Update July 2015

The City of Lexington Reconfirms the Value of High Performance Permanent Repair Material

By: The Streets & Roads Division in Lexington, KY, directed by Albert Miller
Program support was provided by Steve Wallace and Don Koehler of UNIQUE® Paving Materials.

Back in July 2011 the Lexington City News posted and article titled "Patching potholes is routine work for streets and road crews". Since that time the Streets and Roads Division has been tracking pothole repair performance. The following discussion highlights findings from data collected from 2003 through 2014. Project status reports were distributed; July 2015 presented first as a summary, program details in other reports.

- January 2013, pages 6-13, program description and results
- May 2013, page 14, data update
- March 2014, page 15, data update
- **July 2015, pages 1-5, summary review including all data**

Background

Overall, from 2003 through 2011, locally available conventional cold mix was used with an average annual pothole count of 17,635 ranging from 14,369 to 24,061 potholes. In 2012 through 2013 **UPM**® Permanent Pavement Repair Material was used. The average annual potholes count was reduced to 7,002, ranging from 5,972 to 8,032. **Using *UPM* mix reduced pothole count by 10,633 (or 60%).** The cost per pothole was determined to be $32 per pothole. **Reducing the pothole count saved the city $340,256 per year. Reducing the number of pot holes also improves worker safety.**

The primary savings resulted from reducing re-repair to the same potholes. Using the same maintenance crews and procedures, the controlling mechanism was identified as quality differences between **UPM** Permanent Pavement Repair Material and locally available cold mix.

UPM mix performance was bracketed before and after using locally available material, the complete evaluation spanned twelve years. Following nine years of repairs with locally available material, **UPM** mix replaced available cold mix, reducing pothole repairs by 60%. Following the two year **UPM** mix evaluation, locally available cold mix was re-introduced to confirm performance observations. Pothole repair count returned back to the historical high range. Results identified and confirmed a significant improvement in material survivability with **UPM** mix.

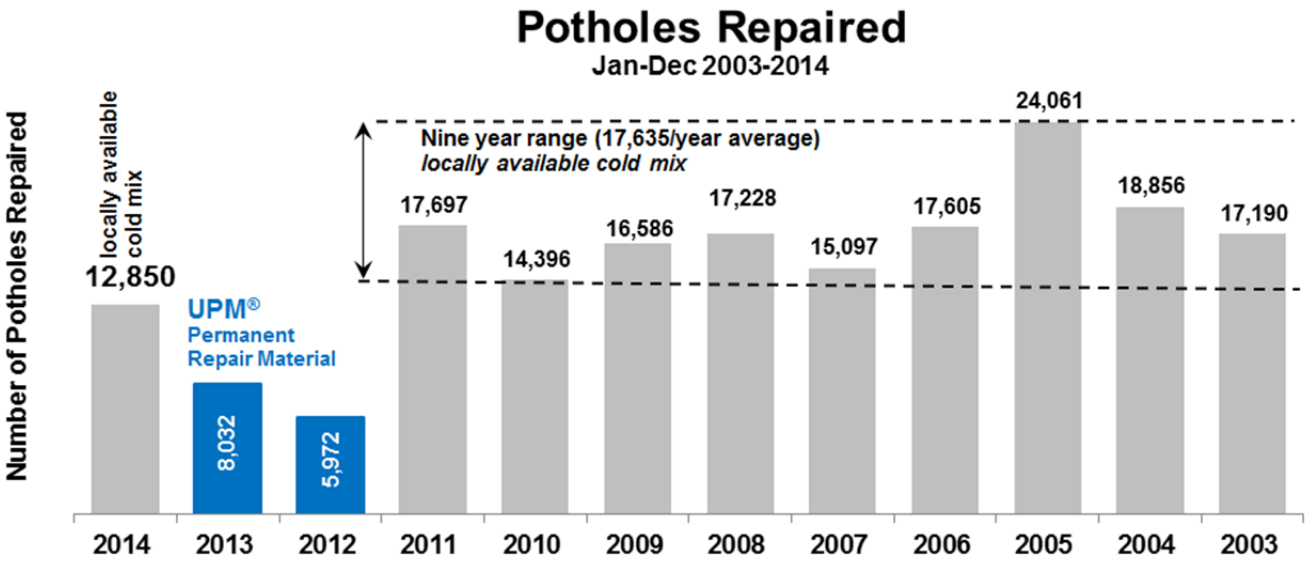
In addition to the remarkable savings, the city reported this was the first time in 9 years they have not had a claim for vehicle damage or injury caused by a pothole on any of the 2,124 lane miles within the city's jurisdiction (2012).

Status: July 2015

In 2014, Streets and Roads elected to re-evaluate locally available cold mix for two reasons:

1. Verify if the drop in potholes using **UPM** Permanent Repair Material could be re-verified.
2. Determine if locally available cold mix had improved.

Partial year results verified that returning to conventional cold mix significantly increased pothole count, increasing the resource commitment by the Streets and Road Division.



From 2003 through 2011 conventional cold mix was used. In 2012 and 2013 **UPM** premium cold mix was used. In 2014 Lexington returned to conventional cold mix. The transition from 2013 to 2014 may have been affected by the combined use of **UPM** mix and conventional cold mix early in the year. The majority of material used through 2014 was conventional cold mix. This may have biased the annual pothole count. If conventional material had been used throughout 2014, the pothole count would have likely been higher based on historical trends.

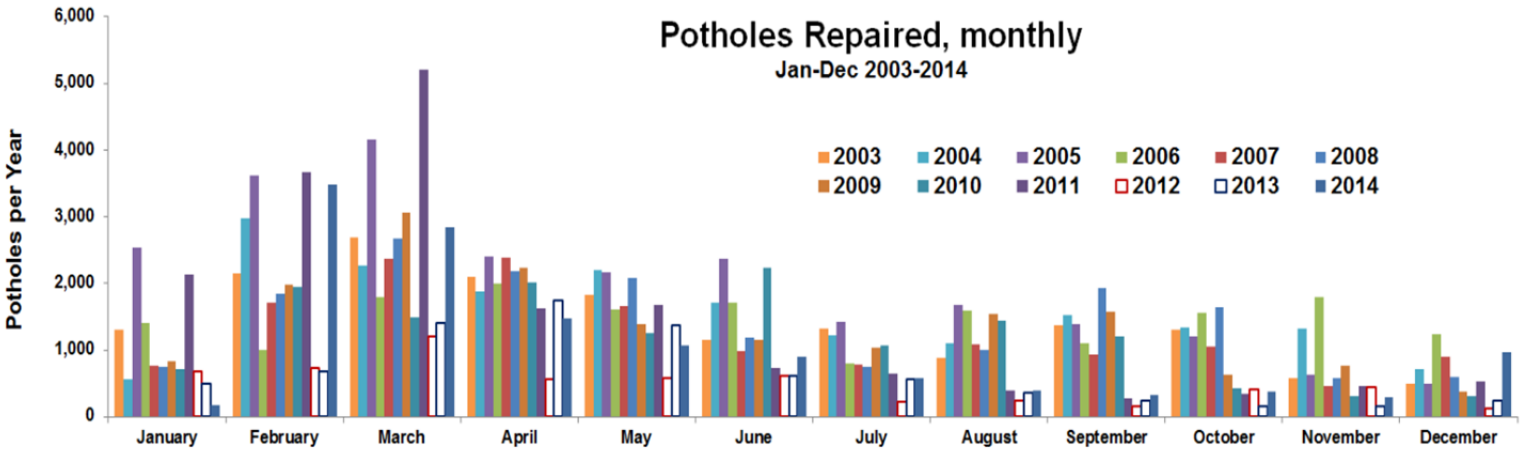
The testing completed by Lexington clearly demonstrates:

- ✓ The value of a controlled test program.
- ✓ Properly managed test programs are sensitive to cold mix quality and are able to differentiate cold mix performance.
- ✓ There are measurable financial benefits to using high quality cold mix with high survivability. This is the identical result observed in the Strategic Highway Research Program sponsored by SHRP study sponsored by the National Academy of Sciences.

Analyzing pothole count month-to-month identifies significant differences. Significant increases in pothole count during the colder-wetter months; January, February, and March were observed. Variations from year-to-year are likely due to weather. The

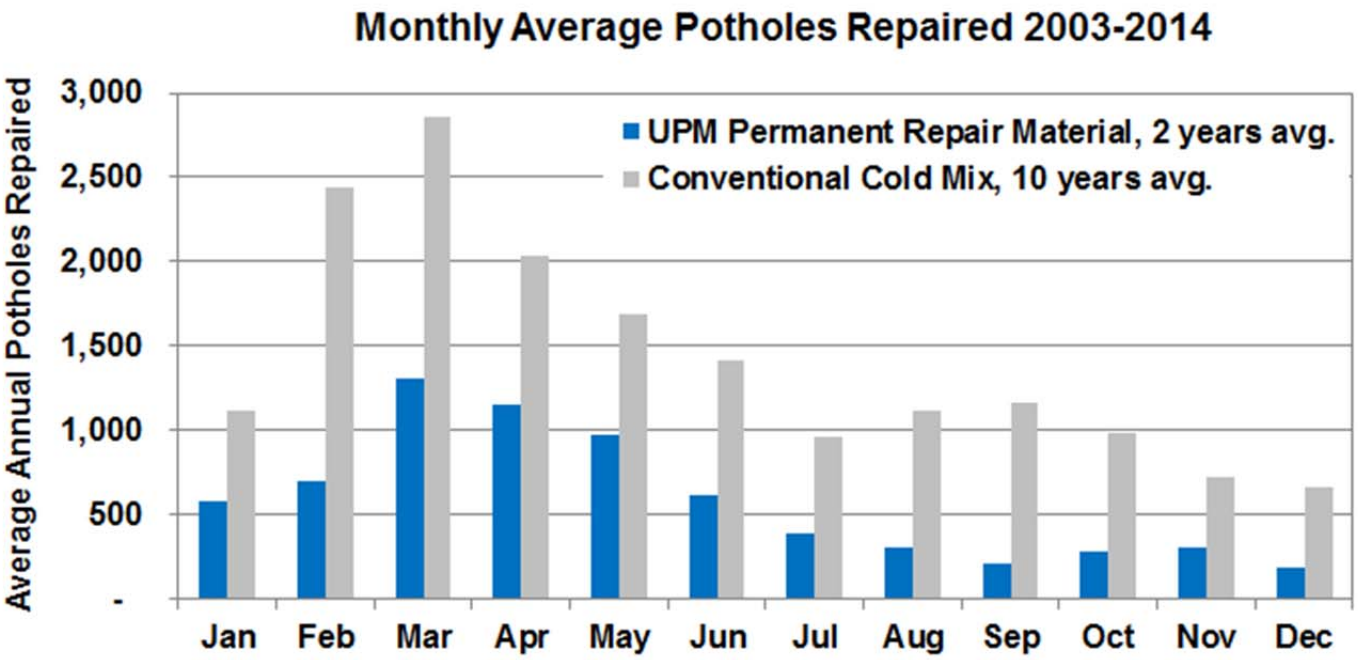
equipment and crews remained essentially unchanged during the demonstration. Pothole formation occurs at an un-predictable rate based on traffic, moisture, freeze-thaw, and overall pavement condition.

Pothole repair count variation from month to month was expected. The city's centralized service and information contact center, LexCall, handles thousands of calls from citizens reporting potholes. The Division of Streets and Roads is extremely aggressive and pro-active in monitoring the city's 2,124 lane miles it's also responsible for repairing and maintaining. Additional details are included throughout the document. The following figure present month-to-month differences for all years included. The years 2012 and 2013 when **UPM** mix was used are not colored for easy of comparison.



Summarizing month-to-month variation (figure above), the average monthly pothole count is offered for comparison. The conventional cold mix data includes 2003 through 2011 plus 2014. The **UPM** Permanent Repair Material included in 2012 and 2013.

The number of potholes varies from month to month corresponding to weather severity. Freeze-thaw cycles are the major cause of potholes occurring in January through March. Freezing water entering the pavement structure freezes, expanding in volume 9.5%. The heaving causes binder aggregate separation. Melting ice leaves a void in the pavement structure, eventually collapsing with traffic load. Once deterioration occurs, the pumping action, in the pavement structure, forces water and air in and out



dislodging fines, aggregate and stripping binder. Poorly coated aggregate or weak binder-aggregate bonding, typical of conventional cold mix, will accelerate the deterioration process. The **UPM** mix limits said deterioration by controlling binder-aggregate characteristics. The binder quantity and superior chemical bonding maintain the cohesiveness (aggregate to aggregate bonding) and aggregate to surrounding pavement (adhesiveness).

Comments from Lexington personnel:
Bill Osborne is involved in all aspects of Streets & Roads Division projects. Bill has been directly involved with each cold mix throughout the 12 year evaluation. Bill describes **UPM** Permanent Patching Material as the best performing with the highest survivability of any cold mix tested.

Keith Martin: (Department/Field Supervisor) Keith was also involved from the onset of the original study. Keith over saw the organization, photos, and documentation of the repairs and monitored the performance between **UPM** mix and the ordinary cold mixes.

Rob Allen: (Deputy Director) Rob provides oversight for Streets & Roads Division projects. Throughout the nine years using conventional cold mix, Rob and others were

not aware of alternatives to repair and re-repair conventional cold mixes. Starting in 2012, the 60% reductions in pothole count accompanied by the $340,256 annual savings were impressive. The second year using **UPM** mix, the savings were maintained, verifying there is a difference in cold mix performance. Reviewing the increased pothole count during the third year when the conventional cold mix were re-tried, again confirmed the value of **UPM** mix versus other cold mixes.

The results from this 12 year controlled field trail demonstrated:

1. Properly designed and managed field evaluations are able to differentiate between cold mix quality and survivability.
2. A measurable and reproducible difference between properly designed and controlled cold mix vs conventional cold mix.
3. High quality cold mix lowers pothole count by reducing re-repairs.
4. High quality cold mix will provide significant savings relative to conventional cold mix, even though premium cold mix is initially more expensive. This is the exact observation made in the Strategic Highway Research Program (SHRP) conducted by the Federal Highway Administration. ***"Use the best materials available to reduce repatching. The cost of patching the same pothole over and over because of poor-quality material quickly offsets the savings from purchasing a less expensive cold mix. In most cases, the poorer performance associated with inexpensive cold mix will result in greater overall costs for patching because of the increased cost of labor, equipment, traffic control, and user delay."***
5. A 2.5 to 1 benefit for **UPM** Permanent Pavement Repair Material relative to conventional cold mix. (Conventional cold mix 2003-2011 plus 2014, average potholes 17,175. **UPM** premium mix 2011-2012, average potholes 7,002. Difference of 10,155 potholes. Using $32/pothole, conventional cold mix $549,011, **UPM** mix was $224,064, a 2.5 to 1 difference).

Status: January 2013

COLD MIX PERFORMANCE EVALUATION

(update 1: Jan- Dec 2012, 1/22/13)
(update 2: Jan- Mar 2013, 5/16/13, updates following report)
(Update 3: Jan-Dec 2013, 3/20/14, updates following report)

By: The Streets & Roads Division in Lexington, KY, directed by Sam Williams.
Program support was provided by Steve Wallace and Don Koehler of Unique® Paving Materials.

Back in July 2011 the Lexington City News posted an editorial titled "Patching potholes is routine work for Streets and Roads crew". The article pointed out that Potholes are a fact of life. Sometimes, it seems they are everywhere. While that is especially true in the spring, the truth is potholes are a year-round problem.

Potholes are often created by the freeze-then-thaw cycle that Lexington experiences in winter and by damage caused by snow removal plowing. "Sometimes, we get multiple work order requests for the same location says Keith Martin, Street Department Supervisor. "If it gets to the point where we have to repair the same place multiple times, then we do an asphalt repair – we take out a section of the road and replace it."

Maintaining high quality roads for the City of Lexington is a high priority for Mayor Jim Gray and the Streets and Roads crews as they worked together on the road.
Reference: Patching potholes is routine work for Streets and Roads crew
Posted Date: 7/6/2011 9:45 am

Striving to improve the overall handling process for potholes, Streets and Roads initiated a cold mix evaluation program. The purpose was to identify possible advantages using alternative pothole repair material. Multiple parameters were considered in determining which candidate materials would be compared. The four primaries are:

1. Survivability - time materials stays in the repair
2. Workability - ease of use during installation
3. Total cost - initial, installation and re-repairs
4. Availability in the Lexington area in bulk and bag quantities

The higher cost of the **UPM** Permanent Pavement Repair Material was initially a detriment in considering premium cold mixes; however, if the labor and equipment

commitment to street repair could be reduced through elimination of redundant repairs, the overall net gain would be substantial and far greater than the increased cost of material. The net result would be increased resources availability to the city.

This line of thought is echoed in the Strategic Highway Research Program report:SHRP-H-353, Innovative Materials, Thomas P. Wilson

"Utilize the best materials available to reduce re-patching. The cost of patching the same potholes over and over because of poor-quality material quickly offsets the savings from purchasing a less expensive cold mix. In most cases, the poorer performance associated with inexpensive cold mixes will result in greater overall costs for patching because of increased costs for labor, equipment, traffic control, and user delay."

Reviewing multiple commercial cold mixes, three products claiming superior performance we selected:

1. **UPM** bulk permanent road repair material
2. Mago bulk cold mix
3. QPR bulk cold mix

Field trials started in December 2011 and will continue for at least a year. Throughout the trial preliminary reports will be issued. Multiple installations both pothole and utility cuts will be photographed and rated.

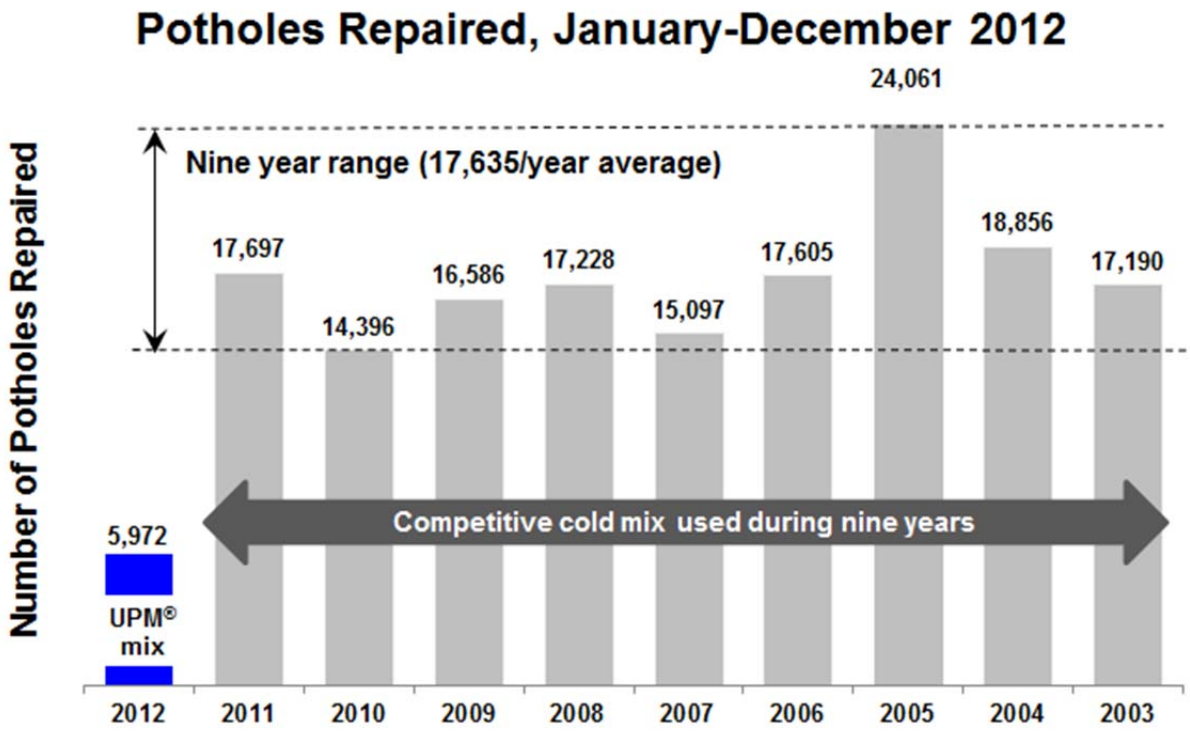
Findings from the field trial will be incorporated into performance specifications used to select the best-in-class cold mix products for the City of Lexington.

This report summarizes the twelve (12) month evaluation, January through December 2012.

Early in the program, it was determined that the **UPM** bulk material was superior to other candidate materials based on workability and survivability. Due to the observed performance differences and limited resources, the city decided to focus on the **UPM** material.

Overall, the *UPM* material outperformed previously used cold mix materials and candidate materials initially included in the evaluation based on survivability and overall lower costs. The greater overall value of this material was quickly obvious through elimination of frequent re-repairs.

The summary graph following, highlights the number of potholes recorded for the nine year period from 2003-2011 (Jan-Dec) with an average of 17,635 per year. **Starting in 2012, the number of recorded potholes decreased to 5,972, a reduction of 66%, significantly below the previous nine year range.**



Reference data provided by the City of Lexington Division of Streets and Roads.

The city's centralized service and information contact center, LexCall, handles thousands of calls each winter from citizens reporting potholes. The Division of Streets and Roads is extremely aggressive and pro-active in monitoring the city's 2,124 lane miles it's responsible for repairing and maintaining. This combination of documenting and reporting allows the city of maintain accurate records of repairs and costs attributed to them each year.

POTHOLES REPAIRED											
	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	
January	678	2133	718	837	748	761	1406	2545	561	1306	
February	724	3670	1955	1979	1841	1710	1001	3614	2980	2156	
March	1206	5204	1489	3054	2673	2372	1795	4153	2274	2682	
April	558	1628	2023	2232	2191	2384	1999	2401	1887	2092	
May	587	1683	1249	1390	2077	1657	1614	2171	2208	1834	
June	615	735	2236	1152	1192	992	1716	2373	1712	1155	
July	219	646	1061	1040	746	774	800	1426	1221	1327	
August	249	401	1437	1549	1002	1085	1590	1664	1103	888	
September	160	280	1197	1574	1936	935	1097	1388	1528	1368	
October	409	340	424	630	1642	1053	1558	1209	1339	1300	
November	447	454	304	768	577	469	1791	626	1322	588	
December	120	523	303	381	603	905	1,238	491	721	494	average
TOTALS											2003-2011
12 Months	5,972	17,697	14,396	16,586	17,228	15,097	17,605	24,061	18,856	17,190	17,635

Annually 2003-2011, the City of Lexington spent an average $564,324 repairing potholes. This is attributed to 17,635 potholes documented during this time period (average). Potholes were counted independent of being newly formed or a re-repairs. It is common to re-repair potholes; repair frequency is related to repair material quality.

It was determined in a fiscal review of costs attributed to pothole repairs in 2011 that the cost to repair an average size pothole was $32.00. For comparison, the $32.00 per pothole was used to compare pothole repair costs.

POTHOLES REPAIRED											
	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	
January	$21,696	$68,256	$22,976	$26,784	$23,936	$24,352	$44,992	$81,440	$17,952	$41,792	
February	$23,168	$117,440	$62,560	$63,328	$58,912	$54,720	$32,032	$115,648	$95,360	$68,992	
March	$38,592	$166,528	$47,648	$97,728	$85,536	$75,904	$57,440	$132,896	$72,768	$85,824	
April	$17,856	$52,096	$64,736	$71,424	$70,112	$76,288	$63,968	$76,832	$60,384	$66,944	
May	$18,784	$53,856	$39,968	$44,480	$66,464	$53,024	$51,648	$69,472	$70,656	$58,688	
June	$19,680	$23,520	$71,552	$36,864	$38,144	$31,744	$54,912	$75,936	$54,784	$36,960	
July	$7,008	$20,672	$33,952	$33,280	$23,872	$24,768	$25,600	$45,632	$39,072	$42,464	
August	$7,968	$12,832	$45,984	$49,568	$32,064	$34,720	$50,880	$53,248	$35,296	$28,416	
September	$5,120	$8,960	$38,304	$50,368	$61,952	$29,920	$35,104	$44,416	$48,896	$43,776	
October	$13,088	$10,880	$13,568	$20,160	$52,544	$33,696	$49,856	$38,688	$42,848	$41,600	
November	$14,304	$14,528	$9,728	$24,576	$18,464	$15,008	$57,312	$20,032	$42,304	$18,816	
December	$3,840	$16,736	$9,696	$12,192	$19,296	$28,960	$39,616	$15,712	$23,072	$15,808	average
TOTALS											2003-2011
12 Months	$191,104	$566,304	$460,672	$530,752	$551,296	$483,104	$563,360	$769,952	$603,392	$550,080	$564,324

In 2012, the city repaired 5,972 potholes spending $191,104, significantly less than the nine-year average. This represents a $373,220 savings or a 66% annual savings for the city.

The primary contributor to the reduction in potholes is a cold mix material that goes in the hole once and stays there.

The absence of multiple re-repairs has resulted in the city saving two thirds of their average budget using **UPM** mix. Increased savings are expected in the upcoming years.

In addition to these remarkable savings, the city reports this is the first time in 9 years they have not had a claim for vehicle damage or injury caused by a pothole on any of the 2,124 lane miles within the city's jurisdiction.

General observations by program participants

Pothole count is 66% lower using the **UPM** material relative to other cold mix materials. Controlled performance evaluations like that conducted by Lexington are the best method to determine the value using a premium cold mix. The process is difficult and can be time consuming; however, the benefits in developing the correct pothole repair strategy are significant.

Director Sam Williams reported that in spite of the warmer temperatures, the city still experienced the freeze-thaw cycles normally expected during the winter months and attributes the cost savings to a high-performance pothole repair material that works.

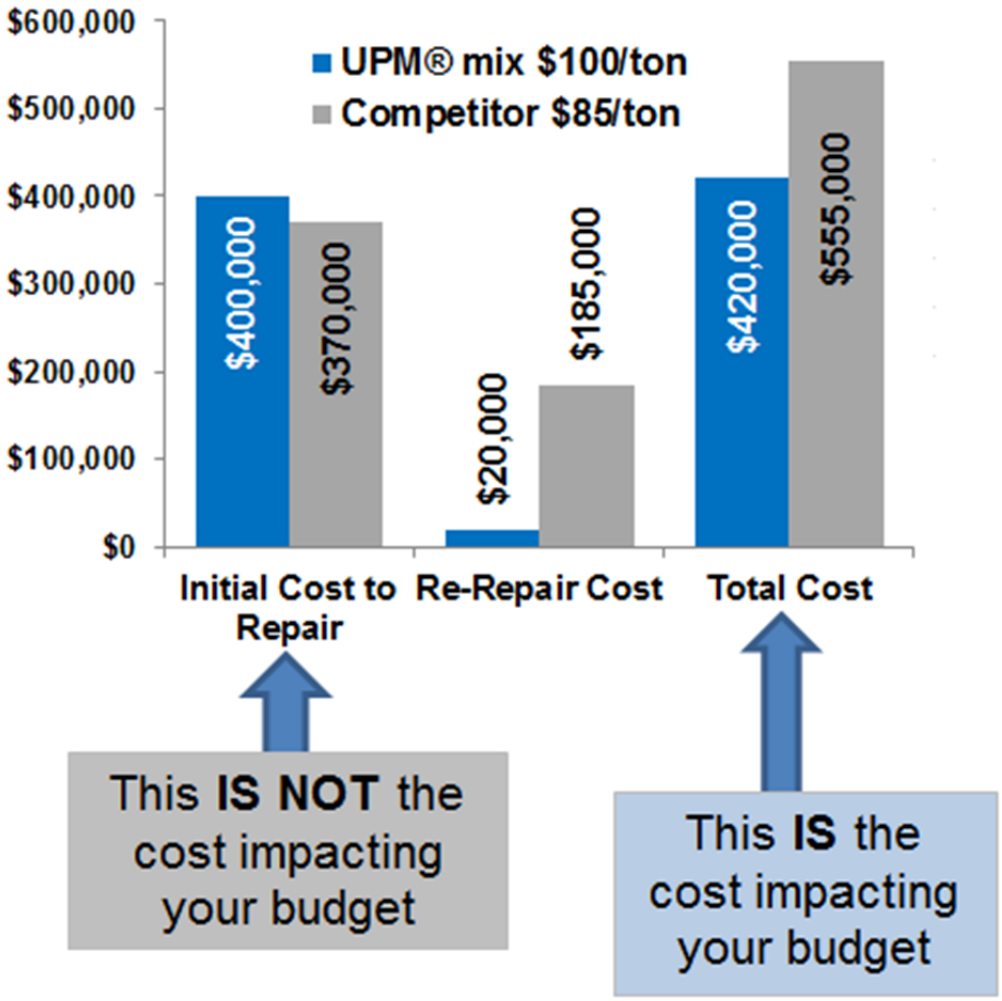
When considering candidate cold mix suppliers it's important to note the different business strategies. When selecting a cold mix product, it is reasonable to assume there will be questions, training and general support issues. The **UPM** high performance cold mix is marketed as the leader in the industry by design and choice! Unique Paving Materials Corporation has maintained their level of quality and consistency since 1959 and plans to continue with un-wavering commitment. Their QC program nearly guarantees each production of **UPM** will match target performance. Unlike hot-mix asphalt specifications which may be state regulated and application specific, design and performance specifications for cold mix do not exist. Without an effective QC program, performance variability will be highly variable.

In addition to the pothole count metrics maintained by the city, maintenance crews were requested to comment on overall handling and performance of the candidate cold mix products. As crews patch potholes it is difficult to record details of every installation as each is slightly different due to the severity of repair and quality of surrounding pavement. Completed repairs not requiring follow up re-repair quickly drop from the maintenance schedule. This creates the opportunity to focus on newly formed potholes or other maintenance projects. After the five month winter evaluation all crews agreed the **UPM** material was superior to other cold mixes used through the previous nine years.

Now more than ever, Federal, State and local governments recognize the importance of spending their limited budgets on a product that works. And, while they understand they may pay a little more upfront for a premium product, both the cost savings and fiscal responsibilities have provided enormous dividends for them and their departments in the eyes of the administration and the tax payers. The total cost including pothole repair and re-repair should be considered in the cold mix selection process to maximize value to the city. As a result a lower cost product may save initial dollars; however, it is the total cost impacting the budget.

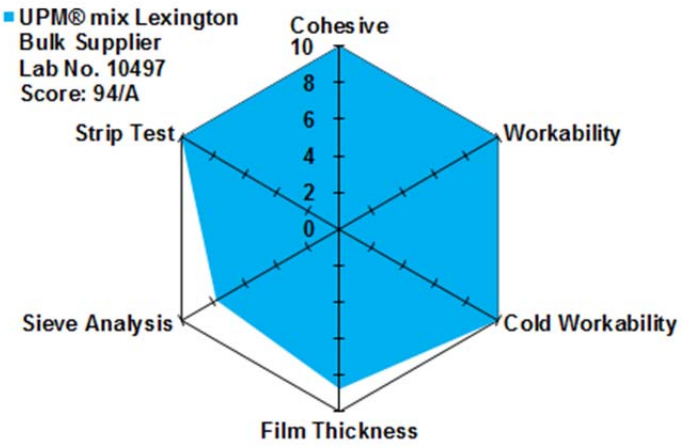
As an example, comparing two cold mix products: **UPM** mix at $100/ton and a competitor at $85/ton. The initial saving is $30,000 dollars based on 2,000 tons per year and difference in survivability rate between the two products of 45 points. (Survivability being the time material stays in the repair). However, the total impact to the budget is calculated at a $135,000 loss due to increased labor and equipment. **When selecting cold mix, the total cost of repair is the amount influencing budgets, not the initial difference in price.** If the cheaper cold mix does not perform, its value is low at any cost.

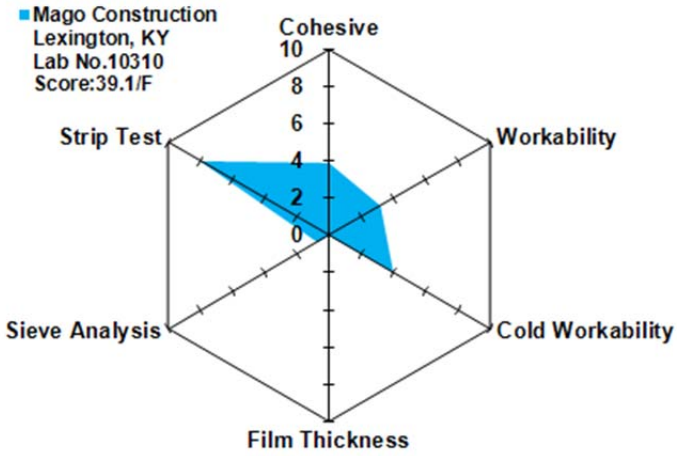
Cold Mix Source	Initial Cost to Repair	Re-Repair Cost	Total Cost
UPM® mix $100/ton	$400,000	$20,000	$420,000
Competitor $85/ton	$370,000	$185,000	$555,000
TOTAL Saving with UPM			$135,000

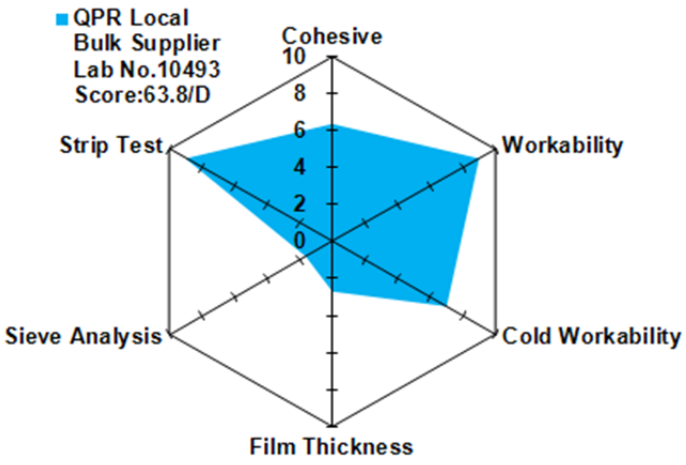


LABORATORY ANALYSIS

Comparing the cold mixes using performance parameters known to correlate with field performance scores the QPR mix at 63.8% or a “D”. Cold mixes scoring less than 80% will experience early failure. Parameters are weighted based on comparative field-lab correlation; creating a balanced rating, if achieved will guarantee superior field performance. All parameters are interdependent; overall field performance deteriorates rapidly if any one parameter fails.







Cohesion & Adhesion
Measures the ability of the material to bond to itself and to the surrounding pavement. Performance related to the capability of the material to remain in place. Maintaining adequate adhesion and cohesion will determine the degree to which material ravels from the pothole.

Workability & Stability
Measures the force required to move and apply the material at greater than 72^{O}F. Workability and stability must be balanced so that the material can be applied and yet stable enough to handle traffic loads. These are a function of gradation, viscosity, and application temperature.

Cold Workability
Measures the force required to move and apply the material in cold weather, less than 32^{O}F.

Film Thickness
Measures the thickness of the asphalt surrounding the aggregate. Testing for the effective film takes into account aggregate gradation and absorption characteristics. Film thickness determines shelf life, cohesion, and workability.

Sieve Analysis
Cold mix is 95% aggregate. Proper gradation is critical to achieve proper compaction, workability and load carrying strength. Surface characteristics, area and absorption are critical to control stripping and workability.

Stripping
Measures the separation of asphalt from the aggregate. Performance relates to water handling characteristics of material in wet environment (i.e. heavy rain).

SUMMARY

The program identified a superior performing cold mix expected to provide significant annual saving to the city and drivers throughout Lexington.

Those individuals participating in the program experienced firsthand the performance advantages working with a premium cold mix engineered to perform.

Incorporating local weather, road condition and local maintenance crews yielded results that are directly applicable to maintenance practices in the area.

The results from this evaluation provided the metrics needed to intelligently select **UPM** mix as the highest value product for road repair in Lexington.

It is recommended that those interested in improving their overall maintenance strategy relative to pothole repair, design and implement a controlled performance evaluation with technically leading suppliers.

Picture with Lexington personnel added 10/19/12.
Report updated to include January through December 2012 results, 1/22/2013
Don Koehler
216-978-9883 cell
dkoehler@uniquepavingmaterials.com

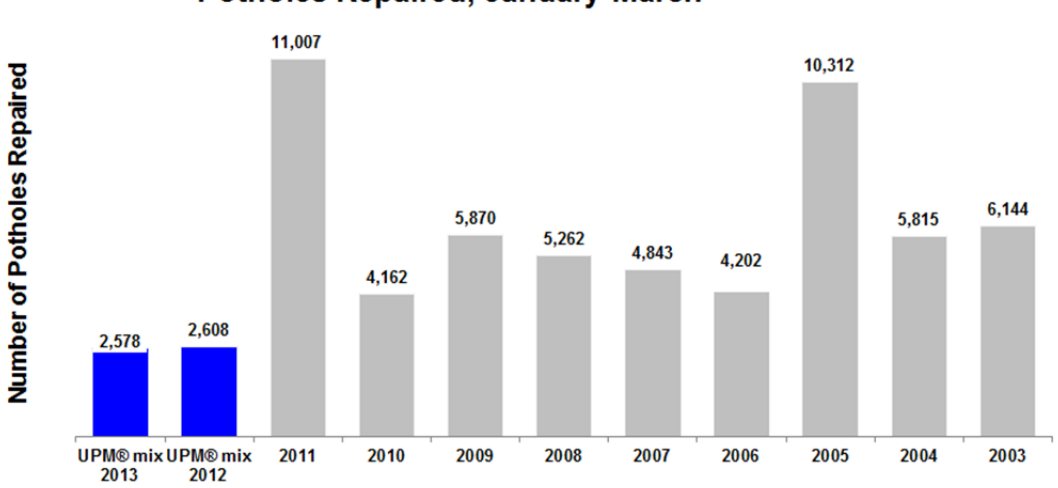
Status: May 2013

Update number 2: January through March 2013, added to the database (5/16/13 DEK).

The first three months of 2013 are tracking with the first three months of 2012. **UPM®** mix reduced pothole repairs by 60%; from an average of 6,402 per three months to 2,593. The estimated dollar saving January through March is $121,404.

Referencing the annual data; **UPM** mix reduced the number of potholes to 5,972 at an estimated repair cost of $191,104; significantly less than the historical $564,324 nine-year average.

This represents a $373,220 savings or a 66% annual savings for the city.



Lexington continues to capitalize on the value resulting from using *UPM* permanent pavement repair material. The resources made available through the elimination of re-repairs are a welcomed addition to the limited maintenance budget. Results will be updated as available.

POTHOLES REPAIRED

	UPM® 2013	UPM® 2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	
January	492	678	2133	718	837	748	761	1406	2545	561	1306	
February	680	724	3670	1955	1979	1841	1710	1001	3614	2980	2156	
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December		120	523	303	381	603	905	1,238	491	721	494	average
TOTALS												2003-2011
12 Months		5,972	17,697	14,396	16,586	17,228	15,097	17,605	24,061	18,856	17,190	17,635
3 months	2,578	2,608	11,007	4,162	5,870	5,262	4,843	4,202	10,312	5,815	6,144	6,402

POTHOLES REPAIRED

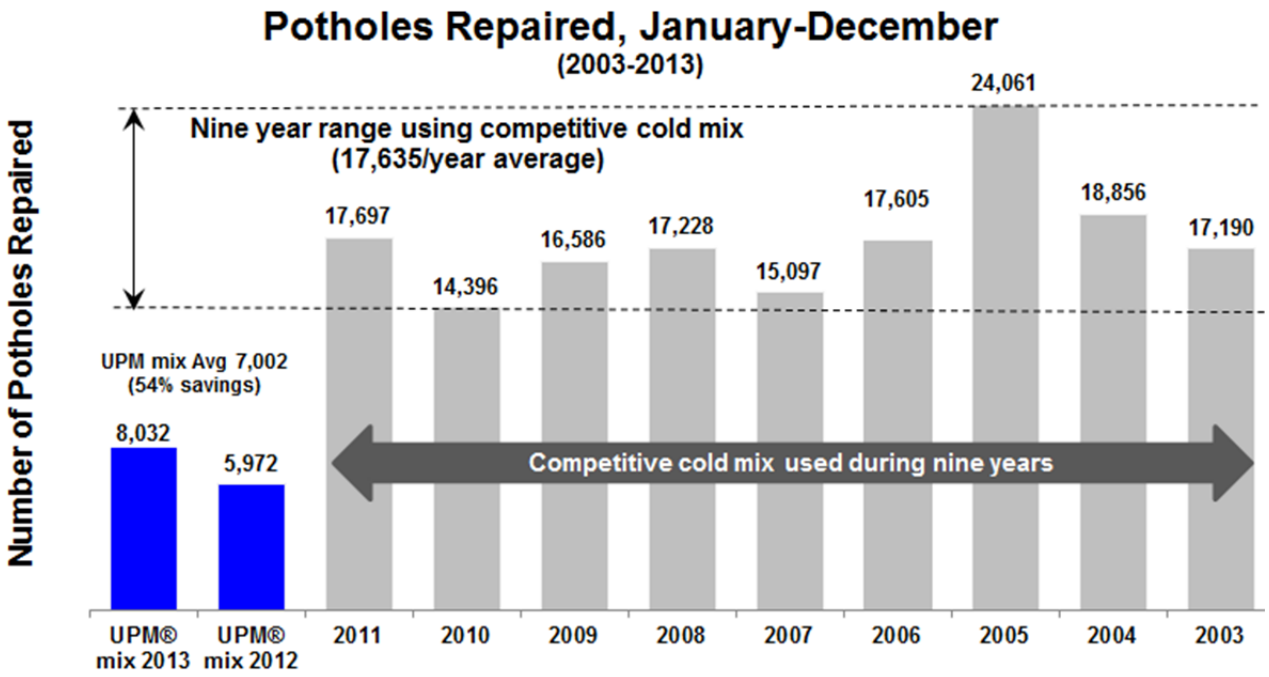
	UPM® 2013	UPM® 2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	
January	$15,744	$21,696	$68,256	$22,976	$26,784	$23,936	$24,352	$44,992	$81,440	$17,952	$41,792	
February	$21,760	$23,168	$117,440	$62,560	$63,328	$58,912	$54,720	$32,032	$115,648	$95,360	$68,992	
March	$44,992	$38,592	$166,528	$47,648	$97,728	$85,536	$75,904	$57,440	$132,896	$72,768	$85,824	
April		$17,856	$52,096	$64,736	$71,424	$70,112	$76,288	$63,968	$76,832	$60,384	$66,944	
May		$18,784	$53,856	$39,968	$44,480	$66,464	$53,024	$51,648	$69,472	$70,656	$58,688	
June		$19,680	$23,520	$71,552	$36,864	$38,144	$31,744	$54,912	$75,936	$54,784	$36,960	
July		$7,008	$20,672	$33,952	$33,280	$23,872	$24,768	$25,600	$45,632	$39,072	$42,464	
August		$7,968	$12,832	$45,984	$49,568	$32,064	$34,720	$50,880	$53,248	$35,296	$28,416	
September		$5,120	$8,960	$38,304	$50,368	$61,952	$29,920	$35,104	$44,416	$48,896	$43,776	
October		$13,088	$10,880	$13,568	$20,160	$52,544	$33,696	$49,856	$38,688	$42,848	$41,600	
November		$14,304	$14,528	$9,728	$24,576	$18,464	$15,008	$57,312	$20,032	$42,304	$18,816	NON UPM®
December		$3,840	$16,736	$9,696	$12,192	$19,296	$28,960	$39,616	$15,712	$23,072	$15,808	average
TOTALS												2003-2011
12 Months		$191,104	$566,304	$460,672	$530,752	$551,296	$483,104	$563,360	$769,952	$603,392	$550,080	$564,324
3 months	$82,496	$83,456	$352,224	$133,184	$187,840	$168,384	$154,976	$134,464	$329,984	$186,080	$196,608	$204,860

Status: March 2014

***Update number 3, January through December 2013, added to the database** (3/20/14 DEK).*

Potholes repaired in 2013, are similar to 2012 and remained significantly below the nine-year average established, 2003-2011. The average number of potholes for 2012-2013 using **UPM** mix was 54% below the nine year average 2003-2011 using conventional cold mix. **The average saving to the city of Lexington is $340,260, annually.**

Referencing the annual data; **UPM** mix reduced the annual average number of potholes from 17,634 to 7,002, reducing the estimated repair cost from $564,324 to $224,064.



Lexington continues to capitalize on the value resulting from using *UPM* permanent pavement repair material. The resources made available through the elimination of re-repairs are a welcomed addition to the limited maintenance budget. Results will be updated as available