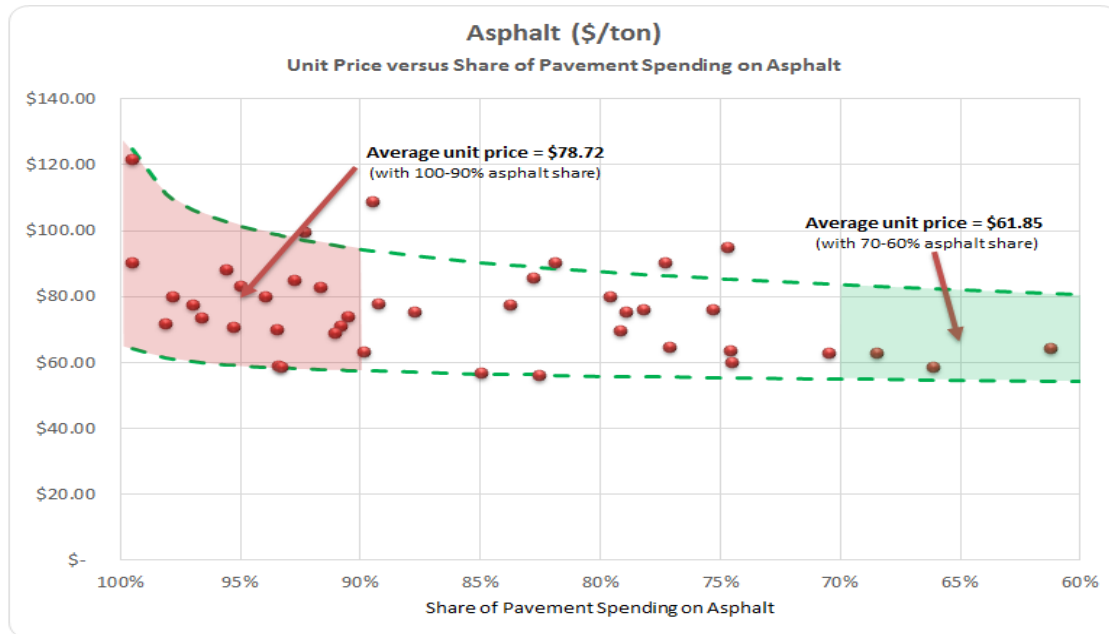


Figure 1. How competition between paving industries adds another level of competitive that is not achieved where only one pavement material is used.

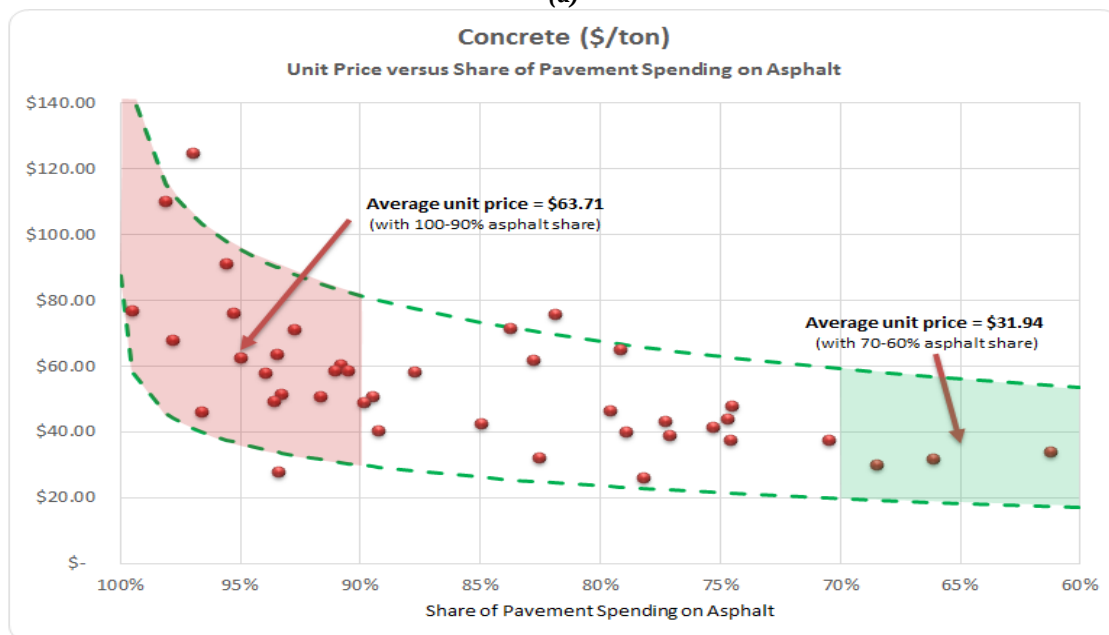
competition between different pavement industries. Such industry competition does not occur where only one pavement material is used regularly or exclusively.

To illustrate how this applies in today's highway and pavement sectors, Figure 2 was developed using publicly available highway agency bid information from Oman Systems . Oman Systems provides construction cost data from web-posting of bids submitted on state DOT highway construction contracts. The database contains historical bid tabulation data for 45 states starting from the mid-1990's to 2000's with the exact start date varying from state to state. As new data becomes available each month, Oman system processes each state's data and updates the information (Oman). Figure 2 shows the average five-year state unit cost price for asphalt and concrete pavements vs the share of market spending of asphalt, which is used as a proxy for competition. The dotted lines represent the 5 and 95th confidence interval of the unit cost for the various competition levels.

The primary item to note is that when competition between the pavement industries increases (as indicated by a decreasing share of asphalt pavement spending), the average unit costs for both concrete and asphalt pavements drop. Several other things can also be concluded. First, no state spends less than 60% of its paving dollars on asphalt pavements and the majority spend more than 85% of their paving dollars on asphalt pavement. In fact, several states spend virtually all of their pavement dollars on asphalt pavements, meaning that there is no diversification in their pavement investment portfolio (an effective pavement type monopoly). Secondly, there is clear trend toward lower unit prices for both asphalt and concrete when the share of pavement spending for asphalt versus concrete decreases from 100% to 60%. In addition, the variability in the unit prices for both materials decreases with increasing levels of competition. Finally, and most importantly, the average five-year state cost data confirms that states that use both pavement types (asphalt and concrete) get a bigger “bang for the buck” than states that use primarily one pavement type. It is also important to note that the States with



(a)



(b)

Figure 2. 2013 weighted unit costs vs. five-year average balance of DOT pavement type usage for asphalt (a) and concrete (b) pavements respectively. **(Oman)**

higher levels of competition tend to be states with a stable and predictable paving program. This implies that sustained programs (for both concrete and asphalt) are important in maintaining predictable and low unit prices.

These results represent a tremendous opportunity for highway agencies looking to extend the purchasing power of their highway dollars. Table 1 illustrates this further. It is a break-even analysis on how different levels of concrete and asphalt pavement usage can impact the amount of total pavement that can be built for a \$200 million/year investment. In this example, assume a state spends 95 percent of the \$200 million/year

Table 1 Break-even analysis for \$200 million per year budget for pavements

Investment Total (\$M)	Concrete Market Share	Expend. on Asphalt (\$ M)	Asphalt Unit Price (\$)	Tons of Asphalt	Expend. on Concrete (\$M)	Concrete Unit Price (\$)	Square Yards Concrete
\$200	0%	\$200	\$78.72	2,540,650	\$ -	\$63.71	-
\$200	5%	\$190	\$78.72	2,413,618	\$10	\$63.71	156,961
\$200	10%	\$180	\$78.72	2,286,585	\$20	\$63.71	313,922
\$200	30%	\$140	\$61.85	2,263,541	\$60	\$31.94	1,878,522
\$200	35%	\$130	\$61.85	2,101,859	\$70	\$31.94	2,191,609
\$200	40%	\$120	\$61.85	1,940,178	\$80	\$31.94	2,504,696

pavement expenditures on asphalt (2nd line in table 1). At this level, with virtually no industry competition, the asphalt bid price would be roughly \$78.72/ton and the concrete bid price would be roughly \$63.71/square yard (from Figure 2).

Thus, the state can purchase a little over 2.4 million tons of asphalt and almost 157,000 square yards of concrete for their \$200 million budget. Now suppose the state instills more competition by introducing a larger portion of concrete pavement into its program (via alternate bidding, programmatic selection or some other means). Assume the state spends the same \$200 million, but this time, only 65% of its budget is spent on asphalt pavement. In this case, with industry competition, the asphalt bid price is \$61.85/ton and the concrete bid price is \$31.94/square yard. For the same \$200 million budget, the state still gets nearly the same tonnage of asphalt, but it also gets an additional 2 million square yards of concrete pavement.

While the examples presented in Figure 2 and Table 1 are based on a rudimentary analysis of publicly available bid data, it is important to acknowledge that there is significant scatter in this data, particularly when asphalt share is greater than 80% and that there are other possible explanations for the change in price with market share. Other factors that could be influencing the relationship between competition and asphalt and concrete unit prices could be the number of bidders per job; project size (eg one large concrete project vs many small asphalt projects), overall paving volume, size of market; etc. While a more in-depth analysis may isolate and quantify these impacts; it is difficult to argue that instilling competition is not a better business practice for a state highway agency. There are no downsides to fostering two healthy industries to compete for state highway projects. In states where both pavement types are specified on a regular basis, healthy industries with skilled personnel develop; construction quality improves; and risks decline, bringing about more cost efficient pavement construction and significant savings.

Alternate Pavement Bidding (APB)

While the above benefits occur regardless of whether the state uses life cycle cost analysis or has embraced the latest mechanistic pavement design tools, the fact is that they are only obtained once an agency has instilled regular competition into their pavement type selection process and it has become standard practice. It is not possible to have such impacts on costs if the competition between industries only occurs on a very limited basis. In such cases, an Alternate Pavement Bidding (APB) strategy can be used

to implement competition in the short term to drive down costs on individual projects and as a way to involve both industries.

Alternate Pavement Bidding is a bidding process where two equivalent pavement designs are developed for a given project and the contractor then chooses on which pavement to submit for his bid. The owner then evaluates the proposals from a life cycle cost perspective and the alternative with lowest total “costs of ownership” wins. The advantage of APB is that it facilitates competition in project selection by allowing more paving contractors and industries to participate on a broad array of projects so as to arrive at the most cost effective project contract. Table 2 shows how this practice has led to lower cost by bringing additional competition to the bidding table.

Table 2. Documented Savings from State DOT Alternate Pavement Bidding (APB) Practices

Agency Savings from Competition due to LCCA and Alternate Pavement Bidding (APB)	
Indiana (Duncan & Holtz, 2013)	- Used on 64 projects - On 26 projects evaluated between 2009 and 2011, APB saved the state \$13M in initial costs and an estimated \$93.4M in Life Cycle Costs
Kentucky (Looney, 2013)	- Used on 44 projects, with a documented savings of \$148M 32 of the 44 projects had both asphalt and concrete bidders, with only two being awarded to concrete - highlighting the incredible savings potential of increased competition
Louisiana (Temple, 2010)	Used APB on 47 projects between 2001 and 2009. Cost savings on these 47 projects is \$120M
Missouri (Ahlvers, 2009)	Used on 124 projects through July 2009. APB yielded a 10% decrease in unit costs for both asphalt and concrete
Ohio (Faulkner, 2010)	Used on more than 10 projects. An industry study of five projects let in 2009 documented a savings of \$58M.
West Virginia (Hall, 2010)	WV has used AD/AB on 13 projects. On their six most recent projects, the state has documented a savings of \$16.4M
New York (Bid results, 2013)	Used on first project in in December 2013. The cost savings was between \$1.3 to \$2.6M vs. costs on Non-APB projects
Michigan (MDOT, 2001)	On Michigan’s first APB project, the low bid was nearly \$3M less than the engineer’s estimate. After considering costs incurred in developing & implementing the APB process for the first time, the net savings was over \$2M
Ontario (Fung, 2006; OMOT, 2012)	- Used on 6 projects between 2000-2006. Total savings were \$28.5M when comparing the lowest concrete vs. the lowest asphalt bids - In April 2012, the Ontario Ministry of Transportation extended ADAB to its arterial, non-freeway roads

The disadvantage of APB is that it requires a second set of plans to be developed and as such, the DOT has to balance additional plan development costs with potential savings due to additional competition. However, that costs depends on when and how the additional plan set is developed. The Louisiana Department of Transportation and

Development (LaDOTD) has been using APB since 1998 and they develop both sets of plans in house and from the very beginning of the project. By doing it this way, they have found that the second set of plans cost on average an additional 11% (approximately \$2000) per project, but the overall the total Benefit/ Cost (B/C) Ratio for plan development and construction cost savings has been 1000/1 (every \$1 spent on plan development saved \$1,000 in construction). (Temple, 2010). The Indiana DOT (InDOT) also tracked development cost on one of their projects. In this project, the consultant cost to develop the second plan set was \$32,030, but the estimated constructed cost savings was approximately \$325,518 (a B/C $\approx$ 10/1). (Duncan & Holtz, 2013) Though not fully described in the reference, a potential reason for the higher cost was when the plans were developed. As stated, LaDOT does their plan development in house and as part of their normal project development. For this specific project, InDOT had the second set of plans developed later in the design process and by a consultant after the original plans were developed.

Finally, it is important to note that the States that have had success with their APB process have involved both the asphalt and concrete paving industries in the development of the process; used structurally equivalent concrete and asphalt sections in their designs; compared the bids objectively by using life cycle cost analysis; and adjusted their bidding / payment practices so that the material quantity risk between asphalt and concrete projects are treated similarly. For additional information, see References (FHWA, 2012) and (Hallin, et al., 2011).

Economic Impacts of Extended Pavement Life on a Pavement Network's Expenditures

While the above benefits of competition can have an immediate impact on an agency's costs, there are also long term benefits from having a competitive paving program. Economic principles show that if an owner wants to minimize the cost of a durable good (i.e. a pavement) that requires repair, maintenance and replacement over time, then they must minimize the present value of those costs, and not minimize the initial costs. Officials who claim that they are keeping taxes down and protecting the public good by minimizing the initial costs despite higher life cycle costs are actually doing just the opposite and making the buyers worse off. (Holahan, 2007)

As an example of how this applies to pavements, assume that an agency has the same constant annual pavement investment of \$200 million previously shown that it can invest in one of two different pavement systems, both lasting 50 years at which time each is reconstructed. The first system is the short-term pavement system, with an initial performance period of 10 years (typical of an asphalt pavement) at which time it receives its first rehabilitation consisting of a "Mill and Overlay." This rehabilitation is repeated every 10 years until Year 50 at which time, the pavement is reconstructed and the process repeats. The initial cost is assumed to be \$300,000/mile and the overlays are assumed to cost \$60,000 / mile each.

The second system is the long-term system that lasts for 30 years before its first rehabilitation and is typical of a concrete system. Until recently, concrete pavements have had higher initial cost of somewhere between 10% – 20% than asphalt pavements. For this example, the cost is assumed to be \$340,000 / mile (13.3% more). In years 30 and 40, the pavement is rehabilitated using patching and diamond grinding that also last 10 years each. These activities cost are typically $\frac{1}{3}$ to $\frac{2}{3}$ the cost of an asphalt overlay,

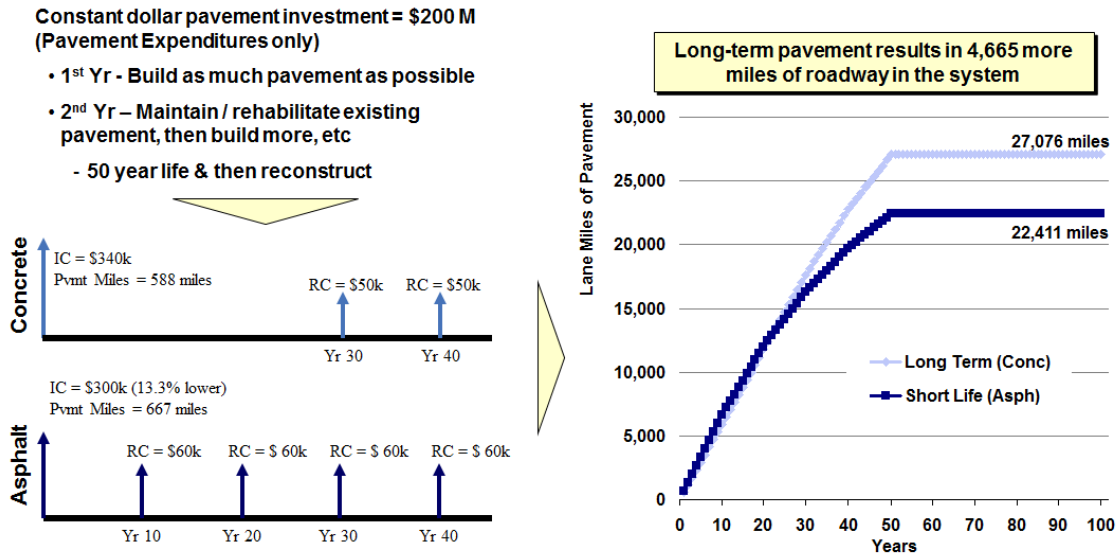


Figure 3: Miles of the roadway using short-life and long-life pavements

but for this example, the cost was set at \$45,000 / mile, or $\frac{3}{4}$ the cost of an asphalt overlay.

Figure 3 shows the results of the investment strategies over a 100 year period. In year 1, there is no roadway and the agency invests all \$200 million in new roadway. In year 2, the agency maintains and repairs what it has, and then with any extra funds, it builds additional roads. This repeats every year: the agency first maintains and rehabilitates what it has, and then with any extra funds it builds new roadways. Because the short-term pavement costs less than the long-term pavement (\$300,000 vs. \$340,000/mile) in the first 20 years, more roadway is built with the short-term pavements. However, between year 20 and 25, the amount of roadway in the long-term pavement system overtakes the amount in the short-term system because less money is being used for rehabilitation and is therefore available for continued expansion. In the end, the long-term system has over 4600 more miles (20%) of pavement than the short-term pavement system even though both have the same annual investment of \$200 million/year.

The other noteworthy item is that each system reaches a plateau at year 50 (the original pavement's life), where all that is happening is the old pavement is being replaced with new pavement. The result for this case is if the agency buys the short-term pavement because it has lower initial costs, its citizens and road users are worse off because they have fewer roads. Figure 4 is another way to look at this. It shows that if an agency only needs 22,411 miles of pavement, it can either invest \$200 million/year in a 10-year pavement system or it can invest \$165 million/year in a 30-year pavement system, saving approximately 17%/year. If the agency buys a 40 year pavement, it only needs to \$143 million/year. The downfall is that takes longer to get to the 22,411 miles because of the lower investment.

It is important to recognize that while this example uses basic economic principals, the phenomenon has been seen on actual pavement systems. In 1994, Iowa did a real world study of a long term (concrete) vs. a short term (asphalt) policy on a rural roadway system where they analyzed performance and costs over a 40 year period from 1954-1993. (Cable, 1996) The study looked at three representative counties of equal size and

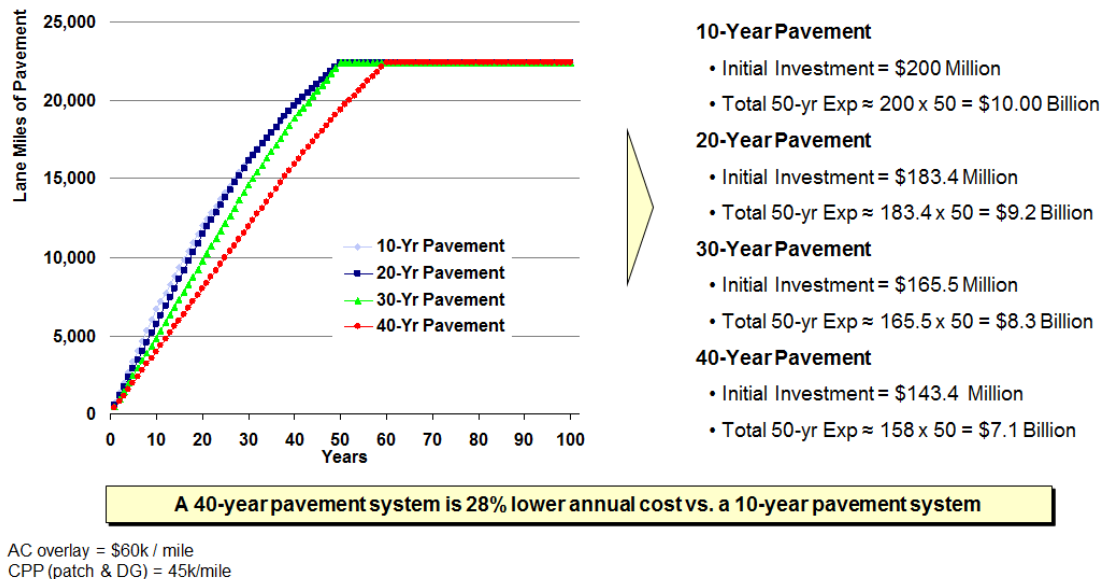


Figure 5. Annual investment need for pavement systems of different initial performance periods to provide a given amount of pavement.

approximately equal paved mileage to evaluate the pavement selection policies employed by each county. The sample counties utilized asphalt, concrete, or a combination of the two surface types. For this paper, only the asphalt and concrete counties are discussed.

The development of the individual asphalt and concrete miles, and total pavement miles in each county over time is illustrated in Figure 5. County A used a concrete policy and designed the pavements using a 20-year design life. County B used an asphalt policy and used it as both the surface of new pavements and as an overlay of the existing

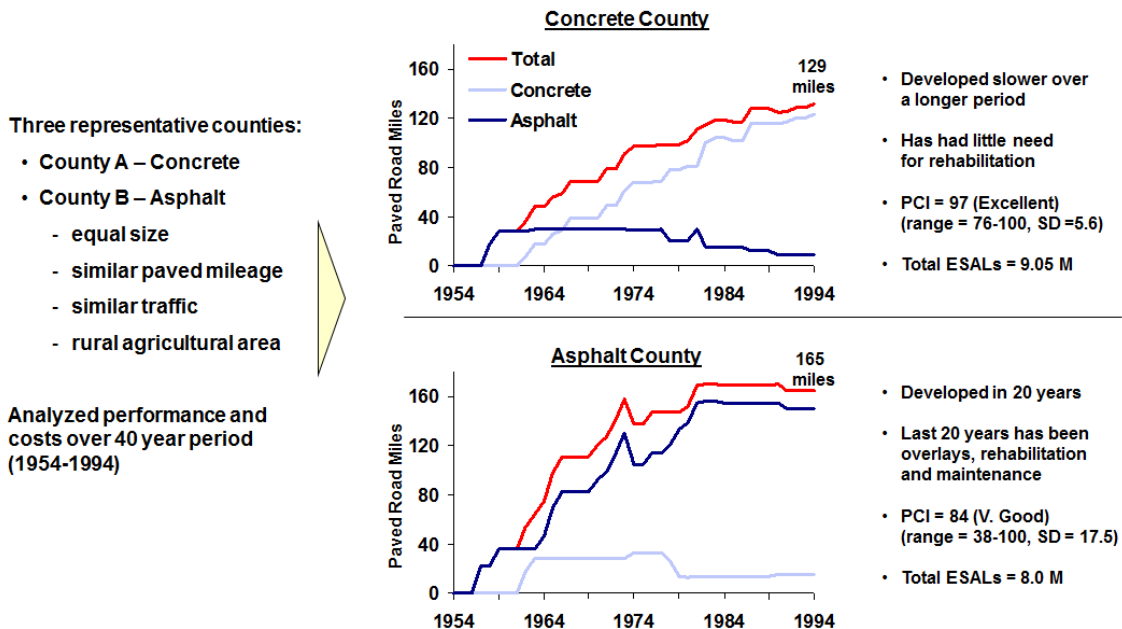


Figure 4. Pavement development for two representative counties in Iowa – one concrete and one asphalt.

pavements. In this county, the asphalt was designed using staged construction and a shorter design life in anticipation of adding depth as traffic increased. As can be seen, the asphalt county paved their basic system at a faster rate, but starting in about 1981, their system was beyond the design life and it was undergoing rehabilitation (no new miles were being added). The concrete county developed their paved system over a longer period of time and at the time of the study; it had little need for rehabilitation.

In addition to looking at roadway development, the study looked at pavement condition as reported by the Pavement Condition Index (PCI). While both systems provided good service, the concrete county maintained a PCI rating of excellent for all pavements except for one, which was built by the State of Iowa in the early 1900s and transferred to the county. The asphalt county had PCI ratings in the range from fair to excellent with an equal number of pavements in the excellent category and good to very good category. However, the asphalt county had PCI performance standard deviation of 17.5 (SD=17.5), which was much higher than the concrete county's PCI performance standard deviation (SD=5.6). Figure 6 summarizes the total pavement expenditures for each county and it shows a large difference in the amounts expended by the two counties. While the asphaltic unit prices per mile were lower for the asphalt county, the additional rehabilitation requirements due to overlays starting around 1981 meant that its total costs were about 2.3 times higher than the concrete county to develop and maintain a system of nearly equal mileage.

Managing a Pavement System to Increase Service Life

The idea that is important to understand is that US is essentially on the plateaus with their pavement systems. Most of the roads currently in use were constructed between 1950 and the 1970's and since that point, the US has been in a maintenance and rehabilitation mode, with the number of roadway miles remaining essentially flat. However, traffic has grown at staggering rates. This has increased congestion, user delays, air pollution and all the other economic costs that go with a dysfunctional roadway system. Though not

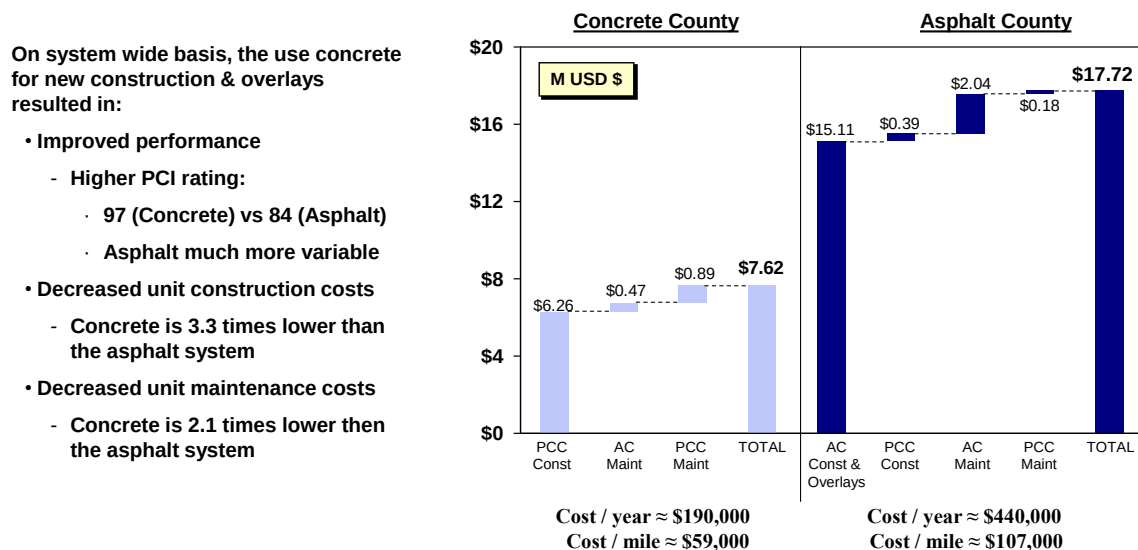


Figure 6. Pavement expenditures for two representative counties in Iowa –one concrete and one asphalt.

the full answer, part of the way to address this is to require and to expect longer lasting pavements so that they system can rise from the lower plateau to a higher plateau as shown in Figure 3. To do this, agencies can adopt a pavement asset management program based in increasing the network's "Remaining Service Interval" and a "Mix of Fixes approach" to determine rehabilitation activities.

Remaining Service Interval (RSI)

Remaining Service Interval (RSI) is a concept that tells the time, expressed in years, before rehabilitation is required for any given pavement section. It essentially defines "how long" the public will be able to use the pavement (Figure 7(a)) (FHWA). For example, a RSI=10 means a road has 10-years until it next needs rehabilitation. Correspondingly, the RSI of a new pavement is equal to the pavement's design life, and the RSI of a pavement with a condition worse than the target condition is zero, meaning rehabilitation should have already occurred.

The primary advantage of RSI is that it is easy to understand. Intuitively, it is easy to understand that a pavement with an RSI=15-years is better than a pavement with an RSI=5-years (a pavement that is serving the public longer is serving the public better). The other major advantage of RSI is that it includes a "time element" that accounts for changing conditions. This allows agencies to differentiate between pavements that are stable and those that are deteriorating, which means they can distinguish between two pavements that have the same condition, but which will require very different management strategies (Figure 7(b)). This type of information keeps DOT's from doing "band aid solutions" that may not be cost effective.

Once RSI is determined for each individual pavement segment, the data is combined to give the Network RSI as shown in Figure 8. The Network RSI is the summation of each pavement section's remaining life multiplied by the miles in that section, and expressed in lane-mile-years (e.g. this network has 51,269 lane-mile-years). The Average Network RSI is Network RSI divided by the total lane-miles of the network (e.g. $51,269 / 3849 = 13.3$ years), which is the average time between rehabilitation activities for any given section. The Network RSI graph gives an overview of a network's health by presenting the data in a way that agencies can easily see how long portions of the pavement will, which allows them to make better programming decisions.

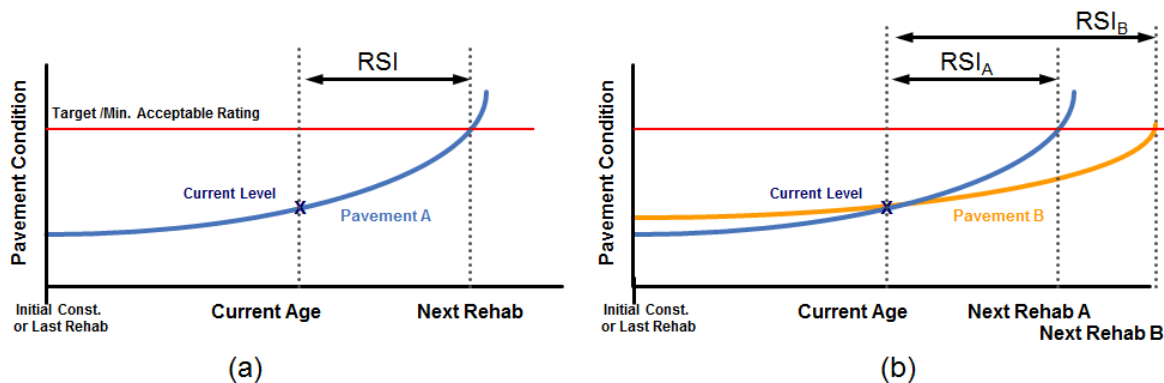


Figure 7. Depiction of remaining service interval.

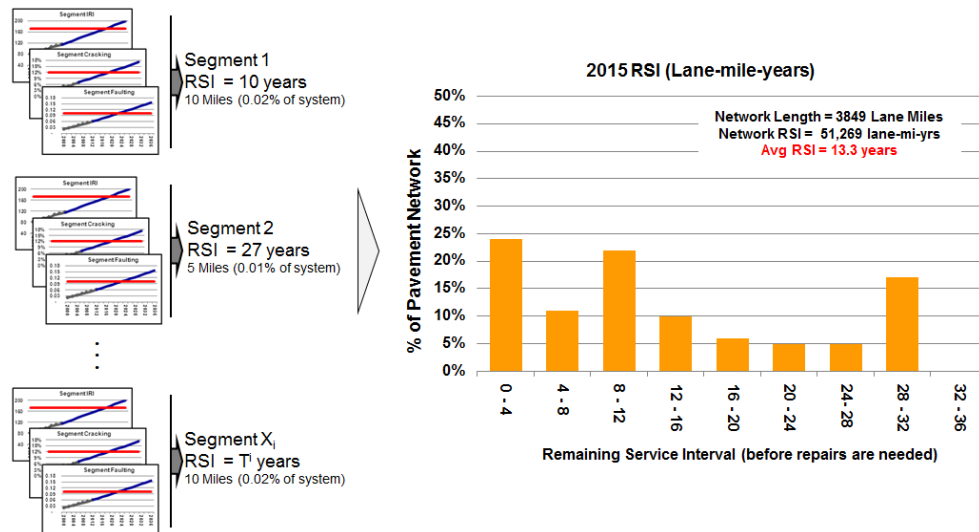


Figure 8. RSI for each segment is combined to create the Network RSI Graph.

Mix of Fixes (Pavement Rehabilitation)

“Mix of Fixes” is a term used to describe rehabilitation alternatives that provide different length of lives – some with short-term lives, some with medium-term lives, and some with long-term lives – that can be used to fill the openings in the Network RSI graph. Short-term fixes are usually preservation activities that repair isolated areas of distress; manage the rate of deterioration; and address functional issues, such as ride, early the pavement’s life. While the life expectancy of preservation techniques is between 2 and 10-years, their primary advantage is that they are relatively inexpensive and can be applied to many miles of pavement.

Medium- to long-term fixes can either be overlays or reconstruction. Concrete and asphalt overlays are used when pavement has medium to high levels of distress and preservation is no longer effective. Rather than just slowing the rate of deterioration, overlays add structure as well as improve a pavement’s functional condition. Reconstruction is used when the pavement has high levels of distress, when overlays are no longer effective, or when standards have changed. The advantage of reconstruction is that it replaces the entire pavement structure so other needs, such as drainage and safety, can be addressed. Depending on the type of overlay or reconstruction activity chosen, a typical service life can be anywhere from 10-years to over 40-years.

By judiciously programing rehabilitation solutions that fall into openings in the RSI graph and balancing costs, agencies can increase the overall Network RSI by ensuring that there is not too much or too little pavement to repair in any given timeframe. This allows agencies to determine how long a given activity needs to perform (eg how long a rehabilitation must last) and analyze the impacts of various activities on the network to determine whether the activities will improve the overall network life or lower it. If done correctly, the life of the network is increased and network’s annual cost are lowered because there are fewer pavements to rehabilitate each year. (Mack & Sullivan, 2014)

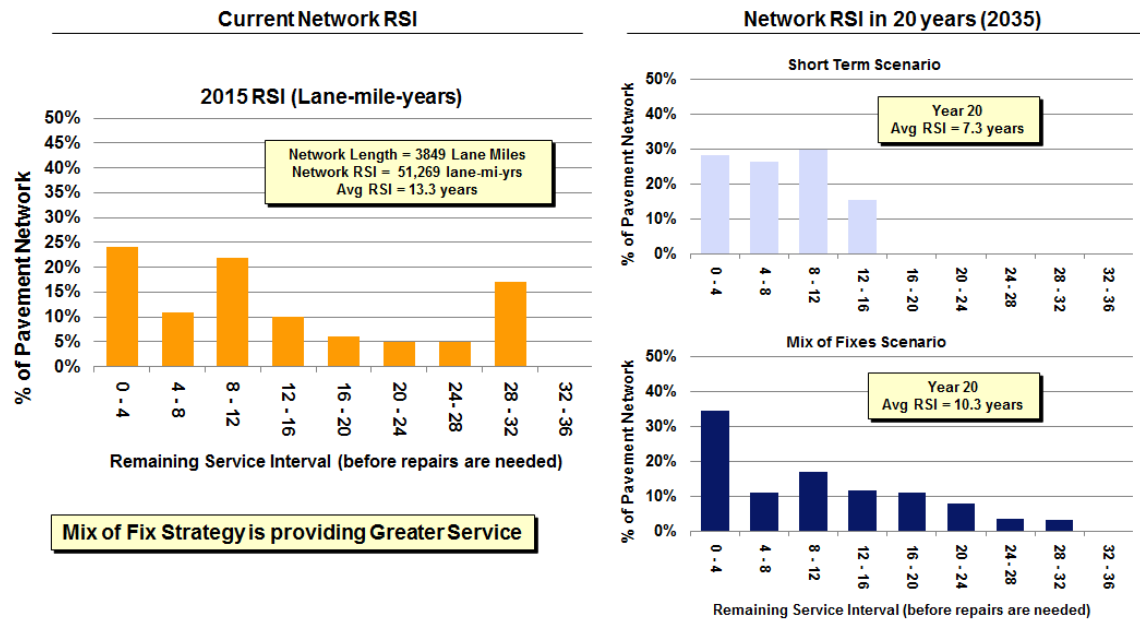


Figure 9. Example of two alternate strategies short-term (8 to 15-Year Fixes) vs. mix of fixes (8 to 30-Year Fixes) same budget & expenditures.

Example

Figure 9 is an example of the long-term impact that pavement rehabilitation selection can have on a network. On the left is the RSI graph for the network from Figure 8. On the right are the projected RSI's in 20 years using two alternate pavement rehabilitation strategies. The first alternate is a typical mill-and-fill overlay strategy that provides 8 to 15-year fixes before the next rehabilitation activity is needed. The second alternate uses a "Mix of Fixes" approach with 10, 15, 20, 25 and 30-year solutions. In both cases, the same budget is available and spent and activities are planned out as best as possible in order to maximize the network RSI.

As can be seen in Figure 9, the short-term scenario has an Average RSI of 7.3-years and the Mix of Fix Scenario has an Average RSI of 10.3-years. Both are lower than the current Average RSI of 13.3-years, which indicates that there is not enough money going into the system to maintain it. However, it can also be seen that the Mix of Fixes scenario is providing greater service because its RSI is 3 years higher.

Conclusion

The U.S. spends over \$90 billion every year on highway improvements, including pavements. Because of the magnitude of this investment, and of the spirited debate currently going on in federal, state and local legislatures about the need to increase this investment significantly, highway officials are under increased scrutiny to demonstrate that they are spending whatever resources they have as wisely and efficiently as possible.

An analysis of current agency bid information from 45 states confirms that competition between the asphalt and concrete paving industries has a demonstrable and pronounced effect on pavement unit prices and agencies' purchasing power. When

competition between the pavement industries increases, the average unit costs for both concrete and asphalt pavements drop, which allows the agency to extend its current budget, and build more pavements for their investment. Few other opportunities have such an ability to address the mounting infrastructure challenges of severely constrained resources and it represents a significant opportunity for highway agencies looking to extend the purchasing power of their highway dollars.

While the short term economic benefits alone are reason to increase competition, economic principals and historical data also show that there are long term economic benefits of a competitive long life network. As the overall life of the individual sections are increased, annual construction and maintenance costs of the pavement are decreased because there are fewer pavements to be rehabilitated each year. This gives agencies the ability to expand their roadway system, which means they are serving the public better.

In order for agencies to start moving towards a longer life system, agencies should actively manage their pavement networks using Remaining Service Interval and Mix of Fixes approach to select their pavement rehabilitation techniques. The essence of these tools is to select short-, medium-, and long-term pavement strategies that have service lives that fall into a time frame that has minimal activities planned, which decrease the amount of pavement that needs repaired at a given time. This in turn lowers pavement cost by spreading them over longer time periods and allows them to expand their system with the same number of dollars (or they can maintain the same system with fewer dollars). Both of these will help the driving public because it reduces congestion and expands the system, or because it will lower their taxes needed for roadway construction.

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