M A S S

INTERCHANGE

Volume 11, Number 2 Winter 1997

CAUTION: POTHOLES AHEAD

Pavement in Serious Need of Repair

MAINTENANCE WORKS

We are a nation of great road builders, however, we have yet to become great road maintainers. For too long the management of our roads has been solely a building effort, i.e., construction and reconstruction, rather than a consistent long range commitment to the preservation of the investments of our citizens. This has not gone unnoticed and I believe it has contributed to a lack of overall support for infrastructure investment. How often have we heard

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Local Technical Assistance/Technology Transfer Center
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Repair Mixtures and Conventonal Tack Materials

REPAIR MIXTURES

Three basic materials are used for pothole repair: an aggregate-binder mixture (patching mix) for filling the hole, a tack material, and materials for edge sealing. However, the tacking and edge sealing steps are often omitted.

Four basic types of mixtures can be used for pothole repairs; hot-mix asphalt concrete (HMA), cold-stockpiled patching materials, sprayed-in-place materials, and loose stone.

• Hot-mix asphalt concrete

Hot-mix asphalt concrete is typically available during the warm-weather months when hot-mix plants are being operated for normal paving operations. Hot-mix asphalt is made by mixing hot asphalt cement with aggregates (coarse stone, sand, and mineral dust). It is transported to the job site and is often called amiesite, macadam, blacktop, or a variety of other names.

• Cold mixes

Cold mixes are designed for use in cold, wet weather when hot-mix plants are not operating, or when hot-mix is not otherwise available. Cold mixes may include locally produced materials mixed at the job site with little control, well-designed mixes such as those developed in Pennsylvania, or proprietary mixes such as UPM™. The more successful cold mixes are characterized by a relatively small top-size (typically 3/8"), a limited amount of minus No. 200 mesh (dust), and crushed angular aggregate. The binder is an emulsified or cut-back asphalt that is matched with the aggregate to minimize stripping and water damage. These cold mixtures are designed to contain thick asphalt films and are often claimed to be self-tacking because of the thick asphalt films.

SPRAY INJECTION

The newest pothole repair method is spray injection. The patches it creates were the longest lasting of those in a SHRP study (SHRP-H-353). The patches can be put down by one operator and in any weather conditions. However, this one operator has to be in a really cool and nifty expensive piece of equipment which can blow dry the pothole, tack with asphalt, spray in patch material at high velocities, and cover the patch with dry aggregate. No compaction is required because the velocity of the spray compacts the patch from the bottom up. The dry aggregate is added to the top to allow vehicles to drive over it right away. This method creates the best patches. However due to the cost of the machine (anywhere from $25,000 for a trailer mounted unit to $150,000 for a self-contained system), it's cost-effectiveness depends on how many potholes your town or city has.

See Mass Interchange (Fall 1994) for a more detailed explanation of spray injection equipment.

• Sprayed-in-place mixtures

Sprayed-in-place mixtures are applied with specialized equipment in which the binder and the aggregate are mixed at the time of application. The binder used in these mixes is typically an asphalt emulsion and may contain specialized polymer-modified binders. The equipment used to spray the aggregate-asphalt binder mixture into the pothole can also be used to blow debris and water from the pothole and to apply tack material.

• Loose stone

Another technique that can be used for pothole repair is to fill the pothole with loose stone and pour a liquid asphalt on the stone to fill the voids and bond the stone together. This technique is often used in low-volume pie-crust roads.

CONVENTIONAL TACK MATERIALS

To enhance the adhesion between the existing pavement and the pothole repair mixture, a tack material is often applied to the existing pavement before filling the hole with mix. Tack materials that are commonly used include asphalt cement, cut-backs, and emulsified asphalt (emulsions).

• Hot asphalt cement

At room temperature, asphalt cement is stiff with a consistency of saltwater taffy. It must be heated to be mixed with stone, sprayed, or poured. When used for tacking (or edge sealing) it is usually heated in a "tar buggy" and poured into the pothole while still hot. It may also be sprayed while it is hot, but this requires special equipment.

• Cut-back asphalt

This material is formed by adding kerosene or gasoline to asphalt cement much like paint thinner is added to an oil-based paint. The net

result is a mixture that can be poured at room temperature. Sometimes cut-backs are heated slightly, 140 °F or so, to make them more pourable. Cut-back asphalt may be poured or sprayed into the pothole.

• Emulsified asphalt

Emulsified asphalt is made pourable by adding water to the asphalt cement. This requires a great deal of energy and is done in a colloid mill by the emulsion manufacturer. The result is very fine droplets of asphalt cement suspended in water. Emulsions are typically brownish in color. They may be sprayed, poured, or mopped into the hole. After they "break" they turn black in color, leaving behind a film of asphalt. Emulsions have an advantage in that they can be applied to a wet pavement, whereas cut-back and hot asphalt cement will not adhere to a wet or damp pavement. A disadvantage of emulsions is that they cannot be subjected to freezing because the emulsification will be destroyed. If an emulsion freezes, it will likely separate into a mass of water with large lumps of asphalt cement. This is similar to what happens to latex paint, which is an emulsion, when it freezes.

• Problems with conventional tack materials

Each of the conventional tack materials described above poses particular problems. In order to be effective, the tack material must be applied in a thin layer and must adhere to the existing pavement material. In most cases, unless heating or infrared drying is used, the edges and bottom of the pothole will be damp. The edges and bottom will typically contain exposed aggregate as a result of the cutting operation. Thus, the tack material must be compatible with all types of aggregate (acidic or basic), old oxidized asphalt cement exposed on the edges and bottom of the repair,

Pothole Patching in Amherst

and Portland cement concrete. Although the binder in cold pothole repair material may be especially formulated to be compatible with the aggregate in the mix, compatibility with the existing pavement cannot be ensured. This is also true of conventional tack materials -- asphalt cement, cut-back asphalt, and emulsions -- because it is difficult to formulate them to be compatible with the entire range of aggregate types that may exist during pothole patching. According to the manufacturer, BONDADE is specially formulated to "wet" the surface of a wide range of aggregate types and to provide a long-lasting, moisture resistant adhesive bond that is compatible with asphaltic materials and aggregates.

Unless tack materials are applied in a relatively thin coat, they can affect the stability of the pothole repair

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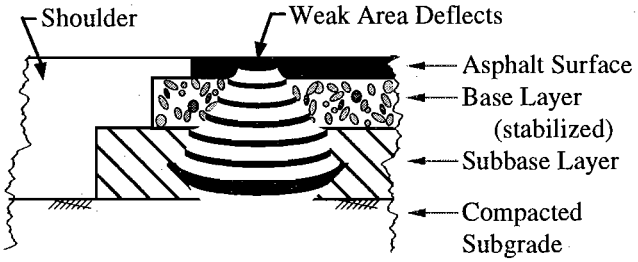
Pothole Repair Failures

The most commonly encountered pothole repair failures are lack of adhesion to the sides or bottom of the repair, dishing, pushing or shoving of the patching mix, loss of material through raveling, delamination of the patching mix and drainage failures. Each of these failures is described below.

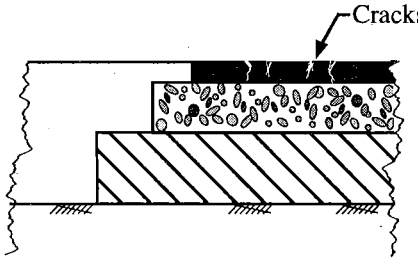
• Poor Adhesion

A lack of adhesion around the edge of the repair eventually leads to cracking and can result in the premature loss of the repair. The cracking is the result of shrinkage stresses caused by temperature changes or loss of volatiles from the mix (cold mixes made with cut-back asphalts). The cracks allow water to enter the repair, resulting in premature failure. When the water freezes, expansion forces are created that can dislodge the repair from the pothole. Water, in combination with traffic loads, can also create hydraulic pressure that can dislodge the repair.

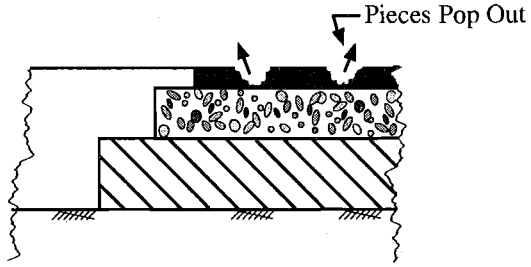
A lack of adhesion between the patch material and the surface of the old pavement can also lead to early failure when cracks form and water penetrates *under* the patch. When the water freezes the repair may be pushed upward, causing cracking and loss of material. This typically occurs during the thaw cycle, leaving the water trapped under the repair to support the patch.



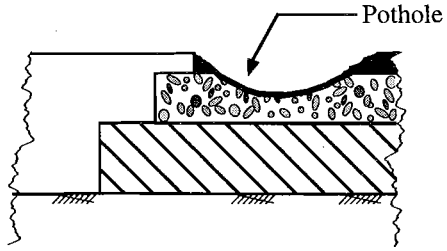
Step 1. Pavement Deflects Excessively



Step 1. Cracks Form, Water Enters



Step 3. Water Freezes, Pavement Pieces Pop Out



Step 4. Pavement Erodes Into Base Layer

FORMATION OF A POTHOLE

• Dishing of Patch

Dishing, defined as settlement of the surface, is the result of inadequate compaction of the repair mix. In the case of utility cuts or pavement widening, dishing may also be the result of inadequate compaction of the underlying pavement.

• Shoving

Shoving is the result of inadequate shearing resistance in the mix and can be the result of a poorly compacted mix, the bleeding of tack or liquid asphalt to the upper portion of the repair, or a poorly designed mix. In this case, a part of the repair is dished, allowing the mix to be shoved to the front of the region where a bump appears. Poor mix design can be the result of a "soft" binder, improper gradation, lack of crushed aggregate faces, and other factors.

• Raveling

Raveling is a loss of mix from the surface of the repair. It results from insufficient cohesion within the mix and can be a mixture-related problem. In severe raveling, the coarse stones become dislodged from the mix and create a depression in the surface. In the most extreme cases, the entire repair may be lost. Stripping -- a loss of adhesion between the stone and the asphalt in the presence of

Continued from Page 4

water -- is one of the primary causes of raveling in pothole repairs, especially in repairs made with cold-stockpiled mixes. Stripping can usually be controlled by the proper selection of anti-stripping agents.

Poor compaction, which allows water to enter the repair, is also a major cause of raveling. Throw-and-go procedures are particularly susceptible to raveling as a result of poor compaction. Allowing hot-mix to cool excessively can also lead to poor compaction.

• Reflection Cracking

Pothole repairs are often called on to perform miracles; for example, when they are placed over severely cracked or deteriorated pavements. In this case, the strength of the repair may not be sufficient to carry the load and to bridge the weak pavement. Cracks that originate in the old underlying pavement and propagate through the patch are called reflection cracks. If they spread, they may cause the patch to fail. Movement of the underlying pavement under traffic loading and water can both accelerate the spread of any cracks that from in the patch.

• Delamination

Delamination is symptomatic of asphalt concrete overlays or thin patches that peel away from the old surface. Conditions such as this can occur when a depression in a utility cut is filled or when an attempt is made to patch failed surfaces. This type of failure is caused by poor adhesion between the old pavement and the patch.

• Poor Drainage

Because water is so damaging, the drainage of the pavement must be considered when evaluating the performance of repairs. If the pothole repair is in a low spot that is continuously wet or if the base is in a low-lying area, these conditions should be noted as a possible cause of any subsequently observed early failures.

Continued from Page 3

mix by bleeding into the mix and effectively over-asphalting the mix. Specialized equipment is required to apply thin coats of hot asphalt cement, cut-back asphalt cement, and emulsions. Such equipment is rarely used in practice because of its cost and complexity. As a consequence, tack material is typically hop-mopped or poured from a "pour pot" onto the edges of the repair. The result is a very thick layer of liquid that cools rapidly on contact and does not "wet" the edge and bottom of the existing pavement. As a consequence, the hot-poured tack often adheres poorly to the existing pavement.

To enhance the adhesion between the existing pavement and the pothole repair mixture, a tack material is often applied to the existing pavement before filling the hole with mix.

EDGE SEALING MATERIALS

As described earlier, a pothole repair edge seal is typically formed with an asphaltic material, either a layer of hot applied asphalt cement or a layer of cut-back or emulsion. The edge seal is designed to seal the joint between the repair and the existing pavement. An edge seal can be beneficial if the mixture in the repair is improperly compacted or if there is a poor bond between the repair mixture and the edges of the hole. Edge sealing is a costly and time-consuming procedure because it requires additional equipment (such as a tar buggy) at the job site.

These previous two articles are excerpts from Guidelines for Field Evaluations of Pothole Repairs, CERF Report: HITEC 95-1, Highway Innovative Technology Evaluation Center, Civil Engineering Research Foundation, 1015 15th Street, NW (Suite 600),Washington D.C. 20005-2605 and have been reprinted with permission.

The Civil Engineering Research Foundation through a cooperative agreement with the Federal Highway Administration (FHWA) created the Highway Innovative Technology Evaluation Center (HITEC) to expedite the introduction of innovative products into the U.S. highway and bridge markets.

HITEC evaluates highway products for which there are no recognized standards or specifications. By providing impartial evaluations of technologies, HITEC hopes to encourage state and local governments to more quickly implement innovative products in the highway system, thereby enhancing the incentives for private industry to invest in highway-oriented research and development.

HITEC was organized to provide a service to specific clients, but also to serve as a clearinghouse for information useful to the transportation community at-large, particularly public sector officials. To help carry out that mission, this report was expanded to include considerable background information on the pothole repair problem. This was done in the hope that, because of the pervasive nature of the pothole problem and consequent continuing interest by highway agencies, the background material and evaluation forms will be useful to agencies involved in evaluating other pothole repair products and proposed solutions.

Continued from Page 1

people proclaiming that we always seem to be working on the same road. DPW's must dispel this belief by not only constructing good pavements but also by maintaining them.

One of the maintenance procedures which can lengthen the life of our roads is proper sealing. Of the materials available for road construction, bituminous concrete, or hot mix asphalt (HMA) has proven to be very serviceable. When properly produced and applied, HMA provides a quality road surface which is relatively easy to maintain. Hot mix asphalt has one inherent flaw; it allows far too much water to pass through its courses, resulting in premature failure of the mix. Cracking, shrinking, raveling, spalling, wheel rutting, damage from ultraviolet light, and failure of the subbase from loss of fines through cracking can all result from weathering of the pavement due to water intrusion. Sealing should be applied before these various distresses are visible, preventing the formation of many defects, and certainly slowing the overall deterioration of the pavement. Proper waterproofing will prolong the life of HMA, provide lower life cycle costs and better driving facilities overall.

In the days before the construction of HMA plants, the common practice was to create mix in place and seal the pavement by spreading liquid asphalt and an aggregate cover. The proliferation of the use of HMA has resulted in a generation of road managers who do not recognize the value of sealing and a public that is not accustomed to this practice and philosophy of road maintenance. One observation that I have made and commented upon is that the public does recognize the value of sealers, evidenced by the number of people who seal their own driveways or pay others to do so; they apparently wish to preserve the investment they have made in their own pavements.

While less glamorous than major construction projects, the management systems that we have in place or at our disposal can prove to decision makers that minor maintenance procedures have great value economically to our communities and states by saving money for other projects and by lowering the burden to taxpayers.

As we prepare for the next century, we will be faced with many challenges and with continued fiscal pressures and constraints. The use of new and old highway maintenance materials as well as our ability to conserve natural resources such as stone and oil products, will allow us to meet these challenges. The result will be a better highway system delivered to the public at lower cost with better overall conditions. These materials are currently available from reputable companies. What is needed are changes in attitudes and road maintenance philosophies to include the application of roadway sealing materials, and other pavement maintenance and management techniques.

Pat Ellis works in sales and marketing for Sealcoating, Inc. of Hingham, MA and was previously the Superintendent of Public Works for the Town of Sandwich, Massachusetts for over 10 years. Pat is also a past president of the Barnstable County Highway Association, and currently serves as a board member of the Massachusetts Highway Association and is a member of the Massachusetts Municipal Association's Public Works Policy Committee.

Most potholes will result from one or more of four main causes:

1. Roads that have *insufficient thickness* to support traffic during winter/spring thaw cycles without localizing failures.
2. *Poor drainage,* which will usually cause failure in combination with thin pavements, but can also affect thick pavements and new overlays.
3. Failures at *utility trenches and castings.*
4. Miscellaneous *paving defects* and cracks left unmaintained or unsealed from water intrusion.

FYI:

Did you know that the gaps caused by potholes are also gaps in liability? A list of 750,000 pothole locations in New York City has been compiled by lawyers and given to the city as notification of defect. Once notified, the city becomes legally responsible for damages resulting from these roadway defects.

How Potholes Develop

A pothole develops when two factors are present at the same time -- water and traffic. This could almost be called the cardinal rule of pothole development, because without water and traffic present at the same time, potholing simply won't develop. *Exceptions to this rule do not exist!*

New Videos

MO-209 Pavement Maintenance and Worker Safety, NACE, 16:07 min.

MO-210 Plows of the Future, NACE, 8 min.

MO-211 Concrete Bridge Protection Repair & Rehabilitation, NACE, 5:15 min.

DC-157 Evaluation Procedures for Deicing Chemicals, NACE, 10:47 min.

ST-163 Snow and Ice Control, NACE, 12:41 min.

ST-164 Stay Ahead of the Storm: Road Weather Info. Systems, NACE, 20:37 min.

ST-165 New Work Zone Safety Devices, NACE, 17:04 min.

Pothole Videos

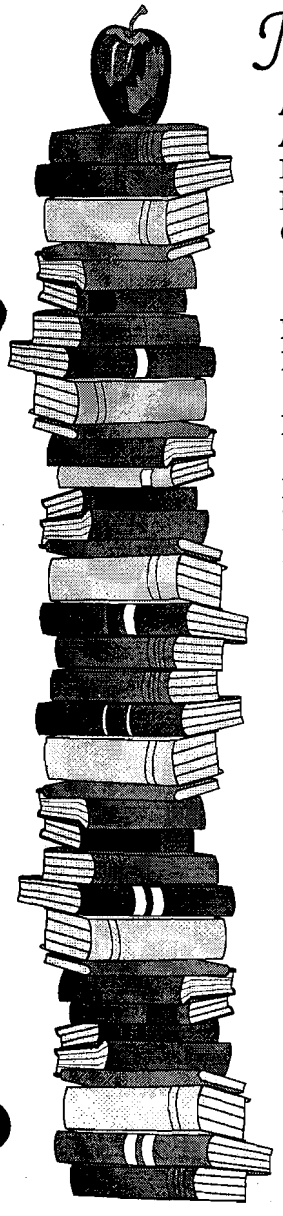
MO-109 Pothole Repair, MNDOT, 56 min.

MO-119 Potholes -- Causes, Cures and Prevention, WADOT, 17 min.

MO-144 Pothole Repair in Surface Treatment Pavement, FHWA, 13 min.

DC-112 Asphalt Paving Inspection, Pothole Repair, WY T² Center, 40 min.

MO-196 Road Repair: Do the Right Thing at the Right Time, MN Local Road Research Board, 21:30 min.



New Publications

ASP-53 Crumb Rubber Modifier (CRM) in Asphalt

ASP-54 The Superpave System

BRI-50 Bridge Maintenance on Local Roads

BRI-51 Bridge Rehabilitation on Local Roads

COC-35 Summary Report of Mechanistic Behavior of High Performance Concretes - Volume 1

D&C-27 Local Low Volume Roads and Streets

DRA-25 Best Management Practices for Erosion Control

DRA-26 Drainage and Erosion Control - Chapter 10 of Highway Design Manual

DRA-27 Roadway Drainage Course Handout

DRA-28 Erosion Control Handbook

MAI-19 Making Pavement Maintenance More Effective

MAI-23 Tips for Conserving Energy & The Environment

MAN-35 Supplemental Specifications to 1988 Standard Specifications for Highways and Bridges

MAN-44 Solid Waste Management

MAN-45 Purchasing Authority

PLA-37 Planning and Financing Capital Improvements Programs

PLA-38 Rural Transportation Planning

PLA-39 Impact of Land Development on County and Local Transportation System Planning

SAF-80 Safety Improvements

T&P-19 Public Awareness & Support

T&P-21 Transition to the Metric System

TRA-48 Improving Traffic Signal Operations

TRA-55 Traffic Operations

UNS-02 Blading Aggregate Surfaces

Pothole References

D&C-14 Pothole Primer

D&C-16 The Engineer's Pothole Repair Guide

D&C-31 Fabrication and Testing of Automatic Pothole Patching Machine

D&C-35 Pavement Patching Guidelines

D&C-38 Innovative Materials Development and Testing -- Vol. 2: Pothole Repair.

D&C-54 Guidelines for Field Evaluations of Pothole Repairs

MAN-20 Pavement Distress and Rehabilitation Manual

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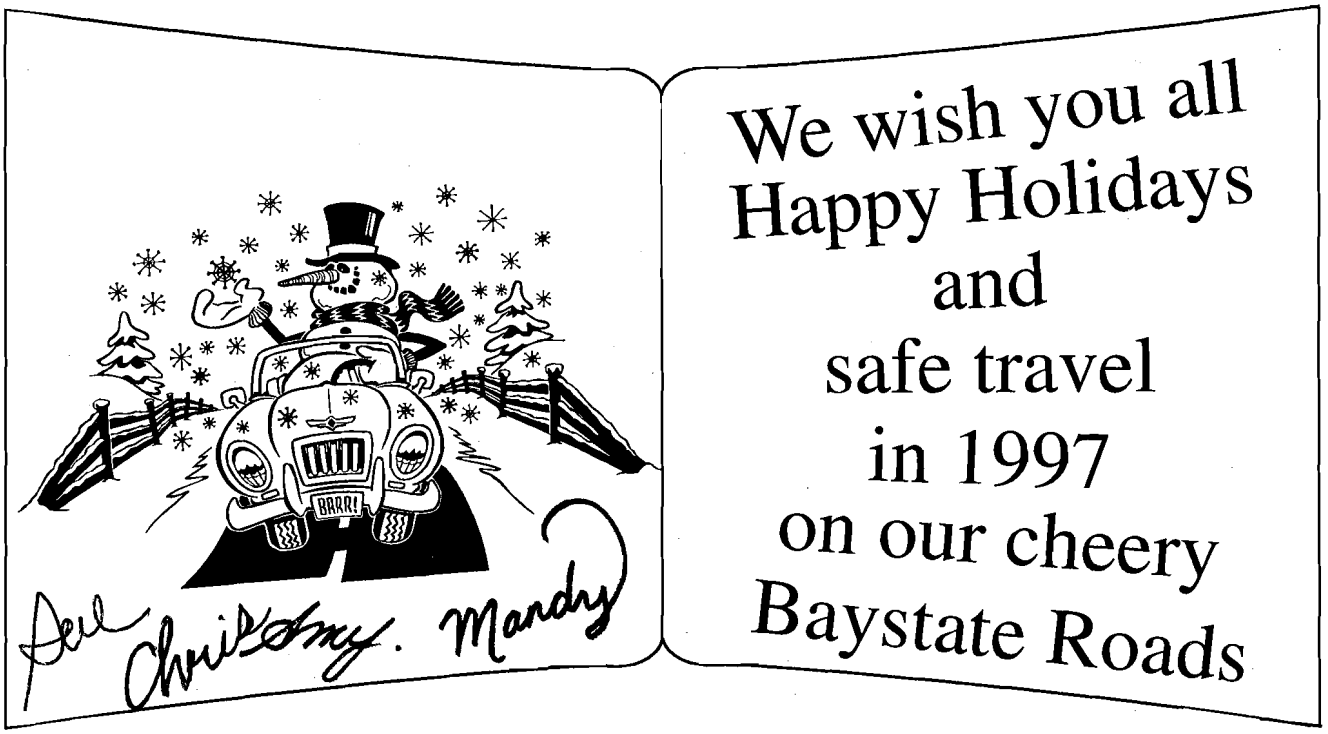

The Baystate Roads Program, which publishes *Mass Interchange* each quarter, is a Technology Transfer (T2) Center created under the Federal Highway Administration's (FHWA) Local Technical Assistance Program (LTAP). FHWA is joined by the Massachusetts Highway Department, the Department of Civil and Environmental Engineering at the University of Massachusetts/Amherst, and local public works departments in an effort to share and apply the best in transportation technologies.

In addition to publishing *Mass Interchange*, the Baystate Roads Program facilitates information exchange by conducting workshops, providing reports and publications and videotapes on request, and offering one-to-one technical assistance on specific roadway issues. Because the program relies on input from many sources, inquiries, articles, and ideas are encouraged.

Local Technical Assistance/Technology Transfer Center

To contact the Baystate Roads Program, call (800) 374-ROAD (in state) or (413) 545-2604.

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First Annual Berkshire County Snow Plow Rally

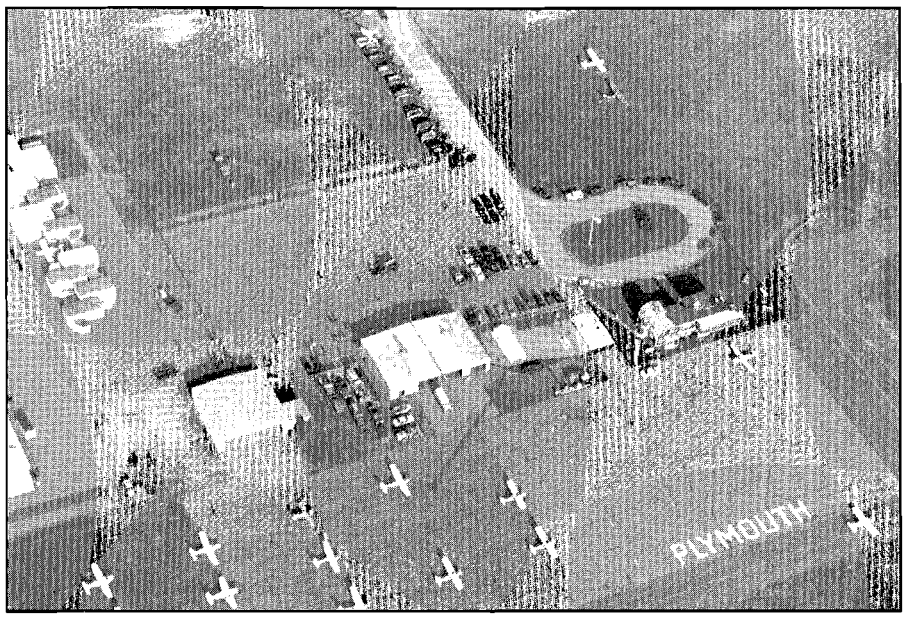
On September 27, 1996, the first Berkshire County Snow Plow Rally was held in Dalton. Five teams rounded out the competition, including representatives from Becket, Lanesborough, Pittsfield, Plainfield, and Washington. The Rally was comprised of five events: a Snow Plow quiz, Backing with Compressor (or in this case, Backing with Chipper), Front Plow Mounting, Pre-Trip Inspection, and the ever popular Snow Plow Slalom.

In an unusual turn of events, the teams assembled were so well versed in their plow mounting and pre-trip inspection skills that all attained perfect scores. In a case such as this, winners are determined solely on the basis of event times. The All-Around Rally winners were Craig Willis and Paul Keiper from Washington, finishing first place in the Pre-Trip Inspection, Front Plow Mounting, and Slalom events. Other first place winners were Pittsfield's Mike Brzostek and Jeff Howes from the Snow Plow Quiz, and Becket Team members Skip Dean and Ray Fletcher in the Backing with Chipper event.

While the weather cooperated and the event was judged successful by all participants, one change will be made next year. Namely, all participants will use the same truck to run the slalom course. The Baystate Roads Program would like to thank event sponsors (Charlie Waterhouse, Jerry Coppola, and the Berkshire Highway Association, All States Asphalt, and the Massachusetts Interlocal Insurance Association. The Massachusetts Highway Department assisted by contributing barrels and supplying two event judges (Jim Fallon and Paul Chrzanowski), and Pittsfield Safety Officer Dan Triceri provided additional support.

Plymouth County Snow Plow Rally

Compared with last year's torrential rain showers, the fourth annual Plymouth County Snow Plow Rally was a real breeze, literally. Sunny but breezy and cool temperatures prevailed for this, the longest running and most well attended Rally in the State. Eighteen teams competed in the usual five events (see Berkshire County Rally article), with the Overall Winners plaque awarded to Alan Viall and Buddy Pucillo, from Easton. Easton was the all around winner last year as well. Reporters and photographers from the Associated Press, the Brockton Enterprise and the Patriot Ledger covered the event, and this reporter was even privy to a bird's eye view, courtesy of the Plymouth County Airport. Congratulations are awarded to all competitors, and thanks to the Plymouth County Highway Association and Massachusetts Interlocal Insurance Association, for once again putting on a superb event.



K. Dodge

Aerial view of the action.

CALENDAR

Hot Mix Asphalt

Speaker:	Mr. Robert Christman
March 5, 1997	Westford Regency
April 2, 1997	Holiday Inn/Mansfield
May 7, 1997	Hotel Northampton
June 11, 1997	Cape Cod Comm. College

Geographic Information Systems

Speakers:	Gordon Daring and Nat Norton
February 5, 1997	Holiday Inn/Mansfield
February 19, 1997	Westford Regency
February 26, 1997	Hotel Northampton

Presentations for Public Boards

Speaker:	Mr. Rockie Blunt
December 17, 1996	Hotel Northampton
December 19, 1996	Sheraton/Plymouth
January 7, 1997	Hawthorne/Salem
January 9, 1997	Westford Regency

Recycled Asphalt

Speaker:	Mr. Paul Brown
March 11, 1997	Hotel Northampton
March 12, 1997	Nichols/Southborough
March 18, 1997	Holiday Inn/Taunton
March 19, 1997	Andover Inn

Public Works Education Conference

Sponsored by the Massachusetts Highway Association and the Baystate Roads Program

June 5-6, 1997	UMass/Amherst

Partnering Concepts

Speaker:	Rocco Vespi
April 15 - 16, 1997	Crowne Plaza/Worcester

Surveying II

Speaker:	Mr. Kenneth Black
May 15, 1997	Holiday Inn/Taunton
May 20, 1997	Nichols College/Southborough
May 22, 1997	Hotel Northampton
May 29, 1997	Wyndham Garden/Burlington