ITS INSTITUTE OF TRANSPORTATION STUDIES

Technology Transfer Program

TECHNICAL TOPICS #2

The Pothole Primer for Planners, Managers and Public Officials

by Larry Santucci, LTAP Field Engineer and Pavement Specialist, Pavement Research Center, UC Berkeley

The Technology Transfer Program is the continuing education arm of UC Berkeley's Institute of Transportation Studies. Our mission is to bridge University of California research with contemporary transportation practice by facilitating the transfer of knowledge and skills from university research to applications in the planning, design, construction, operation and maintenance of efficient and effective state-of-the-art transportation systems.

The Pavement Research Center at UC Berkeley has been advancing pavement technical knowledge for nearly 50 years. The Center has led the way for many important discoveries in the field of pavement design including the development of elements of Superpave mix design technology through the Strategic Highway Research Program (SHRP). Currently the Center is conducting large scale accelerated vehicle testing of pavement structures in partnership with Caltrans, the South African Council of Scientific and Industrial Research, and Dynatest USA. A key role of the Center is the training of pavement engineering personnel. Through the Technology Transfer Program, the Center can provide a link between innovative developments in technology and practical engineering applications.

Introduction

While most of the travelling public knows very little about the structure of the streets and highways they use to get to work or for recreation, they are quite keenly aware when the conditions of their roads are inadequate. The common failure in the road known as a "pothole" brings the road to everyone's attention and when the public gets agitated, politicians are soon to follow. Encounters with potholes annoy the vehicle's occupants and cause significant damage and expensive repairs in the form of tire wear, wheel alignments, and structural fatigue. Pothole repair isn't popular either, since it results in lane closures, congestion and more frustration for the traveling public. Research at the University of California has improved our understanding about pothole formation as well as techniques for

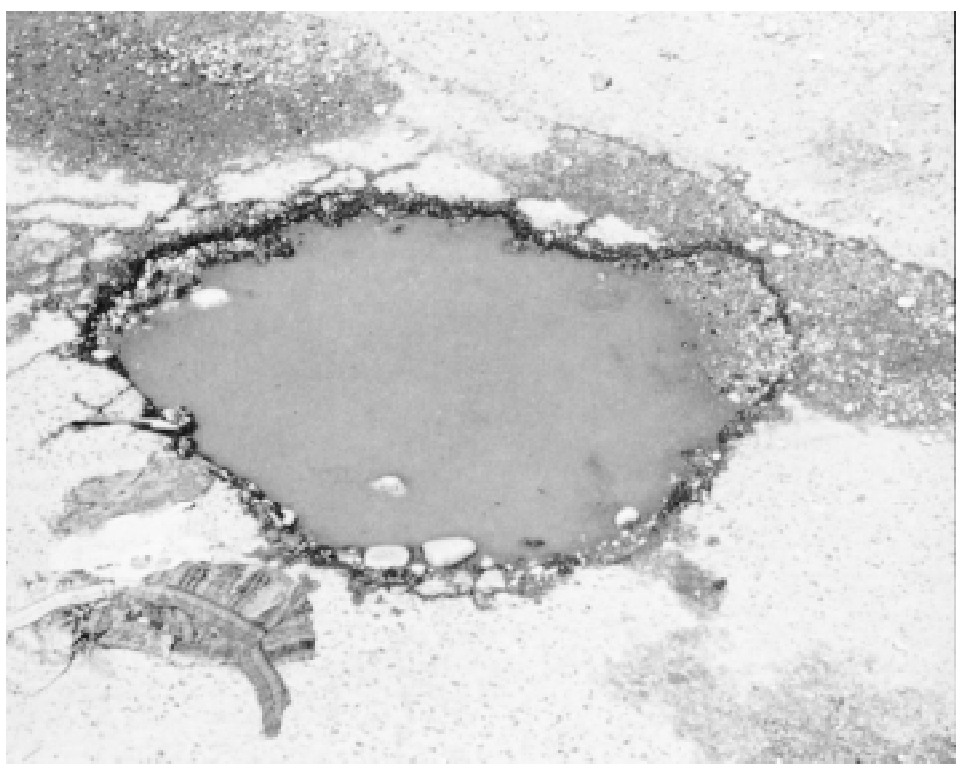

Figure 1. Pothole (photo courtesy The Asphalt Institute)

minimizing their formation and streamlining their repair. Application of this understanding will result in better service to the traveling public, longer lasting repairs and more durability. Concern about our state's crumbling infrastructure ranks high among public officials. While building new roads and highways may curry favor with some, nearly everyone feels the results of inadequate road maintenance.

How Potholes Form

Potholes occur primarily in asphalt pavements, which account for 92% of the nation's roadway surfaces. Potholes are bowl-shaped holes of various sizes in the asphalt pavement such as shown in **Figure 1**. Potholes are usually caused by such factors as a thin asphalt surface; a weak sub-structure; too little asphalt in the mix; poor drainage; or isolated construction flaws. These factors, in combination with heavy traffic, accelerate the formation of potholes. Potholes often reappear in areas where poor techniques were used to repair earlier cut outs or previous potholes.

A pothole may also start as a few isolated longitudinal cracks in the wheel path of the roadway. The amount of cracking increases with time and traffic until an "alligator" crack pattern similar to that shown in **Figure 2** appears in a localized area. Small pieces of the pavement are dislodged by traffic until the pothole begins to form.

Water or moisture is another major contributor to the formation of potholes. Moisture in the base underlying the pavement surface lowers the strength of the pavement and reduces its ability to withstand repeated loads from heavy truck traffic. If this occurs in localized areas as the result of poor drainage, potholes are likely to form. In addition, once cracks appear in the asphalt surface or if the asphalt mix has such a high air void content that water can easily pass through it, surface water can enter the pavement structure and reduce its strength. It is no surprise then that potholes increase in the rainy season or after the spring thaw in colder regions.

"It is a major frustration…when a newly built asphalt pavement is trench-cut shortly after its construction…"

Figure 2. Alligator Cracks (photo courtesy The Asphalt Institute)

Pothole Prevention

The formation of potholes can be significantly reduced during new pavement construction by paying close attention to:

- proper mix and thickness design procedures;
- quality control during construction;
- positive drainage techniques; and
- coordinating utility work so as to avoid post-construction utility cuts.

Mix design is performed prior to constructing the pavement to determine the right combination of asphalt binder, aggregate, and air void space to use in the asphalt pavement. An analysis of the total pavement structure should also be conducted to determine the proper thickness of the various pavement layers needed to support repeated wheel load applications without premature failure. The effect of environmental factors, such as moisture and aging, on the strength of the pavement layers is considered as part of this analysis.

A well-designed asphalt mix, however, is of no value if it is not properly constructed. Quality control measures must be in place to assure the right quantities of materials are used and that the asphalt mix is placed and compacted correctly during construction to produce the desired pavement strength. A critical asphalt pavement property is the amount of air void space in the mix. Enough air space (about 3-5%) must be provided to allow expansion of the asphalt binder during hot weather. However, too much air space allows water to pass through the asphalt pavement surface and weaken the underlying base layers. Research at UC Berkeley has shown that a pavement's resistance to fatigue cracking can be increased three-fold by reducing the void content of an asphalt pavement from 8% to 5%. **Figure 3** illustrates the importance of good pavement compaction during construction. The lower void-content mix not only improves the strength of the pavement but also reduces the number of interconnected voids that allow water to pass through the pavement surface to the supporting base structure.

Water or moisture can permeate into the pavement structure due to a high air-void content or as a result of the construction of the roadway through low-lying areas. Where there is the possibility of moisture, drainage becomes a critical part of the pavement design. The construction and maintenance of adequate drainage systems, such as edge drains or open-graded mix channels are necessary to carry the water away from the pavement structure to reduce future pothole formation.

It is a major frustration for pavement engineers when a newly built asphalt pavement is trench-cut shortly after its construction to install sewer lines or other utilities. The replacement asphalt surface in these excavated sections is seldom of the same quality as the original pavement. The result is often localized distress in the form of pavement depressions and/or potholes. Communication and coordination between agencies and departments so that new pavement construction and utility service work are integrated into the overall pavement design is essential to avoid this source of future pavement distress.

"The important point is that a pavement maintenance plan provides a framework for making sound engineering and economic decisions."

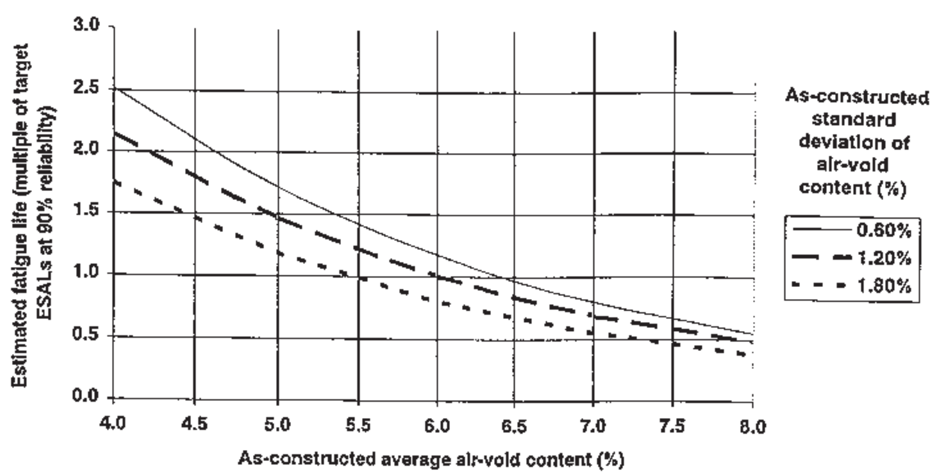

Figure 3. Effects of as-constructed air-void content on pavement fatigue performance (chart from TM-UCB-CAL/APT-97-1)

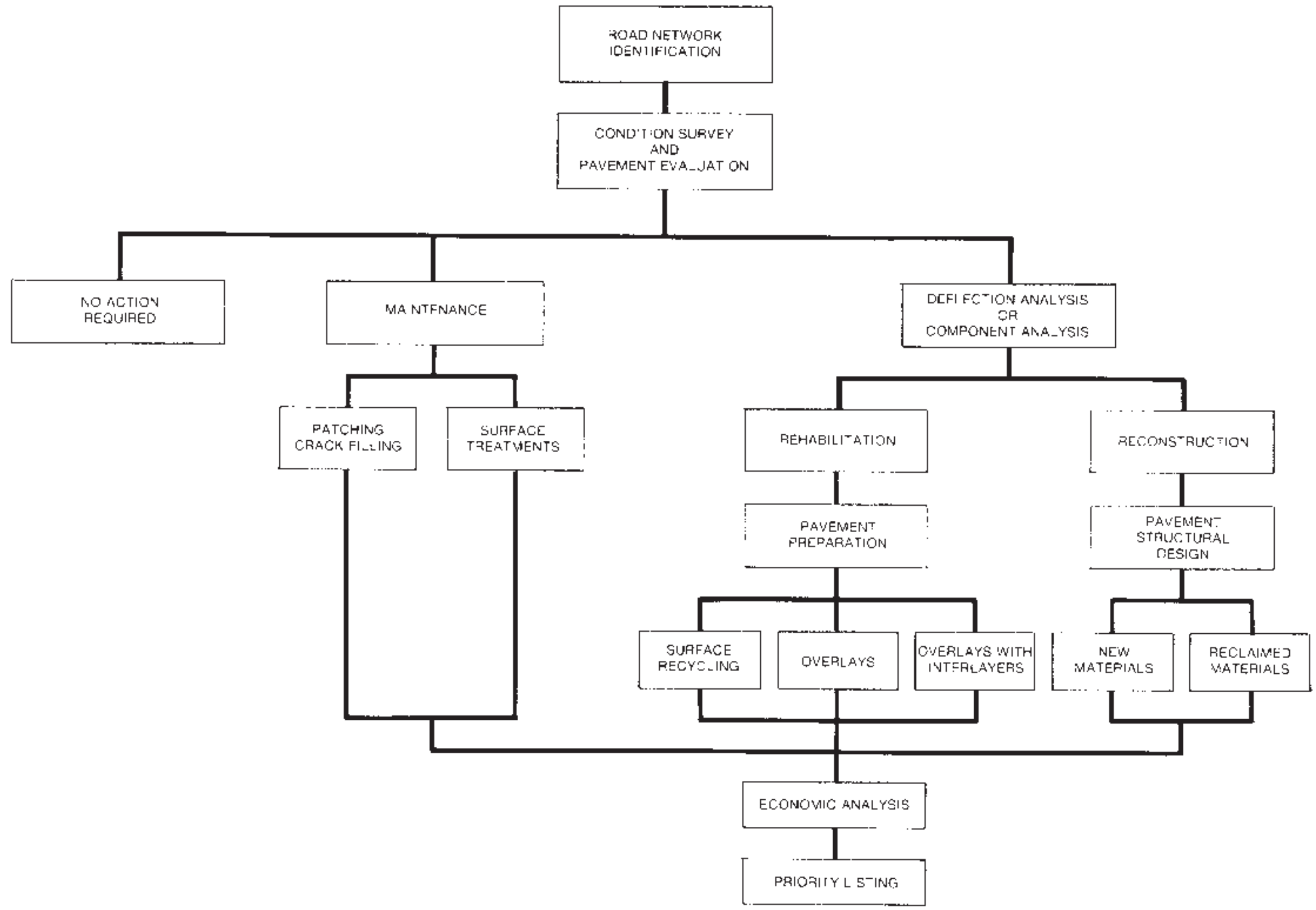

Figure 4. Plan-development guide (courtesy The Asphalt Institute)

Pavement Condition Survey

Unfortunately, most maintenance engineers are not blessed with excellent newly constructed pavements throughout their road network. They are more likely to have older pavements in various states of deterioration needing different levels of maintenance or rehabilitation. A pavement maintenance/rehabilitation plan similar to that outlined in **Figure 4** helps to identify and evaluate courses of action for pavement repair. Pothole repair is but one part of an overall pavement maintenance strategy. The planning system adopted can be an elaborate computerized program or a simple log of pavement distress conditions. The important point is that a pavement maintenance plan provides a framework for making sound engineering and economic decisions.

The first step in developing a plan is to map the various types of pavements in the roadway system. The next step is to conduct a thorough survey of the condition of all pavements in the system. If no action is required, the survey procedure is ended and the pavement condition is noted. If some type of remediation is required, the type of repair (patching, pothole filling, crack sealing, or surface treatment) is selected. If the condition survey suggests that more extensive actions are required, a deflection or component analysis of the pavement may be necessary. The final step is to develop a cost analysis and defensible (i.e., criteria-based) list of priorities for the work required.

Pothole Repair

Pothole repair is a maintenance strategy that falls under the patching option in **Figure 4**. Properly repaired in a timely manner, even a pothole distressed pavement can be put back into serviceable condition until more elaborate maintenance or rehabilitation actions are taken. There are two types of pothole repair—emergency repair and permanent repair.

"An effective pothole program will follow up emergency repairs with permanent repairs during warmer and drier periods"

Emergency repair is generally done when a severe pothole needs to be filled immediately usually when the weather is rainy or during the spring thaw. Several techniques are used for the emergency repair of potholes. They include the throw-and-go method, the throw-and-roll method, the semi-permanent method, and the spray injection procedure. The throw-and-go method involves placing the patch material into the pothole, which may or may not be filled with water and debris, and moving on to the next pothole. Compaction of the fresh mix is left to the traveling public. While this is not the best way to patch potholes, it does have a high production rate. The throw-and-roll method consists of placing the patch material into the pothole, compacting the patch with truck tires, checking that the compacted patch has a crown for surface drainage, and then moving on to the next pothole. The advantage of this method over the throw-and-go method is that the patch is compacted before leaving the repair site. The semi-permanent method involves removing water and debris from the pothole, squaring up the sides of the patch area to provide vertical support for the patch, placing the mix, and compacting the patch material with a vibratory roller or plate compactor. The spray injection procedure consists of blowing water and debris from the pothole, spraying a tack coat of binder on the sides and bottom of the pothole, blowing asphalt and aggregate into the pothole, and covering the patched area with a layer of aggregate before opening the pavement to traffic. A self-contained spray injection unit is shown in ***Figure 5.***

Figure 5. Spray injection device—self contained unit (photo SHRP-H-348)

An effective pothole program will follow up emergency repairs with permanent repairs during warmer and drier periods. The permanent repair procedure depicted in **Figure 6** involves removing the surface and base as deep as necessary to reach firm support, applying a tack coat to the vertical faces and untreated base, backfilling the hole with dense-graded hot mix or a good quality cold mix, and compacting thoroughly to the level of the surrounding pavement. If the prepared hole is more than 6 inches deep, the patch material should be compacted in layers.

Patch materials can range from dense-graded hot asphalt mix for permanent pothole repairs to several types of cold mix using asphalt emulsions or cutbacks and aggregate. Certain proprietary cold mixes use polymer modified or elastomeric systems to help improve the adhesion and strength of the mix in the pothole.

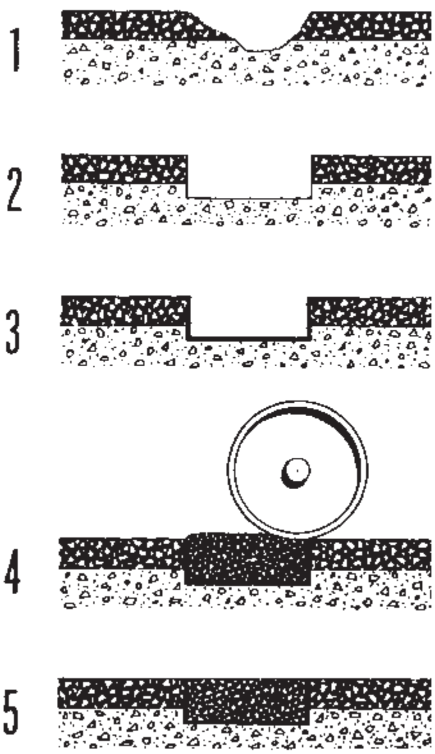

Figure 6. Pothole permanent repair (courtesy The Asphalt Institute)

(1) Untreated pothole, (2) Surface and base remove to firm support, (3) Tack coat applied, (4) Full-depth asphalt mix placed and being compacted, (5) Finished patch compacted to level of surrounding pavement.

Training and Funding

The two most critical factors for a successful pothole repair program are properly trained personnel and adequate funding. The Technology Transfer Program at the University of California, Berkeley provides courses on asphalt pavement maintenance to help address the training issue. Resource material and field engineers are also available to provide local agencies with technical assistance on pavement maintenance problems.

Funding is a management issue. The role of the city or county engineer is to develop a defensible prioritized pavement management plan that assesses the condition of the roadway network and provides a tool to make a cost-benefit analysis of proposed maintenance/rehabilitation projects for the community. This information will then be presented to community administrators and council members to help gain support for an active pavement maintenance program in the budgetary process. Even with limited funds, an active program based on sound engineering and economic analysis will go a long way to satisfy the public that their tax dollars are being used effectively to maintain the infrastructure of the community.

Good luck and happy pothole hunting!

References

1. “Asphalt in Pavement Maintenance”, Manual Series No. 16 (MS-16), The Asphalt Institute, 1983
2. Deacon, J.A., C.L. Monismith, and J.T. Harvey, “Pay Factors for Asphalt-Concrete Construction: Effect of Construction Quality on Agency Costs”, TM-UCB-CAL/APT-97-1, Pavement Research Center, CAL/APT Program, Institute of Transportation Studies, University of California, Berkeley, April, 1997.
3. “Alternatives in Pavement Maintenance, Rehabilitation, and Reconstruction”, Information Series No. 178 (IS-178), The Asphalt Institute, 2nd *Edition, 1994.*
4. “A Pavement Rating System for Low-Volume Asphalt Roads”, Information Series *No. 169 (IS-169), The Asphalt Institute.*
5. “Asphalt Pavement Repair Manuals of Practice”, SHRP-H-348, Strategic Highway *Research Program, National Research Council.*

4/1/99