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Final Report

RECESSED STRIPING IN CONCRETE PAVEMENT

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August 2004

COLORADO DEPARTMENT OF TRANSPORTATION
RESEARCH BRANCH

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16. Abstract:
The durability of markings on concrete pavement has always been a problem. Recently, recesses have been ground into the pavement to allow the markings to sit below the surface of the concrete in hopes that this would reduce the wear on the marking material. However, this method is time-consuming and expensive.

In 1999 – 2000 on project NH 0342-034, Castle Rock Construction modified the screed bar on a paver to form grooves for both shoulder stripes and the skip stripe on a 4-lane divided highway – US 34 east of Kersey from about mp 122 to 124 both east and westbound. The contractor welded pieces of 1/4 inch-thick steel to the bottom of the paver screed to form the grooves as the concrete was placed. The grooves for the shoulder stripes are 4.5 inches wide; the groove for the skip stripe is 8 inches wide.

This study evaluated the condition of the thermoplastic and pavement marking tape stripes through several winters to see if the grooves provided significant protection for the stripes. Placing lane markings in shallow grooves in the pavement results in considerably longer marking life, making the highway safer for drivers.

Implementation:
Retroreflectance measurements showed that stripes recessed below the surface of the pavement in grooves remained useful over the full three-year evaluation period. Forming grooves in plastic concrete as the pavement was placed was essentially cost-free as it required only minimal changes to the paving equipment.

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by

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EXECUTIVE SUMMARY

The durability of markings on concrete pavement has always been a problem. In 1999 Castle Rock Construction modified the paver in use on CDOT project NH 0342-034, US 34 east of Kersey, to form grooves for the lane striping as the concrete pavement was placed. By welding three pieces of 1/4 inch-thick steel to the screed bar on the paver, the contractor was able to form three continuous grooves – one for each shoulder stripe and one for the skip stripe as the concrete was placed. The grooves for both shoulder stripes were 4.5 inches wide; the skip stripe groove was 8 inches wide. The lane marking materials were 3M™ Stamark™ traffic marking tape in the eastbound lanes and thermoplastic traffic markings in the westbound lanes. The areas where the shoulder stripes were outside the grooves – acceleration lanes and deceleration lanes – were marked with Colorado standard epoxy paint with glass beads.

Placing the lane marking stripes in the grooves formed in the surface of the concrete protected the marking material from damage by snowplows and traffic, and it remained in remarkably good condition for the duration of the study. High retroreflectivity numbers on the three-year-old tape, 417 to 514 average for the white and 287 for the yellow, could justify the expense of installing marking tape rather than using epoxy paint.

IMPLEMENTATION STATEMENT

The groove recesses provide significant protection for and lengthen the life of lane markings. It is recommended that the modification to the concrete paving machines be adopted as a standard for use on rural concrete pavement. The placement of striping in grooved pavement is especially cost-effective on highways where the number of intersections and driveways is low. The only cost for implementation is the cost of welding three pieces of 1/4-inch-thick steel to the screed bar on the paving machine.

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BACKGROUND

Pavement marking stripes, because they are higher than the surrounding pavement surface, are subject to rapid wear caused by traffic and snowplows. As they wear they loose visibility – their ability to guide drivers – particularly in wet weather. Wear on the stripes can be greatly reduced and their useful lives considerably increased by placing them in shallow grooves in the surface of the pavement. In the past, the grooves (1/8" – 1/4" deep) have been cut with diamond grinding equipment – a relatively slow and costly process. Now there is another way – on concrete at least.

Figure 1. Shoulder stripe groove formed in plastic concrete.

In 1999 CDOT Region 4 Traffic engineers proposed forming grooves in the plastic concrete as a new concrete highway is laid. A slight modification of the screed bar at the back of the concrete paving machine provided the grooves at no additional expense.

CONSTRUCTION

CDOT project NH 0342-034, a four-lane construction project on US 34 from mp 122.7 to mp 124.8, provided an opportunity to try the new method. Castle Rock Construction grooved the surface of the concrete pavement as it was placed: Three pieces of steel, welded to the screed on the paving machine in the appropriate locations, formed three continuous grooves – one for each shoulder stripe and one for the skip stripe – as the pavement was being placed. The two shoulder grooves were formed 4-1/2 inches wide and the skip stripe groove was formed 8 inches wide to accommodate hi-visibility black-edged tape. The only other changes that had to be made in the paving operation were: 1. At the groove locations, cut gaps in the texturing drag behind

Figure 2. Small pieces of steel welded to the screed formed the grooves.

the paver so the drag didn't round the edges of the grooves. 2. At the grooves, remove the tines from the tining machine so the bottoms of the grooves would provide a smooth surface for paint and tape.

Figure 3. Gaps were cut in the drag to keep the groove smooth.

When an extra lane is added for a short distance to serve as an accel/decel lane at an intersection, the shoulder stripe curves outward to a new position nearer the outside edge of the pavement. Since the positions of all of the grooves are permanently set at a fixed distance from the edge of the pavement by their welded locations on the screed, there is no way to adjust the position of the shoulder stripe groove to allow for the extra lane. At these locations, whether they are on the left or right shoulder, the groove continues at its fixed location relative to the edge of the concrete. The painted stripe leaves the groove at the beginning of the new lane and is painted on the surface of the concrete for the length of the additional lane. The shoulder stripe then bends back toward the center of the concrete at the end of the acceleration lane and rejoins the shoulder stripe groove when the lane ends.

Pavement marking tape and thermoplastic marking material were selected for use in evaluating the effectiveness of the grooves on the project since they are both thick and susceptible to damage by snowplows.

Figure 4. At accel/decel lanes the stripes were placed outside the grooves.

3M Stamark^{tm} tape was used for both shoulder stripes and the skip stripe in the eastbound lanes. All three stripes in the westbound lanes were marked with thermoplastic.   Both the tape and the thermoplastic stripes were stopped at the beginning of the accel/decel lanes and the curved shoulder stripes were marked with epoxy paint. Neither tape nor thermoplastic was used outside the grooves on this project.

Both the thermoplastic and the marking tape cost more than epoxy paint (significantly more in the case of the marking tape). However, data below indicates that by placing the stripes in grooves, their much higher retroreflectance over a longer useful lifetime compared to epoxy may justify the use of the more expensive material. Costs at the time this project was constructed are shown in T**able 1** below for the three types of striping materials used for this evaluation.

Table 1. Marking materials cost – 2000.

Epoxy	$1.53/sq. ft.	
Thermoplastic	$2.05/ sq. ft.	1.3 times Epoxy cost
Tape 4” yellow	$8.25/ sq. ft.	5.4 times Epoxy cost
Tape 4” white	$8.00/ sq. ft.	5.2 times Epoxy cost
Tape 7” white/black border	$9.00/ sq. ft.	5.9 times Epoxy cost

The project was constructed over two summers from 1999 to 2000. The westbound lanes were completed late in the fall of 1999 and carried two-way traffic over the winter with epoxy striping. The next fall, after construction was completed, the grooves were thoroughly sandblasted to remove all remnants of curing compound or cement slurry in the eastbound lanes and the interim epoxy paint in the westbound lanes and the tape and thermoplastic markings were installed.

EVALUATION

Figure 5. The Delta LTL2000 measures retroreflectance in any light condition.

Both types of pavement markings went through several winters with no noticeable wear from traffic or snowplows. Retroreflectance measurements were taken using a Delta LTL2000 Retrometer. This description is on the first page of the Delta Retrometer manual: “The LTL2000 Retrometer is a portable field instrument, intended for measuring the retroreflection properties of road markings in car headlight illumination, the value R1 (coefficient of retro reflected luminance) is used. R1 is a measure of the lightness of the road marking as seen by drivers of motorized vehicles in car headlight illumination. The road is illuminated at an angle of 1.24º and the reflected light is measured at an angle of 2.29º. which corresponds to an observation distance of 30 meters. Thus relevant for a motorist viewing situation under normal conditions.” The retroreflectance numbers generated by the LTL2000 are milli-candellas per lux per square meter.

Typically, when marking tape is applied to the surface of the pavement, the tops of the raised diamonds are quickly damaged by snowplows. In the eastbound lanes, the tape in the grooves remained in excellent condition with no plow damage to the raised diamonds. **Figure 6** shows the right shoulder tape after three winters. There is no visible wear; however, the surface appeared slightly less bright than when it was new, possibly due to the tape being a little dirty – it had been exposed to the elements for three years. After three winters, retrometer readings averaged 514 for the white tape in the right shoulder and 479 for the skip stripe. Readings were an average of 287 on the yellow left shoulder tape. All are well above the minimum acceptance retroreflectance readings for new epoxy paint. In the past there has been some problem with marking tape not adhering to concrete pavement; however, there was no sign of the tape separating from the surface in the grooves on this project. Possibly the grooves provide some protection from lateral forces applied by traffic thus allowing the tape to adhere better to the concrete.

Figure 6. Even after 3 years, the tape was still bright.

The thermoplastic markings in the grooves in the westbound lanes had good retroreflectivity readings, 299 to 378 for white and 154 to 209 for yellow, and showed no traffic or snowplow damage. However, the thermoplastic material, which was between 1/8th inch and 3/16th inches thick, was extensively cracked and had started to separate from the surface of the pavement. Postage stamp-sized pieces were easily picked

Figure 7. The thermoplastic failed due to adhesion loss.

up off the pavement. There were extensive areas of the skip stripe where the wind blast from passing traffic had removed nearly all of the thermoplastic material.

The areas of turn lanes and accel/decel lanes were striped with epoxy paint, as mentioned previously. Its retroreflectivity, 69 to 98 on white and 64 to 75 on yellow, was much lower than either the tape or the thermoplastic. There were areas where the paint had been scraped by plows; however, the retroreflectivity remained about the same as undamaged areas.

Figure 8. Epoxy paint in a groove in perfect condition next to damaged paint on the surface.

At about mp 123.5 in the eastbound lanes, the left shoulder stripe is a double yellow of epoxy paint. The left stripe in **Figure 8** is in a groove; the right stripe is on the surface of the pavement. Retroreflectivity readings for the two stripes are nearly the same – the one in the groove averaged 69.8 for five readings; the one on the surface averaged 70 for five readings. However, as can be seen in the photo, the paint on the surface of the pavement has begun to come off of the concrete.

The areas of the surface stripe (the one on the right) that appear brighter yellow are where the stripe was scraped by snowplows. The places where the paint is gone seem to be part of the scraped areas. However, it is impossible to say whether the snowplows directly caused the missing paint or simply removed paint that was already loose. Most of the paint that shows evidence of scraping was still firmly stuck to the concrete. It is not known whether the same method was used to clean the surface for both stripes before the epoxy was installed; however, the paint and beads in the stripe in the groove were completely undamaged after repeated plowing operations and showed no signs of loosing adhesion to the concrete.

After three winters all of the tape in the eastbound lanes remained in very good condition. There was only one very small – about six inches long – piece that had been damaged by something being dragged over the tape and tearing it. As **Figure 6** shows, the reflective tape was slightly dirty; however, the retroreflectance numbers for the three-year-old tape were higher than those for new epoxy paint.

Table 2. Retroreflectometer readings

Tape – Recessed	May, 2002 Average	September, 2003 Average
Right Shoulder – White	764.8	514.5
Skip Stripe – White	721.6	479.3
Left Shoulder – Yellow	287.8	287.3
Thermoplastic – Recessed		
Right Shoulder – White	305.8	replaced 2003
– Skip Stripe – White	358.6	replaced 2003
– Left Shoulder – Yellow	179.2	replaced 2003
Epoxy Paint – Not Recessed		
– Right Shoulder – White	101.8	replaced
Epoxy Paint*		
Not recessed – Rt. Shoulder – White	83	replaced
Recessed – Lt. Shoulder – Yellow	69.8	replaced
Not recessed– Lt. Shoulder – Yellow	70	replaced

***** At the time this report was written in 2004 retroreflectance minimums for new epoxy paint were 300mcd/lux/m^2 for white and 250 mcd/lux/m^2/ for yellow.

There was some concern about possible effects on vehicle handling during lane changes across the skip-stripe groove, but the researchers did not notice anything during the evaluation visits to the site and heard no mention of complaints by the public. The width and depth of the grooves used on this project are such that they don't try to redirect the tires of a vehicle crossing them during lane changes.

CONCLUSIONS AND RECOMMENDATIONS

The retroreflectivity numbers show that the paint in the grooves definitely retains more of its retroreflectivity than the same paint applied outside the grooves. Thermoplastic markings were protected from traffic and plow damage but the adhesion problems were severe. Marking tape remained in nearly new condition in the grooves. Further evaluation will be needed to see if the added expense of traffic marking tape can be justified. However, the results of this study show that placing lane markings in shallow grooves in the pavement results in considerably longer marking life, making the highway safer for drivers. The best part of forming the grooves during construction is that it is nearly cost-free. It entails a little more hand work at the beginning and end of each day's paving but these areas are mainly hand finished already.

The slipformed grooves for recessing pavement stripes as reviewed in this report would be a cost-effective way to increase the useful life of the stripes on a new concrete pavement. A large part of the problem with traffic stripes as they age is that the marking materials wear off or simply loose adhesion to the surface. The fact that the paint in the grooves at the site on US-34 remained firmly adhered to the pavement gave testimony to the effectiveness of the grooves. Even the thermoplastic that broke up and lost adhesion remained in place longer in the grooves than it would have if it had been exposed to the direct wear of traffic and snowplows

Formed-in grooves are a good option for concrete projects where the need for turn lanes and accel/decel lanes is limited. Since the grooves cannot be curved in relation to the pavement, it is necessary for areas where the pavement widens to be striped outside the grooves. This defeats the purpose of having the grooved pavement to some extent. However, the fact that these areas are used by only a portion of the traffic on the highway makes them last longer also. Grooving the plastic concrete to recess the lane markings would be especially effective for rural interstate highways and other highways with long stretches of highway uninterrupted by intersections and driveways.