PERFORMANCE AUDIT REPORT

Reflective Sheeting Used In Highway Construction Zones

A Report to the Legislative Post Audit Committee
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OBTAINING AUDIT INFORMATION

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Summary of Legislative Post Audit's Findings

How much high-performance reflective sheeting is used on projects let by the Kansas Department of Transportation and the Kansas Turnpike Authority, and how much does the sheeting cost? In 1987, an estimated 227,500 square feet of high-performance reflective sheeting was used on all projects awarded by the Department of Transportation and the Turnpike Authority, at an estimated cost of about $631,000. This represents about one-fourth of one percent of the $232 million projected cost of the highway contracts awarded by the two State entities in 1987. If contractors had been allowed to use regular-grade reflective sheeting instead of high-performance sheeting in all construction zones in 1987, their sheeting costs could have been reduced by $497,000.

Following the Department of Transportation's announcement that high-performance sheeting would be required on all traffic control devices in construction zones, per-day prices paid for traffic control devices rose sharply in 1986, then dropped back down in 1987 generally to below 1985 levels. As a result of the higher prices in 1986, the Department of Transportation spent about $285,000 more than it would have spent at 1985 price levels. Because prices dropped in 1987, the Department spent $84,000 less than it would have spent at 1985 price levels.

Do the performance characteristics of high-performance reflective sheeting appear to justify its use in construction work zones? As required by the 1987 Legislature, the Department of Transportation has hired a consultant to study reflective sheeting on highway signs, including cost and safety factors. The Federal Highway Administration recommends the use of high-performance sheeting on traffic control devices in construction work zones primarily for safety reasons. However, most contractors surveyed did not think that high-performance sheeting improved safety in construction work zones. Some contractors reported that high-performance sheeting on traffic control devices does not provide any benefits in daytime-only construction work zones. Contractors also reported that high-performance sheeting is not as durable as regular-grade sheeting on traffic control devices in construction work zones.

When does the Kansas Department of Transportation require pavement marking materials, and has the Department analyzed the cost-effectiveness of the materials? The Department has adopted a durable pavement marking policy that specifies which materials may be used in urban and rural areas. Department officials said that durable marking materials are generally applied only on new interstate and freeway pavement. However, the durable pavement marking policy does not address temporary pavement markings in construction work zones. The Department's unwritten policy is that, whenever temporary markings are called for in project plans, the contractor has a choice between applying paint or temporary tape. Cities and counties surveyed said they made little use of pavement marking materials other than paint, but all were satisfied with the more durable materials. The Department of Transportation has studied the durability of some marking materials, but has not fully analyzed the cost-effectiveness of the durable pavement marking materials.

REFLECTIVE SHEETING USED IN HIGHWAY CONSTRUCTION ZONES

The Kansas Department of Transportation has adopted federal standards requiring the use of reflective sheeting on highway signs. Department policy specifies the use of high-performance reflective sheeting on certain signs and, since March 1986, on traffic control devices in construction work zones. This policy affects highway contractors and subcontractors, as well as the Department, for all highway projects involving federal or State aid. The Kansas Turnpike Authority has also adopted the same policy of requiring high-performance sheeting on traffic control devices in construction zones.

An April 1986 audit of reflective sheeting recommended that the Department of Transportation conduct a more extensive analysis to determine whether its policy of using high-performance sheeting on permanent signs was cost-effective. Since the earlier audit, a number of additional questions have been raised in this area. They focus on the amount of high-performance reflective sheeting used in constructions work zones on projects let by the Department of Transportation and the Turnpike Authority, as well as the cost, durability, and safety value of the sheeting. Other concerns relate to the use and cost-effectiveness of pavement marking materials. The audit will address the following specific questions:

1. **How much high-performance reflective sheeting is used on projects let by the Kansas Department of Transportation and the Kansas Turnpike Authority, and how much does the sheeting cost?**

2. **Do the performance characteristics of high-performance reflective sheeting appear to justify its use in construction work zones?**

3. **When does the Kansas Department of Transportation require pavement marking material, and has the Department analyzed the cost-effectiveness of the material?**

To answer these questions, the auditors interviewed officials of the Kansas Department of Transportation, the Kansas Turnpike Authority, and the Federal Highway Administration. They reviewed a sample of highway projects let in 1987 by the two State entities. In addition, the auditors surveyed highway contractors, rental firms, and municipalities.

Based on their fieldwork and reviews, the auditors estimated that more than 227,000 square feet of high-performance sheeting were used on all highway construction projects let in 1987, at an estimated cost of about $631,000. High-performance sheeting generally costs at least four times as much as regular-grade sheeting. Despite this higher cost, the Federal Highway Administration recommends the high-

performance sheeting for signs in construction work zones because of greater brightness and visibility. Contractors and rental firms responding to the auditors' survey indicated that the high-performance sheeting used in construction zones was effective only at night, and does not last as long as regular-grade sheeting. With regard to pavement marking materials, the Department of Transportation has adopted an official State policy, but has not fully analyzed the cost-effectiveness of the various materials. This report discusses these and other findings resulting from the audit.

How Much High-Performance Sheeting Is Used on Highway Projects Let by the Kansas Department of Transportation and the Kansas Turnpike Authority, and How Much Does the Sheeting Cost?

In the first nine months of 1987, the Kansas Department of Transportation let 250 highway construction or maintenance contracts that included traffic control, totalling about $165 million. For all of 1987, the auditors estimated that the Department would let about 333 such projects, totalling almost $220 million. In addition, the Kansas Turnpike Authority let 18 projects that included traffic control in 1987, for a total of nearly $12 million.

In accordance with the Department's March 1986 directive, all the signs, barricades, and drums used in construction work zones on these projects were required to have high-performance reflective sheeting. High-performance sheeting costs about 4-5 times as much as regular-grade, but is more highly reflective.

To answer this question, the auditors had hoped to be able to obtain exact figures on the amount of reflective sheeting used on all projects. However, highway project files maintained by the two State entities do not list the amount of high-performance sheeting required on traffic control devices for each project.

To make these determinations, the auditors calculated the minimum amount of sheeting needed on the temporary construction signs, barricades, and drums that were required to meet the project plans for a sample of highway projects. They then projected the results of the sample to all 1987 highway projects. The figures from the sample may be slightly understated because contractors may use more than the minimum number of traffic control devices required on a highway project. On the other hand, the projected estimate could be somewhat overstated because the auditors had to assume that each traffic control device was used on only one highway project.

Using this methodology, the auditors projected that about 227,500 square feet of high-performance sheeting was used on all projects let in 1987. At State contract prices, the cost of this sheeting would be an estimated $631,000. Contractors' sheeting costs would have been much less had they been able to use regular-grade sheeting; however, the effect on the prices that contractors would have charged to the State cannot be estimated. The amount that contractors bid to provide temporary traffic control devices on highway projects jumped in late 1985 following the initial an-

nouncement of the March 1986 policy change to high-performance sheeting. However, the bid prices came back down in 1987, in most cases to below 1985 levels. This shows that forces other than the cost of the sheeting affect the bids being submitted by highway contractors.

These findings are discussed more fully in the following sections.

In 1987, an Estimated 227,500 Square Feet of High-Performance Sheeting Were Used on All Projects Awarded by the Department of Transportation and the Turnpike Authority, at an Estimated Cost of About $631,000

The auditors' sample included 30 Department of Transportation projects and 10 Turnpike Authority projects. The Department of Transportation projects fell into two categories. The 15 larger, more complex sample projects (which included more than one phase or multiple changes in traffic patterns within the construction area) averaged 1,970 square feet of high-performance sheeting per project, while the 15 smaller and less complex projects averaged 387 square feet of sheeting. For the Turnpike Authority, the 10 sampled projects included all sizes of contracts, and averaged 627 square feet of high-performance sheeting.

Based on the sample results, the auditors projected the total amount and cost of high-performance reflective sheeting used in construction work zones for all 1987 highway projects with traffic control. The table on the next page shows these totals.

Reflective Sheeting

Three types of reflective sheeting are used on the surface of highway signs to make them easier to read at night. The effective life of each type of sheeting depends on its use and handling.

Regular-Grade Sheeting

Regular-grade or engineering-grade sheeting is the least reflective of the three types of sheeting. Actual reflectivity varies by the color of the sheeting. According to the Federal Highway Administration, the effective life of this type sheeting is five to seven years. In Kansas, regular-grade sheeting is used for speed limits, route markers, zone signs, and recreational signs. The current contract price the State pays for regular-grade sheeting is $.59 per square foot.

Super-Engineering-Grade Sheeting

Super-engineering-grade sheeting has about twice the reflectivity of regular-grade sheeting. According to the Federal Highway Administration, the effective life of this grade of sheeting is seven to 10 years. The cost of super-engineering-grade sheeting is about $1.60 per square foot. However, the State is just starting to test this material and does not purchase or use super-engineering-grade sheeting on its traffic signs at this time.

High-Performance Sheeting

High-performance sheeting is three to five times brighter than the regular-grade sheeting. According to the Federal Highway Administration, the effective life of high-performance sheeting is at least 10 years. High-performance sheeting is used for stop, yield, do not enter, do not pass, and large overhead signs, as well as the signs, drums, and barricades in construction zones. The State currently pays about $2.63 per square foot for orange sheeting, and about $3.05 per square foot for other colors of high-performance sheeting.

As the table shows, the auditors projected that about 227,500 square feet of high-performance sheeting were used on all highway projects awarded by the Department of Transportation and the Turnpike Authority in 1987. Using current State contract prices for high-performance sheeting, the auditors estimated that the total cost of this sheeting was about $631,000. (The amount and cost of reflective sheeting pur-

chased by State agencies in fiscal years 1986 and 1987 are shown in Appendix A. The sheeting purchased by State agencies was primarily used on permanent signs.)

1987 Highway Projects With Traffic Control

	Department of Transportation Contracts (a)	Turnpike Authority Contracts	Total
Number of Contracts in 1987	333	18	351
Average Square Feet of High-Performance Sheeting per Contract (b)	649	635	648
Projected Total Square Feet of High-Performance Sheeting, All Contracts	216,123	11,432	227,555
Estimated Total Cost of High-Performance Sheeting, All Contracts	$599,094	$32,043	$631,137

(a) Annual totals were estimated from projects let in January through September 1987
(b) Determined from the auditors' sample

The auditors also determined that, on the average, high-performance sheeting accounted for about $1,800 per project, or one-fourth of one percent of the total project cost. For more details on the auditors' estimates of total and average costs, see Appendix B.

High-performance sheeting generally costs 4-5 times more than regular-grade sheeting. Thus, if contractors on State projects had used regular-grade sheeting instead of high-performance sheeting in all construction zones in 1987, their sheeting costs could have been $497,000 less than the $631,000 shown above. It is not possible to estimate how much of this difference would have been passed along to the State in the form of lower bids.

To determine what happened to the State's costs for reflective sheeting on traffic control devices, the auditors wanted to review the actual cost of the sheeting used on projects. However, when contractors submit bids on State highway contracts, they do not itemize the amount to be spent for reflective sheeting. Rather, they bid either a lump-sum amount for traffic control, or they bid specified amounts per-day for various traffic control devices. The auditors estimated that high-performance sheeting accounts for about 50 percent of the cost of a new sign, barricade, or drum. To get an idea of how per-day bids changed after the Department announced its new policy on high-performance sheeting, the auditors reviewed the Department of Transportation's records on contractors' actual average bid prices for traffic control devices on a per-day basis.

Per-day prices paid to contractors for traffic control devices rose sharply in 1986, then dropped back down in 1987 generally to below 1985 levels. The Department of Transportation announced in October 1985 that high-performance sheeting would be required on all traffic control devices, starting with projects let in March 1986. At the same time, the Department began requiring that all traffic control drums had to be made of plastic and meet all requirements of the federal Manual on Uniform Traffic Control Devices.

Department officials said that they expected a 10-15 percent increase in per-day prices for traffic control devices following their announcement of the new requirement. Starting in 1985, the Department kept track of all winning contractors' bids each month for signs, barricades, and drums. The Department put this information and calendar year totals into its computerized system.

The auditors analyzed this information on an average annual basis, and the results are presented in the accompanying table.

Annual Average Prices Bid by Winning Contractors on KDOT Projects

Traffic Control Devices	1985 Avg. Price/Day	1986 Avg. Price/Day	% Change, 1985-1986	1987 Avg. Price/Day	% Change, 1985-1987
Small Signs	$0.377	$0.471	24.9	$0.264	-30.0
Medium Signs	$0.696	$0.862	23.9	$0.635	-8.8
Large Signs	$0.946	$1.490	57.5	$1.175	24.2
Small Barricades	$0.617	$0.898	45.5	$0.548	-11.2
Large Barricades	$1.840	$1.972	7.2	$1.907	3.6
Drums	$0.797	$0.863	8.3	$0.757	-5.0

As the table shows, prices of traffic control devices bid on a per-day basis rose sharply in 1986, following announcement of the new reflective sheeting policy. Annual average prices went up 24-57 percent for small barricades and all sizes of signs in 1986; bid prices of large barricades and drums went up by 7-8 percent. As a result of these higher per-day bid prices in 1986, the Department of Transportation spent about $285,000 more than would have been spent at 1985 average price levels. Department of Transportation officials attribute at least part of this increase to the change in reflective sheeting policy, because contractors had to recover the costs of new traffic control devices. However, there may be other reasons for the rise of bid prices for these devices, such as the fact that more construction projects were awarded in 1986.

The table also shows that average annual bid prices came back down for every type of traffic control device in 1987, and were generally lower in 1987 than in 1985. As a result, the Department actually spent $84,000 less for construction signs, barricades, and drums used in 1987 than would have been spent at 1985 price levels. One possible explanation for this drop in bid prices might be that high-performance sheeting was lasting longer than the contractors initially expected. However, there may well be other competitive forces that determine what prices contractors bid for these devices.

Do the Performance Characteristics of High-Performance Reflective Sheeting Appear to Justify its Use in Construction Work Zones?

The April 1986 audit raised questions about the durability, safety, and cost-effectiveness of high-performance sheeting versus regular-grade sheeting on permanent highway signs. The audit recommended that the Department of Transportation conduct a detailed analysis of the cost-effectiveness of high-performance sheeting versus regular-grade sheeting. The audit suggested that the analysis should be based on the expected life of highway signs, rather than just the expected life of the reflective sheeting.

In mid-1987, the Special Committee on Transportation conducted an interim study that included the subject of reflective sheeting on highway signs. The Special Committee expressed the view that the Secretary of Transportation has the expertise to make the most appropriate decisions regarding the type of sheeting that should be used on road signs, and advised the Secretary to make the most efficient and effective use of the taxpayers' money.

The 1987 Legislature took the next step by requiring the Department of Transportation to conduct a study on this issue. Senate Bill 142, the appropriation bill for the Department, includes the following mandate:

> The Secretary of Transportation shall conduct a study on the use of reflectorized sheeting on state road signs which shall include the types of sheeting used, cost justifications for use of such sheeting, safety factors justifying such use and other factors deemed pertinent to the use of reflectorized sheeting. The Secretary shall submit a report of the findings of such study to the Governor and the 1988 regular session of the Legislature.

In October 1987, the Department of Transportation entered into a contract with Bellomo-McGee, Inc., a Virginia-based firm, to conduct the study of reflective sheeting on highway signs. The consultant's contract requires surveying all 49 other states, reviewing literature concerning reflectivity performance standards, assessing safety factors of high-performance and regular-grade sheeting, conducting economic evaluations of the costs and benefits of the two types of sheeting, and submitting a written report. The safety and economic analyses are to include both construction zone signing and general signing. The study should be done at the end of January 1988, at an estimated cost of $36,800.

To avoid duplication of effort, the auditors did not attempt to conduct the analyses of performance characteristics being done by the consultant. Rather, the auditors looked for other evidence concerning the advantages and disadvantages of high-performance sheeting. They interviewed federal and State officials, reviewed available documents and studies, and surveyed highway contractors to get users' opinions on the durability and safety of reflective sheeting.

In general, the auditors found that the safety issue appears to be the overriding concern cited in the recommended use of reflective sheeting for traffic control devices in highway construction zones. According to nationwide data and Kansas statistics, the number of fatalities in construction work zone accidents is especially high at night. However, most highway contractors surveyed did not think that high-performance sheeting improved safety in construction work zones, especially for work done only during the day. Changing State policy so that high-performance sheeting is not required for daytime projects may be worth exploring, providing the cost savings are not offset by other administrative costs. Finally, surveyed contractors reported that traffic control devices with regular-grade sheeting generally lasted 3-9 months longer than devices with high-performance sheeting.

These findings are discussed more fully in the following sections.

The Federal Highway Administration Recommends the Use of High-Performance Sheeting on Traffic Control Devices in Construction Work Zones Primarily for Safety Reasons

The Manual on Uniform Traffic Control Devices published by the Federal Highway Administration requires that all regulatory and warning signs be reflectorized or illuminated to show the same shape and color both by day and night. Under K.S.A. 8-2003, the Manual has been adopted by the Kansas Department of Transportation. The Manual sets standards for numerous aspects of managing traffic flow through construction zones, but does not recommend any particular type of reflective sheeting. The Manual does establish the color of all signs; warning signs in construction zones are required to be orange, with black letters.

Since 1976, the Federal Highway Administration has approved state use of high-performance sheeting on highway signs, and participated in paying the higher costs. It began recommending the use of high-performance sheeting in November 1987. A draft copy of the Federal Highway Administration report on "Retroreflectivity of Roadway Signs for Adequate Visibility: A Guide," includes the following statement:

> For work zone traffic control devices, [high-performance] sheeting is desirable for advance warning signing, other critical signs and other "stand alone" retroreflectorized devices. The level of retroreflectivity afforded by [super-engineering grade] sheeting is adequate for channelization devices [cones, barricades, and drums], provided the devices are kept clean, because several devices are visible at one time.

Federal Highway Administration officials told the auditors that the reasons for recommending high-performance sheeting in construction work zones include:

—The reflectivity of high-performance sheeting is better than regular-grade orange sheeting.

—High-performance sheeting may help to get the driver's attention when there is little advance warning.
—A lot of dirt or mud can obscure signs in construction work zones.

Highway Contractors' Comments Relating to the Safety Value of Reflective Sheeting

I don't feel a slight increase in visibility is worth the cost involved nor do I think that motorists can tell the difference.

Most of our work involves daytime usage so we see no increased safety for workers.

Too many factors are involved in signing in the motorist's environment to isolate the effect of high-performance sheeting.

The high-performance sheeting is much more visible.

The regular-grade sheeting lasts longer. The high-performance sheeting gets dull faster.

Can't tell much difference; traffic doesn't seem to pay much attention to the signs.

Visibility is about the same for both grades of sheeting.

High-performance sheeting is more visible at night than regular-grade sheeting. However, the highest level of activity is during the daylight hours.

Signs left in place at night might have some benefit with high-performance sheeting, but in daylight you cannot tell the difference.

The only time you have any benefit of high-performance signs is at night, and we don't work at night.

Only improvement is for devices used at night. In fact, glare on signs often make them hard to read.

The high-performance sheeting is really only noticeable at night. With the exception of the end-of-project signs, all other construction signs are removed at night.

There does not appear to be any significant change in the safety to our workers.

On projects done during daylight hours, such as overlays, safety has not been improved.

The Federal Highway Administration and the American Association of State Highway and Transportation Officials have recognized that construction zones present a significant danger to motorists, and that the number of fatalities in construction work zone accidents is especially high at night. Nationwide, about 700 persons are killed annually in work zone accidents. National data show that night work zone accidents account for less than 30 percent of all work zone accidents, but almost 50 percent of the work zone fatalities.

A recent study by the American Association of State Highway and Transportation Officials recommended that work zones should be critically reviewed to assure they include adequate motorist guidance during hours of darkness. None of the studies reviewed by the auditors stated that high-performance sheeting actually reduces accidents in construction zones. One problem with the statistics is that most states (including Kansas) have no data on the exposure of motor vehicles to construction work zones. Another problem is that other factors such as speed, weather conditions, and drivers' use of alcohol or drugs could be more significant than the type of sheeting used in construction zones.

In recent years, an average of about 900 accidents have occurred annually in Kansas construction work zones. In Kansas, night work zone accidents have accounted for about one-third of all work zone accidents, but two-thirds of all work zone fatalities. In the past several years, 6-9 Kansans have been killed annually in work zone accidents.

To get an idea of how high-performance sheeting was perceived by the people who handle it, the auditors surveyed 90 highway contractors and 32 rental firms. Responses were received from 35 of the contractors (39 percent) and 8 rental firms (25 percent). The results from these surveys are discussed in the following sections.

Most Contractors Did Not Think That High-Performance Sheeting Improved Safety in Construction Work Zones

Contractors and rental firms who responded to the survey generally did not agree with the federal and State agencies on the safety value of high-performance sheeting in construction work zones.

Only 16 percent of the contractors and 20 percent of the rental firms said that high-performance sheeting improves safety for workers in construction zones. Likewise, only 20 percent of the contractors said that high-performance sheeting improves safety for motorists in construction zones. On this question, however, 60 percent of the rental firms said they thought that high-performance sheeting improves safety for motorists in construction zones.

Some contractors reported that high-performance sheeting on traffic control devices does not provide any benefits in daytime-only construction work zones. Before adopting its policy on high-performance sheeting, the Department of Transportation considered exempting day-only construction projects from the high-performance sheeting requirement. This idea was rejected because of the increased cost of administration and oversight. The Department also pointed out that the major problem with traffic control was during the nighttime, when high-performance sheeting provided greater visibility than regular-grade sheeting.

Of the 35 contractors' surveys returned, 18 included narrative comments concerning safety issues. Ten of these 18 mentioned that high-performance sheeting is beneficial only at night. Examples of safety-related comments made by contractors are in the box on page eight.

Several of the contractors pointed out that, on their overlay projects, all signs

Highway Contractors' Comments Relating to the Durability of Reflective Sheeting

Transporting and damage is about the same for both grades of sheeting.

High-performance sheeting can be scratched easily, so extreme care has to be used in movement both on and off the project.

High-performance sheeting is very susceptible to abrasion damage from handling, and signs that are moved regularly will have a shorter useful life with high-performance sheeting.

High-performance signs are not as durable; you must be very careful not to scratch. They will not stand the abuse for movable signs that regular-grade signs will.

Reflective sheeting is easily damaged. Constant moving of portable signs gives them a very short life and requires additional manpower for extra care. Damage from the public is twice as high as to regular-grade sheeting.

The high-performance sheeting comes off easier and scratches easier. It takes much more care in handling.

Any contact with high-performance sheeting requires replacement. It is almost impossible to take them down at night and put them up in the morning without damaging the sheeting. On our projects, we only use signs during the day. It is simply pointless to specify the high-performance type signs on overlay projects.

are removed from the project at night. In this situation, they said, the high-performance sheeting provides no safety benefit and it costs more than regular-grade sheeting. The auditors determined that overlay projects generally account for about 10 percent of the dollar total of contracts let each year by the Department of Transportation. Assuming annual expenditure of $22 million for overlay projects, the cost of high-performance sheeting would be about $103,000. If regular-grade sheeting had been used on these projects, the contractors' costs would have been about $22,000.

Under these assumptions, the potential Statewide reduction in sheeting cost is about $81,000. Thus, a change in policy would only be worthwhile to consider if little or no additional administrative costs were incurred by the Department of Transportation.

Contractors Reported That High-Performance Sheeting Is Not as Durable as Regular-Grade Sheeting on Traffic Control Devices in Construction Work Zones

Although the Federal Highway Administration guide says that high-performance sheeting is more durable than regular-grade sheeting on permanent highway signs (an effective service life of 10-15 years for high-performance sheeting versus 7-10 years for regular-grade sheeting) it also states that high-performance sheeting is more fragile and requires more care in handling and storing the traffic control devices.

One question in the survey asked about the expected useful life of traffic control devices in construction work zones. The results on that question are summarized in the following table.

Contractors' Survey Responses on the Useful Life of Traffic Control Devices in Construction Work Zones

Traffic Control Devices	Average Useful Life (in months)		Regular-Grade Lasts Longer By...	
	High-Performance Sheeting	Regular-Grade Sheeting	Months	Percent
Signs	14.1	22.8	8.7	61.7%
Barricades	11.4	18.8	7.4	64.9%
Drums	10.5	13.8	3.3	31.4%

The table shows that, in construction work zones, contractors reported that devices with regular-grade sheeting last 3-9 months longer than devices with high-performance sheeting. Examples of durability-related comments made by contractors are in the box on page nine.

Conclusion

The use of high-performance sheeting on traffic control devices in construction zones apparently has both advantages and disadvantages. On one hand, high-performance sheeting offers greater visibility and brightness at night, which seems to increase its safety value. On the other hand, high-performance sheeting costs more than regular-grade sheeting, and reportedly does not last as long in construction zones. Most contractors surveyed did not think that high-performance sheeting improved safety in construction work zones. Some contractors said that the requirement of high-performance sheeting did not make sense if all signs were removed from the project at night.

Recommendation

To save money for the State, the Department of Transportation should consider revising its policy of requiring high-performance sheeting in all construction work zones, to allow less expensive reflective sheeting on traffic control devices that are used only in daytime. Such a change should be made only if it would result in an overall cost saving.

When Does the Kansas Department of Transportation Require Pavement Marking Materials, and Has the Department Analyzed the Cost-Effectiveness of the Materials?

To answer this question, the auditors interviewed State and federal transportation officials, reviewed the official State pavement marking policy, and surveyed cities and counties concerning their experience with various materials. They found that the Department of Transportation has adopted an official State policy, that the policy does not address the types of temporary materials to be used in construction work zones, and that the Department has not fully analyzed the cost-effectiveness of durable pavement marking materials. The cities and counties surveyed reported that they made little use of any materials other than paint, but all were satisfied with the more durable materials they were using. These and other findings are discussed in detail in the sections that follow.

The Kansas Department of Transportation Has Adopted a Durable Pavement Marking Policy That Specifies Which Materials May Be Used in Urban and Rural Areas

In November 1985, a committee within the Department of Transportation completed a proposed durable pavement marking policy. In March 1986, this policy was approved by the Federal Highway Administration. Before then, federal officials had

to review and approve the higher-cost pavement marking materials on a project-by-project basis.

The type of pavement marking materials recommended by the State policy varies according to the type of pavement, condition of the pavement, and average daily traffic. The written policy suggests that paint should be used on fair to poor surfaces, and on newer surfaces if traffic is less than 2,500 vehicles per day. Conversely, the policy suggests the use of higher-cost materials (cold plastic, thermoplastic, durable tape, or epoxy) if traffic is more than 2,500 vehicles per day.

Department of Transportation officials told the auditors that, because of budget restrictions, the Department of Transportation has not always been able to follow its policy. In those cases, paint would be used instead of higher-cost materials. Department officials said that current practice is for durable materials to be applied (by highway contractors) primarily on new interstate and freeway pavement. In a few cases, district maintenance funds may be used to provide durable marking material for other State highways.

In virtually all cases where paint is used to mark State roads, the paint is applied as necessary by Department of Transportation crews. Regardless of whether paint or more durable materials are used, the Department has a legal duty to keep the roads reasonably safe for the traveling public. The Manual on Uniform Traffic Control Devices provides standard guidelines for pavement markings, but does not specify what types of materials should be used. Those decisions are left up to the State, subject to federal review as mentioned above.

Kansas' Durable Pavement Marking Policy Does Not Address Temporary Pavement Markings in Construction Work Zones

Because the Department of Transportation's current written policy is on durable pavement markings, it does not mention any temporary marking materials. Temporary markings may be used to route traffic around or through a construction area. The Department's unwritten policy is that, whenever temporary markings are called for in project plans, the contractor has a choice between applying paint or temporary tape. One type of temporary tape is removable, and leaves no scar on the new road surface. However, the current policy does not specify when this removable tape may be used. Department officials said that paying a contractor to apply removable tape costs about $1.25 per foot, while paying a contractor to apply paint (or the other type of temporary tape that is not removable) costs an average of 36 cents per foot.

In reviewing the current State policy with the auditors, Department officials said that the policy could be expanded to include temporary pavement markings. At the same time, they indicated that other parts of the policy could be re-examined. These points include the use of epoxy (which has not worked as well as expected), special considerations such as turning and lighting, and more recent data on the actual service life of materials.

Nearly half (14 of 30) of the sampled Department of Transportation projects included some temporary markings. These 14 projects averaged $2,831 in temporary marking materials. Because of the Department's policy, the auditors could not tell whether these markings were paint or marking tape. For all of 1987, the Department spent about $382,000 for temporary markings on construction projects.

Each Type of Pavement Marking Material Has Advantages and Disadvantages

The auditors discussed the various pavement marking materials with officials in the Department of Transportation. Department officials said that for both temporary and non-temporary pavement markings, each type of material offers unique advantages and disadvantages. The table below summarizes the effective service life, traffic volume, reflectivity, and installed cost of the materials, as well as the advantages and disadvantages of each.

Pavement Marking Materials Used in Kansas

	Removable Tape	Paint (a)	Epoxy	Durable Tape	Thermoplastic	Cold Plastic Tape
Effective Service Life	Temporary	Up to 1 year	2-3 years	3-4 years	3-5 years	4-7 years
Traffic Volume	--	No minimum ADT	2,500 ADT or more	2,500-10,000 ADT	2,500 ADT or more	20,000 ADT or more
Reflectivity	Excellent	Poor	Excellent	Very good	Good	Fair to poor
Installed Cost Per Foot,4"Line (Contracted out)	$1.25	$.36 (b)	$.35-.45	$.55-.60	$.40-.55	$1.10-1.25
Advantages	Leaves no visible scar on roadway. Excellent reflectivity.	Least expensive of all materials. Can be applied in a broad range of weather conditions.	Excellent reflectivity. Little damage from snowplows. Not as expensive as tapes.	Easy to apply. Little damage from snowplows. Very good reflectivity. Can be applied as road sections are done.	Good reflectivity. Lasts 3-5 years. Not as expensive as tapes.	Easy to apply. Lasts longest. Stands up under heavy traffic. Can be applied as road sections are done.
Disadvantages	Relatively expensive.	Doesn't last as long as durable materials. Repainting exposes motorists and KDOT employees to danger. Reflectivity is poor. Applied only after entire project is done.	Won't stick if applied at wrong temperature or moisture conditions. Tends to fade in color. Recommended by KDOT only on an experimental basis. Applied only after entire project is done.	Surface preparation required on concrete. Won't stick if applied at wrong temperature or moisture conditions.	Won't stick if applied at wrong temperature or moisture conditions. Some damage from snowplows, due to thickness. Applied only after entire project is done.	Relatively expensive. Poor reflectivity. Can only be used in lighted areas. Some damage from snowplows, due to thickness. Surface preparation required on concrete. Won't stick if applied at wrong temperature or moisture conditions.

(a) Paint may be applied by contractors as a temporary or permanent pavement marking.
(b) The $.36 average cost includes not only paint, but also temporary marking tape that is not removable. When KDOT crews apply paint as a permanent marking, it costs only $.04-.06 per foot.

Weather Causes Striping Tape Not to Stick Properly On Highway 36 Project

Because of a lack of State funds, a construction project let by the Department of Transportation for 2.6 miles of new asphalt between the junctions of U.S. Highway 36 and U.S. Highway 75 did not include pavement markings. While the amount of traffic on this section of highway qualified it for durable tape under the Department's policy, the central office budget did not allow for funding all such projects.

The Department's District Engineer wanted to follow the Department's policy that called for durable tape in this situation, so he decided to use district maintenance funds to have the tape applied. A contract was awarded to 3M Company in April 1987 to provide labor, materials, and supplies for durable tape for this section of highway at a cost of $16,928.

The durable tape was installed on the 2.6 miles of highway on October 13, 1987. It rained on the morning of October 14, and again on October 19 and October 31. Department officials indicated that the optimal temperature for applying the durable pavement marking is 70 degrees. During the 10 days following installation, temperatures varied between a low of 26 degrees and a high of 76 degrees.

Department officials confirmed on December 2, 1987, that the markings were failing to adhere to the pavement. These officials indicated that the failure of the tape may have been caused by low temperatures, by moisture, or both. Failure of the material became apparent when snowplows moved along the highway.

According to Department officials, the 3M Company will replace the durable tape at no cost to the State. This is to be done as soon as weather permits in 1988. In the meantime, the Department has removed the failed pavement markings and replaced them with paint as necessary to guide motorists on Highway 36.

For temporary pavement markings, the table on page 13 shows that paint is much cheaper than the removable tape. However, on new pavement surfaces, Department officials said that paint must be blasted away with sand or water when construction work is completed. They said this process does not cause actual damage to the surface, but it leaves a scar on the pavement that may visually confuse drivers. Temporary tape gives much better reflectivity than paint, and leaves no visible scar on the road surface.

For non-temporary pavement markings, paint is the cheapest alternative as well, but paint does not provide the durability or reflectivity of the tapes or thermoplastic material.

Cities and Counties Surveyed Said They Made Little Use of Pavement Marking Materials Other Than Paint, But All Were Satisfied with the More Durable Materials

To gather information about the use of pavement marking materials in Kansas, the auditors sent surveys to a total of 24 cities and counties in the State. The auditors surveyed the most populous cities and counties on the assumption that they would have more experience with a variety of pavement marking materials. Of the 24 surveys sent, 18 were completed and returned (75 percent). On the whole, the municipalities used paint for about 91.5 percent of their pavement markings.

Six of the respondents used nothing other than paint to mark their streets. The other 12 municipalities used paint 87 percent of the time. The other materials most commonly used were cold plastic, temporary tape, and thermoplastic. All of those re-

sponding indicated that they were satisfied with the pavement marking materials now being used.

The Department of Transportation Has Not Fully Analyzed The Cost-Effectiveness of the Durable Pavement Marking Materials

The table on page 13 shows that durable materials such as tape and thermoplastic cost more to install than paint, and last longer. However, the Department of Transportation has not developed a method for determining whether paint or some other material is the most cost-effective.

A recent Department of Transportation study showed that applying durable tape costs at least nine times more than painting the roadway. Paying a contractor to apply durable tape costs 55-60 cents per foot, while Department crews can apply paint for 4-6 cents per foot. The study found that durable tape would provide the necessary reflectance and durability on a four-lane urban roadway for at least two years, with daytime visibility for three to four years. On rural roads, the study found that durable tape would perform well for at least three years, with daytime visibility for four to five years.

The study said that the painting cycle would have to be at least twice a year to warrant the use of the durable tape. This type of painting cycle would generally occur only in urban areas. Given a twice-a-year painting cycle in an urban area, durable tape apparently lasts 4-8 times longer than paint. It does not appear that the higher cost of applying durable tape can be justified solely on a cost basis, because the installed cost of durable tape is at least nine times higher than paint.

The same Department of Transportation study concluded that the durable tape "can be cost-effective if the painting cycle is twice a year and the factors of safety, less handling and storage of materials, paint settling problems, and the reallocation of manpower are considered." However, these factors were not quantified to show how this conclusion was reached.

It should be noted that the Department has not developed a measure of the cost-effectiveness of the various pavement marking materials over their expected life. It is true that the expected life will vary according to traffic level, type of pavement, weather conditions at time of application, the amount of turning traffic movement, and snow removal techniques. However, if the use of durable markings is to be justified, the Department needs to develop some estimate of the cost per lane mile per year for each of the pavement marking materials.

Conclusion

Kansas has an officially adopted durable pavement marking policy, but does not always follow the policy because of budget factors. The cur-

rent policy also does not address temporary pavement marking materials used in construction work zones. Department of Transportation officials indicated that the policy could be reviewed to include temporary marking materials, and to update other points. Paint is much cheaper than any of the other pavement marking materials, but each has unique advantages and disadvantages. The Department of Transportation has studied the durability of some materials, but has not fully analyzed the cost-effectiveness of the durable pavement marking materials.

Recommendations

1. The Department of Transportation should review and update its official pavement marking policy, and should include temporary pavement marking materials in that written policy.

2. In conjunction with the first recommendation, the Department of Transportation should conduct a more detailed analysis of the cost-effectiveness of durable pavement marking materials. In doing so, the Department should develop estimates of the actual cost per lane mile per year for each type of material.

APPENDIX A

REFLECTIVE SHEETING PURCHASES FOR HIGHWAY SIGNS

The following table shows a summary of purchases made by the Kansas Department of Corrections and the Kansas Department of Transportation for fiscal year 1982 through fiscal year 1987. The Kansas Turnpike Authority purchases are not included in the summary table.

Summary of Reflective Sheeting Purchases

	Regular-Grade Sheeting			High-Performance Sheeting		
Fiscal Year	Square Feet	Cost	Avg. Cost Per Square Feet	Square Feet	Cost	Avg. Cost Per Square Feet
1982	194,725	$135,817	$0.70	47,912	$115,271	$2.41
1983	88,875	63,280	0.71	33,975	88,797	2.61
1984	107,625	80,545	0.75	47,000	122,839	2.61
1985	168,825	122,398	0.73	50,850	140,803	2.77
1986	133,450	86,448	0.65	54,000	152,669	2.83
1987	116,775	73,446	0.63	118,425	345,693	2.92
Annual Average	**135,046**	**$93,656**	**0.69**	**58,694**	**$161,012**	**$2.74**

As the table shows, the purchase of high-performance sheeting more than doubled in fiscal year 1987. An official for the Department of Transportation said that the increase resulted from a continuing emphasis by the Department on the use of high-performance sheeting on highway signs, the March 1986 requirement for high-performance sheeting in construction work zones, and a decision by the Department to use high-performance sheeting on other signing such as for detours.

The following pages show all reflective sheeting purchases made by the Kansas Department of Corrections, the Kansas Department of Transportation, and the Kansas Turnpike Authority during fiscal years 1986 and 1987.

REFLECTIVE SHEETING PURCHASES FOR HIGHWAY SIGNS

AGENCY	DATE	COLOR	TYPE I/II	TOTAL SQUARE FEET	TOTAL COST	COST PER SQUARE FOOT
FISCAL YEAR 1986						
CORRECTIONS	7/25/85	SILVER/WHITE	I	1,800	$ 1,382.40	$ 0.768
CORRECTIONS	9/18/85	YELLOW	I	7,200	4,608.00	0.640
CORRECTIONS	10/2/85	YELLOW	I	9,000	6,300.00	0.700
CORRECTIONS	10/2/85	ORANGE	I	900	630.00	0.700
CORRECTIONS	10/2/85	ORANGE	I	1,200	840.00	0.700
CORRECTIONS	10/2/85	SILVER/WHITE	I	2,400	1,680.00	0.700
CORRECTIONS	10/15/85	SILVER/WHITE	I	3,000	1,920.00	0.640
CORRECTIONS	10/15/85	SILVER/WHITE	I	3,600	2,304.00	0.640
CORRECTIONS	11/20/85	SILVER/WHITE	I	4,500	2,880.00	0.640
CORRECTIONS	11/20/85	SILVER/WHITE	I	3,600	2,304.00	0.640
CORRECTIONS	1/16/86	YELLOW	I	9,900	6,336.00	0.640
CORRECTIONS	2/12/86	SILVER/WHITE	I	3,000	1,920.00	0.640
CORRECTIONS	2/12/86	SILVER/WHITE	I	3,750	2,400.00	0.640
CORRECTIONS	2/12/86	YELLOW	I	1,800	1,152.00	0.640
CORRECTIONS	2/12/86	ORANGE	I	1,800	1,152.00	0.640
CORRECTIONS	3/19/86	YELLOW	I	4,500	2,880.00	0.640
CORRECTIONS	4/14/86	SILVER/WHITE	I	3,750	2,400.00	0.640
CORRECTIONS	4/14/86	SILVER/WHITE	I	3,000	1,920.00	0.640
CORRECTIONS	4/14/86	YELLOW	I	1,500	960.00	0.640
CORRECTIONS	4/29/86	SILVER/WHITE	I	3,000	1,920.00	0.640
CORRECTIONS	4/29/86	SILVER/WHITE	I	3,750	2,400.00	0.640
CORRECTIONS	6/5/86	SILVER/WHITE	I	3,000	1,920.00	0.640
CORRECTIONS	6/5/86	SILVER/WHITE	I	3,750	2,400.00	0.640
				83,700	$ 54,608.40	$ 0.652
TRANSPORTATION	11/1/85	SILVER/WHITE	I	9,375	$ 6,000.00	$ 0.640
TRANSPORTATION	1/14/86	SILVER/WHITE	I	625	400.00	0.640
TRANSPORTATION	1/14/86	SILVER/WHITE	I	7,500	4,800.00	0.640
TRANSPORTATION	1/14/86	SILVER/WHITE	I	11,250	7,200.00	0.640
TRANSPORTATION	1/14/86	GREEN	I	13,500	8,640.00	0.640
TRANSPORTATION	4/29/86	YELLOW	I	7,500	4,800.00	0.640
				49,750	$ 31,840.00	$ 0.640
TURNPIKE AUTHORITY	11/85	WHITE	I	31	$ 59.65	$ 1.909
TOTAL TYPE I FISCAL YEAR 1986 (Regular-Grade)				**133,481**	**$ 86,508.05**	**$ 0.648**
CORRECTIONS	7/17/85	SILVER/WHITE	II	6,000	$ 16,156.80	$ 2.693
CORRECTIONS	11/8/85	SILVER/WHITE	II	6,000	16,977.60	2.830
CORRECTIONS	11/8/85	SILVER/WHITE	II	1,050	2,971.08	2.830
CORRECTIONS	11/8/85	YELLOW	II	3,600	10,186.56	2.830
CORRECTIONS	11/20/85	YELLOW	II	2,100	5,942.16	2.830
CORRECTIONS	11/20/85	SILVER/WHITE	II	2,100	5,942.16	2.830

AGENCY	DATE	COLOR	TYPE I/II	TOTAL SQUARE FEET	TOTAL COST	COST PER SQUARE FOOT
CORRECTIONS	1/16/86	SILVER/WHITE	II	6,000	16,977.60	2.830
CORRECTIONS	2/12/86	SILVER/WHITE	II	3,750	10,611.00	2.830
CORRECTIONS	2/12/86	YELLOW	II	2,250	6,366.60	2.830
CORRECTIONS	2/12/86	YELLOW	II	2,700	7,639.92	2.830
CORRECTIONS	3/19/86	SILVER/WHITE	II	7,500	21,222.00	2.830
CORRECTIONS	3/19/86	SILVER/WHITE	II	1,200	3,395.52	2.830
CORRECTIONS	3/19/86	YELLOW	II	1,200	3,395.52	2.830
CORRECTIONS	3/19/86	YELLOW	II	2,700	7,639.92	2.830
CORRECTIONS	3/25/86	GREEN	II	1,200	3,136.32	2.614
CORRECTIONS	4/14/86	RED	II	375	1,185.30	3.161
CORRECTIONS	4/14/86	SILVER/WHITE	II	1,200	3,395.52	2.830
CORRECTIONS	6/5/86	SILVER/WHITE	II	1,500	4,244.40	2.830
				52,425	$ 147,385.98	$ 2.811
TRANSPORTATION	9/24/85	YELLOW	II	1,125	$ 4,009.50	$ 3.564
TRANSPORTATION	1/14/86	YELLOW	II	450	1,273.32	2.830
				1,575	$ 5,282.82	$ 3.354
TURNPIKE AUTHORITY	7/85	RED	II	300	$ 862.92	$ 2.876
TURNPIKE AUTHORITY	7/85	SILVER/WHITE	II	150	448.80	2.992
TURNPIKE AUTHORITY	7/85	SILVER/WHITE	II	300	897.60	2.992
TURNPIKE AUTHORITY	7/85	ORANGE AND WHITE	II	600	1,655.28	2.759
TURNPIKE AUTHORITY	9/85	SILVER/WHITE	II	450	1,211.76	2.693
TURNPIKE AUTHORITY	9/85	GREEN	II	600	1,725.84	2.876
TURNPIKE AUTHORITY	9/85	BLUE	II	600	1,725.84	2.876
TURNPIKE AUTHORITY	11/85	GREEN	II	150	552.96	3.686
TURNPIKE AUTHORITY	11/85	GREEN	II	75	245.43	3.272
TURNPIKE AUTHORITY	11/85	ORANGE	II	150	588.60	3.924
TURNPIKE AUTHORITY	11/85	YELLOW	II	75	245.43	3.272
TURNPIKE AUTHORITY	11/85	BLUE	II	600	1,758.24	2.930
TURNPIKE AUTHORITY	3/86	ORANGE	II	150	560.40	3.736
TURNPIKE AUTHORITY	3/86	ORANGE	II	600	1,855.92	3.093
TURNPIKE AUTHORITY	3/86	YELLOW	II	225	741.96	3.298
TURNPIKE AUTHORITY	4/86	BLUE	II	300	981.72	3.272
				5,325	16,058.70	3.016
TOTAL TYPE II FISCAL YEAR 1986 (High Performance)				**59,325**	**$ 168,727.50**	**$ 2.844**

FISCAL YEAR 1987

CORRECTIONS	7/1/86	ORANGE	I	1,200	$ 1,140.00	$ 0.95
CORRECTIONS	7/1/86	BROWN	I	900	576.00	0.64
CORRECTIONS	7/1/86	SILVER/WHITE	I	900	576.00	0.64
CORRECTIONS	7/18/86	YELLOW	I	6,300	4,032.00	0.64
CORRECTIONS	8/6/86	SILVER/WHITE	I	3,600	2,304.00	0.64
CORRECTIONS	10/8/86	SILVER/WHITE	I	1,200	748.80	0.62
CORRECTIONS	10/8/86	SILVER/WHITE	I	4,500	2,808.00	0.62
CORRECTIONS	10/8/86	SILVER/WHITE	I	3,600	2,246.40	0.62
CORRECTIONS	10/8/86	YELLOW	I	1,500	936.00	0.62

AGENCY	DATE	COLOR	TYPE I/II	TOTAL SQUARE FEET	TOTAL COST	COST PER SQUARE FOOT
CORRECTIONS	10/8/86	ORANGE	I	900	561.60	0.62
CORRECTIONS	10/8/86	YELLOW	I	1,800	1,123.20	0.62
CORRECTIONS	11/24/86	SILVER/WHITE	I	4,800	2,995.20	0.62
CORRECTIONS	11/24/86	SILVER/WHITE	I	5,400	3,369.60	0.62
CORRECTIONS	12/22/86	SILVER/WHITE	I	4,800	2,995.20	0.62
CORRECTIONS	12/22/86	YELLOW	I	2,700	1,684.80	0.62
CORRECTIONS	5/8/87	SILVER/WHITE	I	2,400	1,497.60	0.62
CORRECTIONS	5/8/87	SILVER/WHITE	I	3,600	2,246.40	0.62
CORRECTIONS	5/8/87	ORANGE	I	1,800	1,123.20	0.62
CORRECTIONS	5/15/87	SILVER/WHITE	I	6,000	3,744.00	0.62
CORRECTIONS	5/21/87	SILVER/WHITE	I	2,400	1,497.60	0.62
				60,300	$ 38,205.60	$ 0.63
TRANSPORTATION	9/16/86	SILVER/WHITE	I	5,625	$ 3,510.00	$ 0.62
TRANSPORTATION	9/16/86	SILVER/WHITE	I	1,500	936.00	0.62
TRANSPORTATION	11/18/86	YELLOW	I	6,000	3,744.00	0.62
TRANSPORTATION	11/18/86	SILVER/WHITE	I	9,000	5,616.00	0.62
TRANSPORTATION	1/31/87	SILVER/WHITE	I	3,600	2,246.40	0.62
TRANSPORTATION	1/31/87	YELLOW	I	1,500	936.00	0.62
TRANSPORTATION	1/31/87	SILVER/WHITE	I	6,750	4,212.00	0.62
TRANSPORTATION	1/31/87	YELLOW	I	4,500	2,808.00	0.62
TRANSPORTATION	1/31/87	ORANGE	I	4,500	2,808.00	0.62
TRANSPORTATION	1/31/87	ORANGE	I	6,000	3,744.00	0.62
TRANSPORTATION	1/31/87	SILVER/WHITE	I	3,750	2,340.00	0.62
TRANSPORTATION	1/31/87	YELLOW	I	3,750	2,340.00	0.62
				56,475	$ 35,240.40	$ 0.62
TOTAL TYPE I FISCAL YEAR 1987 (Regular-Grade)				**116,775**	**$ 73,446.00**	**$ 0.63**
CORRECTIONS	7/1/86	YELLOW	II	1,200	$ 3,395.52	$ 2.83
CORRECTIONS	7/1/86	YELLOW	II	1,050	2,971.08	2.83
CORRECTIONS	7/1/86	SILVERT/WHITE	II	3,600	10,186.56	2.83
CORRECTIONS	7/1/86	YELLOW	II	1,500	4,244.40	2.83
CORRECTIONS	7/1/86	SILVERT/WHITE	II	3,000	8,488.80	2.83
CORRECTIONS	7/18/86	YELLOW	II	2,400	6,791.04	2.83
CORRECTIONS	7/18/86	YELLOW	II	2,400	6,791.04	2.83
CORRECTIONS	7/18/86	YELLOW	II	3,000	8,488.80	2.83
CORRECTIONS	7/18/86	YELLOW	II	1,050	2,971.08	2.83
CORRECTIONS	7/18/86	YELLOW	II	1,800	5,093.28	2.83
CORRECTIONS	7/18/86	SILVERT/WHITE	II	4,500	12,733.20	2.83
CORRECTIONS	9/5/86	YELLOW	II	5,400	15,824.96	2.93
CORRECTIONS	9/5/86	SILVER/WHITE	II	2,100	6,153.84	2.93
CORRECTIONS	9/5/86	SILVER/WHITE	II	2,400	7,032.96	2.93
CORRECTIONS	9/5/86	YELLOW	II	2,400	7,032.96	2.93
CORRECTIONS	11/25/86	ORANGE	II	1,800	5,274.72	2.93
CORRECTIONS	12/17/86	SILVER/WHITE	II	2,400	7,032.96	2.93
CORRECTIONS	12/17/86	YELLOW	II	2,400	7,032.96	2.93
CORRECTIONS	12/17/86	SILVER/WHITE	II	2,100	6,153.84	2.93
CORRECTIONS	12/17/86	YELLOW	II	2,700	7,912.08	2.93
CORRECTIONS	12/17/86	SILVER/WHITE	II	4,500	13,186.80	2.93
CORRECTIONS	12/17/86	YELLOW	II	1,500	4,395.60	2.93
CORRECTIONS	12/17/86	SILVER/WHITE	II	6,000	17,582.40	2.93

AGENCY	DATE	COLOR	TYPE I/II	TOTAL SQUARE FEET	TOTAL COST	COST PER SQUARE FOOT
CORRECTIONS	12/17/86	SILVER/WHITE	II	7,500	21,978.00	2.93
CORRECTIONS	1/23/87	YELLOW	II	2,100	6,153.84	2.93
CORRECTIONS	1/29/87	SILVER/WHITE	II	1,200	3,912.00	3.26
CORRECTIONS	2/6/87	YELLOW	II	5,400	15,824.16	2.93
CORRECTIONS	2/6/87	SILVER/WHITE	II	3,000	8,791.20	2.93
CORRECTIONS	3/23/87	YELLOW	II	1,500	4,395.60	2.93
CORRECTIONS	3/23/87	YELLOW	II	3,600	10,549.44	2.93
CORRECTIONS	3/23/87	SILVER/WHITE	II	1,200	3,516.48	2.93
CORRECTIONS	4/2/87	SILVER/WHITE	II	3,000	8,791.20	2.93
CORRECTIONS	4/2/87	YELLOW	II	3,600	10,549.44	2.93
CORRECTIONS	5/15/87	SILVER/WHITE	II	1,200	3,516.48	2.93
CORRECTIONS	6/30/87	SILVER/WHITE	II	3,750	10,989.00	2.93
CORRECTIONS	6/30/87	SILVER/WHITE	II	3,000	8,791.20	2.93
CORRECTIONS	6/30/87	SILVER/WHITE	II	3,600	10,549.44	2.93
CORRECTIONS	6/30/87	ORANGE	II	3,000	8,791.20	2.93
CORRECTIONS	6/30/87	ORANGE	II	3,600	10,549.44	2.93
CORRECTIONS	6/30/87	ORANGE	II	3,600	10,549.44	2.93
				115,050	$ 334,968.44	$ 2.91
TRANSPORTATION	7/9/86	YELLOW	II	2,250	$ 6,366.60	$ 2.83
TRANSPORTATION	7/21/86	YELLOW	II	1,125	4,357.80	3.87
				3,375	$ 10,724.40	$ 3.18
TURNPIKE AUTHORITY	7/86	YELLOW	II	225	$ 741.96	$ 3.30
TURNPIKE AUTHORITY	7/86	GREEN	II	1,800	5,890.32	3.27
TURNPIKE AUTHORITY	9/86	ORANGE	II	600	1,670.33	2.78
TURNPIKE AUTHORITY	9/86	SILVER/WHITE	II	13	36.63	2.93
TURNPIKE AUTHORITY	9/86	SILVER/WHITE	II	75	219.78	2.93
TURNPIKE AUTHORITY	9/86	SILVER/WHITE	II	100	293.04	2.93
TURNPIKE AUTHORITY	9/86	SILVER/WHITE	II	150	439.56	2.93
TURNPIKE AUTHORITY	11/86	BLUE	II	600	1,963.44	3.27
TURNPIKE AUTHORITY	11/86	SILVER/WHITE	II	300	989.28	3.30
TURNPIKE AUTHORITY	2/87	BLUE	II	600	1,963.44	3.27
TURNPIKE AUTHORITY	2/87	YELLOW	II	600	1,758.24	2.93
TURNPIKE AUTHORITY	2/87	ORANGE AND WHITE	II	600	1,901.52	3.17
TURNPIKE AUTHORITY	2/87	ORANGE AND WHITE	II	600	1,901.52	3.17
TURNPIKE AUTHORITY	3/87	SILVER/WHITE	II	450	1,318.68	2.93
TURNPIKE AUTHORITY	3/87	ORANGE	II	600	1,855.92	3.09
TURNPIKE AUTHORITY	4/87	GREEN	II	1,200	3,926.88	3.27
				8,513	$ 26,870.54	$ 3.16
TOTAL TYPE II FISCAL YEAR 1987 (High Performance)				**126,938**	**$ 372,563.38**	**$ 2.94**

APPENDIX B

1987 Highway Projects With Traffic Control

	Kansas Department of Transportation (a)			Kansas Turnpike Contracts	Total Kansas Contracts
	Per-Day Contracts(b)	Lump-Sum Contracts(c)	Total KDOT Contracts		
Number of Contracts (d)	51	282	333	18	351
Total Cost, All Contracts	$153,917,435	$65,873,873	$219,791,308	$11,913,079	$231,704,387
Average Cost Per Contract	$3,038,604	$233,103	$659,539	$661,838	$660,126
Total HP Sheeting Cost, All Contracts	$291,503	$307,591	$599,094	$32,043	$631,137
Average Cost of HP Sheeting Per Contract	$5,755	$1,088	$1,798	$1,780	$1,798
HP Sheeting Cost as Percent of Total Contract Cost	0.19%	0.47%	0.27%	0.27%	0.27%
Total Square Feet of HP Sheeting, All Contracts	105,726	110,397	216,123	11,432	227,555
Average Square Feet of HP Sheeting Per Project	2,087	391	649	635	648
Average Cost Per Square Foot of HP Sheeting	$2.76	$2.79	$2.77	$2.80	$2.77
Difference in Contractors' Costs If Regular-Grade Sheeting Had Been Used	$229,125	$242,456	$471,580	$25,298	$496,878

(a) Annual totals were estimated from projects let in January through September 1987.
(b) Per-day contracts are generally larger projects that have more than one phase or multiple changes in traffic patterns within the construction area.
(c) Lump-sum contracts are generally for smaller projects that are not bid on a per-day basis.
(d) The projected number of KDOT contracts have been rounded to whole numbers.

APPENDIX C

Agency Response

On January 14, 1988, copies of the draft audit report were sent to the Kansas Department of Transportation and the Kansas Turnpike Authority for review and comment. The Department of Transportation's written response is included in this appendix. The Turnpike Authority did not send a written response, but indicated that it basically agreed with the audit report.

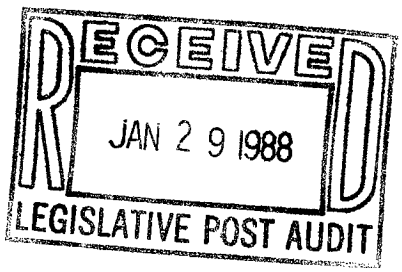
STATE OF KANSAS

KANSAS DEPARTMENT OF TRANSPORTATION
Docking State Office Building
Topeka 66612-1568
(913) 296-3566

Horace B. Edwards
Secretary of Transportation

Mike Hayden
Governor of Kansas

January 28, 1988



Mr. Meredith Williams
Legislative Post Auditor
Legislative Division of Post Audit
109 West 9th, Suite 301
Mills Building
Topeka, Kansas 66612

Dear Mr. Williams:

Thank you for the opportunity to comment on the draft Legislative Post Audit Report, Reflective Sheeting Used In Highway Construction Zones. I would like to direct my comments to the following observations and conclusions in the draft report: the auditor's estimates of square footage of high performance sheeting used on highway projects and cost estimates resulting from such usage, contractors' responses on traffic signing, and pavement marking characteristics and cost estimates.

The draft report notes that the auditors estimated that, "more than 227,000 square feet of high performance sheeting was (sic) used on all highway projects let in 1987." Clarification needs to be made whether this statement is intended to cover both permanent and temporary traffic control devices. Using this estimate of quantity, the report concludes that an estimated $631,000 was spent on high performance sheeting in 1987.

The base estimate of 227,000 square feet of sheeting assumes that a sign or traffic control device is used one time and then discarded or replaced. The estimate does not recognize that signs and traffic control devices are often used on more than one project; consequently, the cost estimate is overstated. If it is assumed that a sign is used on at least two projects, the $631,000 estimate would be reduced by half, and by even more if signs and traffic control devices are used on three or more projects.

The report also notes that bids for traffic control items increased in late 1985 following announcement of the March 1986 policy to use high performance sheeting on construction projects. The conclusion is made that "...forces other than the cost of the sheeting affect the bids...". In fact, we were aware that the policy to use high performance sheeting and plastic drums in construction work zones would require contractors to replace a larger percentage of their inventory than normal. These initial replacement costs in inventory outlays were reflected in the bids for traffic control as should be expected. It is logical that as these initial costs have been amortized, bid prices have stabilized as reflected in the cost comparisons for 1985, 1986, and 1987.

Regarding contractors' responses, the report observes that highway contractors did not think high performance sheeting improved safety in construction work zones. These opinions should be placed in their proper context. First, the majority of contractors are not traffic engineers, and their statements relative to traffic management and safety are not those of expert traffic engineers. Second, in the event of a traffic accident, any resulting liability for the traffic control plans will be with the Department of Transportation. As a means of reducing injuries and fatalities, a great deal of effort is expended by the State to improve traffic control procedures in construction work zones. The use of reflective sheeting is just one component. Comments such as, "traffic doesn't seem to pay too much attention to the signs," may illustrate a lack of understanding of the dynamics and importance of traffic control.

The audit report sought to solicit evaluations on high performance sheeting "by users in Kansas," but presents the responses of contractors and rental firms as representing users. This representation is not accurate. The prime "user" of reflective sheeting is the motorist trying to negotiate a vehicle through a construction work zone at different hours of the day and night and under a variety of atmospheric and weather conditions. Construction work zones present the motorist with an abnormal set of traffic conditions which require communication of additional information for decision-making. A desirable environment is one which assists the motorist to travel safely through a construction zone and protects both the motorist and the construction worker.

I have concerns about the recommendation noted on page 11 of the report which advises the Department to allow both regular grade and high performance sheeting in construction work zones. Such a policy would increase both project costs and construction engineering costs. Contractors would be required to maintain dual inventories increasing their costs. Their increased costs would be reflected in their bids and would be ultimately paid by the agency and the taxpayer. Also, agency construction personnel would be required to determine which traffic control devices are regular grade and which are high performance. Construction engineering costs would increase and personnel would be diverted from other duties. I do not agree with this recommendation.

Regarding the use of paint versus tape on pavement markings, the report concludes that: "Given the higher cost of tape, it is likely that contractors would choose to apply paint." Contractors presently have the option of using either paint or Type I tape for temporary marking (with a few exceptions) and have chosen tape. The average cost of this option is $.36 per foot, not $.04 to $.06 per foot as indicated. There are several reasons for this. Paint requires a paint crew to mark the roadway whereas tape can be assigned to one laborer by the contractor, thereby keeping labor and equipment costs down. Once the project is completed, any paint or Type I tape used for temporary marking must be removed by costly shotblasting or other methods leaving permanent scars on the road surface. Scarring of the road surface leaves a permanent marking which is quite pronounced and leads to driver confusion, especially at night.

Further, I offer the following corrections and clarifications to the table on page 13 of the report:

1). The column "Durable Pavement Marking Materials" should be titled "Permanent Pavement Marking Materials," and should list paint as a permanent pavement marking material.

2) The costs cited for paint ($.04 - $.06) are for paint applied by state maintenance crews, not for painting that is contracted out as would be the case on a project.

3) Paint <u>cannot</u> be applied under any weather conditions, there are limitations.

I concur with the recommendation to review the pavement marking policy to include temporary pavement markings. I have concern however, with the second item in the recommendation concerning the cost effectiveness of pavement marking materials. I agree with the recommendation to conduct a detailed analysis of cost effectiveness so long as the cost effectiveness is weighed against the safety concerns. A pavement marking policy which overemphasizes cost effectiveness could have disasterous results over the long term period. I believe we should continue to provide the greatest margin of safety to our traveling public within the limits of available resources.

Thank you for the opportunity to provide these comments and clarifications to the report.

Sincerely,

Horace B. Edwards

Horace B. Edwards
Secretary of Transportation