DEPARTMENT OF TRANSPORTATION
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Self Extending Asphalt Paver Screeds
Georgia's Experience

CONDUCTED BY:

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Abstract

Asphalt paver screeds are characterized by the extension type: fixed or hydraulically self-extendable. These extensions are in relation to the asphalt screed's paving width capability. Increasing the paving width of a fixed screed requires that the paving operation be stopped and extension sections be mechanically bolted on to the main screed. Hydraulically self-extendable screeds can be widened or narrowed "on the go" while placing asphaltic concrete. Prior to 2002, hydraulically self-extending screeds were rarely approved for use on Georgia Department of Transportation projects.

This report examines information collected on a number of projects that were constructed using self-extending screeds during the past seven years. Detailed within are the advantages, limitations, concerns and recommendations that GDOT has garnered since the initial introduction of this technology to Georgia. Through this process comes the understanding that while self-extending screeds advantages in construction are clear, utilization of the proper extendable screed type should be dependent on construction application. GDOT's research has concluded that for the typical highway construction used on its projects, not all variations of self-extending screeds are equal.

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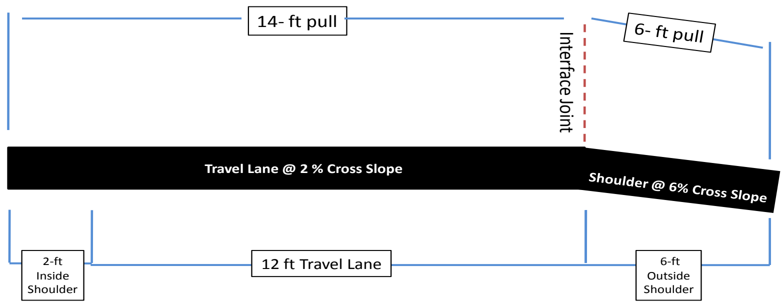
Introduction

In 2002 during a Georgia Quality Initiative Asphalt Committee meeting, representatives of the Georgia Highway Contractor's Association requested that hydraulically extendable screeds be evaluated for acceptance in the State of Georgia. While Georgia Department of Transportation (GDOT) specifications state that approved extendable screeds were allowed, at this time there were no approved screeds in the state. It was agreed that a joint equipment task force comprised of agency, contractor and equipment representatives would evaluate the use and approval of self extending asphalt paver screeds. In response to this process, a number of extendable screeds were approved after evaluations on a number of selected projects. A list of extendable screeds currently being used in the State of Georgia is included in Appendix E.

During the past seven years, the Bituminous Construction Branch of Georgia Department of Transportation's Office of Materials and Research has continued to assess and research self extending asphalt paver screeds. The screed unit technology is innovative in its apparent ease of use during variable width paving. The ability to extend and retract the screed on the go is a significant breakthrough in asphalt paving and has been the prominent attractant to asphalt paving contractors. It provides an economical benefit to the industry by eliminating the costly and potentially unsafe task of adding and removing rigid screed extensions for most paving widths. Variable width paving using a conventional general purpose screed typically requires the use of bolt-on screed extensions to expand the width and obtain a uniform mat texture. In addition, these kinds of extensions are very time consuming and often involve dangerous conditions or temperatures. They can also limit the placement operation on width variability which may result in multiple pulls leaving numerous longitudinal joints.

GDOT's primary interest in this technology is the ability to place a roadway's shoulder and mainline simultaneously and at different cross-slopes. It was hoped that by using this placement operation, a longitudinal joint would be eliminated and provide consistent texture and density across the total pavement width. Historically, when paving a roadway with this typical section, a widening spreader was used in a separate operation to place the shoulder. Experience has shown that the use of widening spreaders can result in a segregated and open longitudinal joint as well as an erratic surface texture with non uniform density. The ability to eliminate potential failures along the mainline to shoulder interface contributes in extending a pavement service life beyond the expected period of time (Illustration 1) making Hot Mix Asphalt (HMA) pavements in Georgia more economically practical.

Illustration 1



During the past year, the Office of Materials and Research's Bituminous Construction Branch has investigated numerous premature HMA roadway failures across South Georgia. For all of these projects, the final asphalt surface wearing course, consisting of either 12.5 mm or 9.5 mm Superpave mix, was in place. Many of the roadways had been paved for only a few months before the first indications of failure were apparent. Most of the distresses that have been observed are in the form of variable width longitudinal streaking (See Photo #1).

Photo 1- Longitudinal Streaks Now Raveling Under Traffic

The more severe failures were associated with top down cracking and raveled out surface aggregate. While investigating these premature HMA failures, one common factor was apparent throughout all of the projects evaluated. On every failing pavement section evaluated for this report, a paver equipped with a hydraulically extendable screed was used for placing the HMA.

A thorough investigation was conducted to determine what factors contributed to the premature pavement failures and determine the best approach for future utilization of this screed technology in Georgia to minimize further occurrences of this nature.

This research report will detail the investigations of these roadway failures including visual observations of the in-place pavement, cores from the in-place pavement, examination of project files and review of the equipment used to place the HMA. This report contains, the results of our investigations including test data, departmental criteria, thermal imaging, photos, and a conclusion based on our findings.

History of Hydraulically Extendable Screed Technology in Georgia

Hydraulically Extendable Screeds have been used in the State of Georgia for a number of years, but have been primarily employed on private and local government funded projects. Many of these older machines are still in operation today; however, they do not provide finished mats meeting GDOT Specifications.

While much of today's hydraulically extendable screed technology is relatively new, different versions of these screeds have been evaluated by GDOT on numerous occasions over the last 20 years. Typically, inconsistent mat texture and density at the main to extended screed transition point has been the initial deficiency observed; however, pavement smoothness has been the primary factor that has prohibited their continual use. The extendable screeds previously evaluated were not equipped with a hydraulic screed assist/lock function to support the heavy screed assembly's individual weight. Therefore, when paving operations were interrupted or stopped; a measureable indention was left in the compacted mat. This indentation could be detected with a straight edge and when measuring smoothness for acceptance using departmental Laser Road Profilers. The weight of extendable screeds is approximately 70 percent greater than the weight of the conventional wedge lock version at average paving widths.

Additionally, older versions of this paver screed technology did not provide an adjustable angle of attack on the extension screed plates. Even after technology advanced to include this adjustment, it as well as the match height adjustment (vertical pressure) had to be modified mechanically. The location of the adjustment mechanism was typically very hard to access and often paving had to be stopped in order to provide the necessary correction. This action resulted in amplifying the inconsistent texture issue being experienced due to the starting and stopping associated with adjusting the multiple screeds plane of travel. It has been determined that screeds without an angle of attack adjustment and/or mechanically adjusted match height extension assemblies can not apply uniform weight or distribute pressure consistently across the entire mat width.

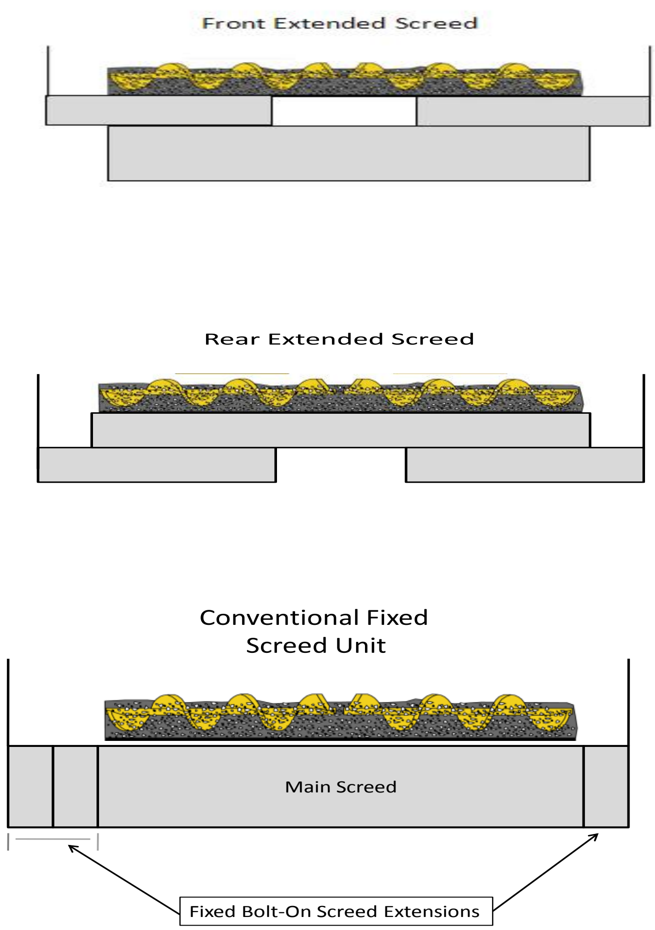
In August 2006, after evaluations of various manufacturers' versions of these screeds, a Bituminous Construction Bulletin was issued to Georgia's HMA contractors. This bulletin included a list of extendable screeds that were evaluated and approved for use in the State for paving widths extending up to 14-ft. The evaluation and approval was based on a limited number of test sections using a variety of HMA mixes that were placed under diverse conditions. The criteria and expectations of all test sections were documented and reviewed with each screed manufacturer's representatives (See Appendix B). Since the release of this bulletin, several additional versions of extendable screeds have been introduced and evaluated.

In September 2007, a follow-up bulletin was issued detailing GDOT's minimum standard requirements for hydraulically extendable screeds. For extendable screeds meeting these prerequisite requirements, use in Georgia was permitted without going through a pre-approval evaluation process (See Appendix C). The bulletin stated that by satisfying established prerequisite criterion in conjunction with meeting all requirements specified in Section

400.3.02.C.3.e of the GDOT Standard Specifications (See Appendix D), extendable screeds were omitted from the pre-approval review plan.

As of 2007, nine different versions of extendable screed technology have been used on GDOT funded projects. Five of these self extenders lead the main screed and four trail the main (See Illustration 2). This report will distinguish between the two types of extensions and discuss data gathered pertaining to both versions.

Illustration 2



Investigation

A total of 15 projects were investigated for this report. A majority of these projects dated back several years and several were actually part of the original test sections used in the initial evaluation of some of the extendable screeds. Other projects are still under construction or have yet to receive final acceptance by the Department. Given that the completion status of these projects differed, the specific testing that was performed varied according to each project's construction stage. While all of the projects included in this investigation showed varying signs of pavement distress, it should be noted that other projects constructed with extendable screeds were inspected that did not exhibit evidence of pavement failures at this time. Additionally, several of these acceptable projects were constructed within the same time period as those currently showing mat deficiencies. Operational factors contributing to unacceptable mixture placement using self extending screeds will be detailed throughout this document.

Construction inspection reports in conjunction with photographs taken during mix placement in the original test sections were reviewed and compared to current pavement wearing course conditions. One very significant detail was discovered. It was determined that slight texture shadowing or streaking observed in the un-compacted mat during placement that was considered of minimum importance does in fact have detrimental long term consequences once opened to traffic. Photo 2 depicts a project photographed during construction in 2007.

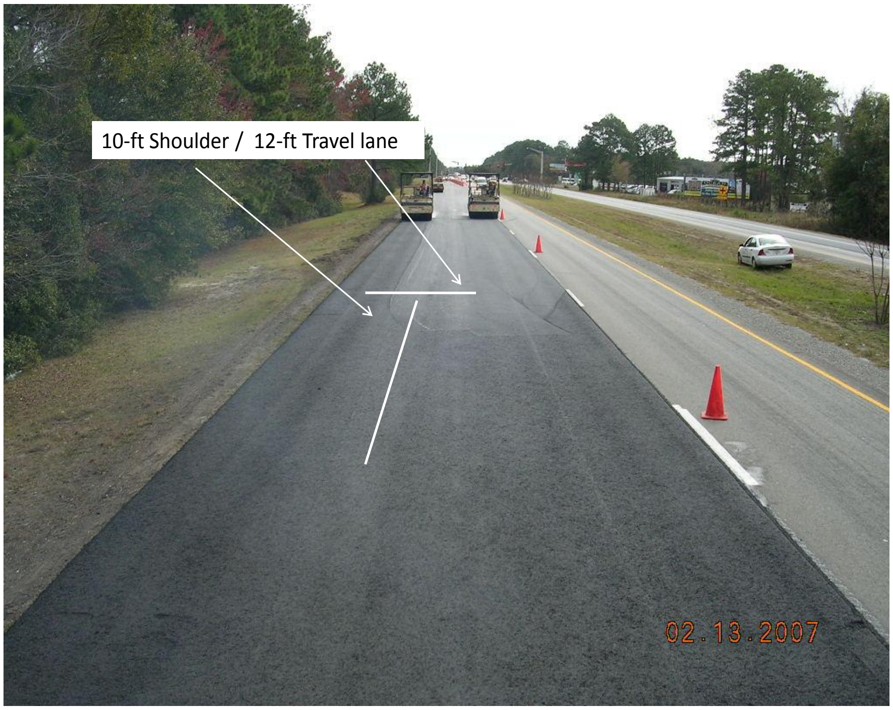


Photo 2 – Project during Construction 2007

At the time of placement, streaks observed in the un-compacted mat appeared to roll out after the compaction process. However, after approximately 2 years of service; the pavement has begun to ravel prematurely at locations where streaking was initially observed in the un-compacted mat (See Photo 3 which was taken in 2009).

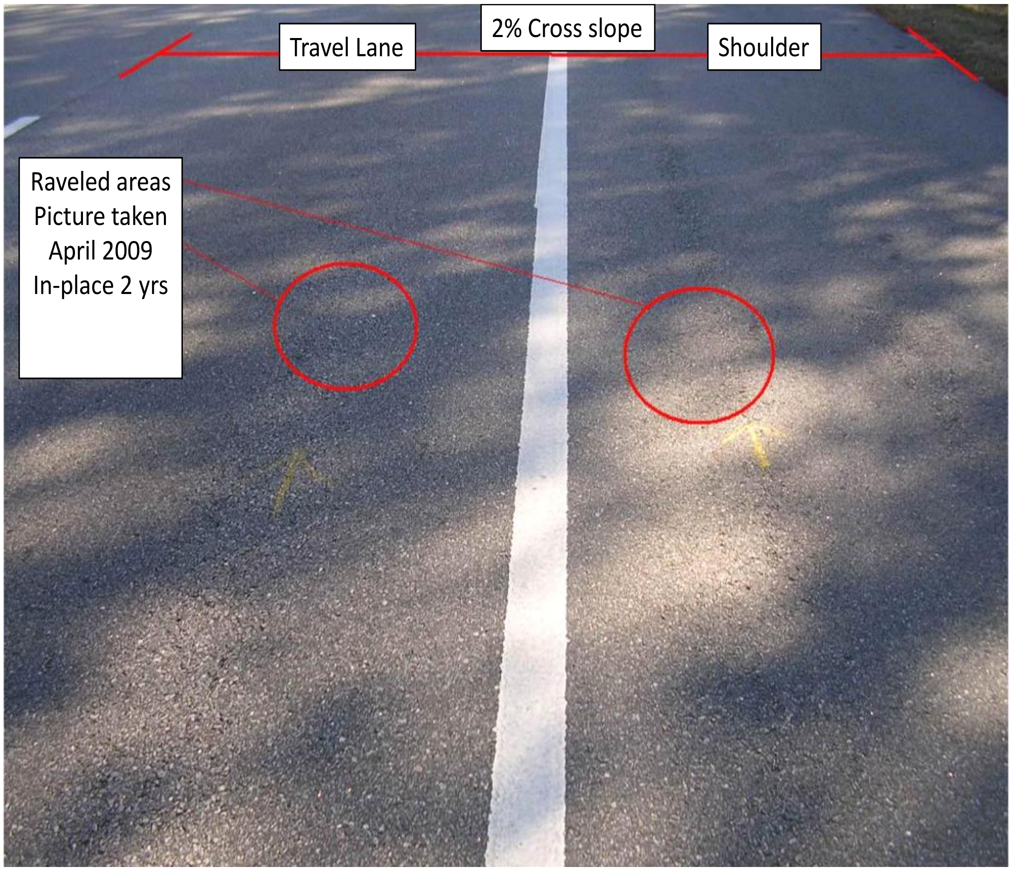


Photo 3 – Project Photo during Investigation 2009

While this observation was only substantiated within the surface (wearing) course during GDOT's investigation, subsurface mixes exhibiting these same deficient properties have been investigated during construction on other projects. Base and intermediate lifts that have been investigated because of similar longitudinal streaking or shadowed textures have yielded unacceptable and inconsistent density or erratic profile when measured transversely across the mat. In the most recent occurrences, the unacceptable pavement was removed and paving was interrupted until screed adjustments were made that yielded acceptable results (See Photo 4).

Photo 4-Paving Project with Inconsistent Mat Texture

As previously detailed, during the early use of self extending screeds to Georgia, this slight shadowing was observed but appeared to roll out during the compaction process. This was especially true when the pneumatic (rubber tire) roller was used. However, after the roadway was subjected to traffic; these deficiencies reappeared in the form of moderate raveling of the surface fines. Over time, water has been hydraulically forced into the open and weakened surface by traffic. This ultimately results in more significant raveling of the pavement layer, and at times total deterioration of the pavement structure.

All of the projects investigated for this report are currently sustaining traffic on the final wear course; however, each roadway exhibits various forms of inconsistent mat texture. They are shown on the following pages in Illustrations 3A – 3G. All of these illustrations represent pavement placed at a consistent cross slope for the travel lane.

TEXTURE INCONSISTENCY No. 1

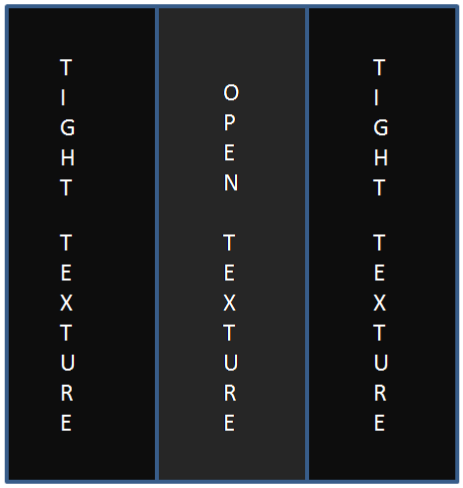


Illustration 3A

TEXTURE INCONSISTENCY No. 2

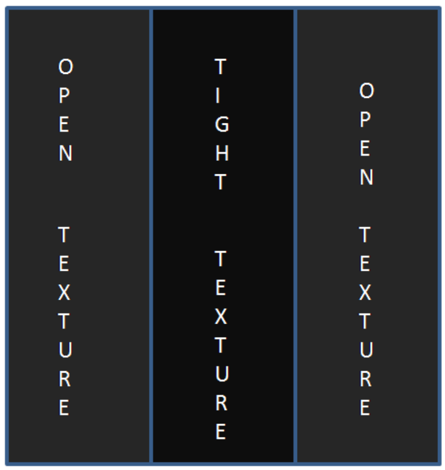


Illustration 3B

TEXTURE INCONSISTENCY No. 3

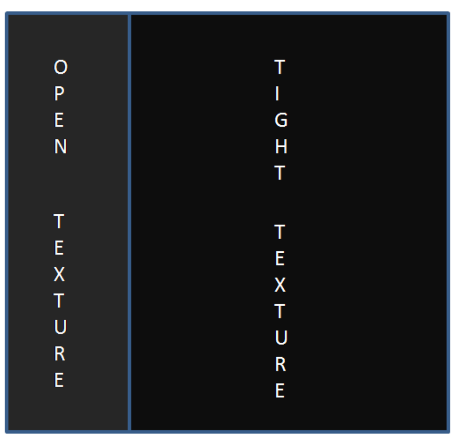


Illustration 3C

TEXTURE INCONSISTENCY No. 4

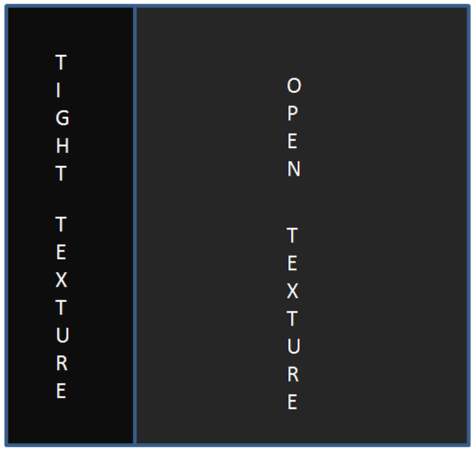


Illustration 3D

TEXTURE INCONSISTENCY No. 5

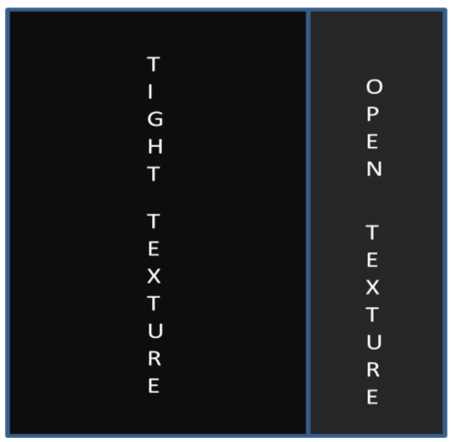


Illustration 3F

TEXTURE INCONSISTENCY No. 6

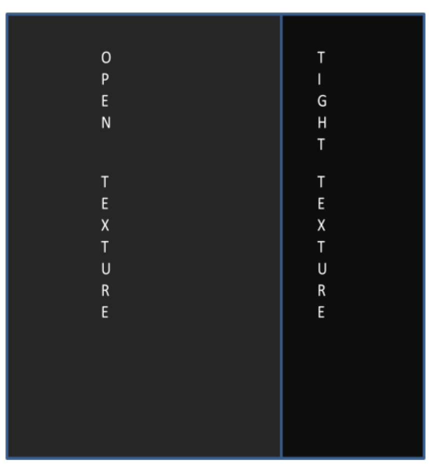


Illustration 3G

Given the varying texture of the in-place mix, it was suspected that inconsistent density was also present in these locations. To test this hypothesis, each project was cored across the mat for density and pavement thickness. Since the type and degree of mat texture deficiency varied from project to project and the intent of this coring operation was to evaluate density consistency across the mat, the amount of cores cut on each project varied. The following table displays these results.

		12-Ft Travel Lane				
		Core Location			Extendable Screed Type	
Project		Left	Center	Right	Front	Rear
A	% Voids	7.7%	11.5%	6.0%	x	
	Thickness	1 1/4	1 1/2	1 3/4		
B	% Voids	7.7%	5.7%	5.7%	X	
	Thickness	1 3/4	1 1/2	1 1/2		
C	% Voids	8.8%	6.0%	8.9%	X	
	Thickness	1 1/2	1 3/4	1 3/4		
D	% Voids	9.9%	11.1%	7.4%	X	
	Thickness	1 1/4	1 1/4	1 1/4		
E	% Voids	6.8%	9.7%		X	
	Thickness	1 3/8	1 1/4			
F	% Voids		9.8%	5.6%	X	
	Thickness		1 1/8	1 1/8		
G	% Voids	7.5%	4.4%	6.0%		X
	Thickness	1 1/2	1 1/2	1 3/4		
H	% Voids	7.0%	13.3%	8.2%	X	
	Thickness	1 1/8	1 1/8	1 1/4		
I	% Voids	3.1%	8.0%		X	
	Thickness	1 1/8	1 1/8			
J	% Voids	8.9%	7.4%	6.8%	X	
	Thickness	3/4	3/4	7/8		
K	% Voids	4.8%	10.2%		X	
	Thickness	1 1/2	1 1/2			
L	% Voids	7.5%	6.9%	7.2%	X	
	Thickness	5/8	3/4	5/8		
M	% Voids		9%	3.2%	X	
	Thickness		1	1 5/16		
N	% Voids	3.4%	11.0%	9.1%	X	
	Thickness	1 1/2	1 1/2	1 3/4n/a		
O	% Voids		5.8%	9.9%	X	
	Thickness		1 1/4	1 1/4		

Table 1-Core Thickness and Air Void Content

During construction, each project referenced in Table 1 met specified density requirements when tested in accordance with GDT 73. In Table 1, the higher air voids correlate with the open or raveled areas and the lower air voids equate to smooth/tight locations. It should be noted, that several of the project test sites proved to have a very thin lift thickness. Project J and L were Let requiring 1-½” of 12.5 mm Superpave; however, the cores obtained on both projects measured extremely thin. All of the projects evaluated were either new construction or were resurfacing projects. The newly constructed pavements were placed over 19mm SP or variable depth leveling used for profile grading. The pavement evaluated on the resurfacing projects was placed over thin lift leveling. While the texture varied across the mat, the density was comparable. The exact cause for these thin measurements could not be determined. The underlying grade condition in these areas may have contributed to the thin surface course measurements. It should be noted that when compared, preliminary and final smoothness reports suggest that erratic screed adjustments may be the primary cause given that the surface course obtained worse smoothness indexes or showed no improvement from the underlying 19 mm Superpave in these sections. The effects of poor screed control on grade and smoothness will be discussed later in this report.

To ensure that the information documented in Table 1 was not influenced by any form of mixture gradation segregation, several projects were evaluated by taking three cores across the mat for extraction and to determine gradation. The following photographs of these projects depict the type of texture inconsistency found. These pictures are followed by the core gradation results.

Photo 5-Open Textured Pavement

Table 2, Site 1, Gradation Photo 5

SIEVE SIZE	JMF %pass	Left %pass	Center % pass	Right %pass
1	100	100.0	100	100
3/4	100	100.0	100	100
1/2	98.0	98.9	98.1	98.3
3/8	88.0	88.5	89.3	88.7
8	42.0	38.8	39.1	40
200	6.0	6.7	6.4	6.5

Table 3, Site 2, Gradation Photo 5

SIEVE SIZE	JMF %pass	Left %pass	Center % pass	Right %pass
1	100	100.0	100	100
3/4	100	100.0	100	100
1/2	98.0	98.1	97.8	98.2
3/8	88.0	90.8	91	88.7
8	42.0	41.7	42	39.7
200	6.0	6.7	5.8	6.1

Photo 6-Very Streaked Texture

Table 4, Gradation Photo 6

SIEVE SIZE	JMF %pass	Left %pass	Center % pass	Right %pass
3/4	100	100	100	100
1/2	100	100.0	100	100
3/8	100	98.5	98.3	98.7
4	67	69.9	71	72.3
8	46	47.7	46.6	48.4
200	6.0	7.1	6.9	7.8

Photo 7-Core Locations Taken on Streaked Project

Table 5, Gradation Photo 6

SIEVE SIZE	JMF %pass	Left %pass	Center % pass	Right %pass
1	100	100	100	100
3/4	100	100.0	100	100
1/2	98.0	98.9	98.7	98.1
3/8	86.0	87.1	87.9	85.2
8	39.0	41.3	39.1	38.2
200	6.0	6.1	6.8	5.9

The above results proved that the mixture composition as related to gradation and AC content was uniform across the full mat width and verified that the unacceptable mat texture originated from a poorly adjusted and/or operated screed. Therefore, GDOT's standard segregation specification may not be sufficient to address the screed related deficiencies.

As of 2008 when these deficiencies became apparent and were first documented, the Department has taken a very proactive position to address future episodes of this nature. A no tolerance policy has been enforced when continually placing mats with these deficiencies, especially when observed in surface mixes during construction.

Screed Management

Both GDOT and Georgia's HMA industry have experienced a vast learning curve since the introduction and use of self extending screed technology in Georgia. During the initial test sections, no one in the Georgia HMA industry possessed the experience or knowledge to effectively adjust and manage the multiple screed function on an ongoing basis. It was found that both rear and front extending screeds presented obstacles when adjusting the vertical height and angle of attack. As with any screed technology, either conventional fixed or self extending screeds, the screed assembly weight should be transferred evenly across the entire width of the pavement. Additionally, the head of material forced under the screed should remain constant. If these conditions are not successfully maintained; uniform grade, texture, and density will not be obtainable.

The material forced under a conventional fixed screed can be readily managed with proper adjustments of the flow sensors, flow gates, auger height, and or conveyor speed. When these adjustments are properly set, a uniform head of material is maintained resulting in a constant volume of mix under the screed at any point across the mat. Material management becomes difficult to maintain; according to the height of the extension, extension angle of attack and the screed plates wear patterns when using a front or rear extendable screed.

Trailing and leading extension screed plates must travel on a precise plane in relation to the main screed in order to prevent inconsistent levels of pre-compaction or double screeding. Inconsistent final mat density and various longitudinal texture streaks are typically associated with the failure to properly maintain this level plane. The following pictures (Photos 8-10) and illustration (Illustration 4) depicts such an occurrence when pre-compaction varies.

Photo 8, Un-compacted Mat Behind Front Extension

Photo 9-Compacted Mat Behind Front Extension

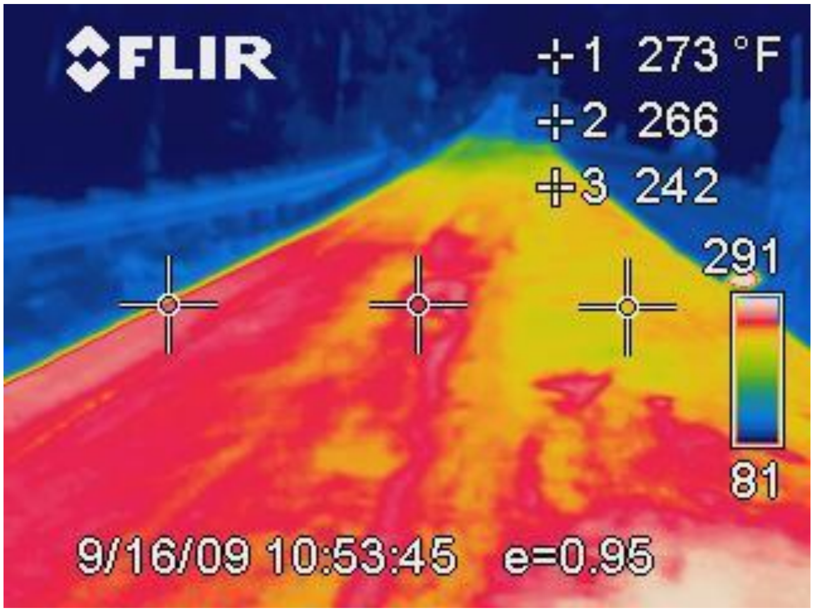


Photo 10, Thermal Image

The previous photographs were taken on a project where the front extendable screed being used exhibited poor alignment of the extension to the main screed. Photo 8 displays the inconsistent pre-compaction and un-compacted material volume across the 14-ft lane. As detailed in the thermal imaging picture (Photo 10), this texture inconsistency was supported by the 31 degree variance measured across the mat. The final compacted pavement continued to exhibit these inconsistencies in the form of longitudinal streaking after the rolling operation as displayed in Photo 9. The following data was collected across the un-compacted and compacted mat with a calibrated nuclear gauge. The five locations taken transversely across the mat are shown in Photo 6 above and correlated to the front extendable screed in Illustration 4.

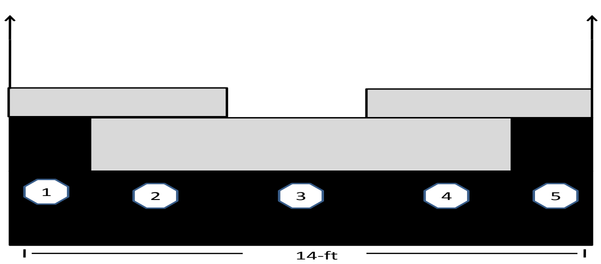


Illustration 4
Density Measurement Points

Two locations measuring approximately 250 feet apart within the area represented by Photos 8-10 were randomly selected to determine what effect the visually observed texture inconsistencies would have on in-place density both un-compacted and after compaction.

Longitudinal Location	Point Measured	**1**	**2**	**3**	**4**	**5**
1	Un-compacted Density (Air Voids)	20.3%	13.5%	18.2%	13.8%	21.3%
"	Final Compacted Density (Air Voids)	6.3%	3.7%	7.9%	4.5%	7.0%
2	Un-compacted Density (Air Voids)	18.5%	12.3%	16.5%	10.7%	18.1%
"	Final Compacted Density (Air Voids)	8.9%	5.7%	10.0%	6.3%	7.4%

Table 6

As shown in Table 6, the density fluctuated significantly across the 14-ft mat. The lowest in-place air voids were obtained at the No. 2 and No. 4 transverse locations. The un-compacted and final density measurements at these points were repeated at the second site and similar results were obtained. This effect is attributed to double screeding at these points. These positions in the mat are located where the extension and the main screed must both strike off the mix. When the extensions are incorrectly adjusted, the volume of the material at these points can be greatly affected by the elevation and angle of attack of the extensions. This condition is similar to a poorly adjusted pre-strike off on a fixed screed, but is amplified by the multiple screed plates making contact. It is a concern that non-uniform areas across the mat with low density (high air voids) is a source of weakness in the pavement. Comparable results have been gathered from numerous projects displaying these same deficient mat properties. On each project investigated during placement, the inconsistencies were attributed to worn screed plates or poorly adjusted extensions.

On the project portrayed in Photo 11, construction deficiencies are linked to differential pre-compaction across the mat.

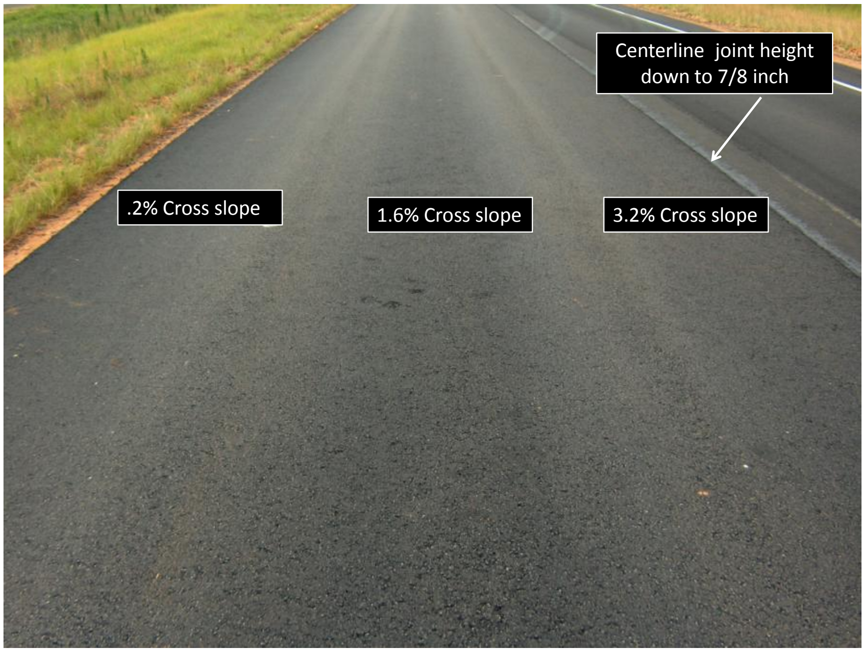


Photo 11- Project with Differential Pre-compaction Using Front Extension

The varying volumes of mix forced under the screed in conjunction with incorrectly adjusted extensions, which unevenly positioned the weight of the screed, created these issues. This, in addition to inconsistently worn screed plates and pre-strike offs, typically leads to improper operation and manipulation of the multiple screed adjustments. While at times, this inappropriate screed operation did improve the immediate mat texture; extreme variations in profile across the compacted mat were often the end result.

In Lane 1 on this project, measurements taken across the mat with a 10-ft straight edge revealed a low area measuring up to a depth of 1/8-inch in the center and more than a ½ inch toward the centerline joint. Cross slope measurements taken at three points across the 14-ft mat revealed significant variation. The inside measured 0.2%, the center measured 1.6%, and the outside (centerline side) measured 3.2%. With more than a 3 % slope on the outside right edge near the centerline, the longitudinal joint height varied from 1-1/8” to 7/8”. Because of the irregular height along the centerline joint, it was impossible for lane 2 to properly tie in and maintain the positive slope towards the outside shoulder necessary to adequately drain water from the pavement. Accordingly, the poor screed condition influenced the flow of mix under the screed plates by altering the frictional resistance which resulted in inconsistent mat height and texture as well as fluctuating final density. It should be noted, that a significant quantity of in-place mix was removed and replaced within this deficient area.

Typically, when texture inconsistencies are observed in the un-compacted mat, the extension angle of attack or vertical height is adjusted. This adjustment should be made in small increments as with all other placement related screed correction. It takes approximately five times the length of the tow arm on the paver screed for the screed to complete the change when the thickness control screw or pull point is adjusted. It is a given that drastic grade changes occur when extreme adjustments to the extensions are made in one action when placing HMA. Often, the two adjustments on the extensions are moved in too large an increment causing the screed to rise or fall. As the angle of attack or height of the extensions is changed during placement, the forces acting on screed change as well. This in turn, moves the screed elevation and alters the mat thickness. These fluctuations in material flow under the screed are more prevalent on front leading extended screeds at most placement widths. This double screeding may not be as common when the screed is fully extended. When poorly adjusted, the front extensions either starve the main screed or overload it since the extensions contact and strike the mixture prior to the main screed. This occurrence can be better understood by referencing Illustration #2 on page 7 above.

On rear extendable screeds, proper positioning of the tow point elevation appears to be extremely important. Since these versions of extenders typically use the same width extension plates as the main screed, more of the screed assembly is located behind the pivot point. When the pull point elevation is too high the main screed wants to nose over and when too low it runs on the tail. This inherently leaves mat texture deficiencies which result in the paver operators' attempts to change the tow point setting while paving. This approach can be successful but must be performed in conjunction with thickness screw adjustments. Unfortunately when performed incorrectly, this generally leads to an exceedingly low or high spot that must be removed. These areas are typically removed prior to the compaction process with a loader. Areas that are not addressed at the time the problem occurs typically exceed the straight edge tolerance specified in the GDOT Standard Specifications or contribute to smoothness failures in that section and have to be removed or patched at a later time. As evidenced by the core thickness displayed in Table 1 and the fluctuating mat texture of the projects evaluated during this investigation, this occurrence is frequently experienced. When using a rear extendable screed, the main and extension must be on the same plane with the same angle of attack. If the extension angle is greater than the main there will be inconsistent weight distribution under the main resulting in varying density. With any type of screed, extendable or fixed, a constant mat depth is maintained when all forces are in balance. The free floating screed principle is dependent on a consistent force of material under the screed to provide the intended leveling action. This can be better understood by referencing Illustration #2 on page 7 above.

In contrast and as previously relayed in the introduction of this report, there have been acceptable projects constructed in Georgia using extendable screed technology. Some of these have even received nationally recognized quality of construction awards that are primarily judged on smoothness and density. Since smoothness is directly correlated with consistent texture, density, and temperature; a similar project was selected to be used as a comparison. Unlike the previously referenced project shown in Photos 8-10 where the mat texture was erratic and unacceptable, the extendable screed used to place the project in Photos 12-13 yielded a visually uniform pavement. Both projects, the deficient one as well as the uniform project, consisted of a fine graded surface mix placed at comparable widths and depths within a day of each other. The ambient air temperature and time of day were also very similar. Both pavers were being assisted by the same manufacturer and type of material transfer vehicle (MTV).

Photo 12-Acceptable Project Placed with Rear Extendable Screed

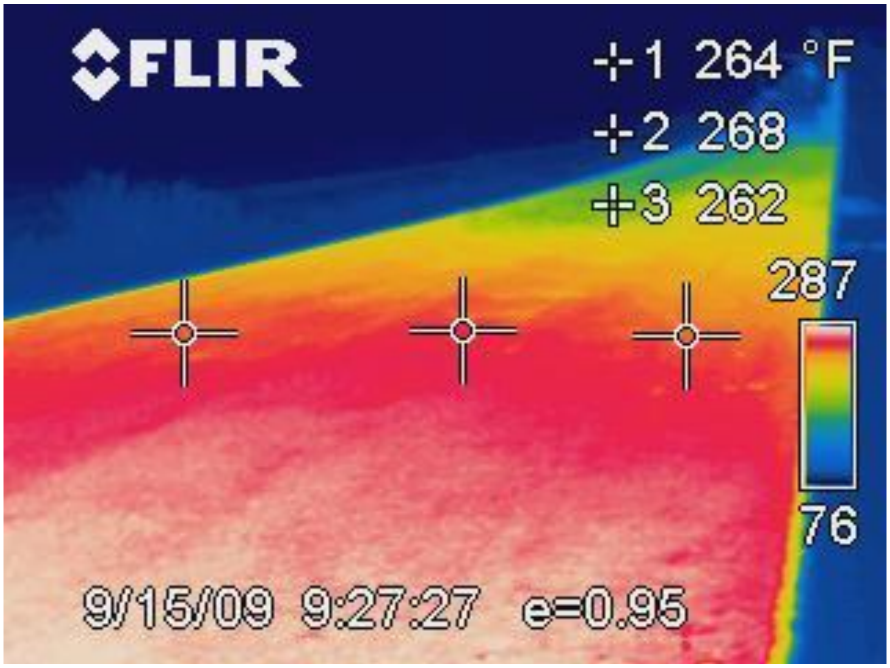


Photo 13-Thermal Image behind Rear Extendable Screed

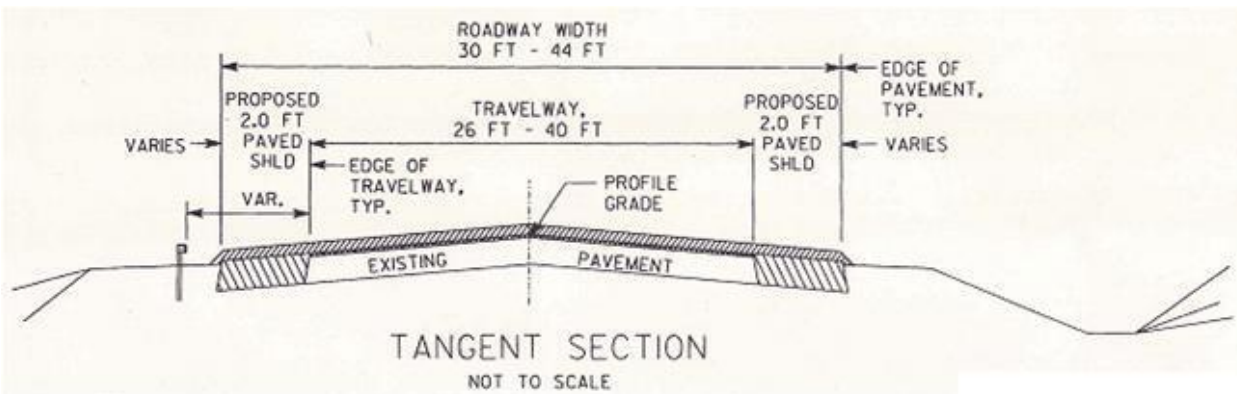
Longitudinal Location	Point Measured	**1**	**2**	**3**	**4**	**5**
1	Un-compacted Density (Air Voids)	12.4%	11.6%	13.4%	11.9%	13.1%
“	Final Compacted Density (Air Voids)	6.1%	5.8%	5.0 %	6.3%	5.1%
2	Un-compacted Density (Air Voids)	11.5%	10.9%	11.8%	11.1%	12.9%
“	Final Compacted Density Air Voids)	4.9%	5.3%	5.1%	6.0%	5.4%

Table 7

As displayed by the thermal imaging and density measured across the mat (Table 7), when adjusted and set-up appropriately these screeds have provided quality pavements.

Thin Lift Leveling and Variable Depth Paving

Georgia's typical approach to resurfacing is to thin lift level the existing pavement prior to placing the new overlay. Generally, this leveling course is placed at approximately 50-75 lbs/yd^2. When a single layer of surface treatment is utilized as a crack relief interlayer, the upper limit would be used. The following illustration (Illustration 5) is an example of a typical project using this approach.



RETAIN EXISTING PAVEMENT AND CROSS-SLOPE. APPLY # 7 STONE SURFACE TREAMENT FULL WIDTH AND LEVEL FULL WIDTH WITH 65 LBS PER SQUARE YARD RECYLCED ASPHALTIC CONCRETE LEVELING. CONSTRUCT 2'-0" SHOULDER PAVING LEFT AND RIGHT IN ACCORDANCE WITH THE ATTACHED DETAILS AND NOTES FOR PAVEMENT WIDENING AND RESURFACING. RESURFACE FULL WIDTH WITH 125 LBS PER SQUARE YARD RECYCLED ASPHALTIC CONCRETE 9.5 mm TYPE I SUPERPAVE, GP 2 ONLY, INCL BITUM MATL & H LIME.

- RESURFACED AREA
- # 7 STONE SURFACE TREATED AREA
- NEW SHOULDER CONSTRUCTION

Illustration 5

As previously mentioned, during the initial introduction of self extending screeds in Georgia, frequent texture inconsistencies were commonly experienced. Even with new screed plates on the assembly or when using a practically brand new screed after only a few hundred tons of mix placement, these issues would appear. Over time, it became obvious to both GDOT and the Contractors using them that inconsistent and excessive screed plate wear was related to thin lift or variable depth leveling. It was noted that during the placement of surface mixes these problems were most severe. Typically, these mixes are placed on resurfacing projects that require thin lift leveling prior to overlay or were part of widening projects for additional lanes where the existing lanes were retained. For these projects, the retained lanes were wedge leveled to take out the existing crown point between the two travel lanes prior to building the new cross slope across both lanes in one direction. On these projects, the superelevated areas were retained and matched on the newly constructed side. This construction practice involves paving at varying depths and widths which usually results in one side of the screed dragging to nothing.

Both of these paving techniques are established practices that have been traditionally employed in Georgia. While these practices are very abrasive and promote screed plate wear, no adverse effects were documented using the established method of paving with conventional fixed screeds. Self extending screeds are significantly heavier than the average weight of their fixed rigid screed counterparts. Rapid wear was observed after turning them on their nose when placing the required leveling as previously described. Table 8 compares various manufacturers fixed screed at 10-ft wide with no bolt-on extensions to the self-extending version.

Manufacturer	Self Extending Screed	Fixed Screed@ 10-ft
Screed W	**8500 lbs**	**5500 lbs**
Screed X	**8000 lbs**	**4500 lbs**
Screed Y	**7200 lbs**	**5000 lbs**
Screed Z	**6900 lbs**	**5500 lbs**

Table 8-Comparison Weights of Screeds

To determine how quickly this wear occurs, a project was selected that required leveling a single layer of surface treatment crack relief interlayer application with a thin lift of 75 lbs/yd^2 of 9.5mm Superpave mix. Approximately 5000 tons of 9.5 mm Superpave leveling mix was required for the project. The front self extending screed used on this project was equipped with new screed plates on the main and extensions prior to placing the leveling mix. Immediately after the 5000 tons were placed, the screed plate condition was inspected and evaluated. As shown in Photo 14, the rounded nose of the main screed plate was worn to a point of being flat.

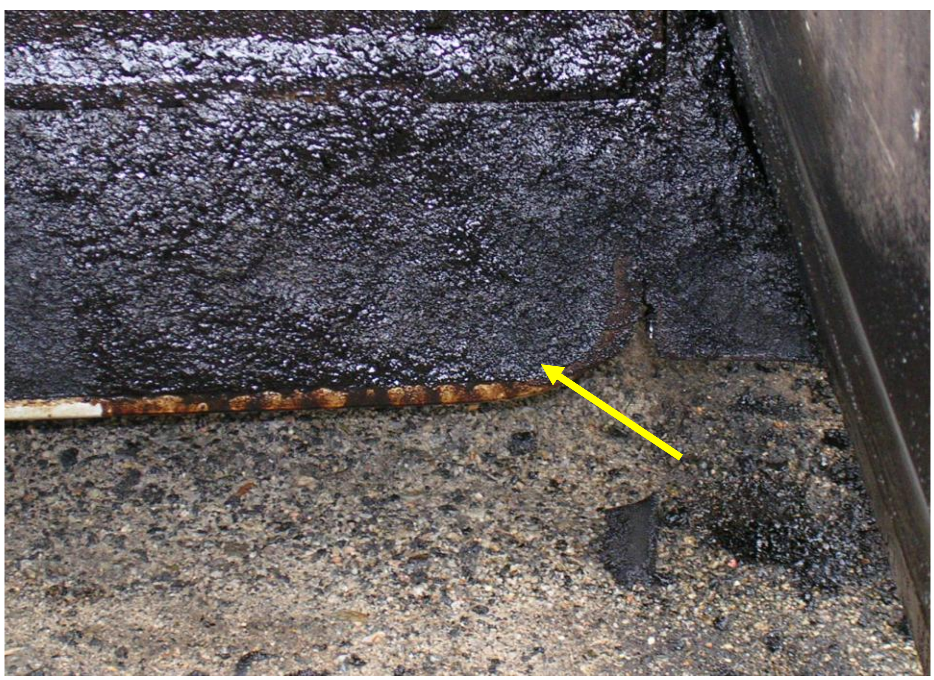


Photo 14-Worn Screed Plate after Leveling

The extension plates were also excessively worn. The extension plates were not completely worn beyond further use as was the main plate; however, the wear was erratic to the point of preventing the proper adjustments required to yield an in-place mat with consistent texture. At that time, the plates were again removed and replaced. Photo 15 shows the nose of a new plate after little use.

Photo 15-New Screed Plate

As seen in these comparison photographs, the curvature needed to allow mix to freely flow under the plate was flattened to a point of no further use after placing only 5000 tons of thin lift leveling.

Georgia’s intended use of leveling is to fill deformities and/or reestablish profile. Rarely can a paver screed be used for this purpose and still be able to float freely. It is necessary that a screed be turned on its nose to maintain quantities during thin lift leveling and drag to nothing on one side during wedge type leveling. A heavy self extending screed is not an ideal piece of equipment to perform this function. Most contractors have begun to use screed plates with extremely high hardness values because of the excessive wear they have experienced.

Once this circumstance was fully understood by the HMA industry in Georgia; most contractors elected to use an older fixed screed to place the leveling. The self extending screeds are predominately being used now for placement of pavements at uniform thickness and grade. With this better understanding of these screeds and their uses, there has been some improvement in overall mat texture quality.

Construction Joints

Since the initial introduction of these screeds, another reoccurring issue has been the quality of "start off" transverse joints. Regardless of whether the extension is leading or trailing the main screed, unacceptable joints continue to be a problem. This issue has been apparent whether pulling off the cold joint from the previous day's pull or coming off of concrete bridge approach slabs (See photo 16-18).

Photo 16-Transverse "Start off" Joint

On the majority of the projects with poor transverse joints, the pulling and tearing displayed in the three related photographs (Photos 16-18) continued for approximately 100-ft before the mat texture became uniform.

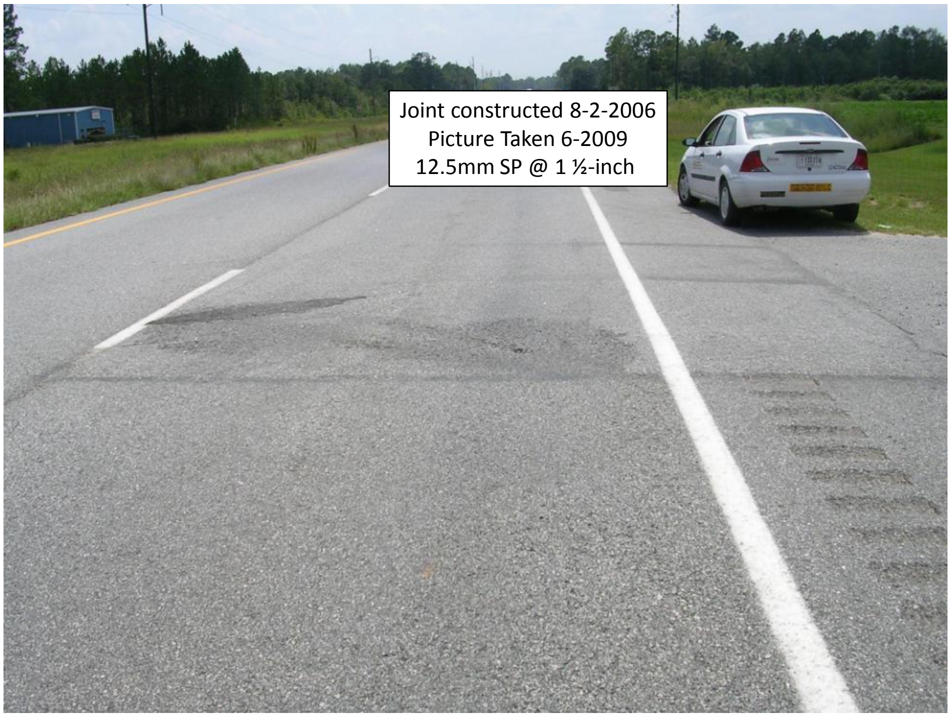


Photo 17- Transverse "Start off" Beginning Joint

Photo 18- Transverse Joint at Concrete Bridge

On a recently completed project, more than 75% of all transverse joints exhibited these characteristics. The more severe areas have begun to ravel out similar to that shown in the previous photographs (16-17). This construction deficiency has been related to poorly adjusted extensions, severely warped or worn plates, or a cold screed when observed on current projects under construction. These heavy self extenders with three screeds that must operate in unison have multiple heating elements and thermostats. They are especially sensitive to temperature differentials across the width of the assembly. As you are aware, a screed's reaction is dependent on the support of the hot mix flowing under it. When the screed plate temperature is not sufficiently warm or consistent across all plates, the screed reacts erratically. Under these conditions, the screed falls as it pulls off the rigid cold mat from the previous day's end joint. In response, the screed operators make rapid and drastic adjustments by turning the grade screws. These attempted corrections, usually results with irregular low or high places in the mat within 20 - 30 feet of the action.

The Georgia Department of Transportation has historically evaluated the 100 foot tie-in at bridges for smoothness acceptance using the Reinhart Profilograph. Since extendable screeds have achieved common use status in Georgia, there have been numerous Specified smoothness requirement failures within these bridge tie-ins. Most documented failures have occurred when the paver starts off at a bridge and not where it ties into one. To address this issue, some contractors have elected to use the paver's electronics referencing an established string line when pulling off the bridge ends. Unfortunately, this technique does not seem to account for or correct poor screed set-up. The project detailed in Photo 18 supports this finding in that it was constructed using the electronics referencing a string line. Within this bridge end area, the outside lane was ½-inch higher than the inside lane at the adjoining longitudinal joint. The roadway was constructed with a 2 percent cross slope across both lanes towards the outside shoulder and a water damming effect was evident in the inside lane. Additionally, approximately 40 feet from the bridge deck in the outside lane; a ½ inch irregular knot or bump was measured with a 10-ft straight edge. Ultimately, the contractor had to mill and replace the pavement in order to satisfy the profile index value established in the GDOT Standard Specifications for bridge approach ride quality.

Temperature Differentials

Over the last seven years of using them, it has been determined that self extending screeds possess multiple dead areas or corners between the extensions where cool material collects. This build up appears to be worse with the use of front extendable versions due to the center trapping mix between the extensions (Photo 19). As you are aware, the temperature of the mix flowing under the screed determines its relative height and movement.

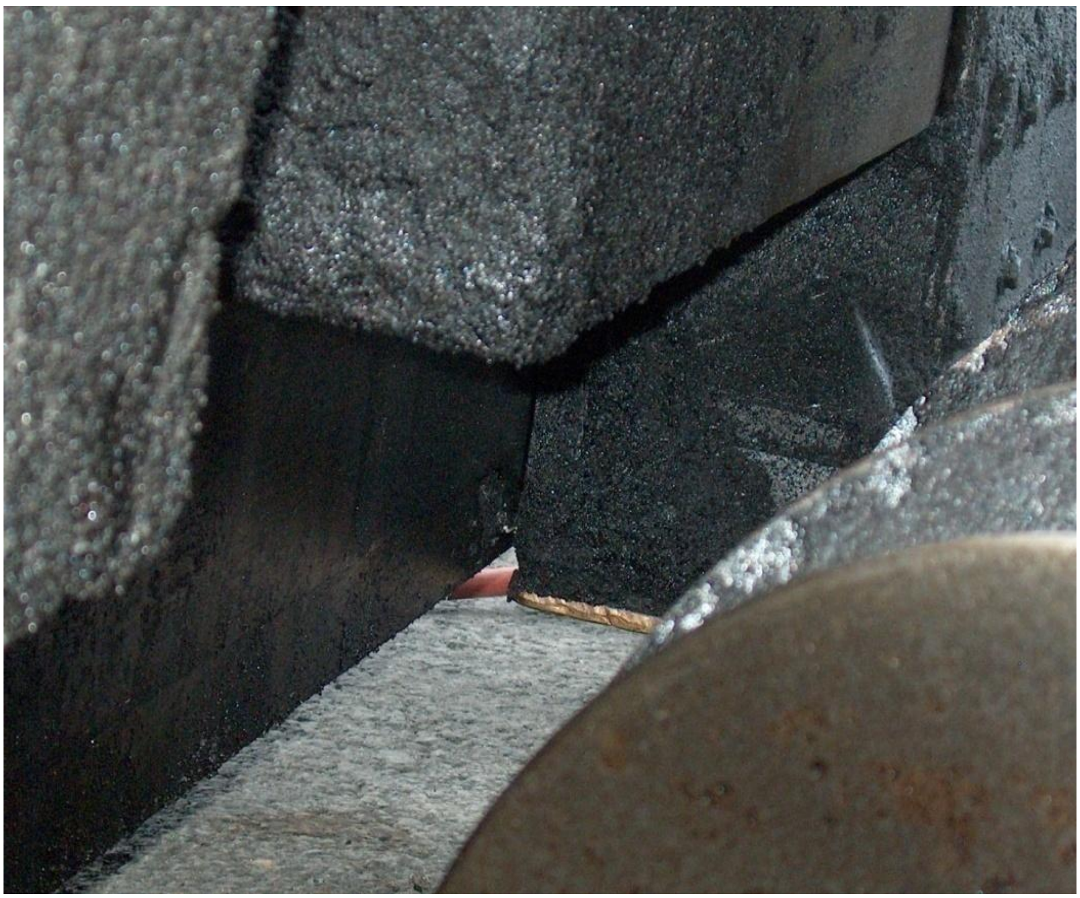


Photo 19- Area between Screeds

As detailed in Photo 20, the referenced resurfacing project exhibited severe streaking, pulling and tearing from cold lumps of mix and screed marks/knots throughout the entire length.

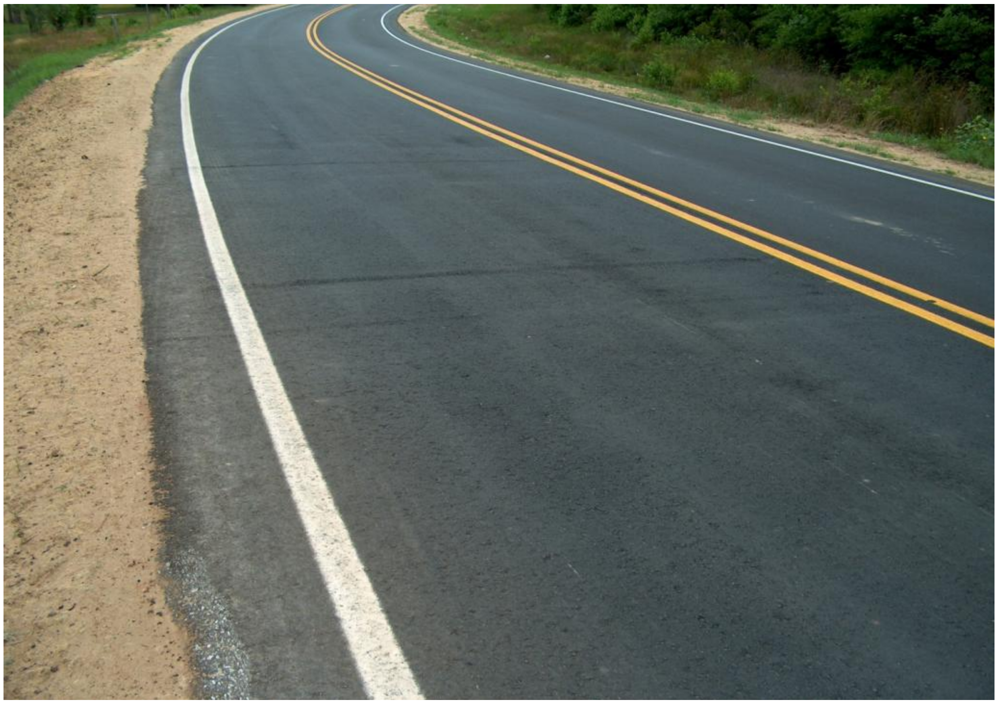


Photo 20-Project with Streaks Placed with Front Extendable Screed

This project was located more than 40 miles from the plant and the contractor did not supply the correct amount of haul trucks to maintain a continuous placement operation. The tendency for material to be trapped between the extensions seems to be more aggravated with the use of finer mixes placed at thinner lifts without the use of a MTV during cooler ambient temperatures. The project depicted in Photo 21 was placed on a hot summer day with a rear extendable screed.

Photo 21-Project Placed with Rear Extendable Screed

Even though the ambient temperature was optimum for paving, the plant was more than 50 miles away and a MTV was not used. There were numerous interruptions in placement and delays while waiting for trucks which allowed the mix accumulated in the dead areas to cool. Poor ride quality, unacceptable bumps and knots, and marginal density were the results. When using self extending screeds, it is imperative to maintain a continuous operation; especially with finer dense graded mixes as previously mentioned in this report.

Summary and Conclusions

Since the Georgia Department of Transportation was approached by the HMA industry in 2002 and asked to consider the use of self extending screeds, a wealth of understanding has been accumulated involving the advantages and limitations of this technology. The ability to eliminate the longitudinal joint between the mainline and shoulder using these screeds was and continues to be appealing to GDOT. Placing both pavements simultaneously while being able to maintain different cross-slopes and still provide consistent texture and density is a definite advantage. Unfortunately, the prime marketing tool for Contractors of the “on the go” extension and retraction adjustment in paving widths has been found to be more of a limitation to GDOT. Our research and evaluation of in-place projects shows that using this capability adversely affects mat quality by drastically altering the head of material and changing the force of the mix under the screed. To remain stable and yield uniform pavements, the free floating screed’s leveling and compaction function is dependent on control of its material force system. Any variation in the paving width directly affects the material reaction, thus changing the screed’s weight disbursement across the mat. Resistance of material ahead of and under the screed to forward motion of the paver must remain constant to achieve uniform texture and density across the HMA mat.

For continued acceptance of this technology in Georgia, the HMA industry must recognize the limitations that accompany the benefits. After evaluating seven years of mixture placement using these screeds, experience shows that they require more preventive maintenance and better educated operators than traditional fixed screeds. They are very sensitive to temperature fluctuations and variable underlying grades. Material Transfer Vehicles with remixing capabilities are necessary during the placement of finer surface mixes on projects that are located long distances from the production plants during cooler ambient temperatures in order to obtain an acceptable and uniform mat quality. It has been established that placement of mixes used in leveling applications involving variable depths and widths rapidly deteriorates the screed plates. This is a function of the high PSI pressure the screed plate is exposed to when not allowed to perform its natural function of free floating during leveling operations. Inconsistent transverse pre-compaction or double screeding across the mat has detrimental consequences on the mat quality as a result of incorrectly adjusted extensions.

As found on the projects that were constructed with extendable screeds over the last few years, slight texture inconsistencies that were observed in the mat during placement are directly related to long term performance and serviceability. While not limited to self extending screeds, the Georgia Department of Transportation has recently initiated a no tolerance policy for the continual placement of HMA pavements that exhibit questionable streaking, tearing, or pulling because of their contribution to reduced long term performance and serviceability.

Given the findings uncovered during the investigations and evaluations performed in preparation of this report, GDOT has serious concerns as to the ability of these screeds to repeatedly provide acceptable in-place HMA pavements. This apprehension is related to the sensitivity associated with the inevitable mechanical adjustments required of extendable screed technology to the performance of satisfactory mix placement. The quality of the HMA pavement they provide is inherently related to mixture volume consistency under the multiple screed points of contact.

It should be noted that some users of these extendable screeds have recently acknowledged the need for better understanding of the operation and mechanics of this technology by providing training workshops to their paving crews. This proactive approach has led to the placement of quality asphalt pavements by these trained crews. However, industry wide education and training is essential if this technology is to be used successfully in the state of Georgia.

Appendix A- List of Illustrations, Photos and Tables

Appendix B

Review Plan for New Equipment

Introduction:

Name:

Description: extendable screed that is heated with an electrical element.

Objectives:

1. Need to review a minimum 16 foot pull which includes shoulders to see the effect of the break over and variable slope. Need to review variable width paving and various coarse mixes for texture consistency.
2. Need to look at several projects, not just one.
3. Augured bolt-on extensions will be used.
4. Specification requirements to concentrate on:
   - Meet current ride ability specifications
   - Meet all acceptance density requirements
   - Straight-edge any deformity detected during interruptions between truck exchanges. Do not use MTV during test at random sites to determine the affects of the heavy screed while not in motion.

Work Plan:

Tests to be performed, method of testing, number and proposed locations

Schedule and specific test plan will need to be set up at a later date

Basic requirements:

1. surface mix, 9.5 mm and/or 12.5 mm
2. minimum 16 foot with shoulder:
3. Prefer 12ft lane with 4 ft shoulder <u>and</u> 12ft lane with 6ft shoulder
4. variable width paving to see extension operate

Implementation:

How the results could be put into practice. If equipment is satisfactory it can be identified as an approved extendable screed.

Appendix C

September 4, 2007

BITUMINOUS CONSTRUCTION BULLETIN
To All HMA Contractors for Georgia Department of Transportation Projects

RE: Criteria for Hydraulically Extended Screeds to be used in Georgia

As many of you are aware, ongoing evaluations have been in progress to verify the acceptability of hot mix asphalt placed at wide widths using the hydraulically extendable screed instead of the typical fixed screed extensions. These test sections were placed to determine if these screeds would completely satisfy the guidelines specified in Section 400.3.02.C.3.e of our Standard Specifications. At this time five hydraulically extended screeds have proven to satisfy the requirements of established review plans. These screeds have provided consistent and acceptable smoothness, density, and texture on each of the tests sites.

Based on the data gathered from these successful tests utilizing various manufactures design of this screed, the following criterion has been established. This criterion must be met prior to being eligible to place Hot Mix Asphalt in Georgia with pavers equipped with hydraulically extendable screeds without going through a pre-approval evaluation process. In accordance with Georgia Department of Transportation Specifications, the Engineer will approve the equipment used to transport and construct hot mix asphaltic concrete. Any paving equipment determined to be unacceptable at any time is subject to removal from a GDOT project. This criteria applies to manufacturers of hydraulically extendable screeds who have previously had at least one model of a mechanically extendable screed approved for use in the state of Georgia.

The criterion is as follows:

1. The screed must be equipped with an electric heating system. This system must be capable of providing controlled heat to the main screed and the extensions. The system must be capable of maintaining an even temperature across the plates to ensure that no tearing or texture inconsistency develops in the un-compacted mat.
2. The screed must be capable of providing at least a 6% positive slope on each side of the hydraulic extensions.
3. The screed must be mounted on a tractor that is equipped with a screed assist function or hydraulic pressure lock. This screed assist should be hydraulically capable of supporting the individual weight of the screed when the paving operation stops or is interrupted, so that no measureable indention is detected in the compacted mat.
4. The screed must have an adjustable angle of attack and downward/upward pressure control for each extension to ensure no significant texture variance from the main screed is provided. The adjustable angle of attack function may be manually controlled, but the vertical pressure adjustment must be power controlled.

Appendix D

Section 400.3.02.C.3.e

Bituminous Pavers

To place hot mix asphaltic concrete, use bituminous pavers that can spread and finish courses that are:

As wide and deep as indicated on the Plans

True to line, grade, and cross section

Smooth

Uniform in density and texture

a. Continuous Line and Grade Reference Control. Furnish, place, and maintain the supports, wires, devices, and materials required to provide continuous line and grade reference control to the automatic paver control system.

b. Automatic Screed Control System. Equip the bituminous pavers with an automatic screed control system actuated from sensor-directed mechanisms or devices that will maintain the paver screed at a pre-determined transverse slope and elevation to obtain the required surface.

c. Transverse Slope Controller. Use a transverse slope controller capable of maintaining the screed at the desired slope within ± 0.1 percent. Do not use continuous paving set-ups that result in unbalanced screed widths or off-center breaks in the main screed cross section unless approved by the Engineer.

d. Screed Control. Equip the paver to permit the following four modes of screed control. The method used shall be approved by the Engineer.

- Automatic grade sensing and slope control
- Automatic dual grade sensing
- Combination automatic and manual control
- Total manual control

Ensure that the controls are referenced with a taut string or wire set to grade, or with a ski-type device or mobile reference at least 30 ft (9 m) long when using a conventional ski. A non-contacting laser or sonar-type ski with at least four referencing mobile stations may be used with a reference at least 24 ft. (7.3 m) long. Under limited conditions, a short ski or shoe may be substituted for a long ski on the second paver operating in tandem, or when the reference plane is a newly placed adjacent lane.

Automatic screed control is required on all Projects; however, when the Engineer determines that Project conditions prohibit the use of such controls, the Engineer may waive the grade control, or slope control requirements, or both.

e. Paver Screed Extension. When the laydown width requires a paver screed extension, use bolt-on screed extensions to extend the screeds, or use an approved mechanical screed extension device. When the screed is extended, add auger extensions to assure a length of no more than 18 inches from the auger to the end gate of the paver. Auger extensions may be omitted when paving variable widths. Ensure the paver is equipped with tunnel extensions when the screed and augers are extended.

Appendix E

List of Extendable Screeds Used in Georgia

1. Blaw-Knox Ulti-Mat, Front Extendable
2. Blaw-Knox Omni-Three, Front Extendable
3. CAT Extenda-Mat 10-20B, Rear Extendable
4. CAT AS2302, Front Extendable
5. Terex (Cedarapids) Stretch 20, Rear Extendable
6. Terex (Cedarapids) Versa Screed, Front Extendable
7. Vogele HR500E-1, Rear Extendable
8. Dyna-Pac F-30, Rear Extendable
9. Carlson EZIV, Front Extendable