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Cold Hand Patching Materials

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Prepared in cooperation with the
U.S. Department of Transportation
Federal Highway Administration

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16. Abstract

This report describes a study comparing the performance of four types of cold hand patching material (cold mix) used by CDOT Maintenance personnel. The primary objective of this study was to compare the cost effectiveness of the different types of cold mix.

Six test sites were located state wide, then all four types of cold mix were used to make repairs at each site. The repairs were monitored for two years to compare performance.

The results of this study show that proprietary cold mixes perform significantly better under adverse conditions than ordinary cold mixes. The increase in performance more than offsets the additional cost of the proprietary mix.

Implementation:

Based on the results of this study and the literature reviewed it is recommended that CDOT use a proprietary type of cold mix for hand patching when hot mix in not available.

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Cold Hand Patching Materials

I. Problem Statement:

A. Description:

Every year, all year long, but especially during winter and spring, potholes appear in asphalt pavement. Safety and public relations require maintenance crews to do something to alleviate the problem as soon as possible; however, since paving stops during cold weather, most asphalt plants are not producing hot mix that could be used to fill the holes. The solution is the use of cold mix to make a repair that will, hopefully, last until paving season starts and hot mix is available to make a permanent repair.

Different types of cold mix vary from recycled pavement that has had a small amount of new asphalt added to proprietary mixes that claim to work under the most adverse conditions. Emulsified or cutback asphalt of a wide range of viscosities is used with the results that the mix can be very hard and brittle in cold weather or soft and slow to cure when it is warm. Costs for cold mix can also vary from low for locally made mixes (occasionally given very colorful names by Maintenance crews) to three or four times the cost of hot mix for products like Sylvax and Styrelf which are two of the mixes tested here.

B. Cost:

Cost for pothole repair is dependent on more than just the price of cold mix. Obviously labor and equipment costs must be added to the cost of buying and storing the cold mix; however, the amount of time that the crews are exposed to traffic and the length of time the road is closed to traffic must also be considered. Something that is easily overlooked is the life of the repair. A pothole that is quickly repaired under marginal conditions may have a life span of days or even only hours. If a patch can be made to last until the next paving season it may be more cost effective to use a high priced cold mix.

C. Conditions:

A repair that has to be made repeatedly is a source for several types of problems. When highway maintenance crews, who are the most visible representatives of the department, have to return to the same location several times to repair the same problem, it becomes more than just a pothole: Drivers begin to wonder if the Highway Department really knows what it is doing. They are not aware of the various problems the maintenance crews are forced to deal with, and they don't care. They just want the highway to be smooth and safe and, most of all, open for traffic, not closed for repairs or construction.

Working near traffic is one of the most dangerous parts of the maintenance workers job. Cold mix that won't stay in place increases the time maintenance workers must be exposed to these dangers. By being able to take the time to make the initial repair properly and/or using a more expensive material for the patch, the amount of exposure time can be reduced. Often, the places with the most traffic are where repair work is done with a "throw-and-go" method. The idea is to get as many of the holes patched as possible, however, the patch may only last a short time before it pops out not only re-opening the hole but adding the cold mix to the debris that is picked up and thrown by the

tires of passing traffic. Conditions that require "throw and go" repairs tend to shorten the life of patches. (They don't do a lot for the patchers either.)

If a repair can be made to last, it may be worth taking longer to "do it right", and/or spending more money for cold mix that stays in the hole. If a patch can be made under adverse conditions and still last through the cold season, the higher cost of proprietary mixes or additional time spent making the repair may be justifiable.

II. Objectives:

This study compared four different cold mixes. All of them are in use by CDOT maintenance crews, however, there is a very large difference in price. The purpose of this study is to determine if one type of cold mix is more cost effective than the others.

III. Study Procedures:

A. Materials:

For the purposes of this study four cold mixes that have had good results in Colorado were tested. They are two proprietary mixes Sylvax and Styrelf, and two generic mixes made using MC-250 cutback asphalt, one with fibers and one without. UPM, from Sylvax, and Styrelf, from Elf Asphalt, are expensive proprietary mixes that are claimed to work well under poor conditions. Sylvax, in a video tape promoting UPM, shows patches being made under standing water. UPM and Styrelf are very sticky even at low temperatures, and do not need to have a tack oil applied to the pavement before they are placed to make a repair. They are also hard to work with cold because they get very hard. Most maintenance crews store them in 55 gallon drums which can be brought inside overnight to warm up so the material can be worked more easily. Although there is some inconvenience in storing the mix in barrels, it keeps the mix fresh even if it is stored through the summer, and reduces the lost material at the stock pile to nearly zero. In addition to the high price of these mixes, about

$70/ton, the fact that some of the asphalt plants in more rural areas are reluctant to make them has reduced their use in some areas. Some Maintenance sections send trucks to the Denver area to buy these mixes, but others buy and use other types of mix that they can get closer to home.

MC-250 asphalt is used to make cold mix that is a good compromise between workability in all weather conditions and durability and reasonable curing time. It is not so stiff that it cannot be worked during cold weather, yet it cures rapidly in warm weather. Polypropylene fibers can be added to increase the durability of the repair, however, they make the material harder to work with. Two batches of MC-250 were used for the tests, one with fibers and one without fibers.

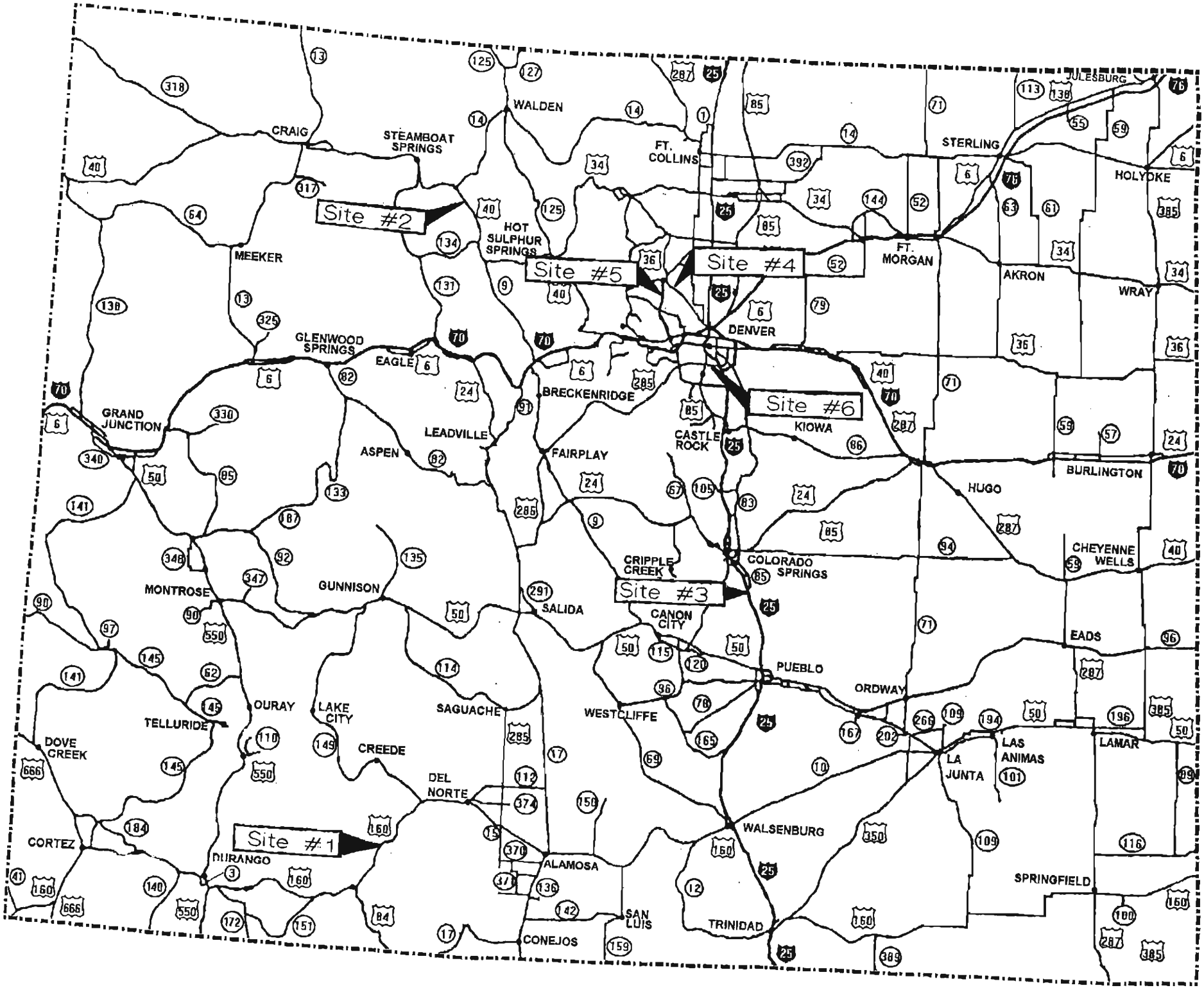
B. Sites:

1. Selection:

To evaluate the mixes under different circumstances, sites were selected with different weather and traffic conditions. The sites selected were: site one on US-160 at mile post 151, west of Wolf Creek Pass, site two on US-40 between mile post 160 and 162 east of Rabbit Ears Pass, site three on I-25 at mile post 132 south of Colorado Springs, site four on US-36 west of the junction with SH-121 at Broomfield, site five on SH-93 between SH-128 and the Boulder city limits, and site six on US 285 at Downing St. in Englewood. All are in relatively high traffic areas; two are in the mountains and four are east of the mountains in relatively flat country. (The site on I-25 near Colorado Springs was overlaid and lost before any information could be obtained.) The map on page five shows the site locations.

2. Repairs:

At each site, patches were made by the maintenance crew assigned to the section of highway involved. The patches were all made using normal procedures for the area; the holes were prepared, and the cold mix placed, and compacted the way they are


Site #1
Site #2
Site #3
Site #4
Site #5
Site #6
JULESBURG
WALDEN
CRAIG
STEAMBOAT SPRINGS
FT. COLLINS
STERLING
HOLYOKE
HOT SULPHUR SPRINGS
MEEKER
FT. MORGAN
AKRON
WRAY
DENVER
GLENWOOD SPRINGS
EAGLE
BRECKENRIDGE
GRAND JUNCTION
LEADVILLE
ASPEN
FAIRPLAY
CASTLE ROCK
KIOWA
BURLINGTON
HUGO
CHEYENNE WELLS
CRIPPLE CREEK
COLORADO SPRINGS
MONTROSE
GUNNISON
SALIDA
CANON CITY
EADS
PUEBLO
ORDWAY
OURAY
LAKE CITY
SAGUACHE
WESTCLIFFE
TELLURIDE
DOVE CREEK
CREEDE
LAS ANIMAS
LAMAR
LA JUNTA
DEL NORTE
CORTEZ
DURANGO
WALSENBURG
ALAMOSA
SPRINGFIELD
SAN LUIS
TRINIDAD
CONEJOS

during normal maintenance. The only exception was the fact that all of the patches made using UPM and Styrelf were made without the use of tack oil. Research Branch personnel delivered the cold mix to the sites in 55 gallon drums, all four types came from stocks being used by maintenance sections, none was specially mixed for the study. The mix used for all of the sites came from the same batch for each type so there was no possibility of having variations in the way the mix was made.

3. Site One:

Site number one was set up on the west side of Wolf Creek Pass in the westbound lane near mile post 151. US 160, in this area, is cracked and patched quite extensively. The edges of the damaged areas were cut square using a slide hammer, then the holes were swept clean and prepared with tack oil. The mix was placed in the hole and raked then packed using the wheels of a one ton dump truck. The patches made using Styrelf and UPM were made without using tack oil, and, since these two mixes are very sticky, the surface was sifted with dirt from the shoulder of the roadway to prevent traffic from tracking the mix out of the hole before it had the chance to cure completely. All of the patches were made in areas that were alligator cracked and had areas about one to two square feet that needed filling. The surface of the pavement was dry and about seventy degrees at the time the patches were made. This site is about 9000 feet in elevation and has an AADT of 1700 with 290 trucks. The average time required to fill a hole was about 15 minutes.

4. Site Two:

Site number two was on US 40 east of Rabbit Ears Pass. Patches were made in both east and westbound lanes in an area from mile post 160 to 162. This highway is in better condition than US 160 so the patches are spread over a wider area. Preparation, placement, and compaction were all done the same as on Wolf Creek. The only exception was that the crew from Rabbit Ears

had a large single axle dump truck which was used to pack the patches. The surface of the roadway was between 50 and 70 degrees. Some of the holes were slightly damp on the bottom when they were patched, but none of them had water standing in them. Site two is at an elevation of about 8000 feet and has an AADT of 1400 with about 196 trucks.

5. Site Three:

Site number three, on I 25 south of Colorado Springs in the southbound lanes was overlaid shortly after the patching work was done, so there was no information gained on the performance of the cold mix. There is video tape of the patching work in progress. On I 25 a vibrating steel roller was used to compact the patches.

6. Site Four:

Site four, on eastbound US 36 west of Broomfield, was done when the air temperature was in the low 50's and the wind was blowing. The cracks and potholes that were patched were damp from snow that had fallen two days before. These patches were made quickly during gaps in traffic. Since this was a "throw-and-go" operation and only small areas were patched, the mix was packed into the holes by the crew stomping on it then letting traffic finish the compaction. No time was taken to square edges or to tack the pavement. This site and site five demonstrated the value of the high priced proprietary cold mixes when they are used to make repairs under conditions that do not allow extensive preparation of the pothole. During a visit to the site two days after the repairs were made, Research personnel found wide variations in the conditions of the repairs. Patches made using MC-250 were completely gone, while others that were only inches away that were made using UPM were in good condition.

7. Site Five:

Site five is on SH 93 between the junction with SH 128 and the Boulder city limits. Work was done on this site on the same day that site four was done. The difference between this site and number four is that the holes could be prepared better on site five. There was time to clean the holes better and tack them before the cold mix was placed. The patches were rolled using the wheels of a one ton dump truck before traffic got on them. During the second visit referred to above, all of the patches were found to be in good condition.

8. Site Six:

Site six, on US 285 at Downing St. in Englewood, was an extreme test for UPM and Styrelf. The MC-250 mixes were not used at this site. An area at the right edge of the westbound lane where a turn lane from Downing St. enters was in bad condition. There was a badly cracked and broken concrete gutter along the edge of the asphalt. This is an area where water stands in the gutter. The water penetrates the cracks in the gutter and enters the base under the pavement causing the asphalt to deteriorate badly. This area had been repaired before using various types of cold

mix. The maintenance crew wanted to try a repair with UPM and Styrelf to see if they would stand up better under the obviously severe conditions.

The damaged pavement was cut out down to the base. Then the entire area, about 100 square feet, was replaced using UPM for the west end and Styrelf for the east end of the patch. Since the asphalt was about six inches thick, the cold mix was laid in two lifts and compacted using a vibrating steel roller on each lift. The patch stood up well to traffic, which is heavy at this location, but it proved that even the expensive mixes are not invincible. About two months after the patch was made it began to fail because of the water that was able to penetrate the base from the cracks in the adjacent gutter. The photo on this page shows the UPM mix being removed. Notice the severe cracking in the concrete gutter to the right of the patch. There was water standing in the gutter when the picture was taken. The patch appears to have been solid for about two inches on top and then loose gravel below. This type of failure has occurred in other large patches using this type of cold mix in other parts of the state. Several large patches made with UPM cold mix were observed by research personnel during this study, both at test sites for the study and at other locations in the state. All of

the patches that failed had a poor base below the patch, either a consistently wet base, as was the case at US 285 and Downing St., or severely cracked asphalt which could not provide adequate support for the patch material.

This is an example of an emergency repair that can be made using cold mix. The surface was made usable for a short time so plans could be made to do the extensive necessary repairs to prevent a recurrence of the problem.

C. Evaluation:

1. Repairs:

Repairs made with MC 250 cold mix require proper preparation of the hole: edges must be squared to the depth of the hole, all loose material must be removed, there can be no standing water in the hole, and the bottom and sides need to be painted with a good tack oil before placement of the cold mix. The performance of patches at all of the sites verifies this. All of the patches made with MC-250 cold mix, both with and without fibers, lasted more than a year if they were made in holes that were properly prepared. None of the patches made using the MC-250 lasted if even one of the preparation steps was left out.

Patches made with UPM and Styrelf remained in place even if the hole was wet and little compaction was possible. The maintenance crew that did the work on US 36 and SH 93 had a problem area where a patch had to be made on US 36. A large pothole had developed in the driving lane but snow melting on the side of the road kept water running through the hole. There was no way to stop the water, so the crew placed UPM in the hole with the water running over it. They packed the mix with the wheels of their truck and went on to the next hole not expecting the patch to even last out the day. To their surprise, the UPM stayed in the hole and never did have to be replaced. There are several places both on US-36 (site four) and on SH-93 (site five) where UPM mix that was placed in less than ideal conditions has stayed and performed well for more than two years.

These two mixes can be used for "throw and go" patches with good results, however, they last better and look better if the edges of the hole were squared before the mix was placed. If the edges of a patch are feathered, rather than having the hole squared, the thin part of the patch tends to wear away under traffic, leaving a small hole at the edge of the patch. This small hole collects water and could help shorten the life of the patch by keeping the joint between the cold mix and the original asphalt wet.

2. Performance:

Visits to the sites in the summer of 1992 made it apparent that there is much more involved in the durability of a patch than just the type of cold mix that is used. In the areas where the time was taken to make the patch using proper techniques, all of the patches stayed very well. After a light rain during the night, the 1-1/2 year old patches on US 160 on Wolf Creek Pass were observed to have moisture in the cracks at their edges, however, none of the patches gave any indication of being loose or ready to fail. All of the cold mix had been placed in holes that were thoroughly prepared by squaring the edges and, for the MC 250 patches, applying a good tack oil. Patches on US 40 and SH 93, which had been properly prepared, were also in good condition.

Since UPM and Styrelf do not require the use of tack oil, there is one less thing to buy, store, transport, and use when patching with them. The fact that the mix can be placed in wet holes also increases the number of available days for making patches and reduces the time a hole is open to cause problems for vehicles. It is advisable to dust the top of the patch after it is compacted so traffic does not track the mix out of the hole before it has time to cure. Maintenance crews can carry Portland cement for this purpose, however fine sand or dirt from the shoulder will work just as well.

3. SHRP Findings:

The Strategic Highway Repair Program (SHRP) is a unit of the National Research Council that was authorized under the Federal Transportation Act of 1987. In an article in the April 1993 issue of Pennsylvania's RTAP news letter Moving Forward RTAP engineer Alan L. Gesford, P.E. wrote about SHRP pothole repair surveys[1]. He quoted a report titled "Innovative Materials and Equipment for Pavement Surface Repairs", where the following findings were presented:

1. Conventional cold mix and hot mix patches made above 32 degrees F last up to 3 times longer than those made below 32 degrees. Patches made with proprietary above 32 degrees last 1.1 times as long as those made below 32 degrees.

2. Hot mix patches made in dry holes last up to 6 times longer than those made in wet holes; cold mix in dry holes lasts up to 3 times longer than in wet holes. For proprietary mixes the effect of a wet hole is not so dramatic: Patches in dry holes last 1.6 times as long as patches in wet holes.

3. Properly prepared and compacted patches last up to two times longer than "throw and go" patches.

4. The average proprietary mix gave 3.5 times longer life than the average conventional cold mix for cold temperatures and wet holes.

5. The average proprietary mix gave 2 times longer life than the average conventional cold mix for cold temperatures and dry holes.

6. Proprietary mixes do not have a significant advantage over conventional cold mixes for temperatures above 32 degrees F., particularly for dry conditions.

D. Cost:

In early 1992 the cost of hand patching was figured to be $198 per day. This figure included $180 for one person and one truck for eight hours, and $18 for one ton of hot mix. At about $70/ton UPM and Styrelf cost nearly four times as much as hot mix

and nearly twice the $43/ton cost of MC-250 with fibers. Patching with MC-250 with fibers costs about $225 per day. Working with UPM the cost is about $250 per day. If we make the assumption that patches made during bad weather with UPM will last twice as long as if they were made using MC-250, the high priced cold mix becomes very cost effective. To make the repairs last the same amount of time costs $450 for the MC-250 and $250 for UPM. If a large percentage of the cold mix is used in poor weather conditions or where proper preparation of a patch is not possible it may be more cost effective to use the higher priced proprietary mix for patching.

It is worth noting that UPM costs about $27 more per ton than MC-250 with fibers. In comparison to a cost of $43 per ton that $27 is a very large increase. However, in the total cost of hand patching, $27 represents only about an hour and ten minutes of work. If an hour and ten minutes per day could be saved by using UPM or a similar product, the time and labor saved would pay for the higher cost of the mix. If one of every six of the patches made using UPM lasted twice as long as they would have if they were made with MC-250 with fibers, the cost of the patching will be the same as if MC-250 with fibers were used. The material costs used here may change, but the relationships will be valid for any price of mix. Based on these figures, the more costly cold mixes can be justified for patches that must be made under extreme circumstances.

It must also be noted that UPM does not work well where it is used to make very large, thin patches several feet across. Traffic will break the patch up in cold weather or shove the mix out of the hole if it is warm. Use of a small vibratory roller or a "thumper" to compact the patch will make it last longer, but, for a dependable repair, it will probably need to be replaced with a hot mix patch as soon as possible.

IV. Conclusions and Recommendations:

Based on the results of this study, the following conclusions and recommendations are presented:

Careful preparation, placement, and compaction is very important, and will increase the life of a patch.

Warm temperatures at the time of the patch improve patch life.

Dry conditions at the time of the patch greatly improve patch life.

Proprietary mixes are designed to perform well under cold and/or wet conditions.

Large, deep patches made with cold mix cannot be expected to perform well.

V. Implementation:

CDOT maintenance crews should use proprietary type cold mix for hand patching potholes. The high cost for the material is more than offset by the increase in life expectancy of the patches.

Large areas should be patched with cold mix only in emergency situations, and should be permanently repaired with hot mix as soon as possible.

VI. References:

1. Gesford, Alan L.; "SHRP Surveys Pothole Repair Nationwide, Moving Forward Volume 11, Number 2. Pennsylvania State University, April 1993.

Appendix A

FIG. 1
This set of photos is of a patch made with UPM by Sylvax. Preparation for a patch starts with trimming the edges and cleaning out all loose debris. For this type of cold mix there is no need to use a tack coat before placing the mix into the hole. All clumps are broken and the mix is levelled slightly above the surrounding surface.

FIG. 2
In FIG. 2 the texture of the UPM mix can be seen. It resembles coated pea gravel. Done on Wolf Creek Pass, US 160, this patch was made when the air temp was about 60 deg. and the surface was about 75 deg. During colder weather the mix is hard and difficult to work with. Bringing it inside over night will make it much easier to work with. During warm weather the patch will feel soft, but will harden in a few days. It is advisable to sift a thin coat of fine sand or dirt over the fresh patch so traffic does not track the mix out of the hole before it hardens.

FIG. 3
The patch is complete and has been rolled using the tires of a one ton dump truck. Notice the shiny surface of the patch.

FIG. 4
This is the same patch after two weeks. The surface is no longer shiny and the patch has hardened. At this time there is no evidence of separation of the patch from the surrounding pavement or of ravelling or any other type of failure. Traffic has compacted the patch to the level of the surrounding pavement.

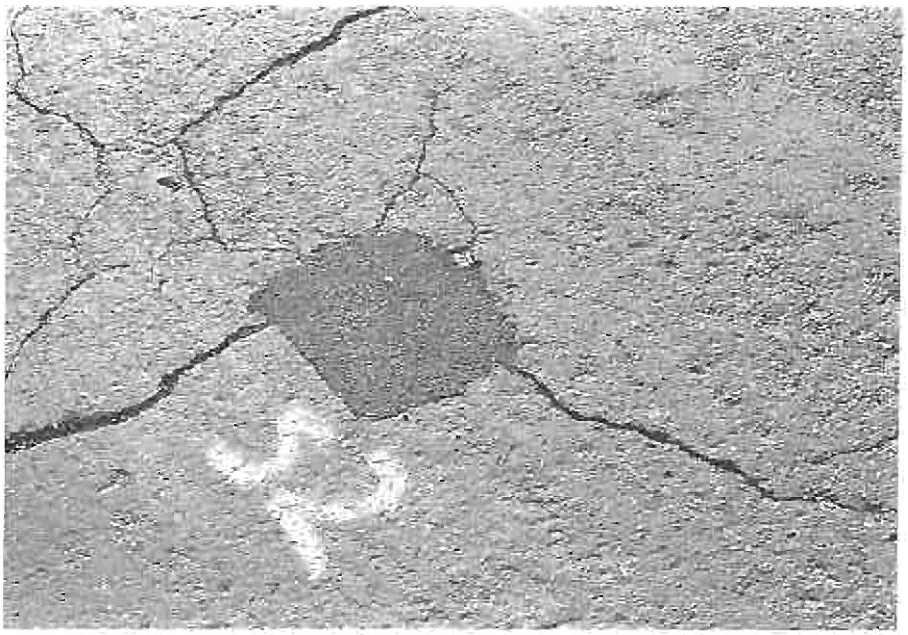


FIG. 5
Three months after the repair was made the patch is still in excellent condition. Comparing this photo to FIG. 4 shows the edges of the patch to be even tighter than they were. There was a light rain the night before this photo was taken. Some moisture is visible in the cracks but there is none around the patch.

FIG. 6
The patch is nearly thirteen months old in this photo. Notice that the cold mix has not ravelled or broken out. A crack has reflected through the patch but it still is tight and shows no signs of failing.

FIG. 7
The next six photos are of a patch made using MC-250 with fibers. This patch is on US 160 on Wolf Creek Pass also. In FIG. 7 the edges of the hole have been trimmed using a slide hammer and all loose debris has been removed from the hole.

FIG. 8
The hole has been filled with the MC-250 mix and raked level. Notice the tack oil on the pavement surface surrounding the hole. MC-250 with fibers is slightly harder to work than the same mix without fibers. The fibers tend to cause the mix to ball up making it harder to get a smooth surface on the patch.

FIG. 9
This photo shows the patch after it was rolled with the truck tires. Notice the tack oil around the edge of the patch and the different texture from the UPM patch in the first series of photos.

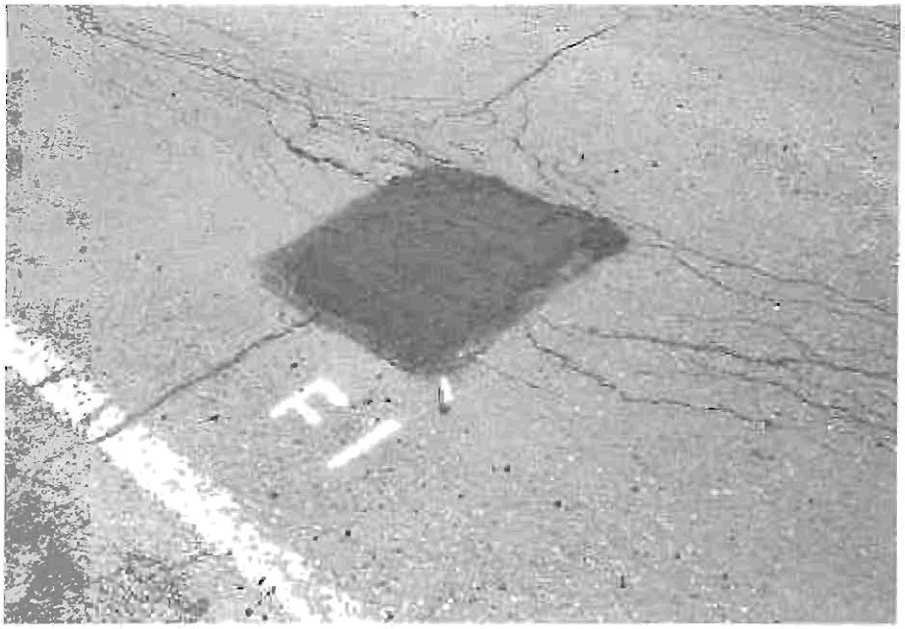


FIG. 10
This is the MC-250 patch after two weeks. Traffic has compacted the surface to the level of the pavement. Compare the surface texture in this picture with the UPM in FIG. 4.

FIG. 11
The MC-250 with fibers patch is tight around the edges and shows no signs of problems after three months.

FIG. 12
After thirteen months the patch is solid. There is no separation around the edges and the alligator cracking around it has not damaged the patch.