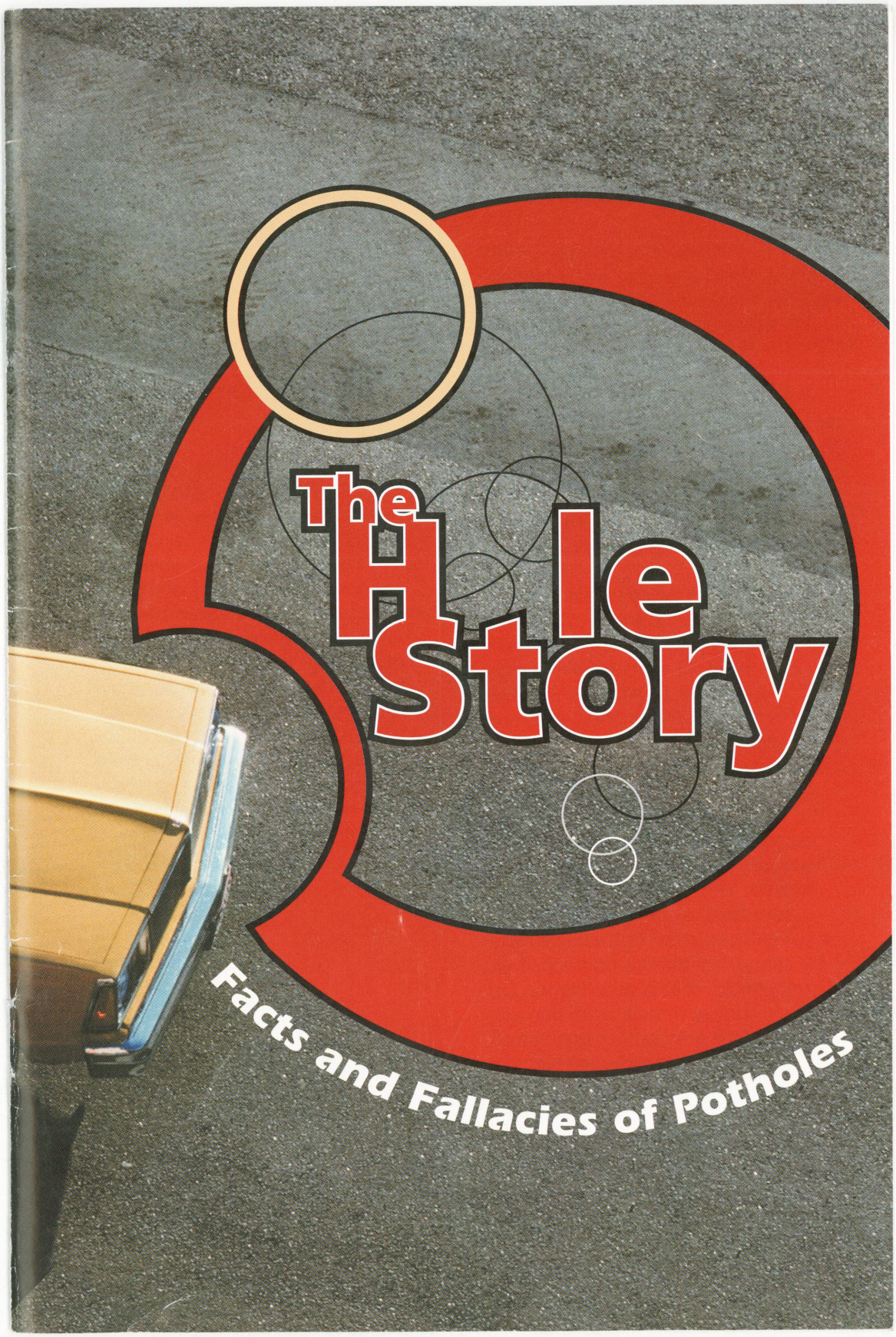

The Hole Story
Facts and Fallacies of Potholes

Why Are They Called Potholes?

Have you ever wondered why "potholes" are called potholes? They don't look like pots. They are shaped only a little like a pot. So how did they come to be called by their common name?

The spring 1998 issue of Maine Local Roads News reprinted an article by L.M. Boyd that was originally published in a 1993 edition of the Pothole Gazette. According to Mr. Boyd, potters (pottery makers) in 15th and 16th century England would take advantage of the ruts that wagon and coach wheels gouged into the roads. These potters would dig in the deep ruts to reach clay deposits that they would take as a cheap source of raw material for making clay pots. Teamsters, driving wagons and coaches over these roads, knew who and what was causing these holes and referred to them as "potholes."

Introduction

We've all heard a lot about "infrastructure" problems lately. And as we bump over the potholes in our local streets, it is easy to feel frustrated and wonder–"Why don't 'they' do something?"

Ironically "they"–your local public works or street department–are probably equally frustrated by increased costs, budget reductions, and deferred maintenance; and "they" probably are as anxious as you to do something.

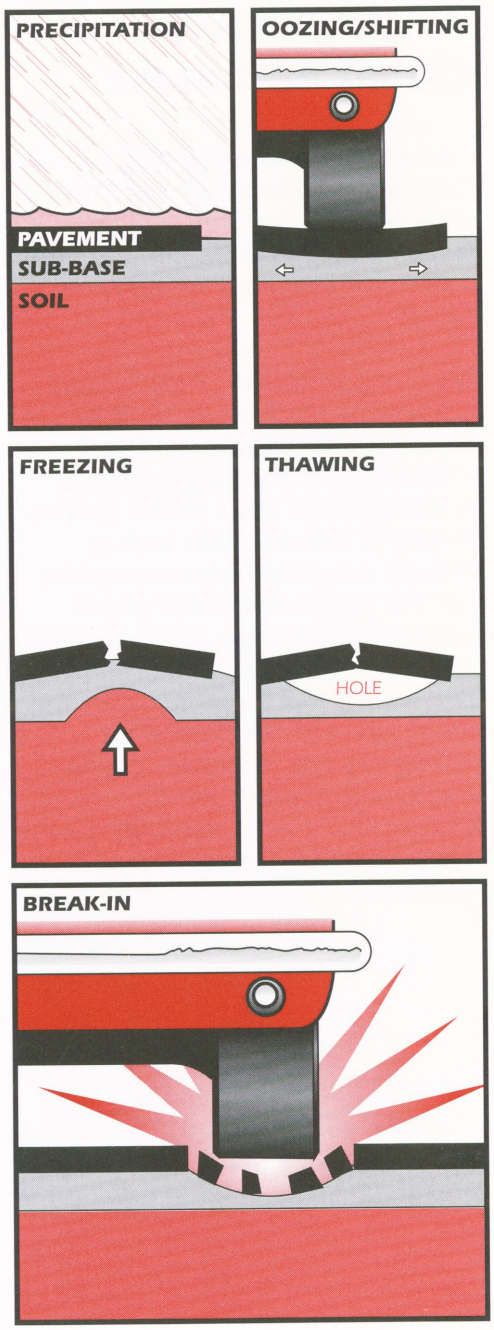
Unfortunately, neither the national media blitz on infrastructure nor local finger pointing will solve your community's pothole problem. Real solutions can only come from a committed and cooperative effort by informed citizens and local public officials. Difficult decisions have to be made and tough priorities set.

In an effort to facilitate this dialogue, the American Public Works Association (APWA) has drawn together some of the engineering facts of local street maintenance and presented them in a short question-and-answer format. We hope that based on this information you and other citizens in your community can become a positive and effective force in working with your local officials for better streets.

What causes a pothole?

The word pothole brings to mind the painful image of that round crater in the middle of the street whose depth and sharp edges play havoc with your car's tires, steering, and suspension system. For the sake of our discussion, let us expand our definition of a pothole to include any hole in the pavement that causes noticeable impact on your automobile and driving.

Simply stated, potholes are created when the pavement or the material beneath it–called the base or subbase–cannot support the weight of the traffic it carries. Two factors are always present in such a failure: TRAFFIC and WATER.



Traffic

Pavements are designed to carry specific types of loads and volumes of usage. Traffic that is too heavy for the pavement design can cause, initially, small hairline (fatigue) cracks in the pavement. After many repeated tire passages over the pavement, these cracks will develop into larger, visible cracks. Even if the design weight of vehicles using a pavement is not exceeded, higher volumes of traffic than it was designed for can also cause fatigue cracking.

A common scenario for traffic induced fatigue cracking runs like this. Over time, a street designed for residential or

light commercial traffic becomes a local public transit route, or it begins to carry increasingly heavy commercial traffic when numbers of trucks begin making deliveries to a local supermarket, strip mall or mall. Fatigue cracks can also be caused by age, expansion and contraction due to extremes in daily temperatures, or from inadequately restored utility cuts.

Water

Water worsens the cracked pavement problem. Ideally, water should, and does, flow over the impervious surface of a properly crowned and sloped pavement to a gutter, storm drain or ditch and quickly flows away. But, when water seeps into the subbase–through cracks in the surface, from ponding in weed clogged ditches or debris clogged storm drains, or from a rising water table–it attacks the subbase from beneath and softens it much like dry hard ground softens to mud. Over a period of time, the subbase material shifts or oozes outward to the sides of the weakened point, leaving a void and nothing to support the pavement above it.

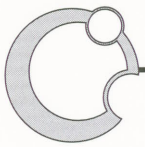
After a while, repeated flexing of the pavement above the void due to repeated wheel loadings of passing vehicles causes the now unsupported pavement to weaken, seriously crack, and ultimately fail or collapse.

In cold climates, this process is dramatically accelerated due to freeze-thaw action. Water is the only substance that expands as it freezes and passes from a liquid to a solid state. When water in cracks and the subbase freezes, it acts like a can of soda pop left by mistake in the freezer expanding the crack or pushing the pavement up. Under repeated freeze-thaw conditions, a flexible asphalt pavement may generate localized humps and a rigid concrete pavement will develop cracks. If the expansive forces are severe, a piece of pavement may actually pop out!

How does water get into the pavement? What can be done to prevent it?

Ideally, water should run off the impervious surface of a pavement in good condition and flow quickly into a gutter and storm drain or ditch to be carried away. Problems develop, however, when the pavement cracks due to age, expansion and contraction due to temperature changes, fatigue from heavy traffic loads, or from inadequately restored utility patches. Water can also permeate the subbase from weed clogged ditches or from rising water tables attacking the subbase from beneath.

And, yes something can be done about these problems! Good construction and maintenance practices can alleviate

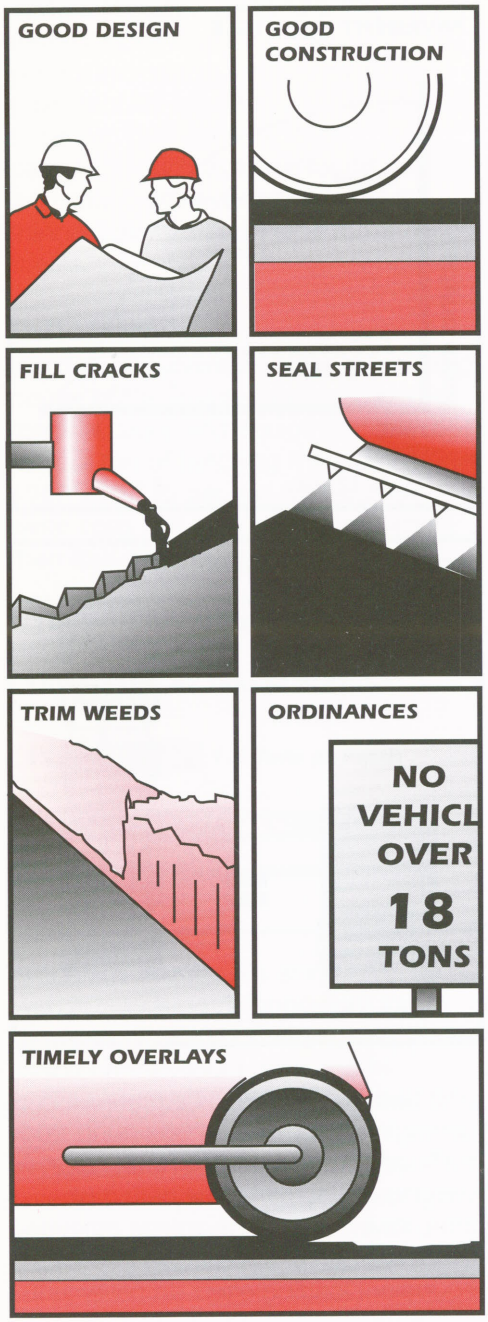


many drainage problems. Additional strength in the form of bituminous and concrete overlays can be added to streets experiencing increased vehicular loads. Cracks that develop can be filled in a timely manner, and on some pavements periodically the entire surface of the street can be sealed with a thin coat of liquid asphalt mixed with sand or crushed stone to make it water-resistant. Portions of the pavement can be removed and recycled back as a new road surface. Ditches along the sides of roads can be kept mowed, and drains can be kept unclogged by periodic cleaning. In addition, communities can adopt subdivision ordinances to ensure adequate pavement design of streets which may in the future serve as collectors or through streets. Truck routing regulations can restrict truck traffic to major arterials designed to carry their weight, and tighter permitting requirements, also, can result in better restoration of pavements over and adjacent to utility cuts.

In the final analysis good design, high-quality materials, and continuous maintenance can substantially prolong the life of pavements and minimize the emergence of potholes.

Every spring they patch the same potholes...Why don't they just do it right the first time?

There are many reasons for this seemingly wasteful repetition of effort. A pothole can be repaired, and the repair last indefinitely–if the causes of the initial failure (poor drainage, weakened subbase, etc.) are also corrected, if the right materials are used, and if the patch is bonded to the old pavement well enough to prevent water from seeping into the subbase along the edge of the patch. Correct patching can take significant amounts of time, manpower, and money. If a local agency is suffering from a squeezed budget, deferred maintenance, and the consequent pothole proliferation, thorough patching may require so much time, manpower, and money that some potholes would have to go unfilled. Instead, many agencies place temporary patches on all potholes with the intention of returning to make permanent repairs on as many as time and money permit. In the meantime, the temporary patches often admit water, and because the subbase was already weakened, subsequent freeze-thaw cycles and repeated traffic loads on the unrepaired subbase cause the patched area to cave in again. Even a permanent patch may fail if underlying



drainage problems persist or if a complete bond was not achieved between the patch and surrounding pavement.

New patching techniques, materials and equipment developed as part of the U.S. Department of Transportation's Strategic Highway Research Program (SHRP) are capable of providing effective cost and manpower solutions to many of the abovementioned problems. For more information on SHRP products see the Washington State Department of Transportation web site at http://www.wsdot.wa.gov, the Federal Highway Administration web site at http://www.fhwa.gov, or the American Association of State Highway and Transportation Officials web site at http://www.aashto.org. Public agencies that do not have Internet access can contact the American Public Works Association for paper copies of the information on these sites.

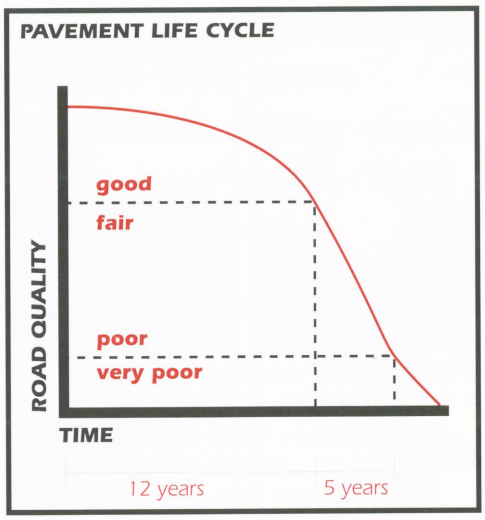
With the taxes I pay, the streets ought to be perfect!...Yet they seem to be falling apart.

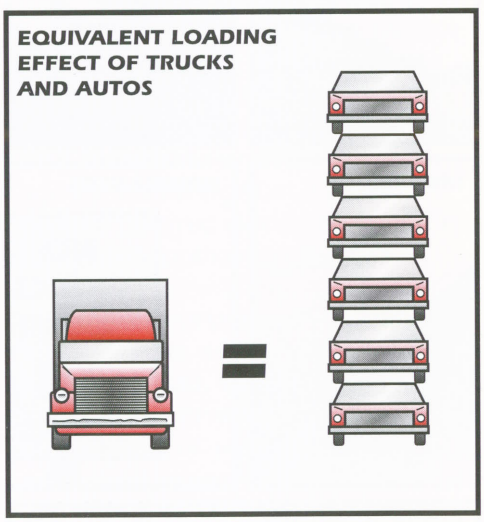
A 1998 study by the American Society of Civil Engineers (ASCE) noted that 59 percent of America's urban and rural roads are in poor, mediocre, or fair condition. As defined by the ASCE and Federal Highway Administration, "poor"

roads are in need of immediate improvement, "mediocre" roads need improvement in the near future to preserve usability, and "fair" roads will likely need improvement in the future. As of FY 99 the national shortfall in funding just to keep roads and bridges in their present condition is $29.7 billion per year, and to improve their condition it would take an additional $18.8 billion per year.

Age

From the moment they are built, pavements begin deteriorating, but not at the same rate each year. Indeed, with routine maintenance a pavement may "ride" well for many years. After a critical point, however, the materials that make up pavements begin to lose their ability to hold together, to resist the intrusion of water and chemicals, and to carry the weight of traffic. When this critical point is reached, pavements begin to crack and "suddenly fall apart." This normal life cycle is shown by the curved line in the figure at the right.





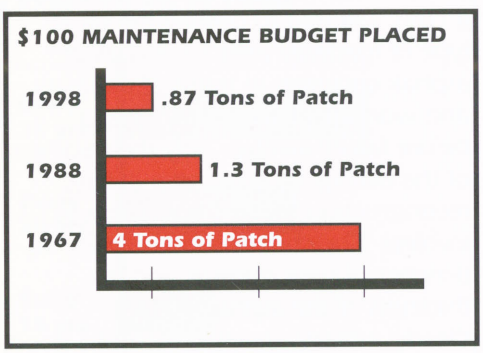
Increased Traffic

However, age is not the only problem. The amount of traffic traveling on roads and streets has dramatically increased, shortening the life of our pavements. Between 1970-95 vehicle miles traveled in the U.S. doubled, but from 1985-95 capital investment and maintenance expenditures, in constant dollars, decreased by 17%. The growth in the number of vehicles has outpaced population growth by 50% during the past two decades. But, far more damaging has been the growth in truck traffic and individual truck/trailer axle weights during this same period of time. Pavement design criteria estimates that a typical 18-wheeler has the equivalent loading effect on pavements

as do between 3,000 and 6,000 passenger vehicles. The effect of this weight increase in terms of decreasing pavement life span has been estimated to be between 10% for thick pavements such as those found on interstate highways and 90% for the thinner pavements on local roads and streets.

Inflation

Inflation has severely eroded the buying power of the maintenance dollar. The material, labor and equipment cost to place a ton of patching material in 1967 was $25 per ton. Today these same costs can be $115 per ton–more than four times as much. Just to stay



even with inflation (let alone keep up with accelerating deterioration) local revenues dedicated to street maintenance would have had to quadruple! They have not. Indeed, most states and municipalities dependent on flat rate gasoline tax revenues saw per vehicle mile revenue decreases over much of the last two decades due to increased fuel efficiency.

Deferred Maintenance

Facing the squeeze of increased costs, less revenue, and citizen resistance to tax increases, many state and local governments have chosen to make "low profile" or "painless" budget cuts. One way to trim operating budgets is to defer preventive and demand maintenance procedures on streets and roads. Preventive maintenance procedures like periodically applying seal coats may have been postponed, "saving" money but allowing more water to seep into the subbase, thereby, accelerating a deterioration rate already fueled by increased age and traffic. Demand type maintenance procedures like patching areas with alligator cracking may have been postponed allowing the condition to worsen and the distressed area to expand. By deferring maintenance, communities start down a spiraling path of deteriorating infrastructure and increasingly costly backlogs of required repairs.

But why won't deferred maintenance save money in the long run?

Referring to the pavement deterioration on the opposite page, Mike Sheflin, Transportation Commissioner of Ottawa-Carlton, Canada, answered the question this way: "Those who carry out low-cost rejuvenation and

resurfacing before rapid deterioration begins extend the pavement life for a fraction of the cost of those who wait 'just a couple of years'...Ask why they waited and the universal answer is 'to save funds.'"

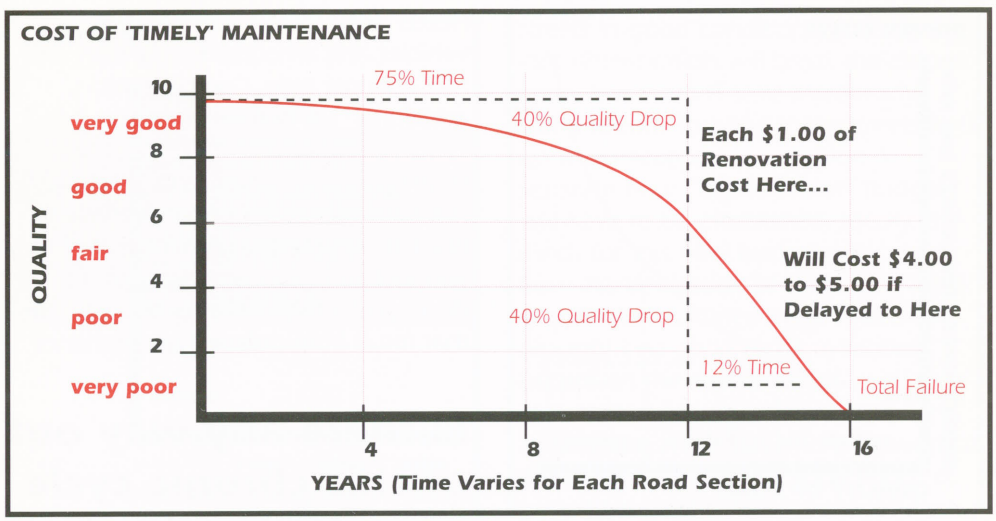
Deferring maintenance has been a popular solution during recent periods of revenue shortfall, and now local governments are facing the consequences. The street for which an overlay was deferred several years ago now needs a complete rehabilitation or reconstruction at five times the cost.

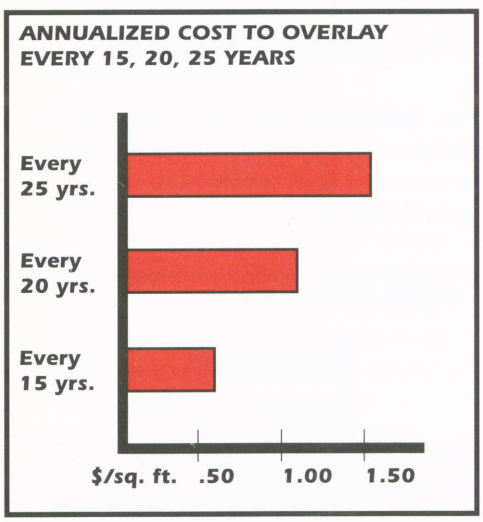
Research and field experience have repeatedly shown that over the long run maintaining good roads in good condition costs substantially less per year than allowing them to deteriorate to the point that major rehabilitation or reconstruction is required. The Michigan Department of Transportation recently issued a report that documented overall budget savings of $6 for every $1 spent performing timely preventive maintenance actions. Copies of this study and the MI DOT Highway Preventive Maintenance Program Guidelines can be obtained from APWA.

WHY? The cost of a rehabilitation effort in terms of time and materials is substantially higher than the cost of routine maintenance and timely resurfacing. In Lee County, Florida, it

COMPARISON OF RECONSTRUCTION VS. OVERLAY (LEE COUNTY, FLORIDA)

costs $175,660 to reconstruct one mile of 24-foot wide collector roadway and it costs $34,860 to overlay the same type of roadway with 1.5 inches of asphalt concrete. In terms of materials and work effort an overlay placed before failure involves only the thickness of the overlay whereas after failure, reconstruction of the same roadway involves 12-inches of subbase material, 8-inches of base material and the thickness of the asphalt surface. Clearly, periodic maintenance of a good road is less expensive than reconstructing it. However, what about the cumulative cost of periodic maintenance? Won't several seal coats or overlays add up to the cost of a rehabilitation project? Fort Collins, Colorado, compared two maintenance strategies: one involved performing high quality maintenance coupled with "appropriately timed" overlays; the other involved deferring overlays several years



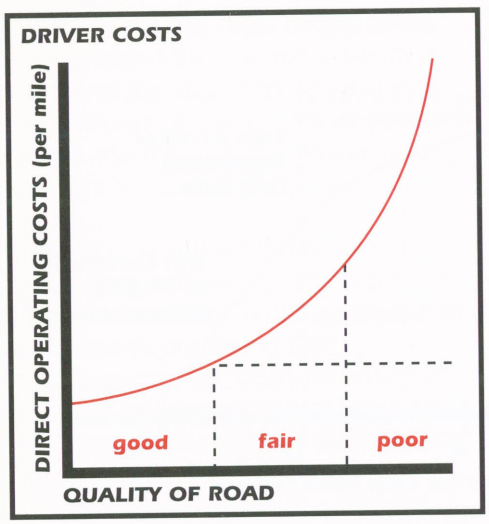


and then carrying out a major rehabilitation. Their analysis found the second strategy to be four times as expensive as the first. Another, more comprehensive study conducted by Thomas R. McDonald, a noted pavement maintenance consultant and author, found that the cumulative cost of a well maintained pavement over a 15 year design life was 3.4 times less than a non-maintained pavement.

In addition to being less costly, the periodic "upward bumps" in the appearance and ride quality of a well maintained pavement give the public a positive perception of the stewardship being exercised over public property.

Don't my driving costs go up on poor pavements?

YES! Poorly maintained roads mean direct out-of-pocket costs to you and every other vehicle owner. Motorists "pay" for poorly maintained pavements in damaged tires, more frequent front-end alignments, more frequent



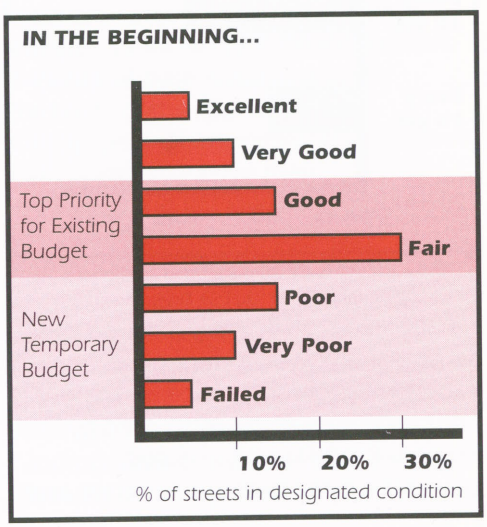
replacement of suspension system components and more frequent traffic accidents–not to mention increased travel times. An FHWA study concluded that the annual cost to all motorists in the U.S. due to operating on poorly maintained roads was $134. See the figure above showing the relationship between pavement condition and user costs.

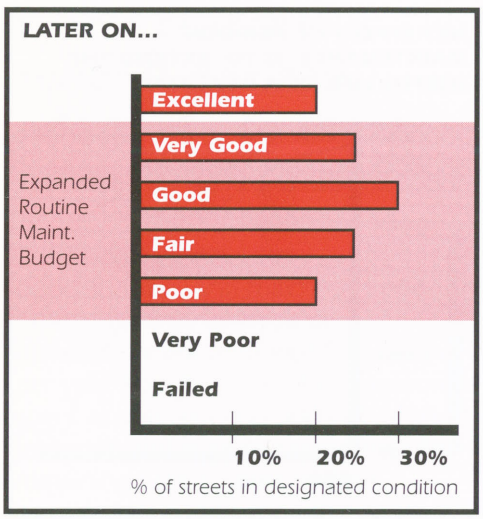
Which costs more - street or car maintenance?

Would paying high taxes for street maintenance produce a net savings to me in vehicle maintenance costs? In many areas a temporary local tax increase of 4 to 5 cents per gallon of gasoline would be more than adequate to meet all pavement maintenance needs. With today's fuel-efficient vehicles, this amounts to less than one-half cent per mile. Compare this additional "tax burden" with the 2 to 3 cents per mile every driver pays for driving on poor pavements, and it is not hard see which option is the real burden on your pocketbook. Either way you look at it, you and every other driver pay a high price for the potholes that result from deferred maintenance.

Is there any way out of this chronic cycle of paying more money for worse roads?

Yes, although it may be painful at first. Most municipal governments find themselves with a street condition profile that looks something like that





shown above, where 30% to 40% of the streets are in poor or failed condition.

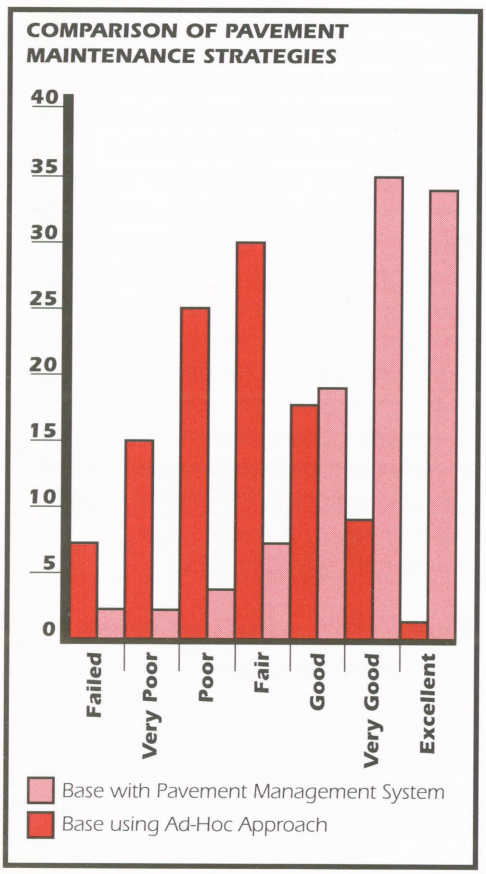
Patching and rehabilitating streets in "poor" or worse condition can consume a street department's budget. Meanwhile, streets that are in good condition but at a point where "timely' lower-cost periodic maintenance is needed to keep them in this condition are left unattended. These streets then slip into the rapid deterioration phase a few years later and increase the percentage of poor to failed streets.

Communities wanting to break this downward spiral will have to exert enough political discipline to reverse their street maintenance prorates. This means that "good" streets in need of periodic maintenance will have to be ranked ahead of what might be termed "failed" or crisis streets when allocating street maintenance funds. Preventing streets in good condition from slipping into deterioration will break the chronic cycle, but it won't save the already failed streets. To bring these streets back up to an acceptable condition a separate new, "capital repair" budget will have to be established. Ideally, the funds for this new budget will come from the dedication of temporary local gasoline taxes. Once these streets are brought into good repair, a modest expansion the regular street maintenance budget will be sufficient to keep the entire pavement network at the point where timely applications of periodic maintenance actions produce optimal value for every street maintenance budget dollar.

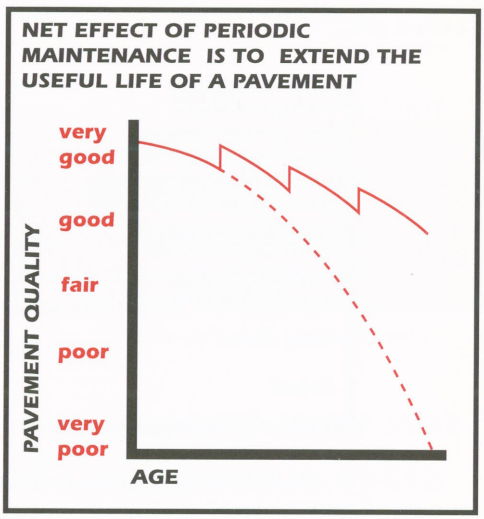
Does this solution work?

Three examples suggest that it does. Several years ago, the Kansas Department of Transportation (KDOT) adopted a strategy of maintaining pavements in the "reverse order" described above. After the first four years, quantities of aggregate and asphalt used by KDOT for surface repairs and resurfacing were reported to be progressively lower each succeeding year until they leveled out at significantly lower annual usage levels.

The U.S. Army Corps of Engineers recently compared the maintenance practices at two Army bases. One base used a pavement management system, Micro PAVER, to help determine optimum timing and the most cost-



effective strategies for periodic maintenance actions. The other base allocated its budget on the ad hoc basis of which roads were in the worst condition. Both bases had nearly identical budgets, but an evaluation of the pavement network conditions on both (on a scale of 0 to 100, with 100 being excellent) found that the first base had an average condition rating of 75 compared with second base's average of 41.



The Michigan Department of Transportation (MI DOT) recently completed a multi-year study on the impact of proactive preventive maintenance programs and has produced a 14-minute videotape, Protecting our Pavements: PREVENTIVE Maintenance. This videotape explains in non-technical terms how applying the right treatment at the right time can significantly extend the service life of a pavement and can save money in the long run. Copies of this videotape can be obtained from any FHWA Division office, state DOT, or FHWA Local Technical Assistance Program Technology Transfer (LTAP T2) Center. You can find the LTAP T2 Center for your state on the Internet at www.ltapt2.org or by calling the American Public Works Association at (202) 393-2792.

Is the current federal gas tax adequate to meet maintenance needs?

The current construction, reconstruction, and maintenance expenditures by all levels of government equals about $62 billion per year. Roughly 60% of this amount is spent at state level on 800,000 miles of interstate and state highways and the remaining 40% is spent by local government agencies on the 2,900,000 miles of roads and streets for which they are responsible. As noted earlier, the American Society of Civil Engineers estimates that an additional national investment of almost $30 billion per year is needed to keep our roads and bridges in their current condition, and another $19 billion per year is needed to accomplish needed improvements.

Most of this additional national investment in pavement and bridge maintenance will have to be spent on our interstate and state highway systems to correct the type of deferred maintenance problems described earlier in this publication. Until problems with the national highway system are corrected, more than 85% of the funds spent on the maintenance of local roads and streets must come from local taxes. Thus, federal funds and discussions on how much money will be included in this or that authorization bill are of very little consequence when it comes to paying for the maintenance of local roads and streets.

The sad truth is that we are going to have to pay the price of long-deferred maintenance at every level of government - federal, state and local. For central cities in large metropolitan areas, this is going to be particularly difficult because suburban commuters who make extensive use of city street networks reside outside these cities and tend to pay local fuel taxes at gas stations near their homes. In these areas a regional approach of allocating revenues from local gasoline taxes would seem to be most appropriate.

What can I do to help?

You have already started by becoming informed about the problem. Learn more about the specifics of your local situation by talking to the staff in your public works, street or highway department. Invite your public works director, street superintendent or county engineer to speak to community groups. Find out how pavement maintenance is being managed in your community. What is your local budget and how does it compare with what is actually needed? Inquire about plans for implementing a pavement management system. Work with your local officials to determine whether truck routing ordinances are needed or

whether regulations governing utility cuts need to be strengthened. Finally, if the local facts show that additional revenue must be raised to break the cycle of deterioration in your street system, support your local officials in this effort. Inform your fellow citizens of the consequences of deferred maintenance and that, in one way or another, we all pay for potholes.

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For information on how to obtain referenced items contact the American Public Works Association at (816) 472-6100, fax (816) 472-1610 or e-mail: paver@apwa.net.

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