'*SAFETY EDGE*' for Improved Road Safety and Pavement Performance

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Technical Paper Abstract
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Developed through the U.S. Federal Highway Administration (FHWA) – *Every Day Counts* initiative, *Safety Edge* is one of five technologies promoted for use throughout the U.S. DOT’s. The *Safety Edge* is a low-cost technology constructed during the asphalt paving operation by shaping the pavement edge to a 30 degree slope. This simple adjustment to the construction of the asphalt edge has been documented to reduce the number of vehicle crashes by allowing drivers to safely recover should they drift off of the paved surface. Although effective for all rural types of roadway, the use of a Safety Edge is particularly found to be useful on rural two lane roadways.

In 2012, the Region of Halton conducted an In-Service Road Safety Review for a 2.8 km section of 20 Sideroad (Reg. Rd. 34). Scheduled to be resurfaced in 2014, this 2-lane rural road operates at a posted speed limit of 60km/hr, and generally comprise of 3.65m wide lanes, with very narrow to no shoulders. Within the review limits, the roadway contains two intersections and two S-curves. The general pavement surface at the time of the investigation was considered to be in poor to fair condition, primarily on account of extensive pavement edge cracking. In addition to the notable road conditions, the review also observed that vehicles often travelled at higher than posted speeds, with loss of control related collisions overrepresented, even with weather factors being omitted.

During the detailed design of this section of roadway, a number of road improvement alternatives were considered that would improve both the pavement performance of the roadway, as well as driver safety. The results of this investigation recommended that the many benefits of constructing a *Safety Edge* would address both concerns. The primary focus of this paper will be to describe how the construction of a *Safety Edge* on 20 Sideroad will not only improve the future performance of the new pavement edge, but also improve the overall safety of the roadway by permitting drivers to recover should they steer off of the pavement surface.

1. INTRODUCTION

The **Regional Municipality of Halton** is located within the western edge of the Greater Toronto Area and includes 25 kms of Lake Ontario frontage.

Covering an area of over 967 square kilometers and comprising of four local municipalities, including part of the corner stone of Ontario's greenbelt system the Niagara Escarpment, the Region of Halton is a balance of nature and sustainable development.

-Past-

The Region of Halton being established in 1974 celebrates its 40th anniversary in 2014. The Region's predecessor 'Halton County' was one of the oldest County's in Canada being settled in the early 1780's, with one of the earliest town hall meetings in 1806.

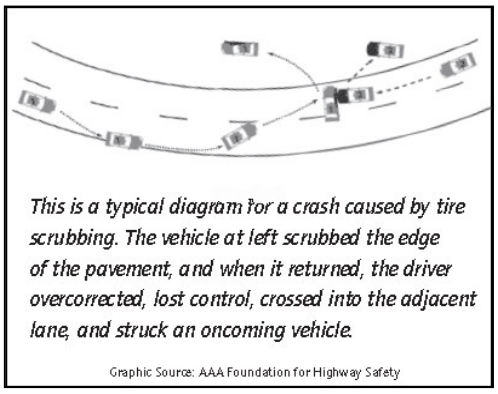
-Present-

From those humble beginnings the Region today has a population of over 480,000 and encompassing four local municipalities, the City of Burlington, Town of Oakville, Town of Milton and Town of Halton Hills, which all continue to experience economic growth and development.

-Future-

In the next 17 years, the Region of Halton estimates the population to increase to 780,000, with 390,000 employment opportunities [1]. To accommodate the expected growth, the Region has developed a Master Transportation Plan [2],that outlines improvements to the transportation system through roadway widening's and increased transit usage, with an ambitious 20% Transportation Modal Split target.

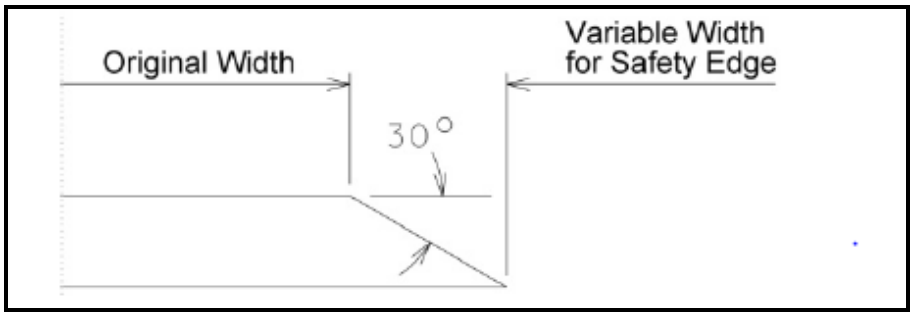
With over 1,000 lane kilometers of regional major arterial roads and a Transportation Capital 10 year budget forecast of $1.2 billion [3], significant investment continues to be made in transportation improvements to meet growth. With this large investment in transportation infrastructure, comes great need for cost betterments and product improvements of all types to be reviewed and assessed for inclusion into our road projects.



This is a typical diagram for a crash caused by tire scrubbing. The vehicle at left scrubbed the edge of the pavement, and when it returned, the driver overcorrected, lost control, crossed into the adjacent lane, and struck an oncoming vehicle.

Graphic Source: AAA Foundation for Highway Safety

This paper will focus on one such enhancement that has been incorporated (Summer 2014) into a Regional roadway resurfacing project, *The Safety Edge*, an asphalt edge paving attachment. This paving attachment allows for the placement of new asphalt at a 30^0 angle with the intent to minimize and lessen the severity of roadway departures, while providing greater ease in re-entering the road during such an occurrence. The result would be a reduction in the risk of over steering and subsequent loss of control accidents. As an additional benefit to this enhancement, improved pavement performance is also anticipated due to the additional lateral support, should vehicles travel on the paved edge.



Graphic credit to Iowa DOT

Picture credit to Carlson Paving

2. BACKGROUND

2.1. Region of Halton – In-Service Road Safety Review

In 2012, the Region of Halton conducted an In-Service Road Safety Review for a 2.8 km section of 20 Sideroad (Regional Road 34), located in the north-west area of the region, illustrated in Figure 1. This rural road runs generally in an east-west direction and is part of the Provincial Emergency Detour Route for Provincial Highway #401; one of the main Greater Toronto Area east-west corridor highways with an AADT of 107,300 for the local 4.5 km section located just south of 20 Sideroad.

Scheduled to be resurfaced in the summer of 2014, this 2-lane road operates at a posted speed limit of 60 km/hr, and will comprise of 3.65m wide lanes, with predominantly narrow (0.50m) unpaved shoulders. Within the review limits, the roadway contains two intersections and two S-curves, with both tangent and varying horizontal and vertical curvilinear alignment.

Average Annual Daily Traffic (AADT) volumes in 2013 were 3,165 with 94% consisting of smaller vehicles, primarily cars and light pick-up trucks. Although the posted speed limit for this roadway was 60 km/hr., information collected at the Automatic Traffic Recorder (ATR) station observed that the 85th percentile speed of the vehicles travelling along this roadway was 90.6 km/hr. Even though the observed travel speed was well above the posted speed limit of the roadway, no speed related collision trends were identified in the study, and thus no further investigation was carried through on this. To assist with enforcement however, two specific 'lay-by' areas have been included in the project design to provide for the occasional use of Radar Message Boards and Police enforcement programs.

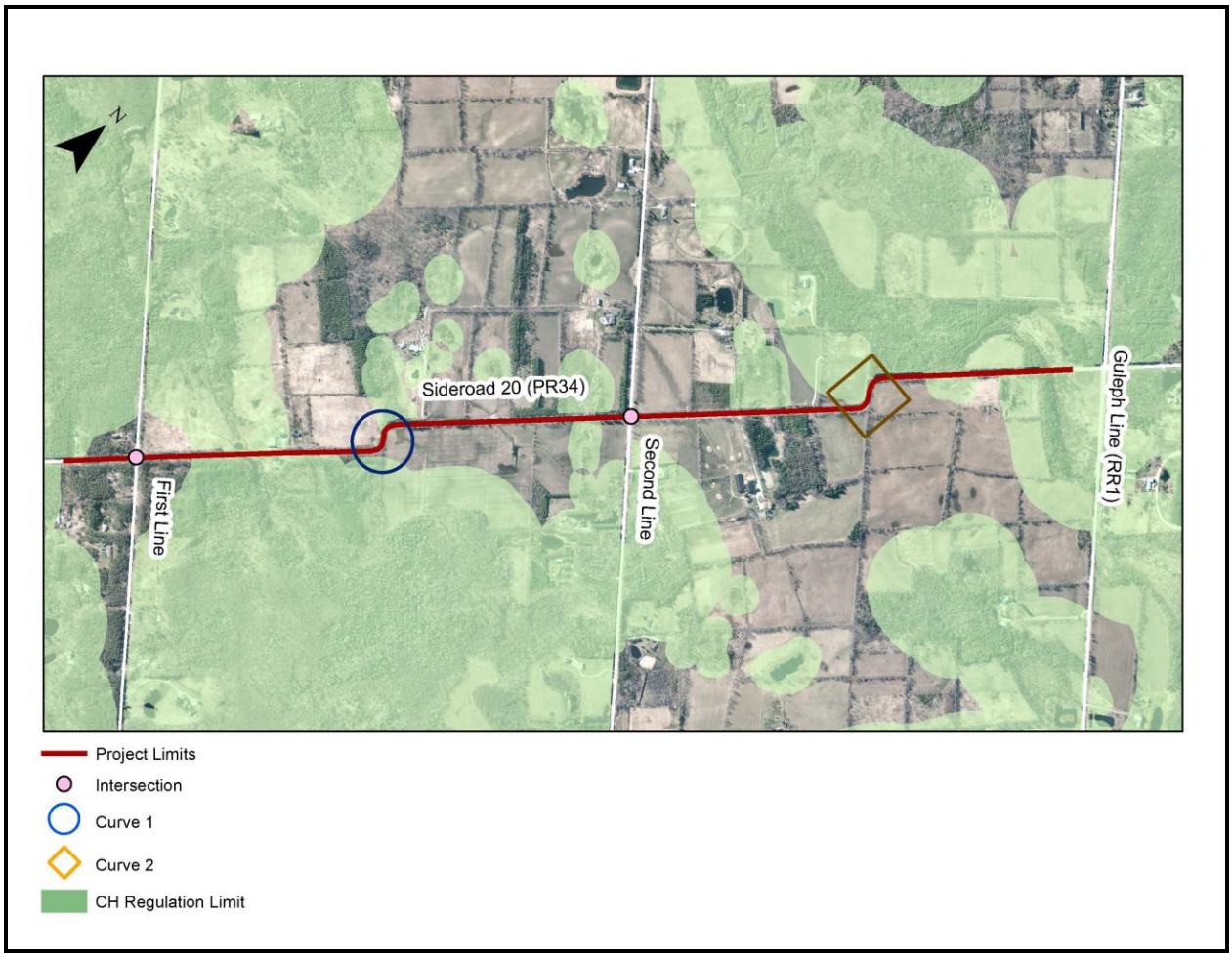


Figure 1: 20 Sideroad project limits

The roadway shoulders vary in width (0.25 to 1.0 m) and generally the corridor does not provide for a level roadside recovery area outside of the limited shoulder area. The topography of the area is primarily governed by Conservation Halton (CH) regulated lands that are adjacent to the road, with both marsh and wooded protected areas in close proximity. Farm and rural residential properties make up the remainder of the lands. The road profile also goes through a number of cut and fill sections, thus resulting in varying shoulder widths, and further challenges for drainage.

In summary, the In-Service Review, had recommendations for enhanced signage, sight-line improvements (vegetation clearing) and delineation devices; all to be addressed through the project. The review also made mentioned to the pavement surface and pavement edges, but no definitive direction was provided. This would come through detail design, specifically on the cause and effect of the existing conditions, with Safety Edge being reviewed as betterment for both safety and pavement performance.

2.2. Literature Review

2.2.1. Federal Highway Administration Association (FHWA) U.S.A.

Developed in North America through the FHWA – '*Every Day Counts'* initiative, Safety Edge is one of five technologies promoted for use throughout the U.S. Department of Transportation (DOT's).

Figure 2: ***FHWA approved 'Safety Edge' sample devices (Picture credit to FHWA and Carlson Paving)***

This simple attachment as shown in Figure 2 is a low-cost adjustment (less than one-tenth of percent increase in asphalt tonnage to the construction of the asphalt edge) that has been documented to reduce the number of vehicle crashes by allowing drivers to safely recover should they drift off of the paved surface. Of course, data may not always record the occurrences where no property damage results such as 'near misses' or unreported events, which may be attributed to the effectiveness of Safety Edge. Although noted to be effective for all rural types of roadway, the use of a Safety Edge is particularly found to be useful on rural two lane roadways with minimum shoulders.

The Iowa Department of Transportation (IDOT) can be seen as a leader in the use of the Safety Edge on all its primary highways, with full integration being implemented as of February 2010. IDOT has added the Safety Edge use into their shoulder design standards (3C-4) [4], as well as having it as a stand- alone standard (3C-6) [5], to be applied on all IDOT two-lane rural highways without shoulder projects.

Another US state agency to pick up on the use of the Safety Edge is the Georgia Department of Transportation (GDOT), which constructed a 42.8 lane-kilometer asphalt overlay on a rural, two-lane undivided highway to monitor its constructability and study its durability [6]. The report also included study findings from other States, including Indiana and New York; however, the Georgia study sites (that compared the Safety Edge with pavement sections with drop-offs of 50 mm) were relatively well matched in terms of shoulder conditions.

A review of the study findings, noted that resurfacing with the Safety Edge treatment did not increase the number of extreme drop-offs over time, and the same could be said for resurfacing without the Safety Edge in reducing the drop-off heights.

Another interesting point is that the service life of the Safety Edge was noted as 7 years in the report, the same service life expected for typical pavement resurfacing in the study areas. This aside, the report

concludes that the application of Safety Edge under a benefit-cost analysis suggests that the treatment is highly cost effective (due to its nominal capital cost) under a broad range of conditions especially for roads with high volume traffic where higher crash frequencies are expected.

An excerpt of the FHWA – '*Safety Evaluation of the Safety Edge Treatment*' recommendations:

- *The safety edge treatment is suitable for use by highway agencies under a broad range of conditions on two-lane highways. While the evaluation results for total crashes were not statistically significant, there is no indication that the effect of the safety edge treatment on total crashes is other than positive.*
- *That the overall effectiveness of the safety edge treatment found in this study was not statistically significant is not surprising given that the magnitude of that safety effect appears to be small (i.e., approximately 5.7 percent). However, the safety edge treatment is so inexpensive that its application under most conditions appears to be highly cost-effective. The effect of the safety edge treatment would be cost-effective for two-lane highways with traffic volumes over 1,000 vehicles per day even if its effectiveness were 2 percent rather than 5.7 percent.*
- *The cost-effectiveness of the safety edge treatment increases with increasing traffic volumes. For roads with higher traffic volumes, the safety edge treatment is highly cost-effective.*

2.2.2. Ontario Ministry of Transportation

Figure 3: one of MTO pilot road sections

The Ontario Ministry of Transportation (MTO) completed a Safety Edge pilot project on three of its resurfacing roads in the fall of 2012.

This pilot study was highlighted in the MTO's "*Road Talk, Ontario's Transportation Technology Transfer Digest*" [7]. The on-going study will be reviewing the collision data before and after application, as well as semi-annual visual inspections to evaluate the integrity of the pavement edges. From the article, it is understood that the focus of the monitoring will also consider the effects of winter maintenances operations (if any), when compared to control sections along the same sections of roadway.

As illustrated in Figure 3, gravel shouldering should be maintained to the top level of the pavement grade, to help with vehicle recovery along this area, as well, as to preserve the integrity of the pavement edge from such vehicle movements. Gravel shouldering was subsequently placed in this MTO example.

3. 20 SIDEROAD RESURFACING PROJECT

3.1. Project Scope

In July of 2013 detailed design for the rehabilitation of 20 Sideroad commenced with a focus on improving the ride quality of 20 Sideroad, as well as the recommendations from the in-service safety review. Originally planned as a standard 'resurfacing' project, it was soon realized that the pavement surface distresses were strong indicators of a structurally deficient roadway, with severe pavement edge cracking. During the pavement design stage, shouldering and lateral support was reviewed and concluded that the addition of the Safety Edge could provide additional support at the pavement edge, for a fairly uncomplicated low cost.

Structurally the road was deficient. Moderate to severe pavement edge, fatigue and alligator cracking was predominating throughout the road limits. Centre-line and transverse cracking, although evident were not as severe as the 'outside in' cracking on the pavement surface. The severe pavement cracking was considered premature, based on the low traffic volumes when compared to the last resurfacing with expanded (foamed) asphalt some twelve years earlier.

A holding strategy was implemented in 2012, with shouldering maintenance and skim patching with a thin layer of HL2 to help extend the life of the pavement edge until the scheduled resurfacing in 2014.

Edge drop-off and loss of material, as seen in Figure 4, at the edge of the pavement was prominent throughout the project. The most severe of the edges were as expected nearest the two curves, Figures 5 and 6, and two intersections within the limits.

Figure 4: 20 Sideroad typical edges, curve and linear sections

Figure 5: 20 Sideroad edge cracking through curve 2 (eastern curve)

3.2. Collision Summary

From January 2010 to December 2013 sixteen motor vehicle accidents were reported. Of this, four were loss of control accidents (curve sections) with only one related to weather conditions (snow and high winds). Of the three remaining occurrences speed was a factor under clear weather conditions prevalent and during daylight hours. Only one report detailed the vehicle 'drove onto loose gravel of shoulder' with the others it was hard to determine if the shoulder edge contributed to the 'loss of control' maneuvers overall.

As noted by a FHWA study, the success of the Safety Edge evaluation results for total crashes were not statistically significant (reduction of 5.7%)[8], however the indication of this treatment on total crashes is none other than positive. Statically the three 'loss of control' occurrences over 4 years with

an average AADT of 3017 per year can be considered negligible. That said any improvement in further reducing or eliminating these types of accident occurrences should be seen as a benefit.

Figure 6: 20 Sideroad pavement conditions through curve 1 (western curve) 2010-left & 2013-right

3.3. Project Design

At the time of the previous rehabilitation (2001), structural improvements which included excavation into the subgrade to re-stabilize the road was considered, but not implemented. Part of the decision not to move ahead with these structural improvements was the anticipated effects on adjacent marsh lands, limited resources, and an assumption that the pavement rehabilitation alone would help improve the support at the new pavement edge. At that time, no direct action was carried through in design to enhance what little shoulder support existed.

During recent project design (and with new available technologies) a cost effective solution was recommended and moved forward that would not only rehabilitate the existing pavement, but also provide additional support at the existing pavement edge. As previously noted, this section of 20 Sideroad is through rural residential and farm lands, with roughly 55% of project limits in Conservation Halton regulated jurisdiction. Any consideration to widen the existing roadway to provide additional pavement edge support would have been challenged.

A total of seven rehabilitation strategies were considered for the rehabilitation of 20 Sideroad, with a Life Cycle Cost Analysis (LCCA) completed comparing all feasible rehabilitation alternatives. Based on the results of the LCCA, and the ability to properly address the lack of shoulder support, and improve roadway safety, the recommended rehabilitation strategy combining the use of geogrids in conjunction with the Safety Edge was selected. Another benefit to this alternative would be that the roadway improvements would be completed without either widening the pavement platform or widening the shoulder widths, critical given the sensitivity of the adjacent lands.

The rehabilitation recommendation was tailored to the changing conditions throughout the project limits, with 50% of the roadway requiring the full removal of the existing pavement surface to permit the placement of the geogrid across the entire pavement platform. The remaining portion of the roadway will only require the placement of geogrid along the edge of the roadway (500mm within pavement, 500mm within shoulder) typical cross-sections illustrated in Figure 7. Through curve 1 additional excavation of subgrade to remove organic soils is required, with additional geo-textile, Figure 8.

It is anticipated that the placement of the geogrid in this area will improve the lateral resistance at the pavement edge; and improve the granular base support for the construction of the Safety Edge.

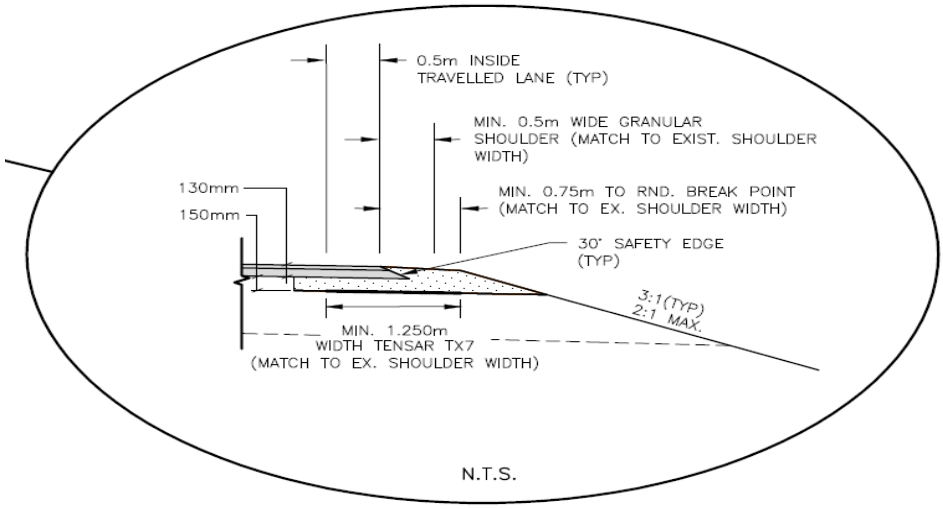


Figure 7: 20 Sideroad shoulder detail cross-section

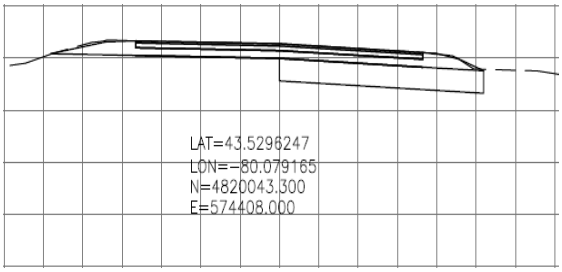


Figure 8: 20 Sideroad through curve 1 additional excavation area

In keeping with the Region's 'green' initiatives a 50% Limestone / 50% Recycled Concrete Mix (RCM) will be used for all Granular 'A' specified material. This action along with Ontario Provincial Standards [9]for recycled use in base asphalt will help off-set some of the raw material requirements for the project.

A key point to outline is the consistency of the pavement lift thicknesses. 20 Sideroad pavement will consists of 90 mm Heavy Duty Binder Course (HDBC) with 40mm HL1 over 150mm of Granular 'A' Limestone/RCM blend, with the Safety Edge application for each lift, Figure 9 is a typical linear section profile showing this consistency. This consistency both horizontally and vertically in pavement lifts should reduce the likely occurrence of reflective cracking from an 'old' base and 'new' top pavement.

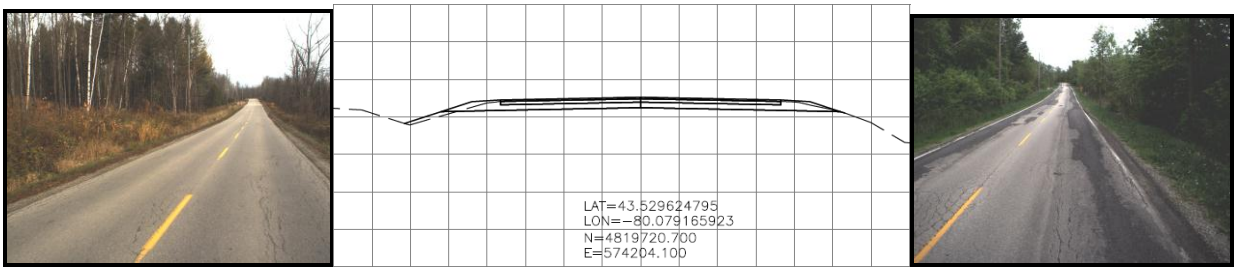


Figure 9: Typical Linear profile with 2010(left) & 2013(right) images

3.4. Post Construction Monitoring

The Region has developed a plan to inspect and document the inspection of the Safety Edge during construction, and follow-up on the construction efforts with a number of post construction studies. The post construction monitoring that will be completed as part of this project includes:

- Collision data comparison assessment – 4 years prior and 4 years post
- Quantification of pavement edge density – Control section vs. Safety Edge section
- Long term performance and integrity of the pavement edge – 4 year post
- Cost-Benefit Analysis review – assessment of geometry and mat density measurements

4. Conclusion and Recommendations

The *Safety Edge* is designed and implemented to save lives by helping vehicles recover should they wander beyond the edge of pavement. In addition to the improved safety performance, it is also expected that the construction of the Safety Edge will help improve pavement edge performance along rural roadways where narrow shoulders exist.

20 Sideroad, a rural two-lane moderately travelled roadway with S-curves and linear sections presented a challenge for resurfacing. Design and safety criteria warranted increased structural strength (additional granular, therefore increased grades, resulting in a wider platform), however due to regulated lands and drainage concerns widening of the platform, or grade increases was not an viable option. An 'outside-in' and 'up-down' approach was taken. The rehabilitation strategy included the use of geo-grid's to improve support within the granular base at the pavement edge, while Safety Edge was included to improve safety and enhance pavement support, thus helping reduce the need for shouldering widening.

This project is planned for constructed in the Summer of 2014, which will be closely monitored and documented. Once completed, the project will be reviewed and annually monitored to determine if the use of the Safety Edge meets design expectations. Should the use of the Safety Edge meet with anticipated results, the application of this low cost enhancement will begin to be considered for other roadway rehabilitation projects within the Regional Municipality of Halton.

References

1. Ontario - Ministry of Infrastructure (2006) 'Growth Plan for the Greater Golden Horseshoe'

2. The Regional Municipality of Halton (2011) '*The Road to Change* – Transportation Master Plan'

3. The Regional Municipality of Halton (2013) ' 2013 Budget and Business Plan'

4. Iowa Department of Transportation Office of Design – Design Manual Chapter 3 -Shoulders and Curbs 3C-4, Revision 2013

5. Iowa Department of Transportation Office of Design – Design Manual Chapter 3 –Shoulders and Curbs 3C-6, Revision 2012

6. US Department of Transportation – Federal Highway Association (2011) 'Safety Evaluation of the Safety Edge Treatment'

7. Ontario -Ministry of Transportation Road Talk Vol. 17 (2012), Issue 2 ‘Ontario’s Transportation Technology Transfer Digest’

8. US Department of Transportation – Federal Highway Association ‘*Highway Safety Information System* – Summary Report Safety Evaluation of the Safety Edge Treatment’

9. Ontario Ministry of Transportation, OPS 1010 – Material Specification for Aggregates