Shoulder Edge Wedge
For
Hot Mix Asphalt Paving

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PREFACE

The New York State Energy Research and Development Authority (NYSERDA) is a public benefit corporation created in 1975 by the New York State Legislature. For more than a quarter century, NYSERDA has been working on finding innovative solutions to the energy and environmental issues that face residents of the Empire State. As part of that mission, the Authority has sought answers that would benefit not only New York's energy and environmental future, but the economy as well. To do so, NYSERDA has traditionally partnered with other state agencies, as well as industrial, commercial, environmental and economic development groups all across New York State.

In 1999, the New York State Department of Transportation (NYSDOT) had just completed a three-year contractual research relationship with a consortium of seven New York State universities, colleges and research institutions. Based on the success of that experience, the Department sought to establish additional partnering arrangements with research consortia to carry out basic and applied research, technology transfer, and short-term consultation services in the fields of engineering, operations, public transportation, management and finance, public policy, and human resources.

As a complement to a university-based constituency, NYSERDA organized a Transportation Infrastructure Research Consortium comprised of seventeen private-sector research entities. The membership is characterized as businesses, not-for-profits, and professionals that have a track record of performing transportation-related research, development, and demonstration as a normal part of their service-related or internal operations. Many of the organizations also have strong relationships with universities, state agencies and authorities, and federal funding agencies, and are already performing collaborative research through those relationships.

In June of 2001, New York State Comptroller’s Contract C012668 was executed and governs the activities of the NYSERDA-administered Transportation Infrastructure Research Consortium. The term of the agreement is for five years, extending from March 1, 2001 through February 28, 2006. The direct and dynamic linkages between transportation, energy, and the environment have continually reinforced the cooperative relationship formed between NYSDOT and NYSERDA. Since its inception, numerous collaborative efforts have been undertaken and the report that follows is a product of that relationship.

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Summary

On many rural two-lane roads, the absence of a constructed shoulder at the edge of the paved surface due to erosion or traffic results in a sharp, nearly vertical drop-off to the grass or gravel surface sometimes many inches below. These shoulder drop-offs pose a serious safety problem when vehicles traveling at highway speeds unintentionally leave the travel lane and enter the unimproved shoulder area. NYS DOT practice for reducing edge drop-off severity is to fill the unpaved shoulder with soil, gravel, or asphalt millings in a separate shoulder construction operation conducted during road paving. Even with continuous maintenance efforts, shoulder edge drop-offs are present particularly on secondary and county highways.

In this project, TransTech conducted a survey of NYS industry to gauge the level of awareness of the edge drop-off problem; inspected test sites of prior shoulder wedge studies; defined performance criteria for shoulder wedge maker designs; identified suitable paving test sites; fabricated shoulder wedge maker prototypes; and, finally, evaluated the field performance at those test sites of two prototypes (TT1 and TT2) designed by TransTech and a third prototype (GASW) designed by the Georgia Department of Transportation.

The following performance criteria were defined by TransTech Systems and reviewed by the New York State Department of Transportation. The shoulder wedge fillet should:

1. Slope from the road edge to the shoulder at an angle of 45 degrees or less from horizontal (per recommendation of the Texas Transportation Institute 1982 study [2]);
2. Have sufficient density to maintain its shape over time; and
3. Have a reasonably smooth surface finish.

After one year of use, test sites produced in prior studies by TransTech in Schenectady County, NY and by the Federal Highway Administration (FHWA) in Georgia all show that the road edge produced by the TransTech TT1 prototype shoulder wedge maker was superior to the road edge produced by conventional paving. The Shoulder edge produced with the TransTech device maintained its integrity and surface finish. The FHWA study test sites further show that the TT1-produced edge was superior to the GASW-produced edge. The findings of the above study may be found in the Federal Highway Administration report titled “Construction of a Safe Pavement Edge: Minimizing the Effects of Shoulder Dropoff” [3].

The shoulder wedge devices used in this study could be installed quickly on most paving equipment with little or no modification to the paver. However it should be noted that certain screed models do require some modification to accept the devices. Operating the devices was simple and straightforward, required no significant increase in labor and an insignificant increase in hot mix asphalt (HMA) used. The resultant shoulder wedge fillet maintained an angle of 30 to 35 degrees consistently throughout the rolling process. The surface finish of the shoulder wedge, though varying with HMA temperature, was much better than the surface finish of the road edge without the shoulder wedge and, in most cases, appeared nearly as good as the surface finish of the mat itself. Though we were unable to directly measure the shoulder wedge density, when a test vehicle was driven over the shoulder wedge, the wedge surface maintained its integrity. By monitoring the test surfaces over time, the relative performance of the wedge fillet produced by the TT2, TT1, and GASW devices will be ascertained. The results of this study are very promising and indicate that further work on the subject of shoulder wedge design and performance should be pursued.
1. Introduction

On many rural two-lane roads, the absence of a constructed shoulder at the edge of the paved surface results in a sharp, nearly vertical drop-off to the grass or gravel surface sometimes many inches below. Even larger drop-offs result when overlays are paved on existing roadways with no shoulder treatment.

These shoulder drop-offs pose a serious safety problem when vehicles traveling at posted speeds unintentionally leave the travel lane and enter the unimproved shoulder area. Especially when the shoulder drop-off exceeds three to four inches, vehicle recovery becomes difficult and all too frequently results in driver loss of control. The significant difference in elevation between shoulder and pavement often causes drivers to overcorrect when attempting lane reentry causing the vehicle to cross the centerline and impact on-coming traffic or roadside abutments. Several recent studies have concluded that reducing the severity of edge drop-offs can facilitate safe roadway reentry and help prevent run-off-road (ROR) crashes, improve motorist safety, and reduce tort liability claims.

The typical current practice for reducing edge drop-off severity is to fill the unpaved shoulder with soil, gravel, or asphalt millings in a separate shoulder construction operation conducted after road paving is completed. This operation entails either closing the road or installing warning devices (cones, barrels, signage, etc.) during the time between completion of paving and the start of shoulder construction; closing the road during shoulder construction; purchasing, hauling, spreading and leveling the filler material; and, finally, removing any installed warning devices or signage to re-open the road. This is the recommended treatment endorsed by the Federal Highway Administration and is followed by most states including New York.

There are, however, those who choose not to back up their paved shoulders. In fact they do nothing at all to mitigate the road edge drop off. A low cost alternative to doing nothing uses a device attached to the paver to produce a paved fillet, or “shoulder wedge,” of forty-five degrees or less at the pavement edge. In the summer of 2003, TransTech tested a first prototype shoulder wedge maker device (TT1) on a portion of Rynex Corners-Pattersonville Road in Schenectady County, NY. In the fall of 2003, at a Georgia test site, the Federal Highway Administration (FHWA) tested the TT1 alongside a Georgia Department of Transportation (GADOT) shoulder wedge device (GASW).

While the GASW operates by simply “striking off” excess asphalt to form the wedge shaped fillet, the TT1 extrudes the fillet—in much the same way as asphalt is extruded underneath the paver screed—to produce a more compacted wedge. The goals of this project are to improve the quality and durability of the shoulder wedge by evaluating the wedge as produced by the GASW and TT1 devices, developing a second TransTech prototype (TT2) and to explore the efficacy of the shoulder wedge produced by these devices through testing on New York State (NYS) roads.

Toward that purpose, TransTech conducted a survey of NYS industry to gauge the level of awareness of the edge drop-off problem; defined performance criteria for the shoulder wedge; identified suitable paving test sites; fabricated shoulder wedge maker prototypes; and, finally, evaluated the field performance of the shoulder wedges produced by the TT1, TT2, and GASW devices at those test sites.

2. Industry survey

In order to document information regarding issues and costs associated with the shoulder wedge method and to gather the opinions of those involved in road construction, maintenance and safety issues in New York State, TransTech designed a rather informal survey. It quickly became apparent, though, based on an overall hesitancy from those receiving the survey that the various contractors and New York State Department of Transportation (NYSDOT) personnel were more than a bit concerned about furnishing information that might result in a future liability issue. In fact, no contractor was willing to answer the survey, and personnel from only three of the NYSDOT Regions provided answers.
It is possible that this general lack of responsiveness could have been a result of the survey recipients not believing that there were any issues whatsoever with shoulder edge drop-offs. However, the discussions that took place, and the emails exchanged, between TransTech personnel and those surveyed gave the impression that people simply did not want their names or organizations attached to any report that might put them in a negative light or might actually be used against them in any future tort liability cases.

In order to overcome this apparent unwillingness to respond, a letter of explanation was emailed to all those asked to fill out the survey. In the letter, the reason for the survey was elaborated on and the question of how the results would be used was answered. It was explained that Dave Clements was spearheading the project from the NYSDOT end and that the results of the survey would be included in the Final Report for NYSDOT. It was further explained that TransTech did not plan to include each specific page from each person/region that filled one out; rather, the answers only would be combined from each question into some general bullets. The recipients were further assured that only the answers and no names of individuals or of specific NYSDOT regions would be included. It was only after sending this letter of explanation that, out of a total of sixteen survey requests sent, three surveys were finally received corresponding to three NYSDOT regions. This dismal 19% response rate is again attributed to the fear that any admissions regarding this subject might prove damaging in any future or pending tort litigation. The survey questions and their bulleted responses are included in appendix 8.1.

Based on the limited response to the survey, it seems that, despite the growing interest by FHWA; the meeting in Atlanta, Georgia; the current Pooled Fund Study on this topic; and the interest of NYSDOT; this is either a non-issue for most of NYS or else, due to the liability issues mentioned previously, it is a safety issue that is seen as too risky to discuss in case there are legal challenges in the future. Based on only the three responses, it does appear to be a problem that can be handled by following current NYS guidelines. Only one responder commented that it would be a benefit to actually eliminate the hazard rather than dealing with it by adding backup material and using barrels and/or cones.

The fact that placing a shoulder edge wedge fillet using one of the three devices would use very little extra material and could eliminate the need for sending another crew out to deal with the backfilling, requiring significant crew time and resulting in unnecessary traffic congestion, does not appear to be a consideration for those responding. This could be because contractors and DOT respondents are required to follow the requirement to back up shoulders. It is unfortunate that more opinions, suggestions and information were not received in the form of survey answers, as that would have enabled a deeper understanding of the overall situation in NYS.

3. Performance criteria

Of all fatal accidents reported in the year 2002, approximately one-third were the product of vehicles leaving the roadway and hitting fixed objects while an additional one-fifth of the fatalities were caused by vehicle rollover or head-on collisions. The above accidents comprise twenty percent of the accidents that occur each year but account for over fifty percent of the fatalities. More than fifty percent of all fatal accidents each year occur on undivided two lane roads. [4]

It has been a known fact that road edge drop-offs are a contributing factor in many of these fatal accidents. When a vehicle partly leaves the driving lane to straddle a vertical edge drop-off of several inches, the driver will experience difficulty reentering the driving lane. The phenomenon known as “tire scrubbing” happens when an inner tire sidewall rubs against the vertical surface of the road edge. This scrubbing effect causes the driver to steer at a greater angle to the road edge until the tire manages to climb back onto the road. Unfortunately, by the time the vehicle reenters the driving lane it may be at an angle to the direction of travel steep enough that driver reaction time is not fast enough to prevent over-steering and loss of control. To compound this effect, the rear tire of the vehicle may encounter the same phenomenon and not reenter the driving lane until the vehicle is almost at a ninety-degree angle to the direction of lane travel. These severe actions may cause the vehicle to veer into the oncoming lane and collide with oncoming vehicles or cause the vehicle to cross the opposite lane of traffic and leave the road on the
opposite side. [1] Shoulder edge drop-offs of four or more inches are considered unsafe. Drop-offs less than four inches, but nearly vertical, are still considered a safety hazard and may cause difficulty in roadway reentry. [2]

In the past, the only way to reduce or eliminate this hazard was to fill the shoulder area to provide a gentle transition from the driving lane to the road edge area. However, a 1982 study by the Texas Transportation Institute concluded that an angled road edge of 45 degrees or flatter would provide a way for vehicles to exit and enter the driving lane with little or no loss of control. This present study demonstrates the shoulder wedge method for providing a transition from driving lane to shoulder area during the road paving process. The method could eliminate the additional labor, equipment, and material of a secondary construction operation and would produce a road edge ramp of less than 45 degrees, as suggested by the above study, with less than one percent increase in hot mixed asphalt (HMA) usage. [2]

A second benefit of the shoulder wedge method concerns road condition and durability. One year after paving, the Rynex Corners-Pattersonville Road test sites showed marked pavement cracking and lane width reduction due to road edge collapse on sections paved without the TT1; all sections paved with the TT1 remained intact. Similarly, FHWA photographs of the Georgia test sites showed that, one year later, the TT1-paved sections remained intact, while GASW-paved sections and conventionally paved sections showed significant cracking and in some cases collapse.

In light of the above observations, the following performance criteria were defined by TransTech Systems and reviewed by the New York State Department of Transportation. The shoulder wedge fillet should:

1. Slope from the road edge to the shoulder at an angle of 45 degrees or less from horizontal (per recommendation of the Texas Transportation Institute 1982 study [2]);
2. Have sufficient density to maintain its shape over time; and
3. Have a reasonably smooth surface finish.

3.1 Apparatus description

Figure 1 shows the TransTech Systems first prototype shoulder wedge maker, TT1. Figure 17 is a photograph of the TT1. This device is mounted to the screed extension adjacent to the end gate. It has a patented internal spring arrangement to hold it in contact with the road surface and allow it to follow any variations in the road edge. It produces an angle of 30 degrees prior to rolling. It also has a patented compound angled surface that forces additional material under the device resulting in a more compacted wedge compared to simple strike-off devices like the GASW.

Figure 2 is an illustration of TransTech Systems’ second prototype shoulder wedge maker, TT2. Figure 18 shows a photograph of the TT2. This device is also mounted to the screed face abutting the end gate. It also has the patented internal spring and compound angled surface. In addition, however, it has an added surface, which runs parallel to the surface of the wedge. This additional length allows the device to smooth surface imperfections as the asphalt moves under it yielding a better surface finish. The TT2 also produces the exiting 30-degree angle prior to rolling.

Figure 3 is a reduced size copy of the actual production drawing supplied by GADOT for their shoulder wedge device, GASW. Figure 19 shows the GASW mounted to the end gate of a paver. This version of the GASW is the fifth revision of the original GADOT design. In accordance with this drawing, TransTech Systems manufactured the particular GASW used for this contract. The GASW is a strike-off design and is attached to the paving machine’s end gate. It uses the end gate spring apparatus to control its vertical position and to keep it in contact with the shoulder surface. It produces a 30-degree angle prior to rolling and uses its large frontal radius and extended bottom surface to smooth the produced wedge surface.
3.2 Apparatus installation

Both the TransTech Systems devices, TT1 and TT2, are attached to the screed face, as referred to in the previous section, by a mounting plate using two ½-13 hex head bolts. Depending on the configuration of the paving machine’s screed, these bolts may be installed in tapped holes in the screed or through clearance holes using nuts and lock washers. Once the mounting plate is fastened in place, the device is inserted through the upper mounting platform and secured with a cotter pin. When paving is to begin, the device is adjusted by turning the acme screw counterclockwise until the fastening cotter pin lifts off the upper platform indicating that the bottom surface of the device is in contact with the road. Maintaining a gap of approximately ½ inch will insure downward pressure on the device keeping it in contact with the road shoulder surface.

As previously mentioned, the GASW, is attached to the paving machine’s end gate using two ½-13 hex head bolts inserted through clearance holes in the device and end gate and fastened with nuts and lock washers. The device is positioned with its back surface against the screed face and the bottom edge of the mounting plate even with the bottom of the end gate.

3.3 Application of the wedge feature

Two paving sites were selected in the NYS Capital District. Once the sites were secured, arrangements were made to make the necessary modifications to the paving machines to accept the three wedge devices. Upon beginning site paving, the wedge devices were randomly selected, installed and adjusted. Each paving site used all three devices. The random sequencing of usage insured that each device was exposed to as many different edge conditions as possible with no advantage to any given device.

3.4 Post application testing

Once application of the wedge feature was complete, two evaluation tasks were performed:

(1) Digital photographs of the shoulder wedge for each prototype and each test site were taken to show the road edge configuration, and measuring equipment was used to measure the rise and run of the angle produced; and

(2) Where conditions allowed, an actual driving test using a vehicle and driver to leave the road surface and reenter at applicable roadway speeds was performed to obtain some qualitative evaluation of driver control.
Figure 1. TransTech Systems Safety Edge TT1

Figure 2. TransTech Systems Safety Edge TT2
4. Test sites

Efforts to secure three test sites began in May. The initial contact was made by the NYSDOT with Callanan Industries. Callanan had the contract to pave sites in Albany County and agreed to assist in the testing. Three locations were offered as possible sites. The first was Rte. 143 in Westerlo. The second site was Rte. 9W in Glenmont. Finally, the third site was Rte. 85 in New Scotland. Dave Clements of the department of transportation instructed TransTech Systems to contact Ron Wolfe of Callanan Industries. Mr. Wolfe is in charge of the paving operations for that company.

After initial contact with Mr. Wolfe was made on May 27, evaluation of the sites and review of the equipment to be used was started. Immediately several problems were identified. These included difficulties with the sites and their appropriateness for our tests, modifications to the paver that were necessary to install the devices and the logistics involved to coordinate all work while minimizing delay of the paving being done. As a result of the extensive problems identified, it was decided by TransTech Systems with the concurrence of NYDOT to pursue available sites in Schenectady County. In addition, Dave Clements was asked on July 14 to contact the head of the Saratoga County Public Works Department to assess the possibility of using sites in Saratoga County.

With the elimination of Albany County sites, work intensified on the Schenectady opportunities. Possible Schenectady County sites included: Curbyush Road in Rotterdam, Lake Rd. in Mariaville, Washout Rd. in Glenville, Spring Rd. in Glenville, and North Mansion Rd. in Duanesburg. Due to several schedule changes by Schenectady County Department of Public Works only two sites were available for testing. The two sites were Washout Road in Glenville and North Mansion Road in Duanesburg. Testing was completed on these two sites while efforts to secure a third site in Saratoga County continued. Due to a communications breakdown with the Saratoga County Department of Public Works, the opportunity to use a site in the county was missed.
At this point, all local counties had finished their scheduled paving for the season and no other sites were available. Dave Clements was contacted and asked for direction regarding completion of the contract in fiscal year 2004. Mr. Clements decided a contract modification should be made and that, with the good results achieved on the first two sites, a third site would not be necessary. TransTech Systems received an e-mail memorandum outlining the contract change on November 8. A copy of the e-mail is included as Appendix 8.2.

4.1 Test site conclusions

What at first appeared to be a straightforward scheduling exercise turned out to be a complicated process that began in May, ran through November, and finally only yielded two of the three desired test sites. The difficulties encountered included weather delays, subcontractor problems, equipment failures, and communication breakdowns. As stated in Mr. Clements memorandum, the causes were beyond the control of TransTech Systems. What was accomplished, however, on the two sites that were ultimately secured and paved—Washout Rd. in Glenville and North Mansion Rd. in Duanesburg—was deemed satisfactory and very promising for the future of shoulder wedge paving technology.

5. Field evaluations

On Washout Rd in Glenville, paving began at the intersection of Ridge Rd. and proceeded approximately 4.3 miles south to the intersection of NYS Rte 5 using a standard topcoat class 6 mix. The southbound lane was paved without the use of any shoulder wedge maker prototypes; the northbound lane was paved using the GASW, TT1, and TT2 prototype devices in turn, each on approximately 1.4 miles of road. Installation of the devices took only a few minutes and adjustments were made as the paving proceeded. There was no difference in the time to pave with or without the devices.

On North Mansion Road in Duanesburg, paving began at the intersection of US Rte. 20 and proceeded approximately 1.6 miles to the intersection of the Schoharie Turnpike again with class 6 mix. A short section, in one travel direction, was paved without the shoulder wedge devices; the remainder of the road, in both travel directions, was divided equally among the three devices. Again, there was no difference in the paving time with or without the devices and no added labor was necessary.

Calculations of the additional hot mix asphalt (HMA) required by the shoulder wedges were made based on the lift thickness and width and length of road and assuming that the lane width is maintained and the shoulder wedge fillet is in addition to lane width. The details of these calculations are shown in Appendices 8.3 and 8.4. The results show that the additional material needed to install the shoulder wedge, if roadway lane width is maintained, is between one half of one percent and one percent of the total HMA tonnage used.

5.1 Shoulder angle and surface finish

Table 1 documents the finished shoulder angles measured after final rolling at both test sites. Site, shoulder location, device used, measured rise and run, and resultant angle are tabulated. The angles measured all individually meet the above-specified performance criterion of being less than 45 degrees from the horizontal with an average angle between 28 and 29 degrees.

The surface finish of the shoulder wedge was affected by a number of factors not related to the design of the devices, the main factor being the temperature of the HMA at the paving machine outlet: the cooler the mix coming from the paving machine, the coarser the surface finish of the wedge. If the mix was between 250° and 275°, the surface finish improved to the point that it was difficult to see a difference between the shoulder wedge and the rolled lane surface.

Figures 4-16 show photos of shoulder wedges formed by the three different wedge maker devices at the
two paving sites. It is clear in the photos that the same device produces different surface finishes, supporting the notion that surface finish is not correlated with device type.

5.2 Mat and shoulder wedge density

The TransTech Systems Pavement Quality Indicator (PQI) was used to characterize the mat evolution at both paving sites. Density, temperature, and moisture measurements were taken before rolling and after each rolling pass at random intervals across the width of the lane surface. For these tests, an assumed maximum theoretical density of 153 pounds per cubic foot (pcf) was used for calibration purposes. Table 2 tabulates the results. The measurements are very consistent both across the width of the individual mats and between the mats of the two test sites. There was no indication of any increase in density at the lane edge (i.e., on the road, inboard of the shoulder wedge) due to any of the wedge-maker devices.

Characterizing the shoulder wedge itself, however, proves problematic: the PQI could not be used because its sensor plate diameter is larger than the width of the wedge face; cores could not be used, as the 2003 FHWA study reported, because cutting cores from the wedge was extremely difficult, and the samples obtained were too fragile to survive even transport to the lab. We concur with the FHWA study, therefore, that the only known practical way to evaluate shoulder wedge performance is to monitor the wedge over time. [3]

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<th>Site</th>
<th>Shoulder location</th>
<th>Device used</th>
<th>Rise (inches)</th>
<th>Run (inches)</th>
<th>Angle (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washout Rd</td>
<td>Northbound lane</td>
<td>GAS W</td>
<td>3</td>
<td>5</td>
<td>31</td>
</tr>
<tr>
<td>Washout Rd</td>
<td>Northbound lane</td>
<td>GAS W</td>
<td>3 ¼</td>
<td>5 ¾</td>
<td>31</td>
</tr>
<tr>
<td>Washout Rd</td>
<td>Northbound lane</td>
<td>TT1</td>
<td>3 ½</td>
<td>6 ½</td>
<td>28</td>
</tr>
<tr>
<td>Washout Rd</td>
<td>Northbound lane</td>
<td>TT1</td>
<td>3 ½</td>
<td>6 ½</td>
<td>28</td>
</tr>
<tr>
<td>Washout Rd</td>
<td>Northbound lane</td>
<td>TT2</td>
<td>2 ¾</td>
<td>4 ¾</td>
<td>30</td>
</tr>
<tr>
<td>Washout Rd</td>
<td>Northbound lane</td>
<td>TT2</td>
<td>3</td>
<td>4 ¼</td>
<td>32</td>
</tr>
<tr>
<td>N. Mansion Rd</td>
<td>Northbound lane</td>
<td>TT2</td>
<td>3</td>
<td>6</td>
<td>27</td>
</tr>
<tr>
<td>N. Mansion Rd</td>
<td>Northbound lane</td>
<td>TT2</td>
<td>3 ¼</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>Test site</td>
<td>When measured</td>
<td>Compaction (%)</td>
<td>Moisture (%)</td>
<td>Temperature (°F)</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------</td>
<td>----------------</td>
<td>--------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>Before rolling</td>
<td>84</td>
<td>3</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>After roller pass 1</td>
<td>89</td>
<td>3</td>
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<tr>
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<td>After roller pass 2</td>
<td>91</td>
<td>3</td>
<td>165</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>After final roller pass</td>
<td>92</td>
<td>3</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>Before rolling</td>
<td>82</td>
<td>4</td>
<td>226</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>After roller pass 1</td>
<td>89</td>
<td>3</td>
<td>183</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>After roller pass 2</td>
<td>92</td>
<td>3</td>
<td>164</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>After final roller pass</td>
<td>93</td>
<td>3</td>
<td>145</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>Before rolling</td>
<td>82</td>
<td>3</td>
<td>219</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>After roller pass 1</td>
<td>104*</td>
<td>9*</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>After roller pass 2</td>
<td>90</td>
<td>4</td>
<td>167</td>
<td></td>
</tr>
<tr>
<td>Washout Rd</td>
<td>After final roller pass</td>
<td>91</td>
<td>3</td>
<td>142</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Mat Density Measurements
<table>
<thead>
<tr>
<th>Test site</th>
<th>When measured</th>
<th>Compactation (%)</th>
<th>Moisture (%)</th>
<th>Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. Mansion Rd.</td>
<td>After roller pass no. 1</td>
<td>89</td>
<td>4</td>
<td>195</td>
</tr>
<tr>
<td>N. Mansion Rd.</td>
<td>After roller pass no. 2</td>
<td>91</td>
<td>3</td>
<td>171</td>
</tr>
<tr>
<td>N. Mansion Rd.</td>
<td>After final roller pass</td>
<td>92</td>
<td>3</td>
<td>145</td>
</tr>
</tbody>
</table>

* Purposely placed gage in a high moisture area to show effect of excess water.

Note that measurements on North Mansion Road are averages reported representing a number of different locations.

Figure 4. GASW on Washout Rd.
Figure 5. GASW on Washout Rd.

Figure 6. TT1 on Washout Rd.
Figure 7. TT1 on Washout Rd.

Figure 8. TT2 on Washout Rd.
Figure 9. TT2 on Washout Rd.

Figure 10. TT2 on North Mansion Rd.
Figure 11. TT2 on North Mansion Rd.

Figure 12. TT2 on North Mansion Rd.
Figure 13. Georgia DOT strike-off on North Mansion Rd.

Figure 14. Georgia DOT strike-off on North Mansion Rd.
Figure 15. TT1 on North Mansion Rd.

Figure 16. TT1 on North Mansion Rd.
Figure 17. TT1 not mounted

Figure 18. TT2 not mounted
Figure 19 Georgia Strike Off Mounted
6. Conclusions and recommendations

After one year of use, the test sites from the 2003 FHWA Georgia study and from the TransTech Rynex Corners-Pattersonville Road study all show that the road edge produced by the TransTech TT1 prototype shoulder wedge maker was superior to the road edge produced by conventional paving. The 2003 FHWA Georgia study test sites further show that the TT1-produced edge was superior to the GASW-produced edge.

In the tests conducted in the current study, all three shoulder wedge devices could be installed quickly with little or no modification to the paver used. It should be noted however that for various available screed designs, some modification of equipment would be needed to facilitate the use of these devices. Operating the devices was simple and straightforward, required no significant increase in labor and an insignificant increase in hot mix asphalt used. The resultant shoulder wedge fillet maintained an angle of 30 to 35 degrees consistently throughout the rolling process. The surface finish of the shoulder wedge, though varying with HMA temperature, was much better than the surface finish of the road edge without the shoulder wedge and, in most cases, appeared nearly as good as the surface finish of the mat itself. Though we were unable to directly measure the shoulder wedge density, when a test vehicle was driven over the shoulder wedge, the wedge surface maintained its integrity. By monitoring the test surfaces over time, the relative performance of the shoulder wedge feature produced by the TT2, TT1, and GASW devices will be ascertained.

The results, so far, of this study are very promising and indicate that further work on the subject of shoulder wedge design and performance should be pursued. Specifically, we recommend: evaluation of data and additional improvements on the wedge making devices to produce a better wedge; research into the design of adapters to support the use of these devices on all OEM manufactured screeds; and support for FHWA Pooled Funds Studies on this subject.

7. References


8. Appendices

8.1 Survey questions and responses

1) Are you familiar in your region with shoulder edge drop-offs?

- Yes.
- Yes.
- I believe so.

2) If so, are shoulder edge drop-offs a problem in your region? Please explain.

- Yes. Edges of shoulder drop-offs are a hazard to the traveling public since they can cause a motorist to lose control of the vehicle. Edge of shoulder drop-offs also tend to remain exposed for extended periods of time with only barrel/cones and signs in place as a warning of hazard.
- No, we backup resurfacing with gravel.
- No, we use shoulder backup. Mostly HMA millings are used.

3) Where are majority of drop-offs located, if they do occur? (Urban/rural)

- Rural.
- They would be in rural, non-curb/gutter sections.
- Rural.

4) Do you have any special concerns in this regard?

- Use of delineation devices does not eliminate the hazard. Creating an edge of shoulder drop-off increases the responsibility of the EIC/Contractor to ensure it is protected properly. Delineation devices do not prevent a motorist from driving into the shoulder edge drop-off. If the drop-off was eliminated, the delineations devices would not be necessary and the errant motorist might be able to drive back onto the roadway without incident.
- No.
- No.

5) If there were a screed attachment that could mitigate this problem during paving/resurfacing by easily producing a compacted 45-degree edge fillet, would this be good news? Why?

- Sure. Anything that would eliminate the drop-off hazard would be beneficial.
- There already is one used to make the Michigan wedge joint.
- No, we would have to modify our pavement section to accommodate it. Also, I believe a
45-degree angle is too steep to be beneficial. Our shoulder backing is placed at 1 on 2 or flatter, “< 27-degrees”.

6) Is there currently any reason/incentive in your region to find an alternative method of addressing shoulder edge drop-offs? Please explain.

- Yes.
- No.
- Not that I am aware of.

7) How are shoulder edge drop-offs currently addressed in your area and what are some of your experiences with alternative techniques? How long does the "fix" last?

- Edges of shoulder drop-offs are marked with barrels/cones and signs in accordance with 619-3.01 G. These devices are spaced in accordance to Table 619-1. This method seems to be effective since we have not had any accidents attributed to the drop-off. The “fix” can last for a few days to several weeks until shoulder backup material is placed.
- See #2. We don’t see many shoulder drop-offs; the gravel back up seems to work.
- Very little experience and not previously thought of as a problem. To my knowledge, the “fix” lasts the life of the pavement.

8) Do you think that the road would have a longer life if a compacted 45-degree edge fillet were used on pavement edges? Please explain.

- No.
- No different than what we are currently doing.
- No, the pavement sub-base section extends beyond the edge of paving and, combined with the shoulder backing, I am not aware of this being a problem.

9) Would use of such a device be a time saver for road crews? (Versus something like bringing in gravel to rebuild shoulders to be nearly flush with the pavement surface at the edge) A money saver? Reduce liability? Please explain.

- It should save time and lessen the amount of work for the contractor. It should also reduce our liability since the hazard would be eliminated and we would not have to rely on proper barrel/cone spacing.
- It may in some instances. I believe our liability for drop-offs is at the edge of pavement not at the edge of shoulder. There was research done in the 1990’s by SHRP or NCHRP on drop-offs. This info was adopted in the NYS Highway Maintenance Guidelines for EOP drop-offs.
- No response.

10) What types of field conditions are normally encountered during pavement resurfacing in terms of shoulder edge drop-offs?

- In several instances, there is an existing edge of shoulder drop-off and now we are
compounding the problem by placing more asphalt.

- Variable. Some minor drop-offs to berms from S&I (snow and ice) abrasives build up.

- We pave in lifts of 3.5-inches to 1.5-inches, from binder to top, each lift is stepped back so that it is completely supported underneath. The finished edge, although not compacted, slopes at the natural angle of the HMA mix, < 90-degree, and there is an angle produced by stepping each lift.

11) What would be the most common equipment interface requirements for a screed/end gate attachment that would produce compacted 45-degree edge fillets?

- The equipment must be capable of producing a consistent edge while not impeding the placement of asphalt.

- Don’t know.

- Don’t know, probably something like the shoe used to produce the Michigan wedge.

One response included a summary paragraph:

“In summary, it appears that our experience with placing a ‘shoulder backup material’ behind the edge of shoulder AC paving has not been bad and we have the flexibility of placing larger ‘volumes’ of material such as millings when the sub-base course and/or underlying shoulder embankment is low or the side slopes are overly steep. Question is: do we want to utilize AC to fill these less than perfect locations versus our normal backup materials (such as millings)?”
Memorandum from D. Clements to G. Antonelli re Test sites

Gary,

This will serve to document decisions made this day in regard to the subject project.

- Due to circumstances beyond the control of TransTech Systems Inc., the number of sites to be evaluated in the final report has been reduced from three to two (Washout Road in Glenville & North Mansion Road in Duanesburg).

- Staff hours spent coordinating and preparing for the third site will be paid under the current contract.

- Focus now will be on delivery on the final report by January 1, 2005 (in time for the January TRB conference), with photos to Gary Frederick as soon as convenient (gfrederick@dot.state.ny.us).

Please let me know if any of the above items need amending.

Thank you,

Dave Clements

David J. Clements, Director
Safety Program Management Bureau
Traffic Engineering & Highway Safety Division
New York State Department of Transportation
50 Wolf Road - POD 42
Albany, NY 12232
Phone: 518-457-3537
Fax: 518-457-1780
E-mail: dclements@dot.state.ny.us
8.3 Hot mix asphalt (HMA) usage on Washout Road

Given:

Lane width: ................................................................. 12 feet
Road length: ............................................................... 4.3 miles
Lift: ............................................................... 3” rolled (0.25 feet)
Maximum theoretical density (MTD): ................. 153 pcf
Rolled density on lane: ............................................. 93% of MTD (142 pcf)
Unrolled density of shoulder wedge: .......... (assumed) 60% of MTD (92 pcf)
Average cost of hot mix asphalt:
  Base ................................................................. $28.00/ton
  Intermediate ..................................................... $32.00/ton
  Top Coat ........................................................... $35.00/ton

HMA used for lane paving:

4.3 miles x 5280 feet/mile x 12 feet/lane x 2 lanes x 0.25 foot lift x 142 pcf / 2000 lbs/ton

= 9672 tons of HMA

HMA used for shoulder wedge application:

4.3 miles x 5280 feet/mile x 0.25 foot rise x 0.5 foot run x ½ x 92 pcf / 2000 lbs/ton

= 62 tons of HMA

% increased HMA usage:

65 tons / 9672 tons = 0.7%

Cost of material to pave lanes:

9672 tons x $35.00/ton = $338,520.00

Cost of material to apply shoulder wedge:

65 tons x $35.00/ton = $2,275.00
8.4 Hot Mix Asphalt (HMA) usage on North Mansion Road:

Given:

Lane width: ......................................................................................... 13.5 feet  
Road length: ....................................................................................... 1.6 miles  
Lift: ............................................................................. 3” rolled (0.25 feet)  
Max theoretical density (MTD): ........................................................... 153 pcf  
Rolled density on lane:......................................................................... 92% of MTD (141 pcf)  
Unrolled density of shoulder wedge:........... (assumed) 60% of MTD (91 pcf)  

Average cost of hot mix asphalt:  
Base: .................................................................................. $28.00/ton  
Intermediate: ...................................................................... $32.00/ton  
Top Coat ............................................................................ $35.00/ton  

HMA used for lane paving:  

1.6 miles x 5280 feet/mile x 13.5 feet/lane x 2 lanes x 0.25 feet lift x 141 pcf / 2000 lbs/ton  

= 4020 tons of HMA

HMA used for shoulder wedge application:  

1.6 miles x 5280 feet/mile x 0.25 feet rise x 0.5 feet run x ½ x 2 shoulders x 91 pcf / 2000 lbs/ton  

= 24 tons of HMA

% increased HMA usage:  

24 tons/ 4020 tons = 0.6%

Cost of material to pave lanes:  

4020 tons x $35.00/ton = $140,700.00

Cost of material to apply shoulder wedge:  

24 tons x $35.00/ton = $840.00