Innovative Infrared Crack Repair Method

Ludomir Uzarowski, PhD, PEng, Golder Associates Ltd.
Vimy Henderson, EIT, Golder Associates Ltd.
Mike Henderson, Region of Waterloo
Bob Kiesswetter, Heat Design Equipment Inc.

Paper prepared for presentation at the
Maintenance and Construction Session: Successes and Innovations in Maintenance Methods
Of the 2011 Annual Conference of the Transportation Association of Canada
Edmonton, Alberta

ABSTRACT

Conventionally cracks in asphalt pavements are repaired by milling the pavement around the crack and placing and compacting new Hot Mix Asphalt (HMA) material. Unfortunately, after a period of time, this often results in two new joints and the crack reflecting through the repair. This may lead to problems such as pavement surface deterioration and moisture moving into the pavement structure.

An innovative crack repair method has been developed that includes heating the area surrounding the crack using an infrared system and removing the material immediately adjacent to the crack. A fine asphalt mix that is rich in asphalt cement is then used to fill the area where material has been removed from. The area is overfilled and then finally compacted, leaving a patch that is well bonded to material below and adjacent and flush with the remainder of the pavement.

Initially infrared technology was used successfully in hot in-place recycling and longitudinal joint construction and has now also been applied to crack repairs with success. The Region of Waterloo and the City of Cambridge have used the infrared crack repair method on both binder and surface course layers. Using infrared technology, it was possible to repair significant cracks and provide a quality pavement. Examples of these projects are included in this paper. The effectiveness of using this technology has been evaluated and monitored through surface smoothness evaluations, density measurements and extracting core samples. The results and findings from these tests are presented in the paper. The results of the density testing indicated that adequate compaction was easily achieved throughout the projects. Cores showed that the new material was well bond to the existing pavement.

Details of this maintenance process and the associated costs in comparison to using conventional methods are described. Generally, the costs of the conventional and infrared methods of crack repair are comparable. Cores taken from an infrared joint repair carried out 12 years ago show that the joint between the new material and the old material is not apparent at the surface or in core samples and there were no surface distresses observed in these areas. Compared with the conventional method, very little new HMA material is required for infrared repairs. Although it is unlikely that the new method will fully replace the conventional one, it can be considered as an additional, proven tool in a pavement maintenance tool box.

INTRODUCTION

The condition of the road network in Canada is important to the development and expansion of the economy and communities throughout the country. Pavement preservation can extend the life of the pavements in a road network by maintaining their condition before it has deteriorated significantly. The Federation of Canadian Municipalities, National Research Council and Infrastructure Canada partnered to develop InfraGuide Best Practice Reports on several topics including "Timely Preventative Maintenance for Municipal Roads"[1]. This report describes maintenance activities that preserve pavement structures and therefore extend the time before reconstruction is required. The maintenance activities listed are:

1. Waterproofing,
2. Strengthening,
3. Protection from debris entering joints,
4. Slowing down the rate of deterioration,
5. Resurfacing and,
6. Drainage [2].

The first three activities all relate to keeping moisture and foreign material out of the pavement structure. Moisture and foreign material, such as soil and vegetation generally enters the pavement structure through cracks in the asphalt layers. The existence of moisture within the pavement structure leads to layers weakening and additional cracks developing and present cracks deteriorating and expanding. Cracks develop in flexible pavements as a result of several factors, including: environmental conditions; poor construction practice; poor material selection; loading; and aging. Several different types of cracks may occur, such as: longitudinal; transverse; fatigue (alligator); thermal; and mapping. Upon the development of cracks on the surface there are multiple methods that can be used to repair the crack and prevent further deterioration of the pavement. The crack repair method depends on the type of crack, severity and extent as well as availability of equipment, local knowledge and experience. The most commonly used crack repair methods include:

1. Filling;
2. Routing and sealing;
3. Patching; and
4. Infrared heating.

The first three methods noted in the list are used extensively in North America while the fourth, infrared heating, is a newer method. It is suggested that cracks should be treated while the pavement is still generally in good condition. In this case the crack repairs are considered as pavement preservation activity and can significantly extend the life of the road [3].

BACKGROUND

On some projects, the Region of Waterloo places the asphalt binder course and then waits one to two years before placing the surface course. This construction staging was used on Bleams Road. In 2008 two binder lifts were placed using an asphalt mix containing both reclaimed asphalt pavement (RAP) and manufactured shingles modifier (MSM). The section involved in this project is 760m long and was designed for an average annual daily traffic (AADT) of 6,000

vehicles with five percent trucks. The portion of Bleams Rd in this project is in Mannheim, Ontario, a small community south of Kitchener. In 2010 random cracks were observed on the surface of the binder course.

A plan was developed to repair the cracks so that a surface course could be placed without potential for cracks propagating. Cores were extracted at the cracks. Figure 1 shows some of the cores. Some cracks were the full depth of the asphalt and others were only in the top lift of the binder course, Core 1 and Core 3 respectively.

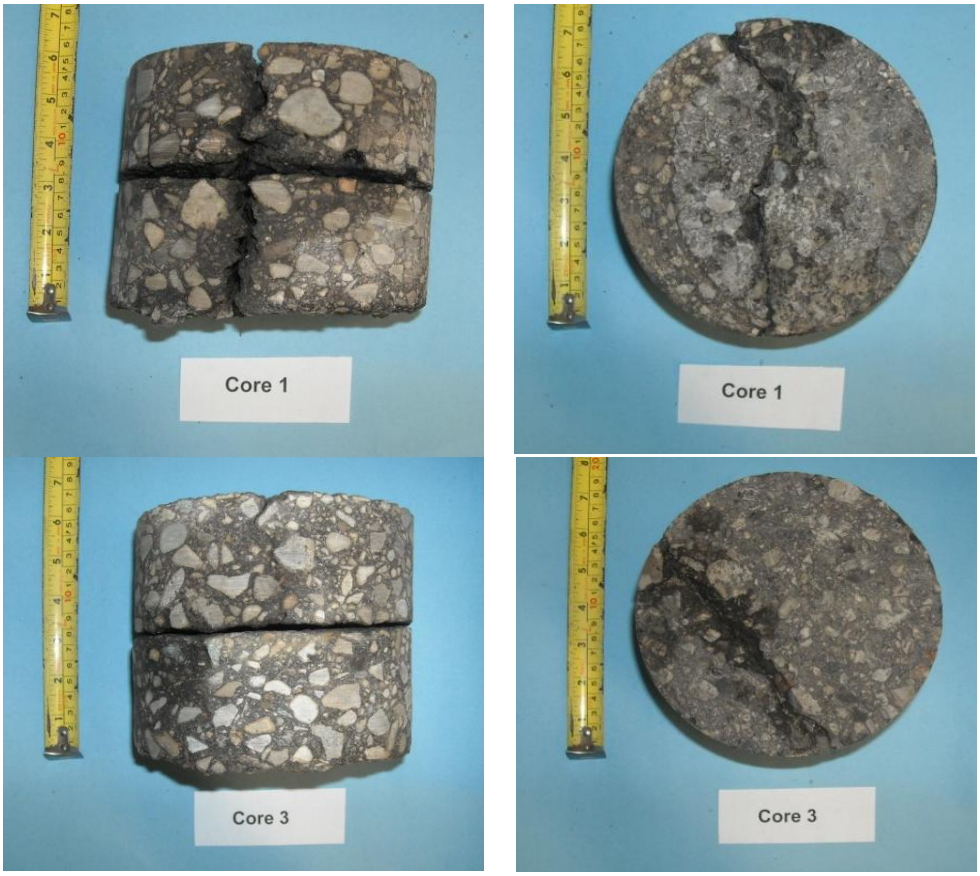

Figure 1 – Cores from the Binder Course of Bleams Rd.

Cracks that were present through both lifts of asphalt, which was determined from the cores or severity at the surface were deemed to require full depth patching. Low to medium severity cracking in the top lift only, were initially considered to be repaired by milling the cracked area and filling with a new hot mix asphalt. Eventually, it was recommended to repair the low to medium severity cracks using infrared heating. The Region of Waterloo decided to use the infrared heating method and evaluate the performance of crack repairs.

OBJECTIVE

It was determined that infrared heating would be used to repair a number of low to medium severity cracks on Bleams Road in 2010. This paper discusses;

1. Different methods of crack repair;

2. Details of the infrared heating repair;
3. Performance of the repairs; and
4. Cost comparison of various crack repair alternatives.

CRACK MAINTENANCE AND REPAIRS

Several methods are available for repairing cracks in flexible pavements. The method that is appropriate for a specific project is dependent on the cause of the crack, type, severity and extent of the crack, available technology and budget. The following four techniques for repairing low to medium severity cracks will be described in this section.

1. Crack sealing;
2. Crack filling;
3. Milling and patching; and
4. Infrared heating.

The fifth and all too common solution is “to do nothing” which unavoidably leads to the crack expanding and the pavement condition deteriorating rapidly.

Crack Sealing and Filling

In order to achieve the best performance from sealing or filling a crack, it is critical to repair it early before it becomes too severe. Cracks that are active, meaning that the width of the crack increases by 15 to 100 percent in the winter season from what it was in the summer months, can be repaired by crack sealing. Crack sealing however should only be used on low severity cracks. The crack is routed and thus cracks that are straight in nature are best for this treatment. After routing the crack should be cleaned and can be filled with a sealant. Typically, hot applied rubberized low modulus sealants are used [4].

Low severity cracks that are not active can be filled. Cracks that are not active are those not showing changes in width between seasons. The crack should be cleaned using compressed air to remove debris within the crack and surrounding area. An asphalt emulsion or hot applied rubberized high modulus crack filling material is then placed in the cleaned crack. The sealant or emulsion fills the crack, therefore eliminating the ability of water to enter the crack and infiltrate the pavement structure. If crack sealant is applied to a crack or the crack is filled with asphalt emulsion at the appropriate time it can be effective in mitigating further deterioration of the pavement and potentially increase the life of the pavement [4].

Milling and Patching

Cracks that are more severe, such as being at a medium severity are past the point when crack sealing is a worthwhile repair method. At this point the crack can be repaired with a patch in order to achieve better performance. The cracked asphalt should be removed by milling; the width of the milling is typically 0.3 to 0.5m. Once the old asphalt is removed, the area should be cleaned and any loose debris removed. A tack coat should be applied and, after the tack is cured, the area should be filled with hot mix asphalt and compacted.

Infrared Heating

Infrared heaters can be used to repair low to medium severity cracks. A severe crack often indicates a base problem and therefore more extensive work such as a full depth repair or resurfacing is likely required. To achieve a quality infrared heating repair, that will perform in the future, the following procedure is typically followed. The cracked area for repair is heated, initially at a higher temperature, for 3 to 5 minutes and then at a lower temperature typically for another 3 to 5 minutes. The surface temperature of the asphalt should never exceed 190°C. The heating time at the lower temperature should be long enough so that the entire lift of asphalt is heated and softened. Figure 2 shows an infrared heater in use on Bleams Road.

Figure 2 – Infrared Heater Softening a Cracked Area

The time required to heat the asphalt is dependent on several factors, including the weather conditions, type of asphalt mix, cleanliness of the asphalt being heated and the initial temperature of the asphalt. Upon heating and softening the area the asphalt is scarified. Scarifying should be initiated at the edges of the heated area and then continued inwards. This process can be done with a rake and the asphalt should be worked until cracks are no longer visible followed by the addition of new hot mix asphalt. The new mix should be relatively fine and rich in asphalt cement. A rejuvenator can also be applied to the worked asphalt to soften the asphalt. Figure 3 shows a cracked area that has been heated, scarified, complimented with additional hot mix asphalt and is being compacted.

Figure 3 – Compaction of Repaired Crack

The quantity of new hot mix asphalt required is determined by how much area needs to be filled, such as depressions or potholes and should be sufficient to achieve the required compaction. The heated area is raked until it is uniform and then compacted with a roller. The repaired area should be flush with the adjacent pavement [5].

PERFORMANCE

Infrared heating was used at multiple locations on Bleams Road in the Region of Waterloo. Figure 4 shows before and after images of a repaired area. Following the crack repairs in summer 2010 the surface course was paved on Bleams Road. In spring of 2011, Bleams Road continued to perform well; no surface distresses were visible and there had been no sign of cracks propagating from the binder course. Density measurements were done following the infrared heat repair. All density measurements were within the required range of 92 percent to 96.5 percent measured. Cores taken across a few of the repaired cracks showed that the new material was fused with the adjacent pavement and the integrity of the layer was reinstated.

Figure 4 – Before and After Photos of Crack Repairs on Bleams Road Using Infrared Heating

In 1997 a repair was made on Waterloo Street in New Hamburg, Ontario, west of Kitchener using infrared heaters. The repair extended across the width of the road. Following the completion of the repair using the infrared heaters, cores were extracted for testing and compaction measurements were carried out. In this project the repair was an entire patch.

Density measurements of the repaired area and the surrounding pavement were all determined to be more than adequate, averaging 97 percent in both areas. The cores that were extracted showed that the asphalt in the repaired area had slightly lower flow, stability and VMA results than the cores from the adjacent area that had not been repaired. The gradation of the asphalt sampled from the repaired area also had a finer gradation than the asphalt from the surrounding pavement. The differences in test results between the repaired area and the surrounding asphalt are considered to be mainly due to the introduction of the new asphalt mix in the repaired area.

At the time of repair the area repaired with infrared heaters looked uniform and no degradation was evident. The entire street was repaved in 2010. Prior to the repaving of the street, the area repaired with the infrared heaters had performed structurally well with only limited repair required. This repair was required due to reflective cracking. The repair in 1997 performed well for 13 years.

BENEFITS

The use of infrared heaters has a significant benefit in terms of the method itself. The process of heating the areas of asphalt with the crack and scarifying it results in a repaired pavement surface with no joints. When a patch is placed to repair a crack there are two joints, each parallel to where the crack had been. There are also two joints perpendicular to where the crack had been that are generally shorter in length. The joints that are parallel to where the crack had been can provide an opportunity for new cracks to develop.

Infrared heaters are an effective tool when cracks have developed past the point where crack sealing is an option. At this stage cracks have often developed adjacent to the initial crack. An infrared heater can be used at this stage to reinstate the integrity of the asphalt layer and improve the condition of the pavement [5]. Also, if the cracks exhibit low severity spalling they can be repaired in one infrared heater pass. In comparison, it is not practical to rout and seal such cracks.

Crack repairs using infrared heaters are more efficient than the conventional mill and fill method. The cracks can be repaired faster and the delay to users can be shortened. The efficiency of the procedure reduces idling of traffic which is beneficial to the driving public and reduces safety hazards. Generally, only a very small quantity of a new hot-mix asphalt is required; it is easy to keep it at the right temperature in a temperature isolated container. Also, compaction of the required cracks is very simple and the required levels are easily achieved. Infrared heater repairs are suitable for any traffic volume pavements. While crack sealants can debond when exposed to high traffic volumes, with the sealant coming out of the crack particularly after prolonged rain periods [4], this issue does not apply to infrared heating repairs.

A potential benefit of infrared heaters is also in asphalt utility cut repairs. As Todres notes [6], utility cuts are inevitable in general on urban streets. Unfortunately the performance of the utility cut area after the work below the surface has been completed and the pavement has been replaced is often poor. This can be due to a variety of factors one of which includes the joints created by patching the utility cut area. These joints should be sealed to prevent them from becoming cracks that allow water ingress into the pavement structure. Another alternative would be to use infrared heaters and produce a seamless utility cut.

A limited field data shows that infrared heating repaired cracks can perform well for 13 or more years. This is longer than crack sealing or conventional mill and fill repairs generally perform.

CHALLENGES

The challenges that are associated with repairing cracks with infrared heaters are similar to those experienced during the initial use of many new technologies. The first being availability and experience. It is inevitable that more trials are needed to successfully implement of this methodology. Further research may be required to fully understand if there is any negative impact of infrared heating on the original asphalt in terms of additional oxidation.

COST

The cost of repairing cracks with infrared heaters is considered competitive and can be comparable or better than other alternatives. The average cost of an infrared heating repair is about $10 to $12 per linear meter. The cost of mill and fill crack repair can range from $10 to $15 per linear meter.

CONCLUSION

Pavement preservation is performed throughout Canada and North America in order to extend the service life of pavements and slow down the deterioration process. One of the significant aspects of pavement preservation is handling cracks and addressing them before they become medium to severe that may rapidly increase the deterioration rate of the associated pavement. Various methods are available for repairing cracks and mitigating access for water to enter the pavement structure. The use of infrared heaters offers a method for repairing cracks that leaves a renewed pavement surface with no joints apparent from the repair.

Infrared heaters were successfully used on two projects in the Region of Waterloo, both of which have performed well to date. The projects demonstrated two different successful applications of infrared heaters for crack repairs and asphalt patching. Density results of the repaired area and surrounding pavement showed that adequate compaction was easily achieved on both projects. The cores showed the integrity of the layer was reinstated. Infrared heaters offer several benefits including efficiency and cost-effectiveness in comparison to other methods and are a useful new alternative for crack repairs.

REFERENCES

1. FCM, Federation of Canadian Municipalities, (2010), InfraGuide Best Practice Reports, Transportation: Sidewalks and Roads, National Guide to Sustainable Municipal Infrastructure, accessed May 2011, http://sustainablecommunities.fcm.ca/Infraguide/Roads_and_Sidewalks.asp
2. FCM, NRC, Federation of Canadian Municipalities, National Research Council, (2003), Timely Preventative Maintenance for Municipal Roads – A Primer, Issue No 1.1, Best Practice by the National Guide to Sustainable Municipal Infrastructure.
3. Hein, D., Croteau, J., (2004), The Impact of Preventative Maintenance Programs on the Condition of Roadway Networks, Transportation Association of Canada Annual Meetings, Quebec City, Quebec.

4. FCM, NRC, Federation of Canadian Municipalities, National Research Council, (2003), Guidelines for Sealing and Filling Cracks in Asphalt Concrete Pavement, Issue No 1.0, Best Practice by the National Guide to Sustainable Municipal Infrastructure.
5. IPRC, Infrared Pavement Repair Corporation, (2010), www.asphaltheater.com/ipr, accessed May 2011.
6. Todres, A., (1999), Utility Cuts in Asphalt Pavements: Best Engineering Practices, APWA International Public Works Congress NRCC/CPWA Seminar Series "Innovations in Urban Infrastructures", Las Vegas, Nevada.