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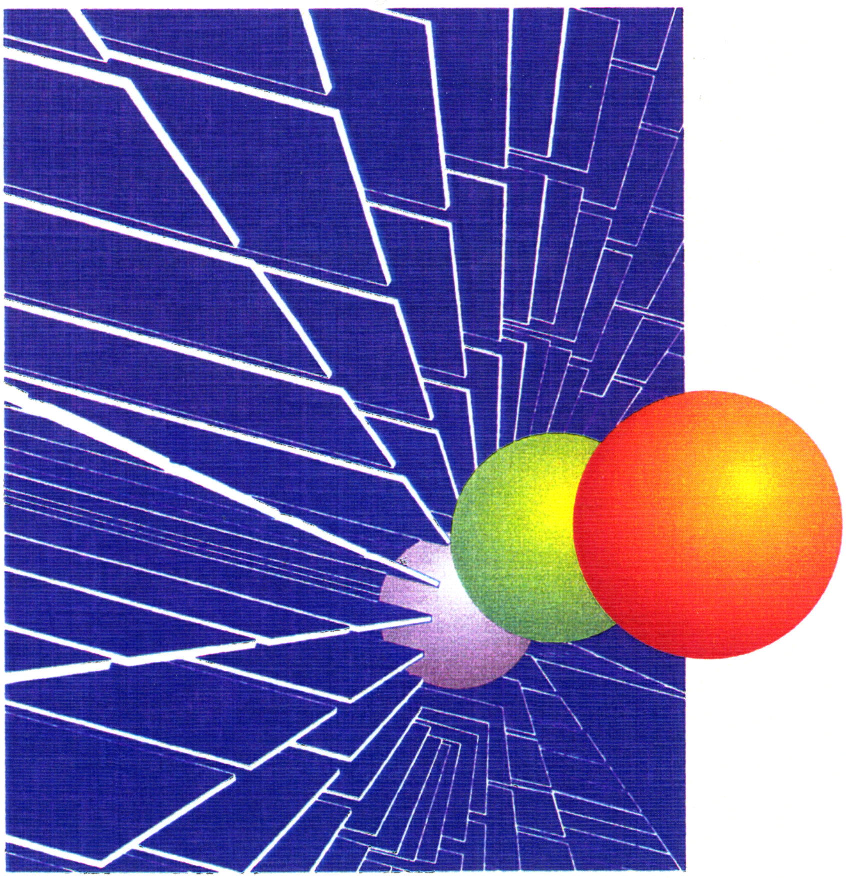
Research, Development and Technology

RDT 00-001B

Construction Report - U.S. Highway 36, Superpave Overlay of Sand Anti-Fracture Layer Over AC/PCC Pavement

RI 99-042



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16. Abstract
The sand anti-fracture (SAF) technology was implemented on U.S. 36 in DeKalb County, Missouri, during the summer of 2000. The SAF layer is a fine aggregate graded asphalt mixture using highly polymerized asphalt binder that gives the SAF layer the ability to withstand more strain compared to a conventional asphalt mix. The SAF layer was incorporated into MoDOT's rehabilitation strategy as a stress relieving membrane. The project includes two test sections that will be used to monitor the performance of the SAF layer. These test sections will be compared to each other to determine the SAF layers effectiveness in reducing reflective cracking, decreasing future maintenance costs, and extending the life of an overlay.

This interim report contains information regarding the construction of this project and initial SAF performance. Visual distress surveys and automated road analyzer (ARAN) data were conducted on the original pavement surface before construction to identify distressed pavement areas, and they also were conducted after construction to evaluate initial SAF performance. Visual distress surveys and ARAN data will be conducted annually until the performance of the SAF can be compared and evaluated to MoDOT's conventional methods, at which time a final report will summarize the findings.

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RESEARCH INVESTIGATION RI99-042

CONSTRUCTION REPORT
U.S. HIGHWAY 36 – SUPERPAVE OVERLAY OF
SAND ANTI-FRACTURE LAYER OVER AC/PCC PAVEMENT

PREPARED BY
MISSOURI DEPARTMENT OF TRANSPORTATION
RESEARCH, DEVELOPMENT, AND TECHNOLOGY

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EXECUTIVE SUMMARY

This project on U.S. Highway 36 in DeKalb County was constructed during the summer of 2000 in District 1. The significance of this project is continuing the evaluation of the sand anti-fracture (SAF) technology. The purpose of the SAF layer is to retard reflective cracking, which in turn, should reduce future maintenance costs and extend the life of the overlay. The SAF technology was first demonstrated in 1998 on Route I-29 in Holt County. The I-29 project consisted of constructing the SAF layer between an existing PCC pavement and a SuperPave overlay. The SAF layer on this project is placed between a composite AC/PCC pavement and a new SuperPave overlay.

The U.S. 36 resurfacing project consists of a 1-inch SAF layer, 2-inch SP190 layer, and 1 ¾-inch SP125 layer. The project includes two test sections that will be used to monitor the performance of the SAF layer. One test section is a control section, which uses MoDOT's standard SuperPave mixes without the use of the SAF technology. The other test section incorporates the 1-inch SAF layer to supplement the SuperPave mixes. These test sections will be compared to each other to determine the SAF layers effectiveness in reducing reflective cracking, decreasing future maintenance costs, and extending the life of an overlay.

The overall construction of the SAF layer was a successful accomplishment. Many of the construction problems that occurred during the I-29 project did not occur on this project. The SAF layer proved to be a stable mix and was able to withstand traffic and heavy construction loads without rutting in the traffic lanes. However, since the SAF layer provides minimal structural support, it will crack and deform upon failure of the underlying layers. Rutting and cracking of the SAF layer occurred on the shoulders where the underlying PMBB failed to support heavy construction loads.

The additional cost of constructing the SAF layer on the U.S. 36 project was approximately $34,000 per lane mile. MoDOT did not benefit from a reduction in pavement repair costs due to the addition of the SAF layer.

The SAF layer will be evaluated on the U.S. 36 project until solid conclusions can be drawn on the SAF's performance. Based upon construction observations and issues that occurred during the U.S. 36 project, Research, Development, and Technology recommends the following:

- The SAF layer should not be used on weak underlying layers. Failure of a weak layer will result in rutting and cracking of the SAF layer.
- The SAF layer is not recommended as an alternative to full-depth pavement repair in areas of structural failures.
- Life cycle cost comparisons of the SAF method and MoDOT's conventional method need to be performed to determine the cost effectiveness of the SAF technology as a pavement rehabilitation option.
- An effort should be made to research the findings of other SAF projects that have recently been constructed in other states.

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INTRODUCTION

Asphalt overlays are the primary pavement rehabilitation strategy used by MoDOT. Asphalt overlays can be used on both existing PCC and asphalt pavements. Asphalt overlays, however, are usually subject to reflective cracks, which decreases the serviceability and life of a pavement. This problem originates with horizontal deformation or movement of the underlying layers, usually at PCCP joints. The movement creates high tensile strains at the bottom of the HMA overlay, which in turn, causes hairline cracks to form. Eventually, the hairline cracks increase in severity and propagate through the layer to the asphalt surface[1].

Reflective cracks in asphalt overlays often accelerate pavement deterioration, which affects ride ability and shortens the life of the overlay. Maintenance crews also can spend much of their time performing crack sealing procedures to help prolong the life of the overlay. In an effort to reduce reflective cracking in asphalt overlays, the sand anti-fracture (SAF) layer was implemented as MoDOT's rehabilitation strategy for the U.S. 36 project. The SAF layer is a sand asphalt mixture containing high-polymerized asphalt binder, which is placed between the existing pavement and the new asphalt overlay. The SAF layer was incorporated into MoDOT's rehabilitation strategy as a stress relieving membrane. The SAF layer is proposed to absorb the high strains that occur at the bottom of asphalt overlays and prevent reflective cracks from forming.

Stress relieving membranes have not worked for MoDOT in the past. In 1986, MoDOT research personnel performed an investigation on four different types of fabrics to control reflective cracking in an AC overlay on PCC pavement[2]. The fabrics were not recommended for the following reasons:

- The high percentage of reflective cracking found in the areas above the fabric covered joints.
- The multiple cracking patterns exhibited in sections with the interlayer fabrics were more difficult and costly to seal compared to one reflective crack with no fabric.
- No apparent differences in performance between test and control sections on longitudinal joints.

A legitimate concern from these earlier tests on fabric types of stress relieving membranes is multiple cracking propagating to the asphalt overlay surface. It is believed this occurs when the membrane spreads the tensile stress over a broader area. Instead of receiving one reflective crack at the surface, finer multiple cracks appear. This situation could lead to greater maintenance requirements.

The SAF layer differs from other membranes in that it is an asphaltic concrete mix. However, compared to a conventional asphalt mix, the SAF mix has a higher voids in the mineral aggregate (VMA), higher asphalt binder content, and lower air voids. The SAF also contains more sand or finer graded aggregate than a conventional mix. The intent of the SAF mix is to utilize the high polymer binder characteristics in resisting more pavement strains than conventional asphalt concrete. Koch Materials, the representative of the SAF technology, have conducted SHRP 4-Point Beam Fatigue Tests on the SAF. Laboratory results show that the SAF can withstand approximately 4.5 times more strain without cracking at one million loading cycles than a conventional asphalt mix[3]. The SAF is able to dissipate energy induced by thermal and load related stresses. The SAF layer, however, has a lower structural coefficient that is about half compared to standard asphaltic concrete. Koch Materials suggests that the structural benefits of the SAF layer are minimal and not significant enough to be a factor in the design thickness of the asphalt overlay[4].

The SAF technology was first applied in Missouri in 1998 on a PCCP rehabilitation project located on Route I-29 in Holt County. The SAF layer was originally proposed by the manufacturer as a method of reducing the amount of pavement repairs performed before an asphalt overlay is constructed. Koch Materials promoted that initial project savings should be realized in the reduction of pavement thickness and less repair to the existing PCC pavement. Hence, the I-29 SAF project was constructed with numerous test sections incorporating various degrees of pavement repair and at variable thicknesses in an effort to evaluate the maxi mum capabilities of the SAF layer. However, with a lower structural coefficient, the SAF layer has since been acknowledged to have limitations as an alternative to pavement repair, specifically in areas of structural pavement failures. MoDOT's intention when designing overlays is to add structure to the underlying pavement. Pavement repairs prior to the overlays should then include only severely distressed areas where there is a structural failure. Otherwise, minor to moderate distresses are generally not repaired. It is these minor to moderate locations where the SAF layer could provide potential benefit by retarding the occurrence of reflective cracking and then extending the serviceability and life of the overlay.

The more recent application of the SAF layer was the U.S. 36 project in DeKalb County. The purpose of this project was to evaluate the SAF layer's effectiveness in reducing reflective cracking in a new asphalt overlay that is constructed over an existing AC/PCC pavement. The U.S. 36 project includes two test sections. One test section incorporates the 1-inch SAF layer while the other section is a control section without the SAF layer. Both test sections have a SuperPave asphalt overlay consisting of a 2-inch SP190 binder course and a 1 ¾-inch SP125 surface course. The test sections will be monitored and compared on an annual basis for a minimum of 5 years where RD&T anticipates conclusions and recommendations to be made. However, further monitoring may be warranted depending on the pavement performance and service life of the pavement. This report contains information on the construction of the project. The recommendations and conclusions included in this report are drawn from construction observations and initial pavement performance.

OBJECTIVES

The objective of this research investigation is to evaluate the effectiveness of the sand anti-fracture layer in reducing reflective cracking in asphalt overlays over existing AC/PCC pavements. The benefits that MoDOT anticipates from the SAF layer are a reduction in reflective cracking, lower maintenance costs, and a longer lasting service life of the asphalt overlay.

TECHNICAL APPROACH

Project Origin

The original pavement was constructed in 1927 consisting of a 6-inch reinforced PCC pavement 22-feet in width. The original pavement also had a 9-inch Type B asphalt shoulder approximately 2-feet in width per side. The pavement was overlaid with asphalt in 1952, 1967, and 1983. A typical section of the existing pavement is illustrated in Figure 1. Figures 2 and 3 illustrate the original pavement conditions that were typical in this project.

The existing pavement was in fair to poor condition. High levels of reflective cracks, longitudinal wheel path cracking, and edge cracking were the main surface distresses that were visible on the asphalt surface constructed in 1983 on U.S. 36. The surface distresses consisted of approximately 6 % of the pavement area. A 5 ¾-inch asphaltic concrete overlay supplemented by a 1-inch SAF layer was proposed as the rehabilitation option for U.S. 36. District 1 elected using the SAF layer under an AC overlay as a means of rehabilitation because of their earlier experience on I-29.

The SAF layer that was constructed on I-29 in Holt County during the summer of 1998 was performing comparably to MoDOT's conventional rehabilitation methods. The original pavement on the I-29 project had many distresses, primarily at the joints caused by D-cracking. Therefore, the SAF technology also seemed to be a good alternative as a pavement rehabilitation strategy on the U.S. 36 project.

The SAF project (Job No. J1P0764) was constructed in June 2000 on the eastbound lane of U.S. 36 in DeKalb County, Missouri. A map showing the project limits is located in Figure 4. The average daily traffic (ADT) for the eastbound lane of U.S. 36 is 6,350 for year 2000 and is projected to be 8,100 for the year 2010. The percentage of truck traffic is 12%.

Pavement Repair

The purpose of the SAF layer is to cover minor pavement distresses and resist reflective cracking from propagating through the new asphalt overlay. Full-depth pavement repairs are necessary at any moderate or high D-Crack areas, high severity punch-outs, blow-ups, and severe distresses as listed in Distress Identification Manual for the Long-Term Pavement Performance Project (SHRP-p-338)[5]. Although MoDOT personnel estimated 6 % of the pavement areas on the U.S. 36 project were distressed, approximately 2 % was selected to be repaired throughout the SAF project. These were the most severely distressed areas, in which there were indications of structural failure. Over 6 % of pavement repairs were performed for the control section on this project. It is highly likely that of the 6 % of pavement repairs conducted not all were repairs to replace structurally failed pavement. It is felt that of the 6 % pavement repairs, 2 % was more representative of repairs to structural failed areas. As indicated earlier, MoDOT does not require pavements to be repaired with minor to moderate surface distresses. It is believed that the overlay should accommodate the minor pavement deficiencies of the underlying layers. Despite this, one could claim that as a result of using the SAF on the U.S. 36 project, a reduction in pavement repair did occur. A summary of pavement repair quantities for both the 2 % and 6 % estimates are located in Appendix A for informational purposes.

Shoulder Rehabilitation

The original lane width on U.S. 36 was 11-feet. The original shoulders were now a part of the traffic lane. Therefore, base widening and shoulder rehabilitation were important components of this project. As Figure 1 illustrates, a 10-inch plant mix bituminous base (PMBB) was constructed approximately 2-feet wide to extend the traffic lane to 24-feet. Shoulders were constructed consisting of a 4-inch PMBB, 4-feet wide. After shoulder re-construction, the SAF layer and the SuperPave overlays were constructed across the entire cross section of the pavement.

Project Construction

After base widening, the new overlay consisted of laying a 1-inch sand anti-fracture layer, 2- inch SuperPave SP190 mix, and a 1 ¾-inch SuperPave SP125 mix, respectively. The special provisions for the SAF layer are included in Appendix B of this report. A copy of the mix designs and material properties for each asphalt mix constructed on the U.S. 36 project are located in Appendix C of this report. The SAF layer and the SuperPave layers were constructed over the entire width of the pavement starting at station 841+52.10 and ending at station 996+25.00. The remaining length of the project (Station 996+25.00 to 1011+25.00) does not contain the SAF layer and will be used as a control section for this investigation. The project ends at station 1011+25.00 for a total length of 2.139 miles.

The overall construction of the SAF layer went very well. Figures 5 and 6 are photos taken of the SAF layer after construction. The SAF layer was very stable and showed no signs of rutting after approximately 40 hours of traffic exposure. Most of the construction issues that occurred on the I-29 project did not occur on the U.S. 36 project. There was no significant rutting. Trucks unloaded the SAF with few difficulties. Only minor blisters formed at the surface. Density was easily achieved.

One construction problem that occurred on this project was the tearing in the SAF mat behind the paver. This occurred often throughout the construction of the layer. Figure 7 illustrates a typical tear mark. This could have been caused by the irregular surface of the existing pavement. The SAF layer appeared to be thicker (greater than 1-inch) at the shoulders of the pavement and thinner (less than 1-inch) in the middle portions. Due to the irregular surface, the paver's screed might have drug the middle portions of the lane and created the tears of the SAF mat. To correct this problem, the contractor's workers scooped SAF material and spread it over the tear marks before compacting. After compaction, the tear marks in the SAF mat were not noticeable, and it was a very smooth and stable layer. From this experience, a level surface is proposed for future use of the SAF layer, which could help alleviate the tearing problem of the SAF mat.

One observation of the SAF mat after compaction on U.S. 36 was its "smooth" appearance. The SAF layer constructed on the I-29 project in Holt County had substandard skid resistance. Testing performed on the I-29 SAF layer indicated an average skid number of 29.8. This skid number is low compared to a conventional asphalt surface that have skid resistance values around 40. The construction on the U.S. 36 project was staged to where the SAF layer was exposed to traffic for a short amount of time and no problems with skid resistance were anticipated. Skid testing should be a requirement for future SAF projects to determine if any safety precautions need to be taken, especially for SAF layers open to traffic for extended periods of time.

Another construction issue that occurred on the U.S. 36 project was the presence of dust balls in the mix. This did not necessarily reflect on the SAF mix since it appears to be noticeable in other MoDOT asphalt mixes. The problem appears to be due to moisture in the drum causing dust particles to stick to the drum fins. After the dust builds up, the dust balls fall into the mix. The size of the dust balls ranged from approximately 2 inches in diameter to small specs. Figure 8 and 9 illustrates the present of dust balls in the mix. This was not common throughout the entire project, but it did occur in some areas of the project.

A third problem was trying to maintain a stable mix temperature at the plant. There were unexplained significant spikes and dips in the mixing temperature range. Appendix D includes temperature recordings of the SAF mix at the asphalt plant. There were several times in which the temperature either exceeded or fell below the recommended mixing temperature of 340 degrees Fahrenheit. The high mixing temperatures of the SAF mix appeared to cause minor blisters to appear on the SAF mat and could have caused aging of the asphalt binder. Lower mixing temperatures could have added to the cause of the SAF mat tears and minor difficulties in unloading trucks.

Finally, rutting and cracking of the SAF layer appeared on the shoulder areas. The shoulder areas only had 4 inches of PMBB, which was not enough to structurally support heavy construction loads. Figures 10 and 11 show the SAF mat on the shoulder area after the underlying layers failed. The SAF layer is designed as a stress relieving membrane to prevent reflective cracking from penetrating to the top of the surface. The SAF layer provides minimal support, which was demonstrated by the failure of the SAF layer over the PMBB at the shoulder areas.

The SAF mix properties proved to be uniform throughout the project. Table 1 contains field verification results of the SAF mix volumetric properties. The SAF mix was sampled and tested for volumetric properties at random locations according to QC/QA procedures. Two revisions were made to the SAF mix at the beginning of construction. One change was eliminating 4% of the limestone screenings and replacing with 4% of the manufactured sand. The second revision was increasing the asphalt content by 0.2%. Due to the visual "dry" appearance of the SAF mat, the revisions were made to make the mix "wetter".

The contractor did an exceptional job in monitoring and controlling the quantity of asphalt binder that went into the SAF mix. As learned from the project on I-29, all asphalt binder screens, flow orifices, and other measuring devices need to be checked for clogging. Figure 12 shows a clogged screen that had to be cleaned in order for the asphalt binder to flow. Unclogged equipment is essential in order to introduce the highly polymerized binder into the SAF mix.

RESULTS AND DISCUSSION

Monitoring Areas & Testing

The Research, Development, and Technology (RD&T) personnel established an 800 ft. monitoring area for both test sections. The monitoring areas include a 50 ft. lead in and a 50 ft. lead out, which are designated areas to take cores for the research investigation. Pavement distress surveys will be performed on the 800 ft. monitoring areas to evaluate the performance of the SAF in retarding reflective cracking. The SAF layer will be evaluated on its performance of retarding reflective cracking compared to the control section. Table 2 shows the locations and layout of each monitoring area for each test section. It is believed that the SAF layer will not reduce full-depth pavement repairs that MoDOT performs on its rehabilitation projects. However, the SAF continues to be evaluated on the I-29 project as a method of reducing full-depth pavement repairs.

After pavement repairs on the U.S. 36 project were completed, personnel from RD&T performed initial distress surveys on each monitoring area. The locations of severe cracks in the existing pavement were marked with tape along a nearby fence on the right-of-way. The intent is to mark locations where reflective cracking may appear first.

The SAF layer is designed as a stress relieving membrane to prevent reflective cracking from penetrating to the top of the surface. During the construction, the SAF layer rutted and cracked on the shoulder areas where the underlying PMBB failed to support heavy construction loads. This demonstrates that the underlying layers of pavement need to be structurally sufficient to hold the loads because the SAF layer has minimal structural support. The purpose of the SAF layer is to help dissipate the tensile strains created by horizontal deformation or movement of the underlying layers, which is the main cause of reflective cracks. The SAF layer will not withstand the vertical movements or deformations of the underlying layers.

After the construction of the SuperPave layers, the RD&T crew performed a final distress survey of the newly constructed surface to verify that no distresses appeared immediately after construction. Pavement markings were then placed on the finished surface of where underlying cracks are located in order to identify areas where cracking will be most likely to occur first. Currently, the pavement surface of U.S. 36 is in good condition. ARAN data shows that the average present serviceability index (PSR) value is 33.9 out of 40 (40 being excellent).

RD&T will monitor the U.S. 36 SAF project annually for a minimum of 5 years, at which the evaluation of the SAF layer could be finalized. However, further monitoring may be warranted depending on the pavement performance and service life of the pavement. The SAF layer will be evaluated to determine the effectiveness of the sand anti-fracture layer in reducing reflective cracking compared to MoDOT's conventional overlays. Measuring reflective cracks on both tests sections will be an important assessment of this project. Also, based upon the surface distresses, a projection will be made on the SAF's effectiveness of extending the service life of the overlay. Finally, a cost-savings from using the SAF layer will be estimated provided there is lower maintenance of sealing cracks and an extended overlay life.

SAF Costs

The cost of constructing the SAF layer is approximately $34,000 per lane mile. This project did not benefit from initial savings due to reduced pavement repairs. The SAF layer increased the initial project cost by $172,500. A life cycle cost analysis will be necessary to prove any monetary savings from lower maintenance costs and extended pavement life. The cost estimates, bid price items, and actual quantities can be found in Appendix E of this report. The cost of the SAF layer was significantly higher for this project ($4.81/yd^2) compared to the I-29 project ($2.97/yd^2). The cost of constructing the SAF layer on the I-29 project was $22,500 per lane mile. The increase in price is most likely due to the surge of the crude oil prices that has occurred in the United States in the year 2000.

CONCLUSIONS

The long-term effectiveness of the SAF layer in reducing reflective cracks cannot be determined at this time. The conclusions in this paper are based upon issues that occurred during construction of the SAF layer on the U.S. 36 project. The main findings are summarized below:

- The SAF layer was able to withstand traffic and heavy construction loads without rutting in the traffic lanes and appeared to be very stable. Trucks unloaded the mix with minor difficulties. Blisters in the SAF mat were not common. Density of the SAF material was easily achieved.

- Tear marks in the SAF mat caused by paving over existing surface irregularities were common throughout construction. They do not appear to be affecting initial pavement performance.

- The SAF layer was overlaid with the SuperPave SP190 mix within two days. However, during the interim time the SAF layer appeared to have substandard skid resistance.

- The SAF mix contained numerous dust balls at certain locations.

- Temperature variations from the specified temperature of the SAF asphalt binder occurred at the asphalt batch plant. Overheating could have led to blisters in the SAF mat and aging of the asphalt. Cool spots may have added to the cause of the SAF mat tears and minor difficulties in unloading trucks.

- Rutting and cracking of the SAF mat occurred on the shoulder areas where the underlying PMBB layer failed under the construction loads.

- SAF mix properties were uniform throughout the project. Also, the amount of asphalt in the mix was controlled and monitored well.

- The SAF layer increased the initial project cost by $172,000 ($34,000 per lane mile). The future cost savings of reduced maintenance and extended overlay life remains to be determined.

RECOMMENDATIONS

Based upon construction observations and issues that occurred during the U.S. 36 project, Research, Development, and Technology recommends the following:

- The existing pavement surface should be level prior to overlay of SAF layer. This will help keep the SAF layer thickness uniform and possibly help prevent tearing in the SAF mat.

- The SAF layer should not be open to traffic for extended periods of time due to substandard skid resistance and possible rutting. Traffic control should be staged, where possible, to not let traffic on the SAF layer at all.

- The plant should be monitored for dust ball build up problems.

- Temperature control is essential. Need improvements at the plant to stabilize and control the temperature of the asphalt mixes.

- The SAF layer should not be used on weak underlying layers. Failure of a weak layer will result in rutting and cracking of the SAF layer.

- All asphalt binder screens, flow orifices, and asphalt tank sticks should be checked for clogging. Unclogged equipment is essential in order to introduce the highly polymerized binder into the SAF mix.

- A life cycle cost comparison is needed to determine the cost effectiveness of the SAF technology as a pavement rehabilitation option.

- Findings of other SAF projects that have recently been constructed in other states should be researched.

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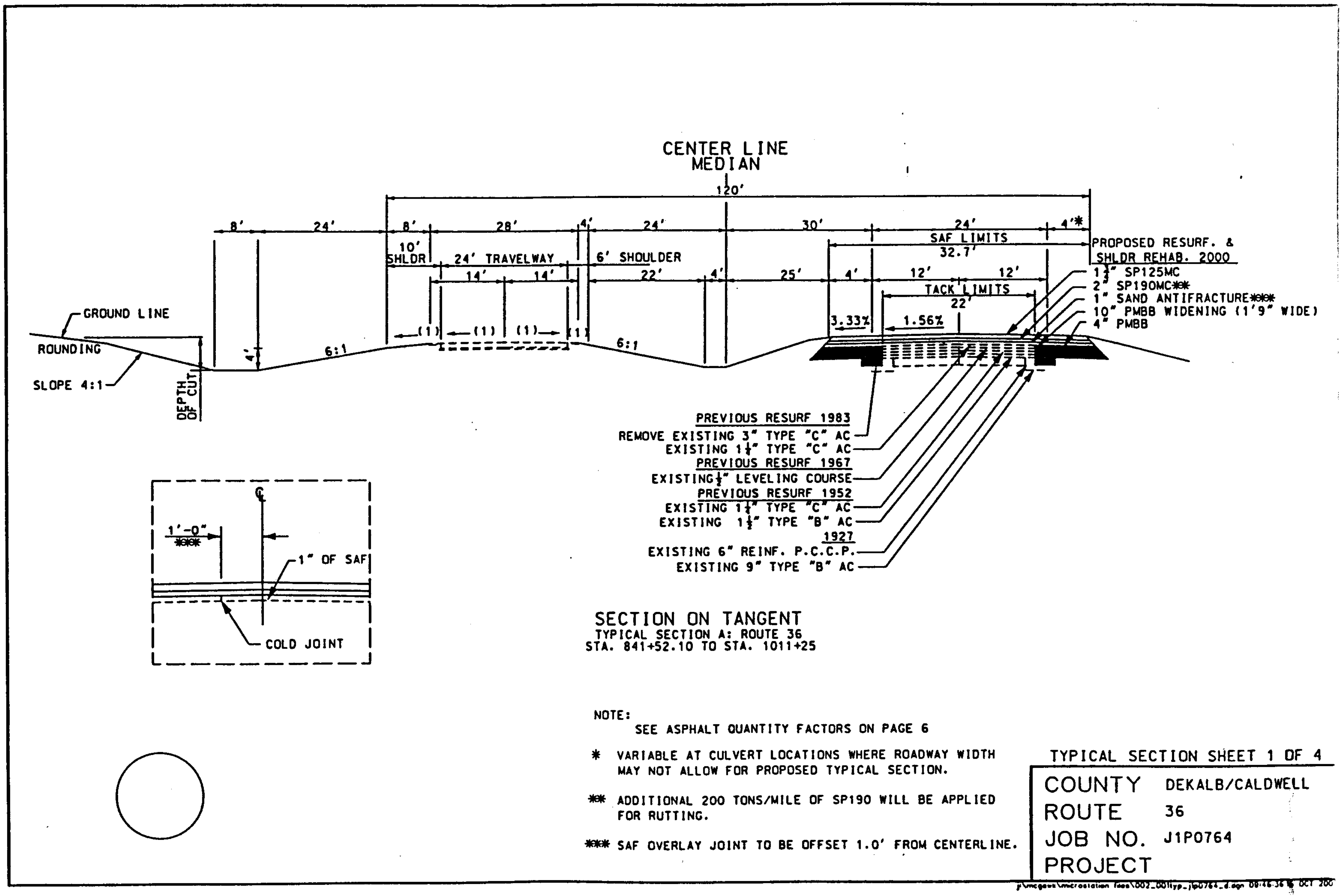


Figure 1 Pavement Cross-Section

Figure 2 – Original Pavement Condition

Figure 3 – Original Pavement Condition

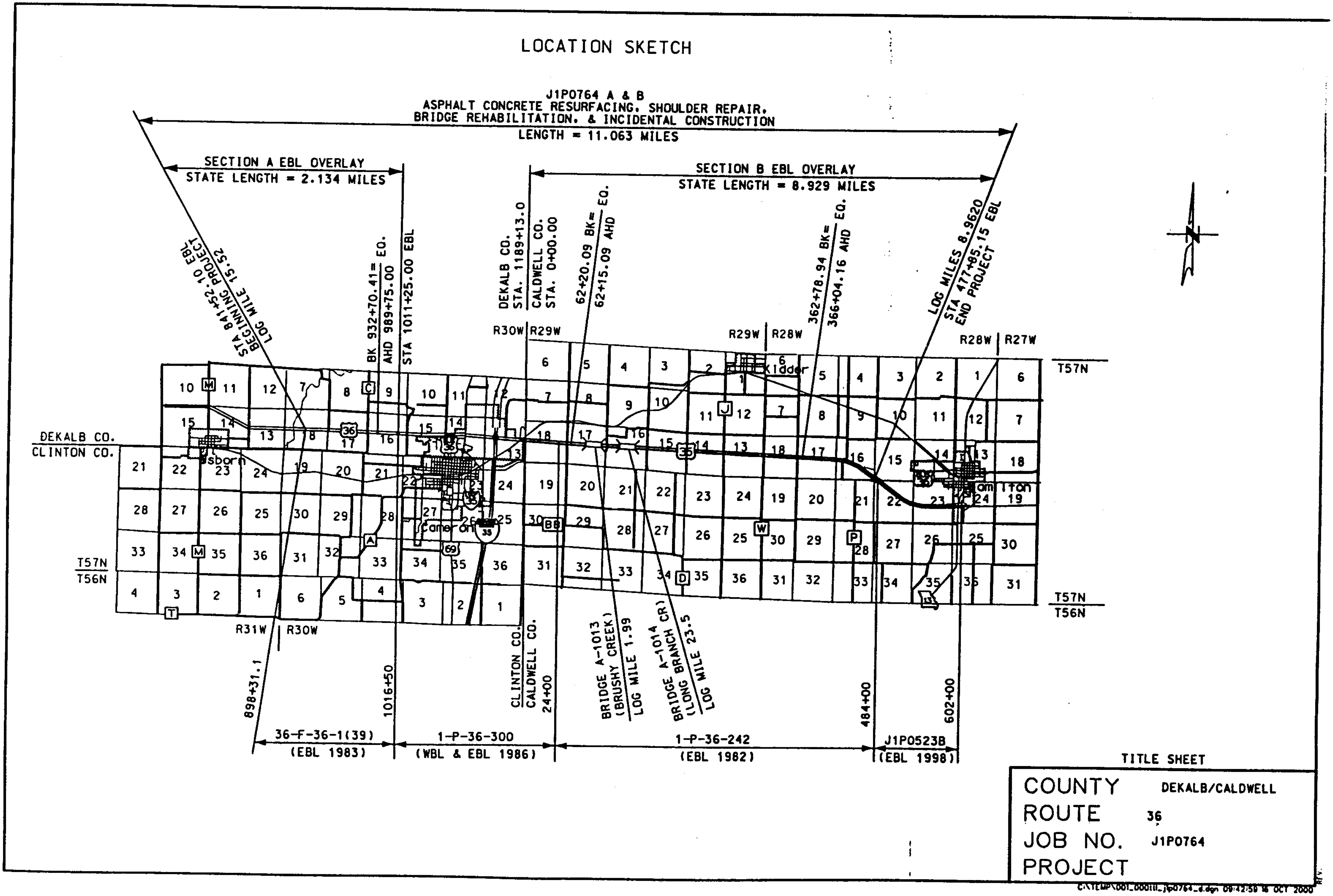


Figure 4 Project Limits

Figure 5 – SAF Layer


Figure 6 – SAF Layer

Figure 7 – Tear Marks in SAF Mat

Figure 8 – Dust ball in SAF mix

Figure 9 – Dust Balls in SAF mix

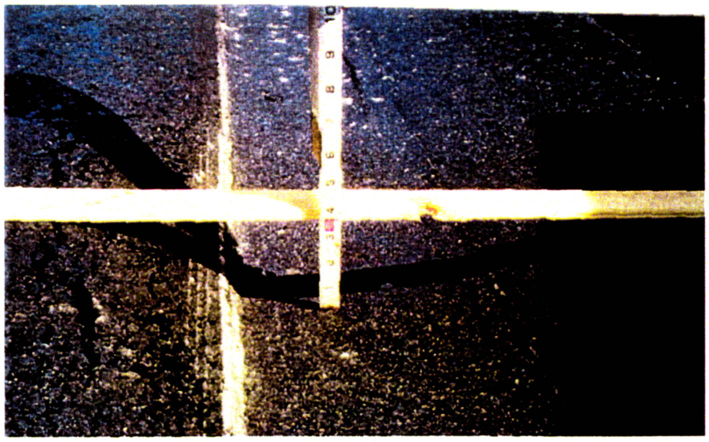


Figure 10 – Rutting of SAF Layer on Shoulder

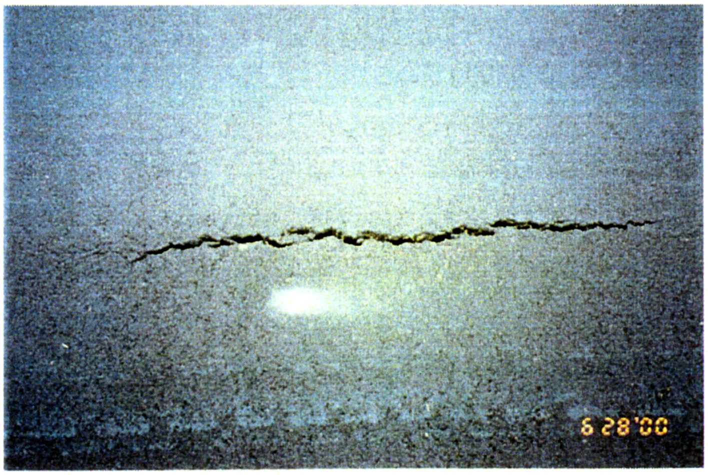


Figure 11 – Cracking of SAF layer on Shoulder

Figure 12 – Clogged Screen at Asphalt Plant

QC/QA SAF Field Testing Results						
QC/QA Tests	GMM	GMB	% VOIDS	VMA	% AC	% Min. Agg.
Mix Design	2.335	2.314	0.9	17.6	8.5	91.5
Sublot A	2.344	2.323	0.9	17.5	8.8	91.2
Sublot A (Rev)	2.348	2.320	1.2	17.5	8.7	91.3
Sublot B	2.335	2.316	0.8	17.9	9.0	91.0

Table 1 – Sand Anti-Fracture Mix (Field Verification)

Sampling and Monitoring Area Layout			
Test Section		**Limits**	**General Description**
SAF Test Section		**891+99 to 900+99 – feet**	**1" SAF Test Section**
➢ 1 ¾" SP125 wearing course ➢ 2" SP190 binder course ➢ 1-inch SAF layer		891+99 to 892+49 – 50' 892+49 to 900+49 – 800' 900+49 to 900+99 – 50'	Lead In Monitoring Area Lead Out
Control Section		**998+60 to 1007+60 - feet**	**0" SAF Control Section**
➢ 1 ¾" SP125 wearing course ➢ 2" SP190 binder course		998+60 to 999+10 – 50' 999+10 to 1007+10 – 800' 1007+10 to 1007+60 – 50'	Lead In Monitoring Area Lead Out

Table 2 – Sampling and Monitoring Area Layout

APPENDIX A

PAVEMENT REPAIR QUANTITIES

STANDARD PAVEMENT REPAIR QUANTITIES OF SECTION A

Log Mile	Station	Driving Lane Length	Passing Lane Length
0	84152.1		
0.014	84226.02	6	6
0.031	84315.78	12	12
0.038	84352.74	20	8
0.045	84389.7	6	6
0.129	84833.22	20	0
0.16	84996.9	6	0
0.171	85054.98	30	0
0.191	85160.58	6	0
0.196	85186.98	6	6
0.21	85260.9	10	6
0.236	85398.18	6	6
0.265	85551.3	6	0
0.297	85720.26	6	0
0.307	85773.06	12	6
0.335	85920.9	8	0
0.379	86153.22	10	0
0.411	86322.18	6	0
0.417	86353.86	0	6
0.434	86443.62	6	6
0.449	86522.82	6	6
0.458	86570.34	6	0
0.47	86633.7	6	6
0.542	87013.86	6	0
0.545	87029.7	0	6
0.55	87056.1	0	10
0.554	87077.22	6	0
0.564	87130.02	6	6
0.586	87246.18	6	6
0.593	87283.14	12	0
0.603	87335.94	20	6
0.608	87362.34	6	0
0.615	87399.3	15	6
0.624	87446.82	30	0
0.631	87483.78	6	0
0.638	87520.74	8	8
0.652	87594.66	6	6
0.672	87700.26	6	0
0.741	88064.58	0	8
0.745	88085.7	12	12
0.764	88186.02	6	0
0.77	88217.7	6	6
0.788	88312.74	6	6
0.799	88370.82	6	6
0.809	88423.62	12	12
subtotal		381	184

Log Mile	Station	Driving Lane Length	Passing Lane Length
0.818	88471.14	6	0
0.824	88502.82	8	0
0.829	88529.22	10	0
0.843	88603.14	0	6
0.866	88724.58	10	0
0.88	88798.5	0	6
0.891	88856.58	8	0
0.895	88877.7	6	6
0.899	88898.82	6	6
0.913	88972.74	6	6
0.925	89036.1	6	6
0.929	89057.22	12	6
0.945	89141.7	6	0
0.951	89173.38	6	0
0.954	89189.22	6	0
0.988	89368.74	0	6
0.998	89421.54	6	6
1.005	89458.5	0	6
1.015	89511.3	40	0
1.019	89532.42	0	6
1.037	89627.46	0	6
1.054	89717.22	6	6
1.076	89833.38	6	6
1.097	89944.26	8	8
1.103	89975.94	6	6
1.118	90055.14	0	6
1.13	90118.5	15	6
1.142	90181.86	50	0
1.159	90271.62	10	0
1.187	90419.46	6	6
1.192	90445.86	6	6
1.198	90477.54	0	6
1.201	90493.38	0	6
1.229	90641.22	6	6
1.253	90767.94	0	6
1.268	90847.14	6	6
1.28	90910.5	6	6
1.307	91053.06	6	0
1.317	91105.86	6	6
1.349	91274.82	40	10
1.361	91338.18	0	10
1.364	91354.02	15	0
1.375	91412.1	0	6
1.38	91438.5	12	12
subtotal		352	202

Log Mile	Station	Driving Lane Length	Passing Lane Length	
1.466	91892.58	8	0	
1.477	91950.66	6	0	
1.482	91977.06	0	0	
1.495	92045.7	0	6	
1.509	92119.62	6	6	
1.515	92151.3	8	8	
1.524	92198.82	8	0	
1.558	92378.34	0	6	
1.562	92399.46	0	6	
1.566	92420.58	0	6	
1.584	92515.62	6	0	
1.651	92869.38	6	6	
1.672	92980.26	10	10	
1.68	93022.5	30	8	
1.697	93112.26	6	6	
1.716	93212.58	6	0	
1.734	99012.22	6	0	
1.765	99175.9	8	6	
1.778	99244.54	0	6	
1.79	99307.9	0	6	
1.795	99334.3	10	0	
1.803	99376.54	6	0	
1.81	99413.5	8	8	
1.847	99608.86	6	8	
1.876	99761.98	0	6	
1.881	99788.38	0	6	
1.89	99835.9	6	0	
1.908	99930.94	8	8	
1.925	100020.7	6	6	
1.944	100121	6	6	
1.952	100163.3	10	10	
1.971	100263.6	15	8	
1.993	100379.7	6	6	
2.005	100443.1	15	8	
2.027	100559.3	12	0	
2.043	100643.7	10	0	
2.055	100707.1	0	6	
2.064	100754.6	0	0	
2.076	100818	6	6	
2.124	101071.4	0	0	
2.136	101134.8	6	6	
subtotal		250	184	
total		983	570	
lanes		11	11	
Pavement Repair		10813	6270	(SQ FT)
		1201.432	696.6597	(SQ YD)

PAVEMENT REPAIR - SECTION A

STATION (LIN. FT.)	STATION (LIN. FT.)	LANE	LENGTH	WIDTH	PAV'T REPAIR (CONC) SY	SUBGR CMP 6" SY	TYPE 5 AGGR 4" SY	VERT. SAW CUT LF	DOWEL BARS EA	REMARKS
SECTION A										
843+53	843+63	D	10	11	12.2	1.22	1.22	32	20	SEE STANDARD PLAN 613.00C
847+89	847+95	D	6	11	7.3	0.73	0.73	28	20	
848+20	848+35	D	15	11	18.3	1.83	1.83	37	20	
849+53	849+93	D	40	11	48.9	4.89	4.89	62	30	
850+42	850+67	D	25	11	30.6	3.06	3.06	47	20	
859+17	859+23	D	6	11	7.3	0.73	0.73	28	20	
861+44	861+56	D	12	11	14.7	1.47	1.47	34	20	
864+41	864+47	B	6	22	14.7	1.47	1.47	50	40	
877+37	877+45	D	8	11	9.8	0.98	0.98	30	20	
885+23	885+35	D	12	11	14.7	1.47	1.47	34	20	
885+78	885+98	D	20	11	24.4	2.44	2.44	42	20	
887+60	887+66	D	6	11	7.3	0.73	0.73	28	20	
902+02	902+52	D	50	11	61.1	6.11	6.11	72	30	
902+65	902+73	D	8	11	9.8	0.98	0.98	30	20	
914+71	914+79	B	8	22	19.6	1.96	1.96	52	40	
919+48	919+78	B	30	22	73.3	7.33	7.33	74	40	
926+97	927+03	D	6	11	7.3	0.73	0.73	28	20	
997+59	997+65	P	6	11	7.3	0.73	0.73	28	20	
997+85	997+91	P	6	11	7.3	0.73	0.73	28	20	
998+33	998+39	D	6	11	7.3	0.73	0.73	28	20	
999+27	999+35	B	8	22	19.6	1.96	1.96	52	40	
1000+18	1000+24	B	6	22	14.7	1.47	1.47	50	40	
1001+18	1001+24	B	6	22	14.7	1.47	1.47	50	40	
1001+58	1001+68	B	10	22	24.4	2.44	2.44	54	40	
1002+55	1002+70	B	15	22	36.7	3.67	3.67	59	40	
1003+77	1003+83	B	6	22	14.7	1.47	1.47	50	40	
1004+43	1004+58	B	15	22	36.7	3.67	3.67	59	40	
1005+59	1005+71	D	12	11	14.7	1.47	1.47	34	20	
1006+44	1006+54	D	10	11	12.2	1.22	1.22	32	20	
1006+98	1007+04	D	6	11	7.3	0.73	0.73	28	20	
1008+18	1008+24	B	6	22	14.7	1.47	1.47	50	40	

SUBTOTAL

SUBTOTAL	613.56	61.36	61.4	1310.0	860.0

D = DRIVING LANE
P = PASSING LANE
B = BOTH LANES

NOTE: CALCULATION FOR FINAL PAY TOTALS ON FOLLOWING PAGE

COUNTY	DEKALB/CALDWELL CO.
ROUTE	36
JOB NO.	J1P0764
PROJECT	

APPENDIX B

SAND ANTI-FRACTURE
SPECIAL PROVISIONS

Z. <u>EXPERIMENTAL SAND ANTI-FRACTURE MIXTURE MSP-97-10B</u>

1.0 Description. This specification covers materials and construction requirements for producing and placing a Sand Anti-Fracture (SAF) bituminous mixture to be placed in one course in conformance with the lines, grades, and typical cross sections shown on the plans, or established by the engineer. SAF is a highly elastic, impermeable, hot mix interlayer that is applied with a conventional paver and roller(s).

1.1 Unless otherwise stated, specification section references are from the version, in effect at the time of this contract, of the Missouri Standard Specifications for Highway Construction and its supplements.

1.2 SAF bituminous mixture is a fine graded highly elastomeric polymer modified asphalt cement mixture. The SAF bituminous mixture shall meet all the requirements for asphaltic concrete in Sec 403, except as modified herein. Delete Sec 403.1 through 403.5 and subsections, Sec 403.8, Sec 403.13.1, Sec 403.18.1 and Sec 403.18.5.

2.0 Materials. All materials shall conform to Division 1000, Materials Details, unless otherwise noted.

2.1 Asphalt Cement. The asphalt cement shall be at least PG 70-34 meeting Sec 1015 and shall be Styrene-Butadiene (SB) or Styrene-Butadiene Styrene (SBS) polymer modified. In addition, the asphalt cement shall meet the following:

Force Ductility Ratio, ASTM P226	0.8 minimum @ (4 C)
RTFO Elastic Recovery, ASTM D5976-96 Sec 6.2	75% minimum @ (° C)
Separation Test, ASTM D5976-96 Sec 6.1	(-13 C) difference max. after 48 hr.

2.2 Blended Aggregate. The blended aggregate shall consist of natural sands, crusher fines and screenings which meet Sec 1002.2.1, except the non-plastic requirement shall not apply. In addition, it shall meet the following.

2.2.1 Gradation. The combined gradation shall meet the following ranges.

Sieve	Percent Passing
3/8 inch (9.5 mm)	100
No. 4 (4.75 mm)	80 - 100
No. 8 (2.36 mm)	60 - 85
No. 16 (1.18 mm)	40 - 65
No. 30 (600 μm)	30 - 55
No. 50 (300 μm)	18 - 32
No. 100 (150 μm)	8 - 18
No. 200 (75 μm)	7 - 12

2.2.2 Natural Sand. No more than 50 percent natural sand by weight shall be used.

2.2.3 Sand Equivalent. The sand equivalent of the total blend shall be a minimum of 70 percent as determined by AASHTO T 176.

2.4 Material Acceptance. All aggregates shall be sampled, tested, and approved by the engineer, prior to use.

3.0 Job Mix Formulas. The contractor shall contact Randy Canfield, Koch Pavement Solutions, 4915 Chelsea, Kansas City, Missouri, 64130-2623, (816) 922-3414, for preparation of the job mix formulas. Koch Materials Company will provide the testing equipment to perform the Force Ductility Ratio testing, the Hveem Stability testing and the Complex Shear Modulus testing, and will provide personnel to conduct the testing in the field lab. Koch Pavement Solutions will provide technical support for production and placement of the SAF mixture.

3.1 The manufacturer of the SAF bituminous mixture shall obtain, in the presence of the engineer, representative samples of asphalt cement and mineral aggregates for tests. The samples of materials shall be of the size specified by the engineer and shall be submitted to the Central Laboratory for testing. The manufacturer shall also develop and submit the job mix formula and present certified test results for the engineer's approval. At least sixty days prior to the manufacturer preparing any of the mixture on the project, the engineer shall have received both the representative samples of the job mix materials and the manufacturer's proposed job mix formula.

3.1.1 No mixture will be accepted for use until the job mix formula for the project is approved by the engineer.

3.1.2 The job mix formula shall be within the master range specified for the SAF bituminous mixture, and shall include the type and sources of all materials, the gradations of the aggregates, the relative quantity of each ingredient, and shall state a definite percentage for each sieve fraction of aggregate and for asphalt cement.

3.1.3 The job mix formula approved for the SAF bituminous mixture shall be in effect until modified in writing by the engineer. When unsatisfactory results or other conditions occur, or should a source of material be changed, a new job mix formula may be requested.

3.2 Proportioning. The engineer will approve the job mix formula and all materials and methods prior to use and will approve the proportions to be used within the following limits.

Asphalt cement, percent	7.5 - 10
Additives	As required

3.3 Mixture Testing Procedures. SAF bituminous mixture shall be tested in accordance with AASHTO Provisional Standard TP 4, Edition 1C, Standard Method for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor, except as herein noted.

3.4 Compaction Criteria.

3.4.1 The number (N) of gyrations required for gyratory compaction shall be as follows:

	Ndesign	Nmax.
Revolutions	25	50
Voids in the Mineral Aggregate (VMA)	18+	18+
Air Voids (Va), percent	1.5 - 2.5	0.5 - 2.0
Hveem Stability @ 140 F (60 C)	18+	18+

4 Point Beam Fatigue (AASHTO TP-8) 1.0 X 10^6 cycles
1000 Micro Strain
10 hz, 68° F (20° C), 3% air voids

3.4.2 The laboratory mix design shall be performed using 100 mm gyratory molds.

3.4.3 Once the job mix formula is approved, job control specimens shall be produced by the manufacturer of the SAF. Job control specimens shall be produced using the approved job mix formula except the specimens shall be compacted using 150 mm gyratroy molds and shall be compacted to Nmax. The Voids in the Mineral Aggregate (VMA) and Air Voids (Va) shall be determined. These values will be used to control the mixture in the field.

3.4.4 The manufacturer of the SAF shall submit the Voids in the Mineral Aggregate (VMA) and Air Voids (Va) for the job control specimens to the engineer. No mixtue will be placed on the project until the job control specimens have been verified by the engineer.

4.0 Construction Requirements.

4.1 Surface preparation. Immediately prior to applying the SAF bituminous mixture, the surface shall be thoroughly cleaned of all vegetation, loose materials, dirt, mud, visible moisture and other objectionable materials, and blown dry with a jet drier as required.

4.2 Weather Limitations. SAF mixtures shall not be placed when either the air temperature or the temperature of the surface on which the SAF mixture is to be placed is below 50 F (10 C).

4.3 Application of Tack. The tack coat shall be applied as set forth in Sec 407 and shall be applied between all layers. The tack shall be undiluted at 0.02 to 0.04 gallons per square yard as determined by the Engineer.

4.4 Gradation Control. In producing SAF mixtures for the project, the plant shall be operated so that no intentional deviations from the job mix formula are made, except as approved by the engineer. The maximum deviation from the approved job mix formula shall be as follows:

Sieve	Maximum Tolerance (Percent Passing by Weight (Mass))
No. 8 (2.36 mm)	± 4.0
No. 200 (75 µm)	± 1.0

4.5 Asphalt Content. The asphalt content shall be within ± 0.3% of the approved job mix formula.

4.6 Spreading and Finishing.

4.6.1 It is recommended that the plant be hot before beginning production of the SAF mixture. The SAF layer shall have an average thickness of 1 inch (25 mm) and shall have a minimum thickness of 3/4 inch (19 mm) and a maximum thickness of 1 1/4 inch (31 mm).

4.6.2 Density. Density of the in-place SAF mixture shall be 97 ± 1% of the maximum specific gravity as determined by AASHTO T 209. Compaction operations shall start promptly after placement of the SAF mixture. Compaction temperature ranges shall be as provided by the asphalt cement supplier. SAF mixture shall be compacted in pavement deformities greater than 3/4 inch (19 mm) in depth in front of the paver. Deformities larger than 3 inches (75 mm) in depth shall be filled with approved SP125, or SP190 or mixture prior to placement of the SAF mixture. If cores are taken, it is recommended to place paper in front of the paver at the location where the core will be taken. SAF is extremely adhesive.

4.6.3 The SAF mixture shall be covered with the binder course within five days after placement.

4.6.4 After final rolling, the SAF should be deep black in appearance. The surface texture should be tight. Small flushed areas approximately 1 foot by 1 foot every 200 feet are normal. More flushing than this may indicate that the mixture is out of specification. Areas determined unacceptable by the Engineer, in accordance with this specification, shall be removed and replaced at no additional cost.

4.6.5 Small blisters may occur in the mat after rolling. This can happen during a hot, wet season. If blisters occur, they can be overlaid or removed with a roller as determined by the Engineer.

4.7 Verification specimens of the SAF mixture produced for the project shall be made in accordance with MSP-95-03N "Superpave Asphaltic Concrete Pavement".

4.7.1 The Voids in the Mineral Aggregate (VMA) and Air Voids (Va) shall be within ± 1.0% of the approved job control specimens when compacted to N_{max}. Mix verification, performed in the field laboratory, shall use 150 mm gyratory molds.

4.8 Test Strip.

4.8.1 This work shall consist of constructing SAF bituminous test strips for each mix design to determine the needed adjustments to meet specifications.

4.8.2 Test strips shall be constructed after approval of a job mix formula and calibration of the SAF bituminous mixing plant. Tack coat shall be applied to the roadbed section followed by the placement of approximately 250 tons (230 Mg) or one hour's production, which ever is less, of approved mix in a single lane within the project limits. The paver and rollers to be used on the project shall be used to put down the test strip. Separate test strips shall be provided for each mix design. Acceptable test strips shall meet density and all other specification requirements for the mixture tested.

4.8.3 Density will be determined in accordance with this specification. Steel wheel rollers in the static mode shall be used for compaction of the mixture. Pneumatic rollers and steel wheel rollers in the vibratory mode shall not be used. If necessary additional test strips shall be constructed until a rolling pattern has been established which will provide the specified density. A new test strip shall also be required whenever a change in the job mix formula occurs, the compaction method or the compaction equipment is changed or unacceptable results occur. Test strips which do not have the specified density shall be removed as directed by the engineer. No additional mix shall be laid until a rolling pattern, acceptable to the engineer, has been established on a test strip.

4.8.4 The materials in test strips approved by the engineer will be paid for at the unit price bid for those materials as provided in the contract. All materials in unacceptable test strips removed by the contractor shall become the property of the contractor and will be disposed of by the contractor at the expense of the contractor.

4.9 Any traffic damaged or marred areas shall be repaired by the contractor at no additional charge.

5.0 Method of Measurement.

5.1 Measurement of SAF bituminous mixture complete in place, including any multiple passes or courses, will be made to the nearest square yard (meter). Measurement of individual passes or courses will not be made. Final measurement of the completed surface will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

6.0 Basis of Payment.

6.1 The accepted quantity of SAF bituminous mixture will be paid for at the contract unit price for SAF bituminous mixture, per square yard (meter).

APPENDIX C

SUPERPAVE AND SAF MIX DESIGNS

SAF00-29

MISSOURI HIGHWAY AND TRANSPORTATION DEPARTMENT - DIVISION OF MATERIALS

ASPHALTIC CONCRETE SAND ANTI-FRACTURE MIXTURE

JOB NO.= J1P0764
PROJECT ACNH-36-1(64) ROUTE= 36 COUNTY= Caldwell-Dekalb DATE= 6/25/00

PRODUCT CODE / FACILITY CODE / PRODUCER-LOCATION	IDENT.	BULK SP. GR.	APPAR. SP. GR.	FORMATION / LEDGES / % CHERT	% ABS
	01MA0512	2.602	2.732	Bethany Falls / 9-12	1.8
	01MA0513	2.574	2.723	Bethany Falls / 9-12	2.1
	01MA0514 •	2.506	2.751	Bethany Falls / 9-12	3.6
	01MA0536	2.609	2.654	Grand River	0.7
	0MFO0058	1.025		PG 70 -34 Gyro Mold Temp. 279° F - 300°F	

MATERIAL IDENT. 01MA0512 01MA051301MA051401MA0536 || 01MA051201MA051301MA051401MA0536 COMB GRAD

00-29	3/8"	MFS	LSS	NS	PERCENT	5.0	25.0	40.0	30.0	GRAD
1"	100.0	100.0	100.0	100.0	||	5.0	25.0	40.0	30.0	100.0
3/4"	100.0	100.0	100.0	100.0	||	5.0	25.0	40.0	30.0	100.0
1/2"	100.0	100.0	100.0	100.0	||	5.0	25.0	40.0	30.0	100.0
3/8"	100.0	100.0	100.0	100.0	||	5.0	25.0	40.0	30.0	100.0
#4	51.8	100.0	100.0	100.0	||	2.6	25.0	40.0	30.0	97.6
#8	6.4	66.2	74.0	100.0	||	0.3	16.6	29.6	30.0	76.5
#16	4.4	33.4	46.0	98.7	||	0.2	8.4	18.4	29.6	56.6
#30	4.0	16.5	32.0	92.3	||	0.2	4.1	12.8	27.7	44.8
#50	3.6	8.0	23.0	53.8	||	0.2	2.0	9.2	16.1	27.5
#100	3.2	5.0	18.0	7.3	||	0.2	1.3	7.2	2.2	10.9
#200	2.8	3.6	16.0	0.9	||	0.1	0.9	6.4	0.3	7.7

LABORATORY * ||	Gmm=	2.335	% VOIDS= 0.9	Gyro Dia.=	6	Ndes =	25	MIX COMPOSITION
CHARACTERISTICS ||	Gmb=	2.314	VMA= 17.6	Gyro Wt.=	4900	Nmax =	50	MIN.AGG. 91.5 %
AASHTO T-4 ||	Gsb=	2.568		S.E. =	56			BINDER CONTENT 8.5 %

CALIBRATION NUMBER = 00114 MAST. GA. BACK. CNT.= 2217 A1 = - 2.181628
MASTER GAUGE SERIAL NO. = 770 SAMPLE WEIGHT = 6800 A2 = 2.700016

* Mixture Properties Based on Contractor's Mix Design

SP190 00-100 R1

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE SP190 MC

JOB NO.= J1P0764
PROJECT= ACNH-36-1(64) ROUTE= 36 COUNTY= DeKalb-Caldwell DATE= 08/11/00

PRODUCT CODE / FACILITY CODE / PRODUCER-LOCATION	IDENT.	BULK SP. GR.	APPAR. SP. GR.	FORMATION / LEDGES / % CHERT	ABS.
	01MDP063	2.594	2.723	Beth. Falls / 9-12	1.8
	01MDP064	2.581	2.721	Beth. Falls / 9-12	2.0
	01MDP065	2.570	2.718	Beth. Falls / 9-12	2.1
	01MDP066	2.578	2.726	Beth. Falls / 9-11	2.1
	90MA0755	2.256		Hyd. Lime	
	94SDS302	1.037		PG 70-22 Gyro Mold Temp. 288°-298°F	

MATERIAL

IDENT.	10SPLS	07SPLS	04SPLS	SPMSLS	90MA0755		10SPLS	07SPLS	04SPLS	SPMSLS	HLACHL	COMB
00100	01MDP063	01MDP064	01DMP065	01MDP066	HLACHL	PERCENT	13.0	27.0	21.0	38.0	1.0	GRAD
1"	100.0	100.0	100.0	100.0	100.0		13.0	27.0	21.0	38.0	1.0	100.0
3/4"	80.0	100.0	100.0	100.0	100.0		10.4	27.0	21.0	38.0	1.0	97.4
1/2"	6.7	95.6	100.0	100.0	100.0		0.9	25.8	21.0	38.0	1.0	86.7
3/8"	1.9	60.5	100.0	100.0	100.0		0.2	16.3	21.0	38.0	1.0	76.5
#4	1.3	4.0	51.8	100.0	100.0		0.2	1.1	10.9	38.0	1.0	51.2
#8	1.2	2.6	6.4	66.2	100.0		0.2	0.7	1.3	25.2	1.0	28.4
#16	1.1	2.3	4.4	33.4	100.0		0.1	0.6	0.9	12.7	1.0	15.3
#30	1.1	2.1	4.0	16.5	100.0		0.1	0.6	0.8	6.3	1.0	8.8
#50	1.1	2.0	3.6	8.0	100.0		0.1	0.5	0.8	3.0	1.0	5.4
#100	1.0	1.8	3.2	5.0	99.0		0.1	0.5	0.7	1.9	1.0	4.2
#200	0.9	1.5	2.8	3.6	98.0		0.1	0.4	0.6	1.4	1.0	3.5

LABORATORY	Gmm=	2.458	% VOIDS=	4.0	TSR=	80.7	Nini=	8	MIX COMPOSITION	
CHARACTERISTICS	Gmb=	2.360	V.M.A.=	13.2	-200/AC=	0.9	Ndes=	100	MIN.AGG.	94.8 %
AASHTO TP4	Gsb=	2.577	%FILLED=	69.7	Gyro Wt.=	4795	Nmax=	160	ASPHALT CONTENT	5.2 %

CALIBRATION NUMBER = 00081 MAST. GA. BACK. CNT.= 2230 A1 =-6.915346
MASTER GAUGE SERIAL NO. = 770 SAMPLE WEIGHT = 7000 A2 = 4.154202

*Mixture Properties Based on Contractor's Mix Design

SP125 00-103

MISSOURI DEPARTMENT OF TRANSPORTATION - DIVISION OF MATERIALS

ASPHALTIC CONCRETE TYPE 125 MC

JOB NO.= J1P0764
PROJECT= ACNH-36-1(64) ROUTE= 36 COUNTY= Caldwell-DeKalb DATE= 06/28/00

PRODUCT CODE / FACILITY CODE / PRODUCER-LOCATION	IDENT.	BULK SP. GR.	APPAR. SP. GR.	FORMATION / LEDGES / % CHERT	% ABS.
1	01MDP067	2.581	2.714	Beth. Falls / 9-12	1.9
	01MDP068	2.552	2.714	Beth. Falls / 9-12	2.3
	01MDP069	2.572	2.728	Beth. Falls / 9-12	2.2
	90MA0755	2.258		Hyd. Lime	
	94SDS302	1.037		PG 70-22 Gyro Mold Temp. 288°-298°F	

MATERIAL IDENT.	01MDP067	01MDP068	01MDP069	90MA0755	||	01MDP067	01MDP068	01MDP069	90MA0755				COMB
00103	07SPLS	04SPLS	SPMSLS	HLACHL	PERCENT	26.0	36.0	37.0	1.0				GRAD
1"	100.0	100.0	100.0	100.0	||	26.0	36.0	37.0	1.0	0.0	0.0	0.0	100.0
3/4"	100.0	100.0	100.0	100.0	||	26.0	36.0	37.0	1.0	0.0	0.0	0.0	100.0
1/2"	95.6	100.0	100.0	100.0	||	24.9	36.0	37.0	1.0	0.0	0.0	0.0	98.9
3/8"	60.5	100.0	100.0	100.0	||	15.7	36.0	37.0	1.0	0.0	0.0	0.0	89.7
#4	4.0	51.8	100.0	100.0	||	1.0	18.6	37.0	1.0	0.0	0.0	0.0	57.6
#8	2.6	6.4	66.2	100.0	||	0.7	2.3	24.5	1.0	0.0	0.0	0.0	28.5
#16	2.3	4.4	33.4	100.0	||	0.6	1.6	12.4	1.0	0.0	0.0	0.0	15.6
#30	2.1	4.0	16.5	100.0	||	0.5	1.4	6.1	1.0	0.0	0.0	0.0	9.0
#50	2.0	3.6	8.0	100.0	||	0.5	1.3	3.0	1.0	0.0	0.0	0.0	5.8
#100	1.8	3.2	5.0	99.0	||	0.5	1.2	1.9	1.0	0.0	0.0	0.0	4.6
#200	1.5	2.8	3.6	98.0	||	0.4	1.0	1.3	1.0	0.0	0.0	0.0	3.7

LABORATORY	|| Gmm=	2.439	% VOIDS=	4.0	TSR=	82	Nini=	8	MIX COMPOSITION		
CHARACTERISTICS	|| Gmb=	2.341	V.M.A. =	14.2	-200/AC=	0.8	Ndes=	100	MIN.AGG.	94.4	%
AASHTO TP4	|| Gsb=	2.576	%FILLED=	72	Gyro Wt.=	4758	Nmax=	160	ASPHALT CONTENT	5.6	%

CALIBRATION NUMBER = 00117 0 MAST. GA. BACK. CNT.= 2212 0 A1 =-5.239326
MASTER GAUGE SERIAL NO. = 770 0 SAMPLE WEIGHT = 7100 0 A2 = 3.536100

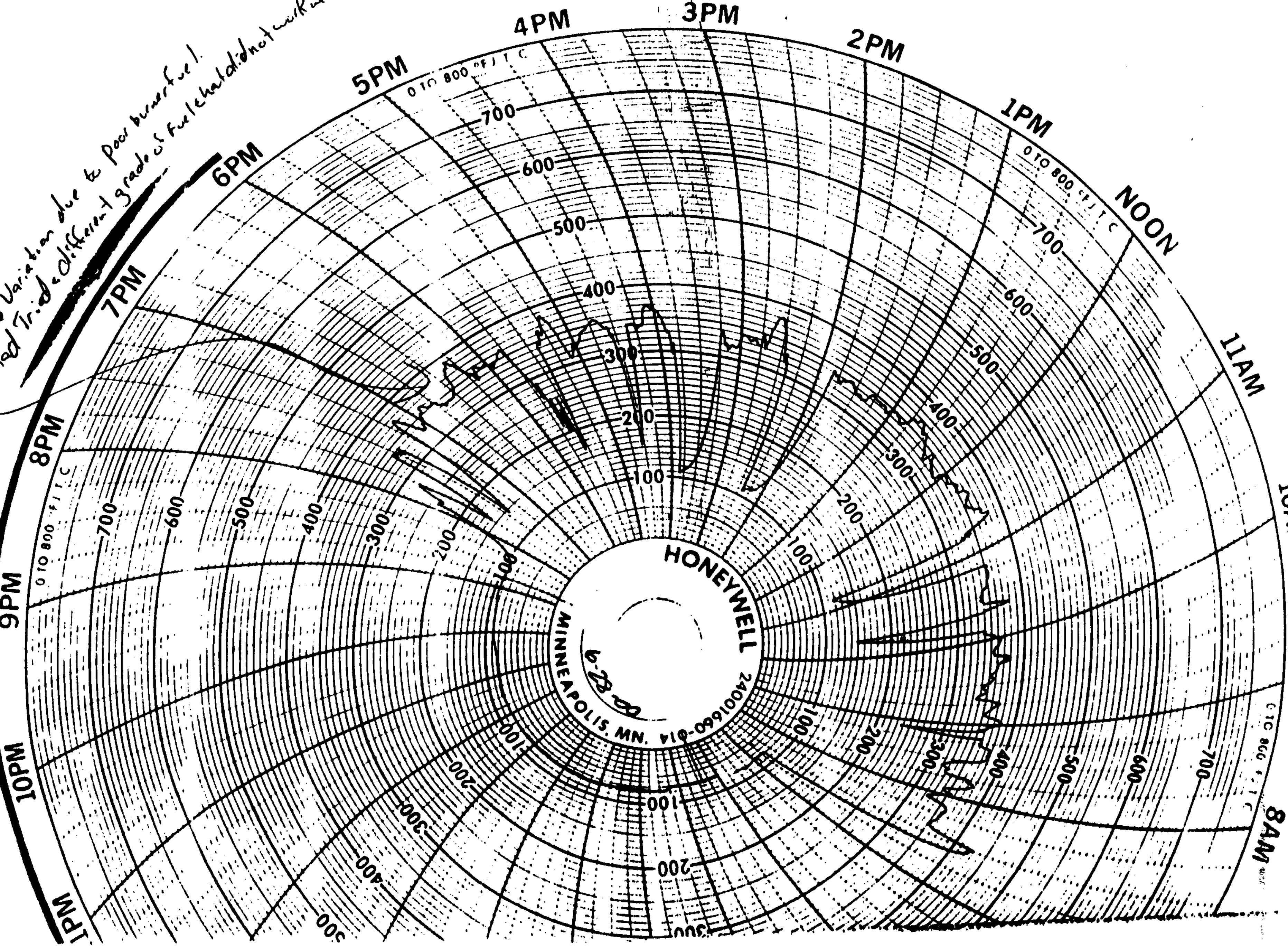
*Mixture Properties Based on Contractor's Mix Design

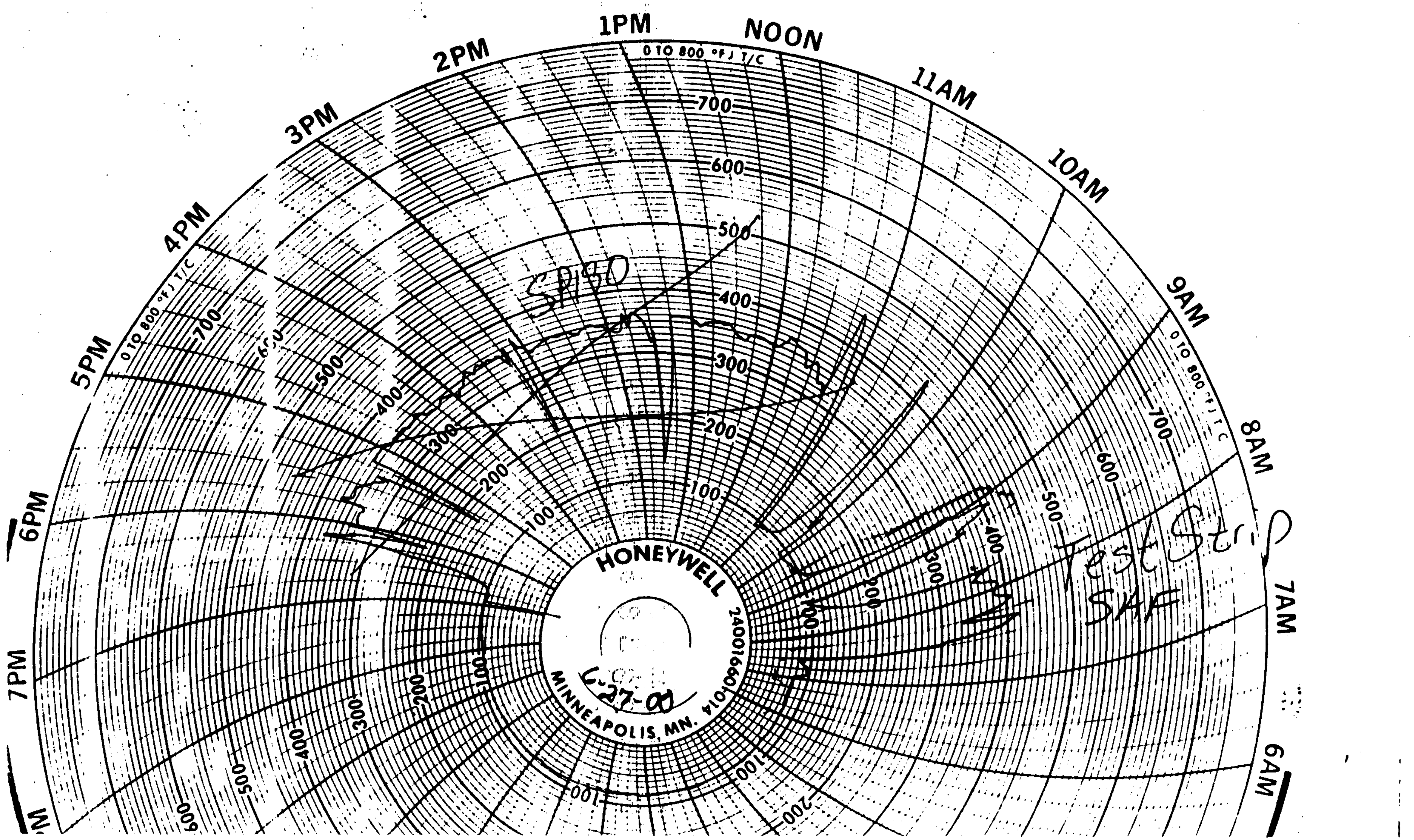
APPENDIX D

PYROMETER READINGS AT ASPHALT PLANT

Plant Mix @ Plant While producing = Doesn't account for cooling while in S.. Depends on How long it sits.

Temperature Variation due to poor burner fuel.
Had Tried different grades of fuel & that did not work well.





1PM
NOON
11AM
10AM
9AM
8AM
7AM
6AM
2PM
3PM
4PM
5PM
6PM
7PM
0 TO 800 °F J T/C
HONEYWELL
24001660-014
MINNEAPOLIS, MN.
SP150
Test Strip
6-27-00

APPENDIX E

SAF Cost Estimate, Bid-Price Items, and Quantities

SAF Layer and Minimum Pavement Repair

Actual Pavement Repair Quantities for Pavement with the SAF Layer

(Station 841+52.1 - 932+70.4)		Equation: (Station 932+70.4 BK = Station 989+75.0 AHD)	
(Station 989+75.0 - 993+25.0)		SAF Start: 841+52.1	SAF End: 993+25.0
Length of SAF Section:	9468.3 ft	1.7932 miles	
Original Pavement Width:	22.0 ft		

SAF Material Cost (Calculated for 1.7932 mile length)

Total SAF		**Shoulders**	**Total SAF**
(32.7 ft. Pvmt Width)	-	(8.7 ft. Pvmt Width)	(24 ft. Width)*
34401.1 yd^2	-	9152.5 yd^2	25249 yd^2

Total SAF (yd^2)	25,249.00	
Unit Price	$4.81	
Total SAF Cost	$121,448	per 1.7932 miles
SAF Cost per mile	**$67,727**	

* Cost base on 24' lane width.

SAF Cost per lane-mile (12') = $34,000

MISSOURI DEPARTMENT OF TRANSPORTATION

TABULATIO BIDS

CALL ORDER : 102
LETTING DATE : 12/10/99 10:00 a.m.

CONTRACT ID : 991210-102
DISTRICT : 01

COUNTIES : DEKALB CALDWELL

CERTIFIED BY DIVISION OF DESIGN

DIVISION ENGINEER

LINE NO / ITEM CODE / ALT ITEM DESCRIPTION	QUANTITY		(1) 0011146 APAC-MISSOURI, INC. UNIT PRICE	AMOUNT	(2) 0010378 NORRIS ASPHALT PAVING CO. UNIT PRICE	AMOUNT	(3) 0010179 HERZOG CONTRACTING CORP. UNIT PRICE	AMOUNT
SECTION 0001 ROADWAY J1P0764								
0010 2022010 REMOVAL OF IMPROVEMENTS		LUMP	18000.00000	18000.00	75000.00000	75000.00	30000.00000	30000.00
0020 2031000 CLASS A EXCAVATION	316.000	CUYD	16.97000	5362.52	10.00000	3160.00	21.00000	6636.00
0030 2037075 COMPACTING IN CUT	5.000	STA	280.00000	1400.00	150.00000	750.00	75.00000	375.00
0040 2131000 SHAPING SHOULDERS CLASS 1	11.120	MILE	8635.00000	96021.20	3750.00000	41700.00	8000.00000	88960.00
0050 3012000 MINERAL AGGREGATE (BITUMINOUS BASE) PG64-22	2582.000	TONS	36.20000	93468.40	31.78000	82055.96	28.00000	72296.00
0060 3013002 ASPHALT BINDER (BASE WIDENING) PG64-22	122.900	TONS	36.16000	4444.06	171.20000	21040.48	180.00000	22122.00
0070 3014000 MINERAL AGGREGATE (BASE WIDENING) PG64-22	2296.000	TONS	36.16000	83023.36	31.78000	72966.88	31.75000	72898.00
0080 3016017 ASPHALT BINDER (BITUMINOUS BASE) PG 64-22	138.200	TONS	36.20000	5002.84	171.20000	23659.84	175.00000	24185.00
0090 3105001 GRAVEL (A) OR CRUSHED STONE (B)	133.000	CUYD	98.70000	13127.10	25.00000	3325.00	60.00000	7980.00
0100 4039075 BITUMINOUS TEST STRIP	2.000	EA	5000.00000	10000.00	2500.00000	5000.00	2500.00000	5000.00
0110 4039736 ASPHALT BINDER (ASPHALTIC CONCRETE) PG 70-22 (SP125MC MIX)	1512.900	TONS	40.67000	61529.64	220.00000	332838.00	220.00000	332838.00
0120 4039737 MINERAL AGGREGATE (ASPHALTIC CONCRETE) PG 70-22 (SP125MC MIX)	22570.000	TONS	40.67000	917921.90	25.12000	566958.40	30.50000	688385.00
0130 4039804 ASPHALT BINDER (ASPHALTIC CONCRETE) PG70-22 (SP190MC MIX)	1688.500	TONS	38.95000	65767.08	220.00000	371470.00	220.00000	371470.00
0140 4039805 MINERAL AGGREGATE (ASPHALTIC CONCRETE) PG 70-22 (SP190MC MIX)	27868.000	TONS	38.95000	1085458.60	25.12000	700044.16	30.00000	836040.00
0150 4039905 MISC. SAND-ANTIFRACTURE	35865.800	SQYD	4.81000	172514.50	7.50000	268993.50	5.00000	179329.00
0160 4071005 TACK COAT	11770.000	GAL	0.85000	10004.50	0.85000	10004.50	0.75000	8827.50
0170 4081010 PRIME-LIQUID ASPHALT RC 70 OR MC 30	880.000	GAL	1.70000	1496.00	3.00000	2640.00	2.25000	1980.00

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0180 6011000 FIELD LABORATORIES		LUMP	1000.00000	1000.00	10000.00000	10000.00	2500.00000	2500.00
0190 6012000 SPECIAL FIELD LABORATORIES		LUMP	25000.00000	25000.00	50000.00000	50000.00	7500.00000	7500.00
0200 6062203 BRIDGE ANCHOR SECTION, 8 FT. POSTS (SAFETY BARRIER CURB)	4.000	EA	996.72000	3986.88	996.72000	3986.88	1000.00000	4000.00
0210 6062302 TRANSITION SECTION, 8 FT. POSTS	4.000	EA	350.00000	1400.00	350.00000	1400.00	350.00000	1400.00
0220 6063015 TYPE A CRASHWORTHY END TERMINAL	19.000	EA	1786.00000	33934.00	1786.00000	33934.00	1800.00000	34200.00
0230 6066610 END ANCHOR	11.000	EA	542.50000	5967.50	542.50000	5967.50	557.00000	6127.00
0240 6069903 MISC. MODIFIED TYPE A GUARDRAIL (8 FT POSTS) SEE SPECIAL PROVISIONS	10450.000	LF	12.06000	126027.00	12.06000	126027.00	12.00000	125400.00
0250 6122017 IMPACT ATTENUATOR (17 SAND BARRELS)	2.000	EA	5950.00000	11900.00	5950.00000	11900.00	7600.00000	15200.00
0260 6122020 REPLACEMENT SAND BARREL	1.000	EA	550.00000	550.00	550.00000	550.00	1200.00000	1200.00
0270 6122030 IMPACT ATTENUATOR (RELOCATION)	2.000	EA	500.00000	1000.00	500.00000	1000.00	100.00000	200.00
0280 6132000 PAVEMENT REPAIR (CONCRETE)	1324.000	SQYD	81.50000	107906.00	81.50000	107906.00	82.00000	108568.00
0290 6132001 SUBGRADE COMPACTION (6 INCH DEPTH) (PAVEMENT REPAIR)	132.000	SQYD	2.00000	264.00	2.00000	264.00	2.00000	264.00
0300 6132003 FULL DEPTH SAW CUT (PAVEMENT REPAIR ONLY)	3435.000	LF	5.85000	20094.75	5.85000	20094.75	6.00000	20610.00
0310 6132005 DOWEL BAR (DRILLING, FURNISHING AND INSTALLING)	2455.000	EA	3.35000	8224.25	3.35000	8224.25	3.50000	8592.50
0320 6132010 TYPE-5 AGGREGATE FOR BASE (4IN. THICK) (PAVEMENT REPAIR)	132.000	SQYD	3.00000	396.00	3.00000	396.00	3.00000	396.00
0330 6161005 CONSTRUCTION SIGNS	2450.000	SQFT	4.80000	11760.00	4.80000	11760.00	5.50000	13475.00
0340 6161020 CHANNELIZER (DRUM)	172.000	EA	35.00000	6020.00	35.00000	6020.00	35.00000	6020.00
0350 6161040 FLASHING ARROW PANEL	8.000	EA	850.00000	6800.00	850.00000	6800.00	1200.00000	9600.00
0360 6161071 TRAFFIC BARRIER DELINEATOR, WHITE	46.000	EA	5.00000	230.00	5.00000	230.00	5.00000	230.00

MISSOURI DEPARTMENT OF TRANSPORTATION

TABULATIC BIDS

DATE : 12/10/99
PAGE : 102 -4

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COUNTIES : DEKALB CALDWELL

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0370 6161072 TRAFFIC BARRIER DELINEATOR, AMBER	46.000 EA	5.00000	230.00	5.00000	230.00	5.00000	230.00
0380 6161130 INSTALLING GIVE EM A BRAKE, 48 IN. X 48 IN. SIGN	2.000 EA	40.00000	80.00	40.00000	80.00	50.00000	100.00
0390 6175010 RELOCATING TEMPORARY TRAFFIC BARRIER	860.000 LF	8.00000	6880.00	8.00000	6880.00	8.00000	6880.00
0400 6176000 STATE FURNISHED CONCRETE TRAFFIC BARRIER	860.000 LF	18.00000	15480.00	18.00000	15480.00	18.00000	15480.00
0410 6181000 MOBILIZATION	LUMP	245000.00000	245000.00	380000.00000	380000.00	600000.00000	600000.00
0420 6191000 PAVEMENT EDGE TREATMENT	587.000 LF	8.00000	4696.00	5.00000	2935.00	3.00000	1761.00
0430 6205301 PREFORMED REMOVABLE MARKING TAPE 4 IN., SOLID WHITE	76.800 100F	78.00000	5990.40	73.00000	5606.40	100.00000	7680.00
0440 6205303 PREFORMED REMOVABLE MARKING TAPE 4 IN., SOLID YELLOW	10.000 100F	78.00000	780.00	73.00000	730.00	100.00000	1000.00
0450 6205401 PREFORMED SHORT TERM MARKING TAPE 4 IN. SOLID WHITE	11.100 MILE	1000.00000	11100.00	1100.00000	12210.00	850.00000	9435.00
0460 6205402 PREFORMED SHORT TERM MARKING TAPE 4 IN., INTERMITTENT WHITE	2.800 MILE	650.00000	1820.00	500.00000	1400.00	1100.00000	3080.00
0470 6205403 PREFORMED SHORT TERM MARKING TAPE 4 IN., SOLID YELLOW	11.200 MILE	1000.00000	11200.00	1100.00000	12320.00	850.00000	9520.00
0480 6205501 THERMOPLASTIC MARKING MATERIAL 4 IN., SOLID WHITE	587.100 100F	29.00000	17025.90	17.00000	9980.70	28.00000	16438.80
0490 6205502 THERMOPLASTIC MARKING MATERIAL 4 IN., INTERMITTENT WHITE	146.800 100F	29.00000	4257.20	17.00000	2495.60	28.00000	4110.40
0500 6205503 THERMOPLASTIC MARKING MATERIAL 4 IN., SOLID YELLOW	589.500 100F	29.00000	17095.50	17.00000	10021.50	28.00000	16506.00
0510 6206431 CONCRETE TRAFFIC BARRIER MARKING, 13 IN., SOLID WHITE	5.000 100F	30.00000	150.00	60.00000	300.00	100.00000	500.00
0520 6206432 CONCRETE TRAFFIC BARRIER MARKING, 13 IN., SOLID YELLOW	5.000 100F	30.00000	150.00	60.00000	300.00	100.00000	500.00

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0530 6207000 PAVEMENT MARKING REMOVAL (PAINT)	5.000	100F	50.00000	250.00	200.00000	1000.00	100.00000	500.00
0540 6207005 PAVEMENT MARKING REMOVAL (TAPE)	87.000	100F	13.00000	1131.00	40.00000	3480.00	45.00000	3915.00
0550 6208066 RAISED SNOWPLOWABLE PAVEMENT MARKER WITH 1 MONO-DIRECTIONAL WHITE OR CRYSTAL REFLECTOR	734.000	EA	28.00000	20552.00	26.00000	19084.00	30.00000	22020.00
0560 6224010 MODIFIED COLD MILLING (DEPTH TRANSITIONS)	11911.000	SQYD	2.10000	25013.10	6.40000	76230.40	2.25000	26799.75
0570 6261000 BITUMINOUS RUMBLE STRIP	1143.300	100F	11.25000	12862.13	4.50000	5144.85	4.00000	4573.20
0580 7251012 12 IN. CORRUGATED METALLIC-COATED STEEL PIPE	90.000	LF	54.50000	4905.00	26.95000	2425.50	35.00000	3150.00
0590 8023000 TYPE 3 MULCH	7.900	ACRE	750.00000	5925.00	595.00000	4700.50	600.00000	4740.00
0600 8051000 SEEDING	7.900	ACRE	750.00000	5925.00	595.00000	4700.50	600.00000	4740.00
0610 8061013 STRAW BALE DITCH CHECK	2.000	EA	200.00000	400.00	100.00000	200.00	100.00000	200.00
0620 8061019 SILT FENCE	3254.000	LF	2.20000	7158.80	2.00000	6508.00	2.00000	6508.00
SECTION TOTALS				$ 3,443,059.11		$ 3,572,510.05		$ 3,885,171.15
SECTION 0002 BRIDGE DWG. NO. A10131, J1P0764 AT STA. 104+78.0								
0630 2021035 SEAL COAT REMOVAL (BRIDGES)	4213.000	SQFT	1.05000	4423.65	2.00000	8426.00	2.00000	8426.00
0640 2021051 REMOVAL AND STORAGE OF EXISTING BRIDGE RAIL	281.000	LF	10.00000	2810.00	10.00000	2810.00	10.00000	2810.00
0650 7032021 SUBSTRUCTURE REPAIR (UNFORMED)	10.000	SQFT	200.00000	2000.00	200.00000	2000.00	200.00000	2000.00
0660 7034215 SAFETY BARRIER CURB	298.000	LF	60.00000	17880.00	60.00000	17880.00	60.00000	17880.00
0670 7035010 REPAIRING CONCRETE DECK (HALF-SOLING)	750.000	SQFT	20.00000	15000.00	20.00000	15000.00	20.00000	15000.00
0680 7035020 FULL DEPTH REPAIR	50.000	SQFT	1.00000	50.00	1.00000	50.00	1.00000	50.00
0690 7035031 SLAB OVERHANG REPLACEMENT	298.000	LF	200.00000	59600.00	200.00000	59600.00	200.00000	59600.00

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0700 7037025 CONCRETE WEARING SURFACE	479.000	SQYD	50.00000	23950.00	50.00000	23950.00	50.00000	23950.00
0710 7123610 SLAB DRAIN	22.000	EA	200.00000	4400.00	200.00000	4400.00	200.00000	4400.00
SECTION TOTALS			$	130,113.65	$	134,116.00	$	134,116.00
SECTION 0003 BRIDGE DWG. NO. A10141, J1P0764 AT STA. 131+08.0								
0720 2021035 SEAL COAT REMOVAL (BRIDGES)	4216.000	SQFT	1.05000	4426.80	2.00000	8432.00	2.00000	8432.00
0730 2021051 REMOVAL AND STORAGE OF EXISTING BRIDGE RAIL	281.000	LF	10.00000	2810.00	10.00000	2810.00	10.00000	2810.00
0740 7032021 SUBSTRUCTURE REPAIR (UNFORMED)	10.000	SQFT	200.00000	2000.00	200.00000	2000.00	200.00000	2000.00
0750 7034215 SAFETY BARRIER CURB	298.000	LF	60.00000	17880.00	60.00000	17880.00	60.00000	17880.00
0760 7035010 REPAIRING CONCRETE DECK (HALF-SOLING)	350.000	SQFT	20.00000	7000.00	20.00000	7000.00	20.00000	7000.00
0770 7035031 SLAB OVERHANG REPLACEMENT	298.000	LF	200.00000	59600.00	200.00000	59600.00	200.00000	59600.00
0780 7037025 CONCRETE WEARING SURFACE	479.000	SQYD	50.00000	23950.00	50.00000	23950.00	50.00000	23950.00
0790 7123610 SLAB DRAIN	16.000	EA	200.00000	3200.00	200.00000	3200.00	200.00000	3200.00
SECTION TOTALS			$	120,866.80	$	124,872.00	$	124,872.00
CONTRACT TOTALS			$	3,694,039.56	$	3,831,498.05	$	4,144,159.15