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STATE OF SOUTH DAKOTA	PROJECT	SHEET	TOTAL SHEETS
	NH-P 0043(15)	1	18

Plotting Date: 01/08/2015
Revised Date: 01-08-2015 jpr

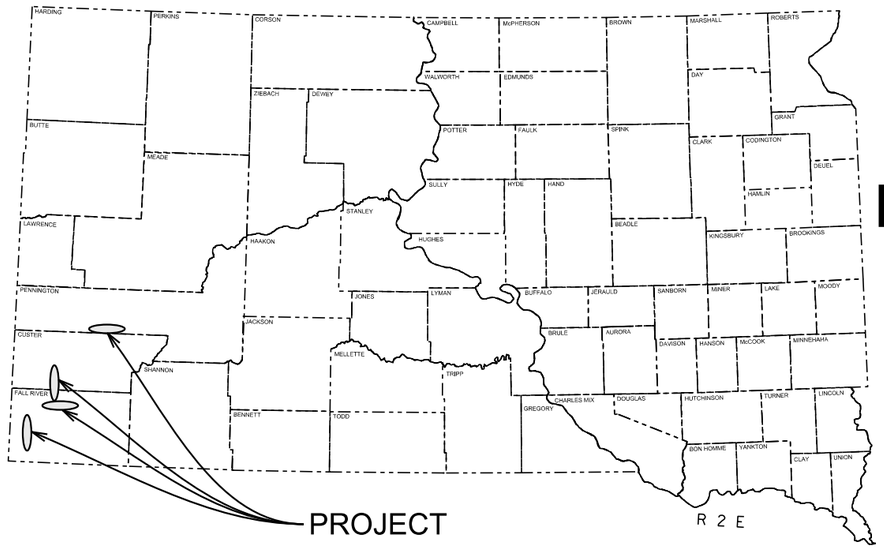
STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION

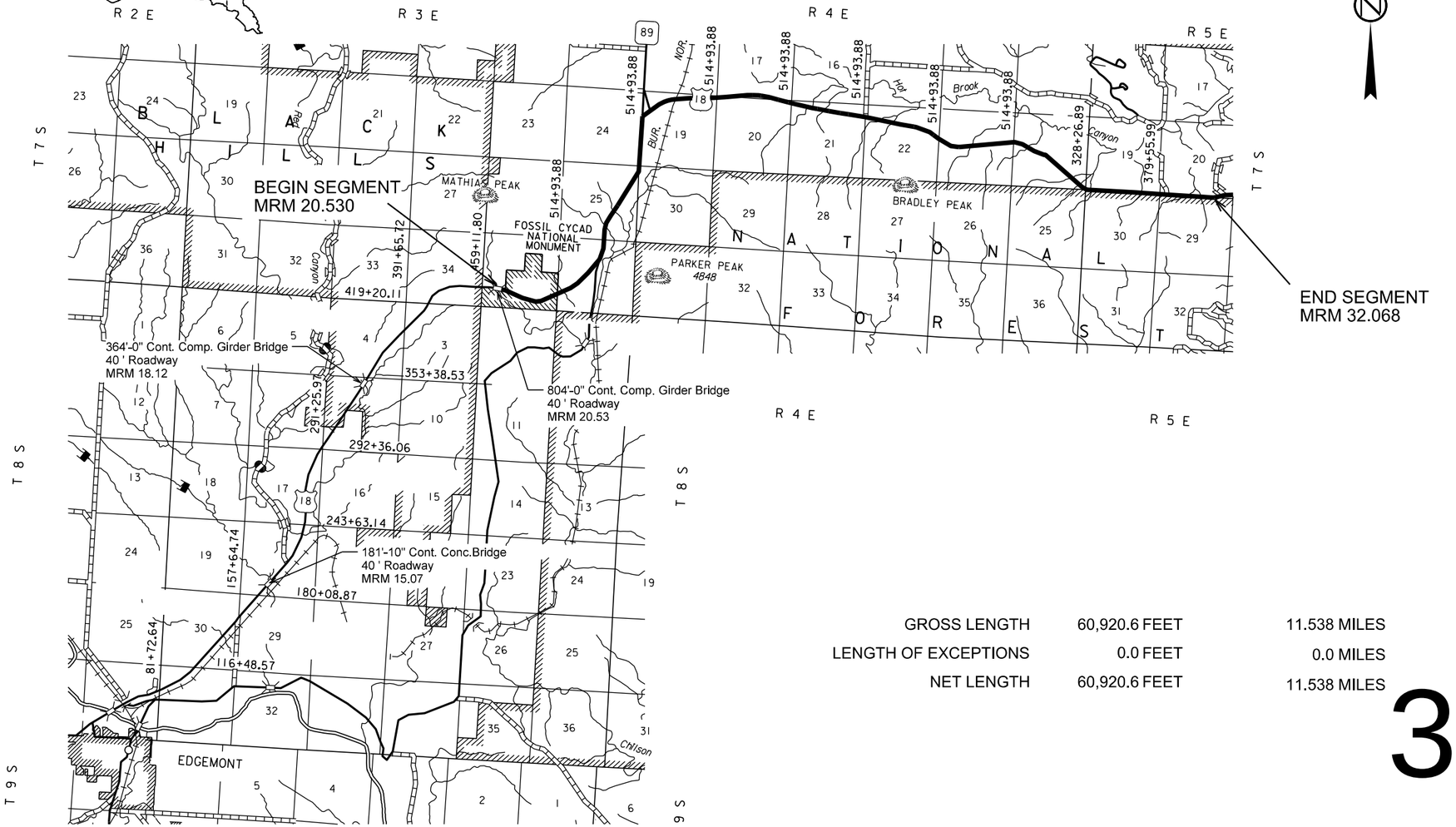
PLANS FOR PROPOSED

PROJECT NH-P 0043(15)
HIGHWAYS US18, SD40, SD 89 & SD 471
PENNINGTON, CUSTER & FALL RIVER COUNTIES

ASPHALT SURFACE TREATMENT

PCN 047K





INDEX OF SHEETS

1- 3 General Layout W/Index
4 - 13 Estimate With General Notes & Tables
14 Pavement Marking Detail
15 Sign Details
16 Mobile Operation Detail
17 - 18 Standard Plates

047K
US 18 MRM 20.530 to 32.068
DESIGN DESIGNATION

ADT (2013)	1853
ADT (2033)	2347
DHV	479
D	50%
T DHV	12.9%
T ADT	28.3%
V	65 MPH

STORM WATER PERMIT

No Permit Required

GROSS LENGTH	60,920.6 FEET	11.538 MILES
LENGTH OF EXCEPTIONS	0.0 FEET	0.0 MILES
NET LENGTH	60,920.6 FEET	11.538 MILES

3

STATE OF SOUTH DAKOTA	PROJECT	SHEET	TOTAL SHEETS
	NH-P 0043(15)	2	18

Plotting Date: 01/08/2015
Revised Date: 01-08-2015 jpr

SD 40 MRM 32.000 to 38.828
DESIGN DESIGNATION

ADT (2013)	867
ADT (2033)	1258
DHV	284.3
D	51 %
T DHV	1.7%
T ADT	3.8%
V	35 MPH

① MRM 32.66
Str. No. 52-320-430
Concrete Slab
132.8' = 0.025 Miles

② MRM 32.98
Str. No. 52-322-427
Concrete Slab
104.5' = 0.020 Miles

③ MRM 33.38
Str. No. 52-327-427
Concrete Slab
105.1' = 0.020 Miles

④ MRM 33.73
Str. No. 52-328-428
Concrete Slab
93.9'= 0.018 Miles

⑤ MRM 33.85
Str. No. 52-329-430
Concrete Slab
79.6' = 0.015 Miles

⑥ MRM 34.13
Str. No. 52-332-431
Concrete Slab
114.5' = 0.022 Miles

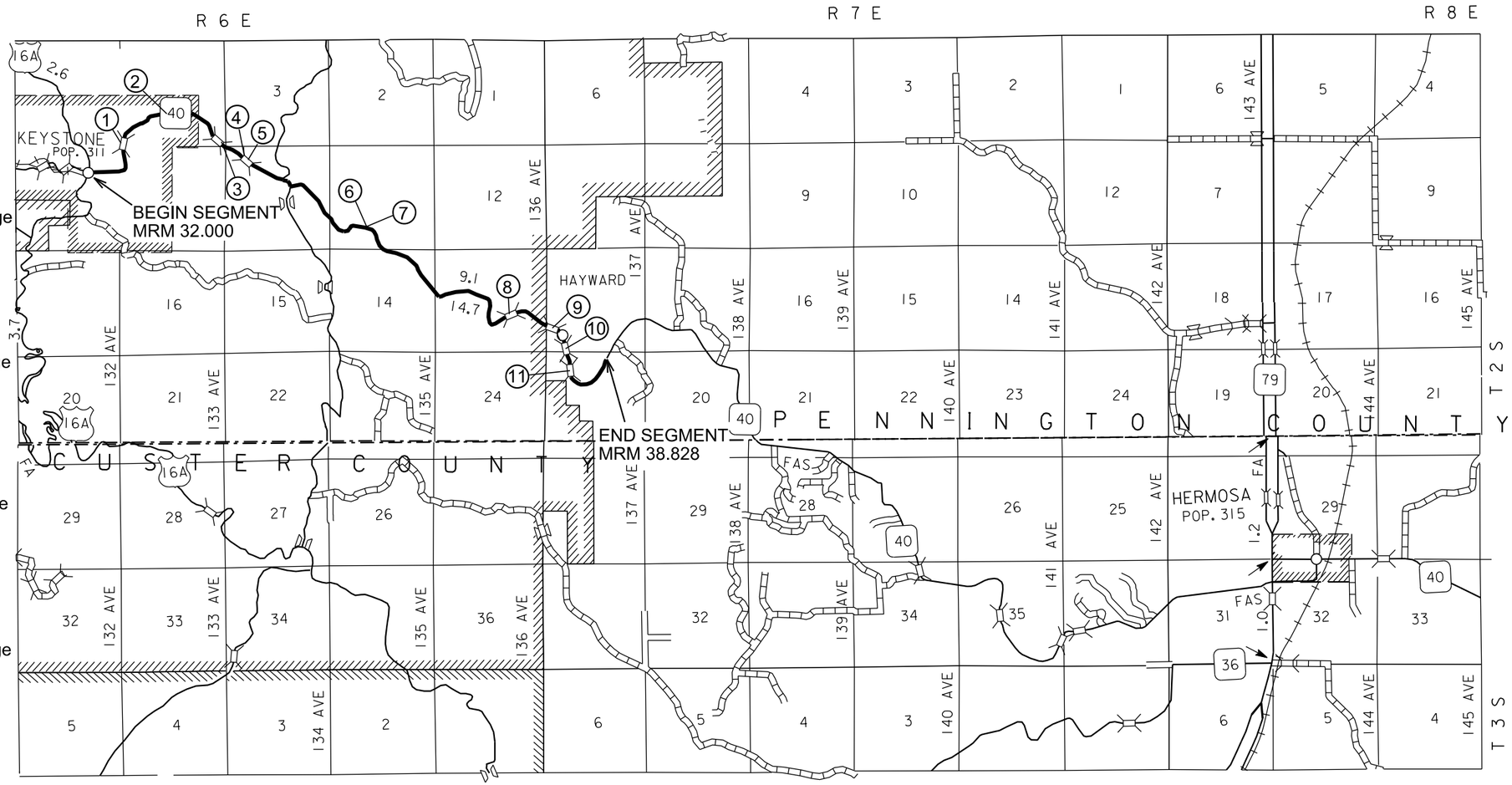
⑦ MRM 34.68
Str. No. 52-337-433
Concrete Slab
165.1' = 0.031 Miles

⑧ MRM 37.33
Str. No. 52-357-446
Composite Steel and
Concrete Girder Bridge
152.3' = 0.029 Miles

⑨ MRM 37.80
Str. No. 52-361-447
Composite Steel and
Concrete Girder Bridge
212.1' = 0.040 Miles

⑩ MRM 38.06
Str. No. 52-362-449
Composite Steel and
Concrete Girder Bridge
197.3' = 0.037 Miles

⑪ MRM 38.26
Str. No. 52-362-451
Composite Steel and
Concrete Girder Bridge
197.0 = 0.037 Miles



GROSS LENGTH	36,051.8 FEET	6.828 MILES
LENGTH OF EXCEPTIONS	1,554.2 FEET	0.294 MILES
NET LENGTH	34,497.6 FEET	6.534 MILES

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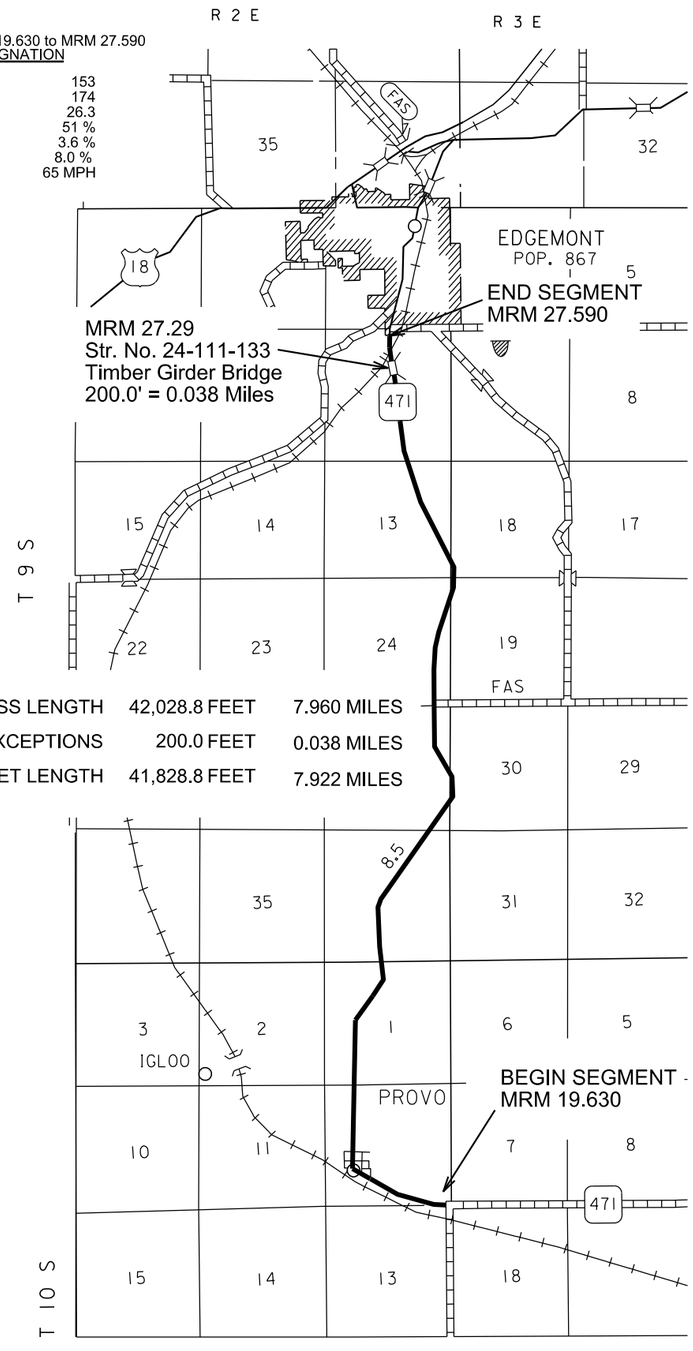
STATE OF SOUTH DAKOTA	PROJECT	SHEET	TOTAL SHEETS
	NH-P 0043(15)	3	18

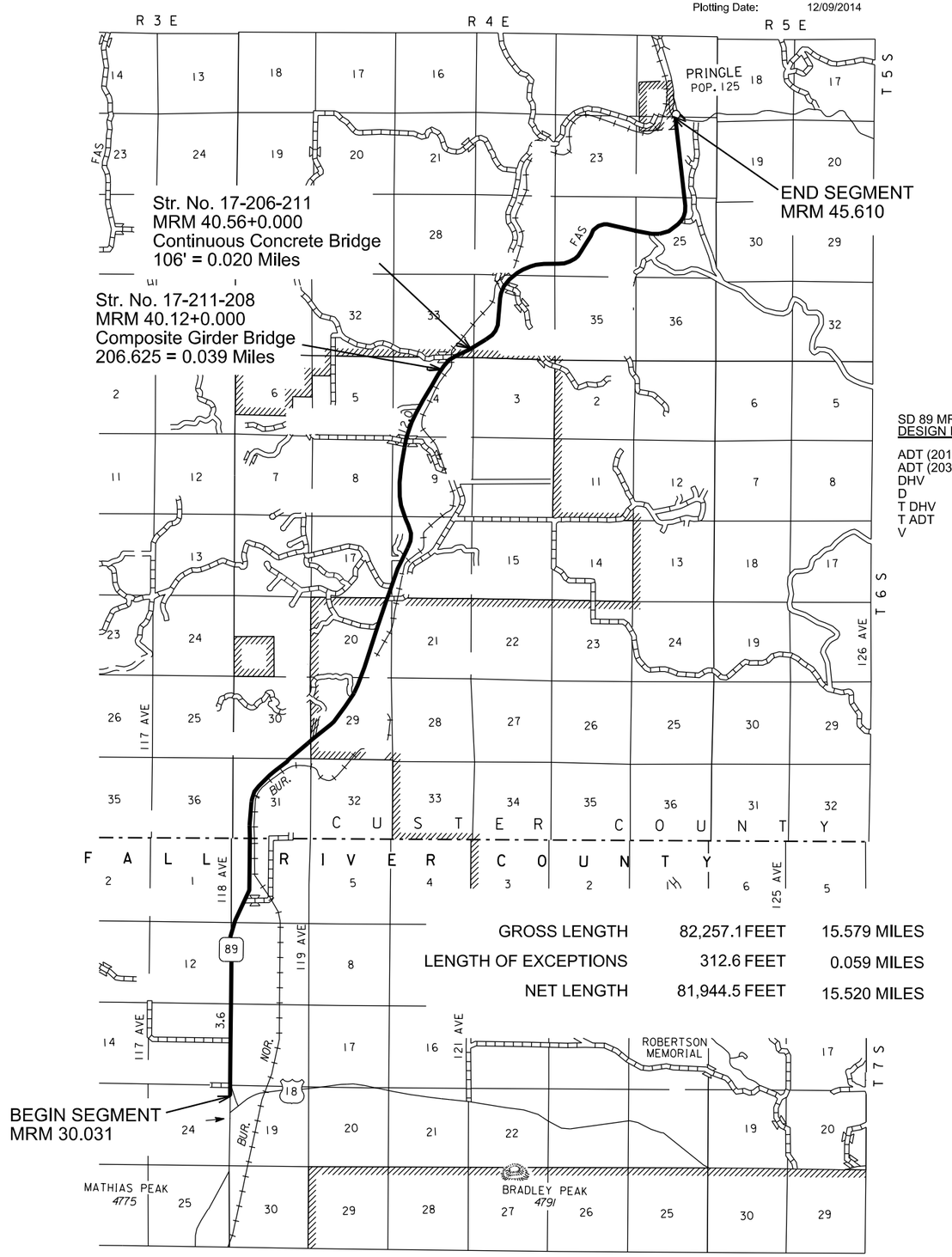
Plotting Date: 12/09/2014

SD 471 MRM 19.630 to MRM 27.590
DESIGN DESIGNATION

ADT (2013)	153
ADT (2033)	174
DHV	26.3
D	51 %
T DHV	3.6 %
T ADT	8.0 %
V	65 MPH



GROSS LENGTH	42,028.8 FEET	7.960 MILES
LENGTH OF EXCEPTIONS	200.0 FEET	0.038 MILES
NET LENGTH	41,828.8 FEET	7.922 MILES



SD 89 MRM 30.031 to 45.610
DESIGN DESIGNATION

ADT (2013)	357
ADT (2033)	415
DHV	62.6
D	51 %
T DHV	13.4 %
T ADT	29.5 %
V	65 MPH

GROSS LENGTH	82,257.1 FEET	15.579 MILES
LENGTH OF EXCEPTIONS	312.6 FEET	0.059 MILES
NET LENGTH	81,944.5 FEET	15.520 MILES

Plot Scale - 1:200

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STATE OF SOUTH DAKOTA	PROJECT	SHEET	TOTAL SHEETS
	NH-P 0043(15)	4	18

Revised date 1-8-15 jpr

ESTIMATE OF QUANTITIES

Bid Item Number	Item	Quantity	Unit
009E0010	Mobilization	Lump Sum	LS
330E0300	SS-1h or CSS-1h Asphalt for Fog Seal	175.3	Ton
360E0020	AE150S Asphalt for Surface Treatment	868.1	Ton
360E1030	Type 2A Cover Aggregate	3,113.7	Ton
360E1030	Type 2A Cover Aggregate	1,229.3	Ton
360E1030	Type 2A Cover Aggregate	1,013.8	Ton
360E1030	Type 2A Cover Aggregate	3,769.4	Ton
633E0055	Cold Applied Plastic Pavement Marking, Railroad Crossing	2	Each
633E1300	Pavement Marking Paint, White	1,416.0	Gal
633E1305	Pavement Marking Paint, Yellow	1,048.0	Gal
633E5040	Grooving for Cold Applied Plastic Pavement Marking, Railroad Crossing	2	Each
633E6020	Pavement Marking Masking, 25"	144	Ft
634E0010	Flagging	640	Hour
634E0020	Pilot Car	160	Hour
634E0100	Traffic Control	7,564	Unit
634E0120	Traffic Control, Miscellaneous	Lump Sum	LS
634E0630	Temporary Pavement Marking	83.8	Mile
998E0100	Railroad Protective Insurance	Lump Sum	LS

TABLE OF QUANTITIES BY HIGHWAY SEGMENT

	US 18	SD 40	SD 89	SD 471		
MRM to	**20.530**	**32.000**	**30.031**	**19.630**		
MRM	**32.068**	**38.828**	**45.610**	**27.590**	**Total**	
Item					**Quantity**	**Units**
Mobilization	LS	LS	LS	LS	**Lump Sum**	**LS**
SS-1h or CSS-1h Asphalt for Fog Seal	57.5	24.4	69.7	23.7	**175.3**	**Ton**
AE150S Asphalt for Surface Treatment	287.7	104.9	348.3	127.2	**868.1**	**Ton**
Type 2A Cover Aggregate	3113.7	1013.8	3769.4	1229.3	**9126.3**	**Ton**
Cold Applied Plastic Pavement Marking, Railroad Crossing	0	0	0	2	**2**	**Each**
Pavement Marking Paint, White	390	231	527	269	**1416**	**Gal**
Pavement Marking Paint, Yellow	288	171	389	199	**1048**	**Gal**
Grooving for Cold Applied Plastic Pavement Marking, Railroad Crossing	0	0	0	2	**2**	**Each**
Flagging	160.0	160.0	200.0	120.0	**640**	**Hour**
Pilot Car	40	40	50	30	**160**	**Hour**
Traffic Control	1809	1417	2669	1669	**7564**	**Unit**
Traffic Control, Miscellaneous	LS	LS	LS	LS	**Lump Sum**	**LS**
Temporary Pavement Marking	23.1	13.7	31.2	15.9	**83.8**	**Mile**
Railroad Protective Insurance	0	0.0	0.0	LS	**Lump Sum**	**LS**

SPECIFICATIONS

Standard Specifications for Roads and Bridges, 2004 Edition and Required Provisions, Supplemental Specifications, and Special Provisions as included in the Proposal.

ENVIRONMENTAL COMMITMENTS

An Environmental Commitment is a measure that SDDOT commits to implement in order to avoid, minimize, and/or mitigate a real or potential environmental impact. Environmental commitments to various agencies and the public have been made to secure approval of this project. An agency mentioned below with permitting authority can influence a project if perceived environmental impacts have not been adequately addressed. Unless otherwise designated, the Contractor's primary contact regarding matters associated with these commitments will be the Project Engineer. These environmental commitments are not subject to change without prior written approval from the SDDOT Environmental Office. The environmental commitments associated with this project are as follows:

COMMITMENT H: WASTE DISPOSAL SITE

The Contractor shall furnish a site(s) for the disposal of construction and/or demolition debris generated by this project.

Action Taken/Required:

Construction and/or demolition debris may not be disposed of within the State ROW.

The waste disposal site(s) shall be managed and reclaimed in accordance with the following from the General Permit for Highway, Road, and Railway Construction/Demolition Debris Disposal Under the South Dakota Waste Management Program issued by the Department of Environment and Natural Resources.

The waste disposal site(s) shall not be located in a wetland, within 200 feet of surface water, or in an area that adversely affects wildlife, recreation, aesthetic value of an area, or any threatened or endangered species, as approved by the Project Engineer.

If the waste disposal site(s) is located such that it is within view of any ROW, the following additional requirements shall apply:

1. Construction and/or demolition debris consisting of concrete, asphalt concrete, or other similar materials shall be buried in a trench completely separate from wood debris. The final cover over the construction and/or demolition debris shall consist of a minimum of 1 foot of soil capable of supporting vegetation. Waste disposal sites provided outside of the State ROW shall be seeded in accordance with Natural Resources Conservation Service recommendations. The seeding recommendations may be obtained through the appropriate County NRCS Office. The Contractor shall control the access to waste disposal sites not within the State ROW through the use of fences, gates, and placement of a sign or signs at the entrance to the site stating "No Dumping Allowed".

2. Concrete and asphalt concrete debris may be stockpiled within view of the ROW for a period of time not to exceed the duration of the project. Prior to project completion, the waste shall be removed from view of the ROW or buried and the waste disposal site reclaimed as noted above.

The above requirements will not apply to waste disposal sites that are covered by an individual solid waste permit as specified in SDCL 34A-6-58, SDCL 34A-6-1.13, and ARSD 74:27:10:06.

Failure to comply with the requirements stated above may result in civil penalties in accordance with South Dakota Solid Waste Law, SDCL 34A-6-1.31.

All costs associated with furnishing waste disposal site(s), disposing of waste, maintaining control of access (fence, gates, and signs), and reclamation of the waste disposal site(s) shall be incidental to the various contract items.

COMMITMENT I: HISTORICAL PRESERVATION OFFICE CLEARANCES

The SDDOT has obtained concurrence with the State Historical Preservation Office (SHPO or THPO) for all work included within the project limits and all designated option borrow sites provided within the plans.

Action Taken/Required:

All earth disturbing activities not designated within the plans require review of cultural resources impacts. This work includes, but is not limited to: staging areas, borrow sites, waste disposal sites, and all material processing sites.

The Contractor shall arrange and pay for a cultural resource survey and/or records search. The Contractor has the option to contact the state Archaeological Research Center (ARC) at 605-394-1936 or another qualified archaeologist, to obtain either a records search or a cultural resources survey. A record search might be sufficient for review; however, a cultural resources survey may need to be conducted by a qualified archaeologist.

The Contractor shall provide ARC with the following: a topographical map or aerial view on which the site is clearly outlined, site dimensions, project number, and PCN. If applicable, provide evidence that the site has been previously disturbed by farming, mining, or construction activities with a landowner statement that artifacts have not been found on the site.

The Contractor shall submit the records search or cultural resources survey report and if the location of the site is within the current geographical or historic boundaries of any South Dakota reservation to SDDOT Environmental Engineer, 700 East Broadway Avenue, Pierre, SD 57501-2586 (605-773-3180). SDDOT will submit the information to the appropriate SHPO/THPO. Allow **30 Days** from the date this information is submitted to the Environmental Engineer for SHPO/THPO review.

If evidence for cultural resources is uncovered during project construction activities, then such activities shall cease and the Project Engineer shall be immediately notified. The Project Engineer will contact the SDDOT Environmental Engineer in order to determine an appropriate course of action.

SHPO/THPO review does not relieve the Contractor of the responsibility for obtaining any additional permits and clearances for staging areas, borrow sites, waste disposal sites, or material processing sites that affect wetlands, threatened and endangered species, or waterways. The Contractor shall provide the required permits and clearances to the Project Engineer at the preconstruction meeting.

Separate measurement and payment will not be made; all work associated with furnishing and constructing the safety edge shall be incidental to the asphalt concrete placement bid item.

COMMITMENT R: FIRE PREVENTION IN THE BLACK HILLS AREA

This project is located within the confines of the Black Hills Forest Fire Protection Boundary.

Action Taken/Required:

The Contractor shall adhere to the "Special Provision for Fire Plan".

ASPHALT SURFACE TREATMENT RATES OF MATERIALS

US Highway 18, MRM 20.530 to MRM 32.068

AE150S Asphalt for Surface Treatment applied 40 feet wide,
24.9 tons/mile (Rate = 0.25 gallons per square yard)

Type 2A Cover Aggregate applied 40 feet wide,
270 tons/mile (Rate = 23 pounds per square yard)

SS-1h or CSS-1h Emulsified Asphalt for Fog Seal applied 40 feet wide,
5.0 tons/mile (0.05 gallons per square yard)

SD Highway 40, MRM 32.000 to MRM 38.828

AE150S Asphalt for Surface Treatment applied 23 feet wide,
16.1 tons/mile (Rate = 0.28 gallons per square yard)

Type 2A Cover Aggregate applied 23 feet wide,
155 tons/mile (Rate = 23 pounds per square yard)

SS-1h or CSS-1h Emulsified Asphalt for Fog Seal applied 30 feet wide,
3.7 tons/mile (0.05 gallons per square yard)

SD Highway 89, MRM 30.031 to MRM 45.610

AE150S Asphalt for Surface Treatment applied 36 feet wide,
22.4 tons/mile (Rate = 0.25 gallons per square yard)

Type 2A Cover Aggregate applied 36 feet wide,
243 tons/mile (Rate = 23 pounds per square yard)

SS-1h or CSS-1h Emulsified Asphalt for Fog Seal applied 36 feet wide,
4.5 tons/mile (0.05 gallons per square yard)

SD Highway 471, MRM 19.630 to MRM 27.590

AE150S Asphalt for Surface Treatment applied 23 feet wide,
16.1 tons/mile (Rate = 0.28 gallons per square yard)

Type 2A Cover Aggregate applied 23 feet wide,
155 tons/mile (Rate = 23 pounds per square yard)

SS-1h or CSS-1h Emulsified Asphalt for Fog Seal applied 24 feet wide,
3.0 tons/mile (0.05 gallons per square yard)

TABLE OF MATERIAL QUANTITIES

Highway	Begin	End	Total Length	Length Exceptions	Net Length	Width	Type 2A Cover Aggregate	AE150S Asphalt for Surface Treatment	SS-1h or CSS-1h Asphalt for Fog Seal
	MRM	MRM	(ft)	(ft)	(ft)	(ft)	(ton)	(ton)	(ton)
US 18	20.530	32.068	60920.6		60920.6	40	3113.7	287.7	57.5
SD 40	32.000	38.828	36051.8	1554.2	34497.6	23	1013.8	104.9	24.4
SD 89	30.031	45.61	82257.1	312.6	81944.5	36	3769.4	348.3	69.7
SD 471	19.630	27.59	42028.8	200.0	41828.8	23	1229.3	127.2	23.7
		Totals	**221258.4**	**2066.8**	**219191.6**		**9126.3**	**868.1**	**175.3**

TABLE OF EXCEPTIONS

Highway	MRM	Description	Length (ft)
SD 40	32.660	Str. # 52-320-430	132.8
SD 40	32.980	Str. # 52-322-427	104.5
SD 40	33.380	Str. # 52-327-427	105.1
SD 40	33.730	Str. # 52-328-428	93.9
SD 40	33.850	Str. # 52-329-430	79.6
SD 40	34.130	Str. # 52-332-431	114.5
SD 40	34.680	Str. # 52-337-433	165.1
SD 40	37.330	Str. # 52-357-446	152.3
SD 40	37.800	Str. # 52-361-447	212.1
SD 40	38.060	Str. # 52-362-449	197.3
SD 40	38.260	Str. # 52-362-451	197.0
SD 89	40.120	Str. # 17-211-208	206.6
SD 89	40.560	Str. # 17-206-211	106.0
SD 471	27.590	Str. # 24-111-133	200.0
		Total	**2066.8**

TYPE 2A COVER AGGREGATE

Cover Aggregate shall conform to the requirements for Type 2A.

Quality tests on the Cover Aggregate for abrasion and soundness are required by specification. The Contractor shall notify the Area office prior to sampling and a representative from the Area office shall witness all sampling of aggregates to be submitted to the Central Testing Laboratory for quality testing. Satisfactory test results for the Cover Aggregate shall be obtained prior to its use on the Project.

After the aggregate stockpiles have been produced, the Contractor shall submit samples of the aggregates from stockpiles on each project site to the asphalt supplier, prior to construction, to evaluate the mix design and verify compatibility of the aggregate and asphalt. The mix design shall be submitted to the Engineer and to the Bituminous Engineer at least two weeks prior to the start of construction. With the mix design submittal, the Contractor shall also submit to the Bituminous Engineer a sample of each aggregate and emulsion. The design shall be verified by the Department. Approval of the mix design and compatibility test shall be made by the Engineer prior to starting work.

SHOULDER WORK

Prior to construction the Contractor shall inspect the shoulders for vegetation. If vegetation exists, the Contractor shall notify the State to kill the existing vegetation. The Contractor shall notify the State a minimum of 2 weeks prior to starting work. Vegetation and accumulated debris shall be removed from the shoulder surface by the Contractor prior to the asphalt surface treatment.

BROOMING

Loose material remaining on the surface shall be broomed off during the cool period of early morning of the day following application or as directed by the Engineer. Brooming shall be done with care, so that aggregate is not dislodged before setting. Additional brooming may be required as directed by the Engineer. The loose material resulting from the brooming shall be swept onto the roadway inslopes.

Upon completion of brooming operations a windrow of cover aggregate shall not exist along the edge of the roadway. This material shall be leveled to match the existing inslopes. Any remaining windrows of cover aggregate along the edge of the roadway shall be removed by the Contractor at the Contractor's expense.

BRIDGES AND APPROACH SLABS

Asphalt surface treatment shall not be placed on any bridges or approach slabs along the project. Bridge joints shall be covered with an approved masking material to prevent the asphalt surface treatment from coming in contact with the bridge and/or bridge joint. All loose aggregate shall be cleaned from the bridge and around the guardrail posts.

EXISTING PAVEMENT CONDITIONS

The existing pavement conditions for each project are listed in the table below. The descriptions are from the McLeod procedure for seal coat design.

LOCATION	EXISTING PAVEMENT CONDITION
US 18 MRM 20.5 to MRM 32.1	Smooth non-porous
SD 40 MRM 32.2 to MRM 38.8	Slightly porous and oxidized
SD 471 MRM 19.6 to MRM 27.3	Slightly porous and oxidized
SD 89 MRM 30.0 to MRM 45.6	Smooth non-porous

ASPHALT FOR SURFACE TREATMENT MIX DESIGN

The asphalt surface treatment shall be designed by the Contractor in accordance with the Modified McLeod Design Procedure found in Volume II of Appendix C of the Preventive Maintenance Surface Treatments Report. The asphalt surface treatment design will be prepared by qualified personnel experienced in asphalt surface treatment design and submitted to the Department for review and approval at the time materials are sampled and submitted for quality and compatibility.

The surface design will be based on the traffic volume(s) and pavement conditions contained in the plans. The final application rate for the asphalt binder and cover aggregate will be determined after the source of the material is known and field adjustments are made. The design will include the following information:

1) Aggregate gradation.
2) Bulk specific gravity of the aggregate.
3) Loose unit weight of the aggregate.
4) Asphalt type and rate of application.
5) Aggregate rate of application.

Appendix C Volume II. Guidelines for Design of Asphalt Surface Treatment is reproduced below:

Volume II. Guidelines for Design of Asphalt Surface Treatments

Introduction

This volume presents the guidelines for the design of asphalt surface treatments. The guidelines first cover some general information regarding the aggregate and the asphalt emulsion. The guidelines then address the specific material properties that are used in the recommended design procedure. Finally, the design equations for the aggregate and emulsion application rates are presented. An example design problem, illustrating the design procedure in a step-by-step manner, is also presented.

Aggregate

Aggregate Type

Three aggregate types—quartzite, limestone, and natural aggregates—are commonly used throughout the state. Quartzite is more common in the eastern part of the state, whereas limestone is more common in the western part of the state. Natural aggregates are found in the central as well as the northeast portion of the state. Other aggregate types, such as river gravel and granite, have been used for asphalt surface treatments but are not common.

The selection of the aggregate type should be based on the availability and cost of aggregates in the area. The performance of asphalt surface treatments with specific aggregate types should also be considered in the selection. On specialized applications, such as for high-volume roadways, additional considerations may need to be taken into account. For example, crushed aggregate can provide improved retention and durability characteristics.

Aggregate Shape

The ideal shape for the aggregate is cubical and angular, as opposed to flat and rounded. Flat particles tend to orient on their flattest side under traffic loadings and can become completely covered with emulsion and create a bleeding problem. In addition, these completely embedded particles prevent proper embedment of particles that lie on top of the embedded particles, resulting in continued particle loss. With cubical aggregates, the particle height is essentially the same regardless of its orientation, resulting in more uniform particle embedment.

Angular or crushed aggregate particles are preferred over rounded particles. Rounded aggregates are more susceptible to rolling and displacement under traffic, especially in locations of stopping or turning traffic. Angular particles tend to lock together and provide better long-term retention and stability.

Aggregate Gradation

The aggregate gradation plays a key role in the design, construction, and performance of asphalt surface treatments. **The gradation requirements shown in this design procedure are for information only and the standard specifications for Type 2A Cover Aggregate shall be used.** The ideal gradation comprises the following characteristics:

Aggregate Gradation (Continued)

- The aggregate should be similarly sized. A one-size aggregate provides a more uniform thickness and a more consistent and proper embedment of the particles, which improves the retention and performance of the asphalt surface treatment. Similarly sized particles also help improve the surface friction and drainage capabilities of the asphalt surface treatment.

- The aggregate bands should not be too wide. Allowing a wide range of aggregate retained on a particular sieve will result in widely varying gradations and differing performance. A tight gradation band ensures consistency and uniformity of the asphalt surface treatment.

- The gradation should limit the amount of fines (material passing the 0.075 mm [No. 200] sieve). Fine materials create dust and can be a safety hazard for passing vehicles. Furthermore, fine materials absorb emulsion and can affect the bonding characteristics and performance of the asphalt surface treatment.

To better account for these ideal properties, the aggregate gradations in table II-1 are recommended for all roadways. The maximum aggregate size is 9.52 mm (3/8 in). The gradation also forces the majority of the aggregate to a small range to create a more uniform asphalt surface treatment. The gradation also addresses the amount of fines by limiting the material passing the 0.075 mm (No. 200) sieve to one percent. The recommended gradation for sections using a second choke stone layer are also provided in the table.

Table II-1.
Ideal aggregate gradations for asphalt surface treatment designs.

Sieve Size	Percent Passing	
	Aggregate	Choke Stone
12.7 mm (1/2 in)	100	100
9.52 mm (3/8 in)	90 – 100	100
6.35 mm (1/4 in)	40 – 70	100
4.75 mm (No. 4)	0 – 15	85 – 100
2.36 mm (No. 8)	0 – 5	10 – 40
1.18 mm (No. 16)	–	0 – 10
0.300 mm (No. 50)	–	0 – 5
0.075 mm (No. 200)	0 – 1	0 – 1

Flat and Elongated Particles (Flakiness Index)

Like small particles, flat and elongated particles can become completely embedded in the emulsion and thus prevent larger aggregate particles from achieving proper embedment. The flakiness index—determined in accordance with the Central Federal Lands Highway Division (CFLHD) DFT-508, *Standard Method of Determining the Flakiness Index and Average Least Dimension of Aggregates*—should be performed to limit the amount of flat and elongated particles. The Flakiness Index is a measure of the percentage, by weight, of flat particles. For most applications, the Flakiness Index should be limited to 30 percent (i.e., the weight of flat and elongated particles should not exceed 30 percent of the total aggregate weight). For special applications such as high-volume roadways, the limit should be tightened to 20 or 25 percent.

Asphalt Emulsion

Emulsification is a process in which two otherwise incompatible materials are blended together. In the case of asphalt emulsion, the two incompatible materials are asphalt and water. An asphalt emulsion consists of asphalt particles dispersed in water, which is stabilized using a chemical solution (also known as an emulsifier). Upon application, the water and asphalt separate, a process referred to as "breaking" of the emulsion. The water then evaporates leaving the asphalt as the bonding agent.

Emulsion Classification

Asphalt emulsions are classified into three categories—anionic, cationic, and nonionic—referring to the electrical charge of the emulsifier surrounding the asphalt particles. Anionic emulsions have a negative electrical charge surrounding the asphalt particles, and cationic emulsions have a positive charge.

Because opposite electrical charges attract, anionic emulsions should be used with aggregates that have a positive charge (such as limestone and natural aggregates). Likewise, cationic emulsions should be used with aggregates that have a negative charge (such as quartzite).

Emulsions are further identified based on how quickly they revert back to asphalt cement. The following terms are used to classify the emulsion grades:

- Rapid-setting (RS)
- Medium-setting (MS)
- Slow-setting (SS)
- Quick-setting (QS)

The grades indicate the speed at which the emulsion will become unstable and "break" coming into contact with the aggregate. An RS emulsion breaks very quickly and has little or no ability to mix with an aggregate. An MS emulsion will mix with coarse aggregate but not fine aggregate. SS and QS emulsions are designed to mix with fine aggregates.

High-float emulsions (designated as HF) allow a thicker film of asphalt material on the aggregate, which enhances the bonding and retention. They are designated as such because they pass the Float Test (ASTM D139 or AASHTO T50). High-float emulsions are recommended for use with dusty aggregates (greater than 2 percent fines).

Numbers are used in the classification to indicate the relative viscosity of the emulsion. Lower numbers indicate a lower viscosity or more fluid material (i.e., an MS-2 is more viscous than an MS-1). Letters are also sometimes used following the designation: "h" indicates a harder base asphalt, "s" indicates a softer base asphalt, and "p" indicates a polymer-modified asphalt.

Table II-2 shows the classifications for asphalt emulsion. Standard specifications are available for anionic asphalt emulsions (ASTM D977 or AASHTO M140) and for cationic asphalt emulsions (ASTM D2397 or AASHTO M208).

Table II-2. Classifications of asphalt emulsions.

Anionic Asphalt Emulsions	Cationic Asphalt Emulsions
RS-1	CRS-1
RS-2	CRS-2
HFRS-2	—
MS-1	—
MS-2	CMS-2
MS-2h	CMS-2h
HFMS-1	—
HFMS-2	—
HFMS-2h	—
HFMS-2s	—
SS-1	CSS-1
SS-1h	CSS-1h

Asphalt Surface Treatment Design

Asphalt surface treatments should be designed so that the proposed materials are of sufficient quality and have the desired properties to provide the expected performance. Proper design also ensures that the proper application rates are being used. The design procedure presented herein is a modified version of the McLeod design procedure (McLeod 1969) and is currently being used by the Minnesota Department of Transportation (Janisch and Gaillard 1998).

The procedure is based on two basic principles:

- The aggregate application rate is designed to provide an asphalt surface treatment that is one stone thick (i.e., there should be a single layer of uniformly sized particles) with minimal excess.
- The voids in the aggregate are designed to be 70 percent filled with asphalt cement for good performance (i.e., the particles should be 70 percent embedded).

Emulsion Properties

Residual Asphalt Content

A portion of an asphalt emulsion consists of water, which evaporates as the binder breaks. The amount of asphalt cement that remains after breaking is referred to as the residual asphalt content. It is important to consider the residual asphalt content because it represents the amount of material that is available for bonding to the aggregate. In general, the residual asphalt content is about 65 to 70 percent (i.e., 65 to 70 percent of an asphalt emulsion consists of asphalt cement).

As mentioned, the objective of this design procedure is to achieve 70 percent embedment of the average-sized aggregate. To accomplish this, the emulsion must be at the top of the average-sized aggregate before curing. If only 70 percent of the aggregate is covered initially, the asphalt height will be about 30 percent too low after curing.

Aggregate Properties

Median Particle Size

The median particle size is the theoretical size through which 50 percent of the material passes. It is determined from the gradation chart using the following sieve sizes: 25.0 mm (1 in), 19.0 mm (3/4 in), 12.5 mm (1/2 in), 9.5 mm (3/8 in), 6.3 mm (1/4 in), 4.75 mm (No. 4), 2.36 mm (No. 8), 1.18 mm (No. 16), 0.300 mm (No. 50), and 0.075 mm (No. 200).

Flakiness Index

The Flakiness Index is a measure of the percentage, by weight, of flat particles. It is determined by testing a sample of aggregate particles for their ability to fit through a slotted plate. The test is conducted in accordance with the Central Federal Lands Highway Division (CFLHD) DFT-508, *Standard Method of Determining the Flakiness Index and Average Least Dimension of Aggregates*. The weight of the material passing the slots is divided by the total weight of the aggregate sample to determine the percent of flat particles or Flakiness Index.

Average Least Dimension

The average least dimension represents a reduction of the median particle size after accounting for the amount of flat particles. It represents the asphalt surface treatment thickness in the wheelpath after traffic has reoriented the particle on their flattest side. It is determined from the median particle size and flakiness index using the following equation:

$$H = \frac{M}{1.139285 + 0.011506FI} \qquad \text{(Eq. II-1)}$$

where:

H = Average least dimension, in.
M = Median particle size, in.
FI = Flakiness index, percent.

Loose Unit Weight

The loose unit weight is required in order to determine the voids in the aggregate in a loose condition. The voids represent the available space for the asphalt binder after placement and rolling. The loose unit weight is a function of the gradation, shape, and specific gravity of the aggregate. It should be determined in accordance with ASTM C29.

Bulk Specific Gravity

Bulk specific gravity represents the weight of aggregate as compared to the weight of water. Different aggregate types have different unit weights or specific gravities. This factor affects the application rate of the aggregate because a heavier aggregate will require more weight of aggregate (or a higher application rate) than a lighter aggregate to cover the same area. Bulk specific gravities for aggregates typically range from 2.40 to 3.00. Natural aggregates are generally about 2.40, and quartzite and limestone aggregates are generally around 2.60.

Voids in the Loose Aggregate

The voids in the loose aggregate represent the voids after the aggregate is placed on the pavement. It is based on the loose unit weight and can be determined using the following equation:

$$V = 1 - \frac{W}{62.4G} \qquad \text{(Eq. II-2)}$$

where:

V = Voids in the loose aggregate.
W = Loose unit weight of the aggregate, lb/ft^3.
G = Bulk specific gravity of the aggregate.

For one-sized aggregate, this factor will typically be around 50 percent. Rolling will reduce the amount of voids, typically to around 30 percent. Traffic will further reduce the amount of voids to around 20 percent.

Aggregate Absorption

Aggregates, especially porous aggregates, will absorb a portion of the asphalt emulsion. This will affect the amount of asphalt binder that is available for bonding with the aggregate. To ensure that enough binder remains, this factor must be taken into account when designing the emulsion application rate. An absorption correction factor of 0.09 l/m^2 (0.02 gal/yd^2) is recommended for aggregates with absorption greater than 1.5 percent. Quartzite is generally not too absorptive and will not require an adjustment. Some limestone and natural aggregates, however, may require an adjustment to the emulsion application rate.

Other Design Properties

Traffic Volume

The traffic volume will influence the amount of asphalt binder that is required to provide sufficient embedment of the aggregate. All other factors equal, roadways with higher traffic volumes will require less asphalt binder. This may appear to be the opposite of what is typically expected. However, consider that traffic causes a reorientation of the particles until they eventually lie on their flattest side. More traffic thus results in a greater probability that the particles will be laying on their flattest side and will result in a thinner asphalt surface treatment. Less traffic will result in a thicker asphalt surface treatment and will thus require more asphalt binder to achieve sufficient embedment. Table II-3 provides the recommended traffic correction factor to be used in determining the emulsion application rate. Failure to account for this factor will result in bleeding in the wheelpaths.

Table II-3. Recommended traffic correction factors.

Traffic (ADT)	Traffic Factor
< 100	0.85
100 – 500	0.75
500 – 1000	0.70
1000 – 2000	0.65
> 2000	0.60

Traffic Whip-Off

A portion of the aggregate will get thrown off the roadway before final curing and embedment under traffic has occurred. This is accounted for in the procedure using a traffic whip-off factor. The factor is based on the traffic volume and traffic speed of the roadway. Low-volume, residential streets will have about a 5 percent loss, whereas the loss on high-volume, high-speed roadways will be around 10 percent. The factor can be computed using the following equation:

$$E = 1 + \frac{P}{100} \qquad \text{(Eq. II-3)}$$

where:

E = Traffic whip-off factor.
P = Expected loss of aggregate, percent.

Thus, an expected loss of 10 percent results in a traffic whip-off factor of 1.10.

Existing Pavement Condition

The surface condition of the existing pavement will greatly influence the amount of asphalt emulsion that is required. A dry, porous pavement will absorb a tremendous amount of asphalt binder and thus affect the emulsion application rate. Conversely, a new pavement (or a pavement with bleeding on the surface) will absorb much less binder. The varying condition is accounted for in the design procedure by the surface correction factor. The recommended value, based on the pavement surface texture, is provided in table II-4.

The same application rate cannot be used for all roadways with varying conditions. Similarly, the surface condition should be monitored during placement, and the application rate adjusted as needed to address areas of differing condition.

Table II-4. Recommended surface correction factors.

Existing Pavement Surface Texture	Surface Correction Factor, gal/yd^2
Black, flushed asphalt	-0.01 to -0.06
Smooth, non-porous	0.00
Slightly porous and oxidized	+0.03
Slightly pocked, porous, and oxidized	+0.06
Badly pocked, porous, and oxidized	+0.09

Design Equations

Once the inputs are determined, the application rates can be calculated using the McLeod design equations. The equations for aggregate and emulsion application rates are presented below.

Aggregate Application Rate

The following equation is used to determine the aggregate application rate:

$$C = 46.8\left(1 - 0.4V\right) \times H \times G \times E \qquad \text{(Eq. II-4)}$$

where:

C = Aggregate application rate, lbs/yd^2.
V = Voids in loose aggregate.
H = Average least dimension, in.
G = Bulk specific gravity.
E = Traffic whip-off factor.

Emulsion Application Rate

The emulsion application rate is determined using the following equation:

$$B = \frac{2.244 \times H \times T \times V + S + A}{R} \qquad \text{(Eq. II-5)}$$

where:

B = Binder application rate, gal/yd^2.
H = Average least dimension, in.
T = Traffic correction factor.
V = Voids in loose aggregate.
S = Surface correction factor.
A = Aggregate absorption factor, gal/yd^2.
R = Residual asphalt content of binder.

Minnesota performs an additional calculation of the emulsion application rate to account for snowplow damage (Janisch and Gaillard 1998). The emulsion application rate is recalculated using the median particle size instead of the average least dimension. This new emulsion rate provides the required rate if the aggregate particles are not reoriented, and thus is more representative of the rate required outside the wheelpath. The average of the two rates is then used as the starting point in the field. Minnesota has found that if this additional calculation is not performed, insufficient binder is applied in non-traffic areas, and snow plows shave off the aggregate.(Janisch and Gaillard 1998).

Example Design Problem

A 68 kg (150 lb) sample of quartzite aggregate has been submitted for design. The roadway has traffic levels of 2,125 vehicles per day. The pavement surface is slightly pocked, porous, and oxidized. A CRS-2 emulsion with a residual asphalt content of 66.5 percent will be used as the binder. Determine the emulsion and aggregate application rates for this project.

Step 1. Determine the aggregate gradation, bulk specific gravity, and percent absorption.

Laboratory testing of the aggregate revealed the gradation as shown in table II-5. Testing in accordance with AASHTO T 84-94 indicates a bulk specific gravity of the aggregate of 2.61. The aggregate absorption based on AASHTO T 84-94 is 0.55 percent, so no correction is needed.

Table II-5. Gradation results for design project.

Sieve Size	Percent Passing
12.7 mm (1/2 in)	100
9.52 mm (3/8 in)	95
6.35 mm (1/4 in)	62
4.75 mm (No. 4)	12
2.36 mm (No. 8)	3.2
0.075 mm (No. 200)	1.3

Step 2. Determine the mean particle size.

The median particle size (M) is determined by plotting the gradation results and reading off the size at which 50 percent of the particles pass. The median particle size represents the theoretical size at which half the stones are larger and half are smaller. For the given gradation, the median particle size is determined to be 5.8 mm (0.23 in).

Step 3. Determine the flakiness index.

To determine the flakiness index, the aggregate particles are fitted through slots. The results of this testing is shown in table II-6.

Table II-6. Results of flakiness index test.

Size Fraction	Weight Retained on Slot, grams	Weight Passing Slot, grams
12.5 to 9.5 mm (1/2 to 3/8 in)	54.2	12.3
9.5 to 6.3 mm (3/8 to ¼ in)	123.3	43.5
6.3 to 4.75 mm (1/4 in to No. 4)	184.4	89.5
Total	**361.9**	**145.3**

Using these results, the flakiness index (FI) is determined as follows:

$$FI = \frac{Weight\ of\ \ Flat\ Chips}{Weight\ of\ \ Sample} = \frac{145.3}{361.9 + 145.3} = 0.286 = 28.6\ percent$$

Step 4. Determine the average least dimension.

The average least dimension (H) is the expected thickness of the asphalt surface treatment after the aggregate has been reoriented on their flattest side from traffic. It is determined using equation II-1 as follows:

$$H = \frac{M}{1.139285 + 0.011506FI} = \frac{0.23\ in}{1.139285 + 0.011506 \times 28.6} = 0.157\ in$$

Step 5. Determine the loose weight of the aggregate.

A metal cylinder with a volume of 0.014 m^3 (0.50 ft^3) was loosely filled with aggregate and weighed. This process was repeated three times, the results of which are shown in table II-7.

Table II-7. Results of loose unit weight testing.

Test Number	Weight of Aggregate, kg (lbs)
1	20.57 (45.25)
2	20.60 (45.32)
3	20.59 (45.29)
Average	**20.59 (45.29)**

The loose unit weight (W) is then determined as follows:

$$W = \frac{Weight\ of\ \ Aggregate}{Volume\ of\ \ Cylinder} = \frac{45.29\ lbs}{0.50\ \ ft^3} = 90.58\ lbs/\ ft^3$$

Step 6. Determine the voids in the loose aggregate.

The voids in the loose aggregate (V) is determined using Equation II-2 as follows:

$$V = 1 - \frac{W}{62.4\,G} = 1 - \frac{90.58\ lbs/ft^3}{62.4\ lbs/ft^3 \times 2.61} = 0.44$$

Step 7. Determine the aggregate application rate.

With the inputs determined above, Equation II-4 is used to determine the aggregate application rate ©:

$$C = 46.8\left(1 - (0.4V)\right) \times H \times G \times E$$
$$= 46.8\left(1 - (0.4 \times 0.44)\right) \times 0.157 \times 2.61 \times 1.10 = 17.3\ lbs/yd^2$$

Example Design Problem (Continued)

Step 8. Determine the emulsion application rate.

The emulsion application rate is determined using Equation II-5. The calculation is performed twice – once for the wheelpath areas (using the average least dimension) and again for the non-wheelpath areas (using the median particle size). These calculations are shown below:

$$B = \frac{2.244 \times H \times T \times V + S + A}{R}$$
$$= \frac{2.244 \times 0.157 \times 0.60 \times 0.44 + 0.06 + 0.00}{0.665} = 0.23\ gal.yd^2$$

$$B = \frac{2.244 \times M \times T \times V + S + A}{R}$$
$$= \frac{2.244 \times 0.23 \times 0.60 \times 0.44 + 0.06 + 0.00}{0.665} = 0.30\ gal.yd^2$$

The average of the two results (0.27 gal/yd^2) is used as the starting point in the field.

PERMANENT PAVEMENT MARKING

The Contractor shall survey and mark the location of no passing zones prior to covering pavement marking.

The Contractor shall repaint all the existing pavement marking paint including centerline, edge line, lane lines, arrows, gore areas, etc. The Contractor will be required to inventory and mark, with appropriately colored tabs, the extent and location of the existing word messages, turn arrows, stop bars, railroad crossings, pedestrian crossings, gore areas etc. before the markings are obliterated. Locations of pavement marking tape shall be masked. The Contractor shall provide a copy of the pavement marking inventory to the Engineer. The cost of tabs shall be incidental to the temporary pavement making bid item. All costs associated with this work shall be incidental to the pavement marking bid items.

Application of permanent pavement marking may begin 7 calendar days following completion of the fog seal and shall be completed within 14 calendar days following completion of the fog seal.

Striper and advance and trailing warning vehicles shall be equipped with flashing amber or arrow panel warning lights.

RATES OF APPLICATION

Centerline striping (yellow) – 25.0 gallons per mile. *
4” Edgeline striping (white) - 33.8 gallons per mile. **
Glass Beads – 8 lbs. per gallon of paint

* Rate is a Region average. The actual gallons used will vary depending upon the number of No Passing Zones.

** Rate is for both edge lines.

TABLE OF PAVEMENT MARKING QUANTITIES

Highway	Begin	End	Length	Pavement Marking Paint, White	Pavement Marking Paint, Yellow	Temporary Pavement Marking
	MRM	MRM	(Mile)	(Gal)	(Gal)	(Mile)
US 18	20.530	32.068	11.5	390	288	23.1
SD 40	32.000	38.828	6.8	231	171	13.7
SD 89	30.031	45.610	15.6	527	389	31.2
SD 471	19.630	27.590	8.0	269	199	15.9
		Totals	**41.9**	**1416**	**1048**	**83.8**

GROOVE PAVEMENT FOR COLD APPLIED PLASTIC MARKINGS

The grooving shall be completed within the following tolerance:

Depth of Groove: 100 mils, ± 10 mils.

The bottom of the groove shall be uniform and free of loose material. The groove shall be flat and of uniform depth for the entire width of the groove.

The Contractor shall establish a positive means for the removal of the grinding and/or grooving residue. Solid residue shall be removed from the pavement surfaces before being blown by traffic action or wind. Residue shall not be permitted to flow across lanes being used by public traffic or into gutter or drainage facilities. Residue, whether in solid or slurry form, shall be disposed of in a manner that will prevent it from reaching any waterway in a concentrated state.

Grooving on bridge decks will not be required. The Contractor shall not damage bridge joints near any pavement marking grooving. Markings on bridge decks shall be surface applied.

PAVEMENT MARKING FOR RAILROAD CROSSING

The bid items for pavement marking for railroad crossing are provided to mark the crossing located on SD 471, MRM 27.4. The quantity provided is for marking each direction as shown on the standard plate.

TRAFFIC CONTROL – GENERAL NOTES

1. Unless otherwise stated in these plans, no work will be allowed during hours of darkness. Hours of darkness are defined as ½ hour after sunset until ½ hour before sunrise.

2. Storage of vehicles and equipment shall be as near the right-of-way as possible. Contractor’s employees should mobilize at a location off the right-of-way and arrive at the work sites in a minimum number of vehicles necessary to perform the work. Indiscriminate driving and parking of vehicles within the right-of-way will not be permitted. Any damage of the vegetation, surfacing, embankment, delineators, and existing signs resulting from such indiscriminate use shall be repaired and/or restored by the Contractor, at no expense to the State, and to the satisfaction of the Engineer.

3. Existing guide, route, informational logo, regulatory, and warning signs shall be temporarily reset and maintained during construction. Removing, relocating, covering, salvaging and resetting of existing traffic control devices, including but not limited to, traffic signal heads, delineation, and signing, shall be the responsibility of the Contractor. Non-applicable signing and all traffic control devices shall be covered or removed during periods of inactivity. Periods of inactivity shall be defined as no work taking place for a period of more than 48 hours.

4. The cost of removing or covering non-applicable signs shall be incidental to the contract lump sum price for, Traffic Control, Miscellaneous.

5. Construction signing mounted on portable supports shall not be used for a duration of more than 3 days, unless approved by the Engineer. Construction signing that remains in the same location for more than 3 days shall be mounted on fixed location, ground mounted, breakaway supports.

6. The quantity of Signs paid for will be for the greatest number of installations per sign in place at any one time regardless of the number of set-ups on the route. Each route will be measured separately for payment.

7. Any delineators and signs damaged or lost shall be replaced by the Contractor at no cost to the State.

8. All materials and equipment shall be stored a minimum distance of 30’ from the traveled way during nonworking hours.

9. The Contractor shall provide documentation that all breakaway sign supports comply with FHWA NCHRP 350 or MASH crash-worthy requirements. The Contractor shall provide installation details at the preconstruction meeting for all breakaway sign support assemblies.

10. The Contractor shall be required to have a person available 24 hour/day, 7 days/week to maintain traffic control devices. The name and cellular telephone number of this individual shall be given to the Engineer at the preconstruction meeting.

11. The Contractor or designated traffic control subcontractor shall make night inspections at the initial set up of traffic control and every week thereafter to ensure the adequacy, legibility and reflectivity of each sign and device. A written summary of each inspection shall be given to the Engineer within 24 hours after completion of the inspection. The cost for the nighttime inspection work shall be incidental to the contract lump sum price for Traffic Control, Miscellaneous.

12. Vehicles working in traffic or alongside traffic shall be equipped with a flashing amber light visible from all directions. The amber light shall be mounted on the uppermost part of the vehicle. Lights must have peak intensity within the range of 40 to 400 candelas and must flash at 75 ± 15 flashes per minute. Vehicle flasher/hazard lights are not acceptable. All haul trucks shall be equipped with a second flashing amber light that is visible from the backside of the haul truck. The costs for the flashing amber lights shall be incidental to the various related contract bid items.

13. All construction operations shall be conducted in the general direction of traffic movement.

14. The Contractor shall maintain traffic in accordance with applicable MUTCD Standards, Section 4.4 and 634 of the Specifications, and the details shown in these plans.

15. If there is a discrepancy between the traffic control plans, standard plates, and the MUTCD – whichever is more stringent shall be used, as determined by the Engineer.

TRAFFIC CONTROL – GENERAL NOTES (CONTINUED)

16. Temporary Road Markers (Tabs) shall be used for lane closure tapers or lane shift tapers and shall be installed at 5' spacing. Tabs used for tapers and shifts will not be measured for payment. All costs associated to furnish, install, maintain (including replacement as required by the Engineer at no added cost to the Department), and remove all markers will be incidental to the contract lump sum price for Traffic Control, Miscellaneous.

17. The Contractor shall place a Loose Gravel sign at each end of the project and at 2 mile intervals or at side roads as directed by the Engineer. An advisory speed plaque (W13-1p) of 40 MPH or less shall be attached to this sign. A Motorcycles Use Extreme Caution sign shall follow the Loose Gravel sign. These signs shall be left in place until the driving surface conditions are acceptable to return traffic to normal highway speeds.

18. Drums are required in all lane closure tapers.

19. Road Work Next ## Miles and End Road Work signs shall be installed on fixed location, breakaway supports at the beginning and end of each route as directed by the Engineer.

20. Traffic shall be maintained on the driving lanes. Use of the shoulder as a driving lane will not be permitted. Any damage to the shoulder due to rerouted traffic or Contractor's equipment shall be repaired at no expense to the State.

21. Traffic approaching the project from intersecting roadways, streets, and approaches must be adequately accommodated. Major intersections or large commercial entrances may require additional signing, flaggers, and channelizing devices on a temporary basis until work activities pass these areas.

22. The pilot car shall be a four wheeled vehicle with the Contractor's name prominently displayed on both sides of the vehicle. A 36" x 18" black on orange sign G20-4, PILOT CAR (top line) FOLLOW ME (bottom line) shall be mounted in a conspicuous position on the rear of the vehicle. The pilot car will be equipped with a flashing amber light.

23. When a pilot car is used, the delay to the traveling public shall not exceed 15 minutes.

24. The second set of flaggers shall be on duty during all daylight hours until the surface has been lightly broomed as described in these plans.

25. This second set of flaggers shall provide each motorist entering completed portions of the project with a printed notice on the Contractor's letterhead similar to the one shown below. Cost of the notice shall be incidental to the other traffic control items.

"CONTRACTOR'S LETTERHEAD WITH MAILING ADDRESS AND PHONE NUMBER"

THIS HIGHWAY IS BEING RESURFACED WITH AN ASPHALT SURFACE TREATMENT. THIS TYPE OF CONSTRUCTION HAS THE POTENTIAL OF CAUSING VEHICLE DAMAGE SUCH AS CHIPPED WINDSHIELDS AND BROKEN HEADLIGHTS DUE TO ROCKS BEING THROWN BY HIGH SPEED ONCOMING OR PASSING TRAFFIC. YOU MAY WISH TO CONSIDER TAKING AN ALTERNATE ROUTE. IF YOU PROCEED, KEEP TO THE RIGHT AND DRIVE 40 MPH OR LESS. ANOTHER FLAGGER AND A PILOT CAR WILL BE ESCORTING YOU AROUND THE ASPHALT SURFACE TREATMENT APPLICATION AREA.

THANK YOU

TEMPORARY PAVEMENT MARKING

Temporary pavement markings for the centerline of the roadway throughout the full length of the project shall meet the requirements of Section 634 of the Specifications. Covers on tabs shall be removed prior to opening roadway to normal traffic.

The Contractor shall use double protective marker covers, so that one protective marker cover is removed after application of the asphalt surface treatment and one protective marker cover is removed after the application of the fog seal.

The Contractor shall be responsible for maintaining a visible and reflective centerline throughout the project. Any marking covered or damaged shall be replaced prior to the end of the day. All costs associated with this work shall be incidental to the contract unit price per mile for Temporary Pavement Marking.

In addition, No Passing Zone areas shall be marked by signs as noted below.

The Contractor shall use DO NOT PASS and PASS WITH CARE signs to mark no passing zones on roads following application of asphalt surface treatment.

Highway	ESTIMATED DO NOT PASS SIGNS	ESTIMATED PASS WITH CARE SIGNS
US18 MRM 20.5 to 32.1	5	5
SD 40 MRM 32.0 to 38.8	4	4
SD 471 MRM 19.6 to 27.6	11	11
SD 89 MRM 30.0 to 45.6	19	19

Flagger symbol signs (W20-7) and flaggers, or a shadow vehicle equipped with high-intensity rotating, flashing, oscillating or strobe lights shall be positioned on the roadway shoulder in advance of the workers for the installation of temporary road markers. The traffic control device used shall be moved to provide proper warning of the work operation. A ROAD WORK AHEAD (W20-1) sign, a worker symbol sign (W21-1) or a BE PREPARED TO STOP (W3-4) sign shall be mounted on the rear of the shadow vehicle. The method of traffic control used by the Contractor for this work shall be approved by the Engineer.

The measurement for payment of temporary pavement marking will include the tabs with double covers, with one pass to remove the first cover after the chip seal, and one pass to remove the second cover after the fog seal for a total of 2x the segment length.

All costs for temporary pavement marking including furnishing, applying, removing protective covers, maintenance and removal of tabs shall be incidental to the contract unit price per mile for Temporary Pavement Marking.

INVENTORY OF TRAFFIC CONTROL DEVICES US 18

SIGN CODE	DESCRIPTION	NUMBER	SIGN SIZE	UNITS PER SIGN	UNITS
R4-1	DO NOT PASS	5	24" x 30"	18	90
R4-2	PASS WITH CARE	5	24" x 30"	18	90
W3-4	BE PREPARED TO STOP	2	48" x 48"	34	68
W8-6	TRUCK CROSSING	2	48" x 48"	34	68
W8-7	LOOSE GRAVEL	12	48" x 48"	34	408
W13-1P	ADVISORY SPEED (plaque)	12	30" x 30"	21	252
W20-1	ROAD WORK AHEAD	2	48" x 48"	34	68
W20-4	ONE LANE ROAD AHEAD	2	48" x 48"	34	68
W20-7	FLAGGER (symbol)	4	48" x 48"	34	136
W21-2	FRESH OIL	2	48" x 48"	34	68
SPECIAL	MOTORCYCLES USE EXTREME CAUTION	12	48" x 48"	34	408
G20-1	ROAD WORK NEXT __ MILES	2	36" x 18"	17	34
G20-2	END ROAD WORK	2	36" x 18"	17	34
G20-4	PILOT CAR FOLLOW ME	1	36" x 18"	17	17
				TOTAL UNITS	**1809**

INVENTORY OF TRAFFIC CONTROL DEVICES SD 40

SIGN CODE	DESCRIPTION	NUMBER	SIGN SIZE	UNITS PER SIGN	UNITS
R4-1	DO NOT PASS	4	24" x 30"	18	72
R4-2	PASS WITH CARE	4	24" x 30"	18	72
W3-4	BE PREPARED TO STOP	2	48" x 48"	34	68
W8-6	TRUCK CROSSING	2	48" x 48"	34	68
W8-7	LOOSE GRAVEL	8	48" x 48"	34	272
W13-1P	ADVISORY SPEED (plaque)	8	30" x 30"	21	168
W20-1	ROAD WORK AHEAD	2	48" x 48"	34	68
W20-4	ONE LANE ROAD AHEAD	2	48" x 48"	34	68
W20-7	FLAGGER (symbol)	4	48" x 48"	34	136
W21-2	FRESH OIL	2	48" x 48"	34	68
SPECIAL	MOTORCYCLES USE EXTREME CAUTION	8	48" x 48"	34	272
G20-1	ROAD WORK NEXT __ MILES	2	36" x 18"	17	34
G20-2	END ROAD WORK	2	36" x 18"	17	34
G20-4	PILOT CAR FOLLOW ME	1	36" x 18"	17	17
				TOTAL UNITS	**1417**

INVENTORY OF TRAFFIC CONTROL DEVICES SD 471

SIGN CODE	DESCRIPTION	NUMBER	SIGN SIZE	UNITS PER SIGN	UNITS
R4-1	DO NOT PASS	11	24" x 30"	18	198
R4-2	PASS WITH CARE	11	24" x 30"	18	198
W3-4	BE PREPARED TO STOP	2	48" x 48"	34	68
W8-6	TRUCK CROSSING	2	48" x 48"	34	68
W8-7	LOOSE GRAVEL	8	48" x 48"	34	272
W13-1P	ADVISORY SPEED (plaque)	8	30" x 30"	21	168
W20-1	ROAD WORK AHEAD	2	48" x 48"	34	68
W20-4	ONE LANE ROAD AHEAD	2	48" x 48"	34	68
W20-7	FLAGGER (symbol)	4	48" x 48"	34	136
W21-2	FRESH OIL	2	48" x 48"	34	68
SPECIAL	MOTORCYCLES USE EXTREME CAUTION	8	48" x 48"	34	272
G20-1	ROAD WORK NEXT __ MILES	2	36" x 18"	17	34
G20-2	END ROAD WORK	2	36" x 18"	17	34
G20-4	PILOT CAR FOLLOW ME	1	36" x 18"	17	17
				TOTAL UNITS	**1669**

STATE OF SOUTH DAKOTA	PROJECT	SHEET	TOTAL SHEETS
	NH-P 0043(15)	13	18

Revised date 1-8-15 jpr

INVENTORY OF TRAFFIC CONTROL DEVICES SD 89

SIGN CODE	DESCRIPTION	NUMBER	SIGN SIZE	UNITS PER SIGN	UNITS
R4-1	DO NOT PASS	19	24" x 30"	18	342
R4-2	PASS WITH CARE	19	24" x 30"	18	342
W3-4	BE PREPARED TO STOP	2	48" x 48"	34	68
W8-6	TRUCK CROSSING	2	48" x 48"	34	68
W8-7	LOOSE GRAVEL	16	48" x 48"	34	544
W13-1P	ADVISORY SPEED (plaque)	16	30" x 30"	21	336
W20-1	ROAD WORK AHEAD	2	48" x 48"	34	68
W20-4	ONE LANE ROAD AHEAD	2	48" x 48"	34	68
W20-7	FLAGGER (symbol)	4	48" x 48"	34	136
W21-2	FRESH OIL	2	48" x 48"	34	68
SPECIAL	MOTORCYCLES USE EXTREME CAUTION	16	48" x 48"	34	544
G20-1	ROAD WORK NEXT __ MILES	2	36" x 18"	17	34
G20-2	END ROAD WORK	2	36" x 18"	17	34
G20-4	PILOT CAR FOLLOW ME	1	36" x 18"	17	17
				TOTAL UNITS	**2669**

PAVEMENT MARKING MASKING

Pavement Marking Masking provided in the Estimate of Quantities is for protecting the cross walk, in Keystone, SD 40, MRM 33.17.

Just prior to beginning the asphalt surface treatment and the fog sealing operation, all durable pavement markings and pavement marking tape shall be covered with an approved pavement marking masking material to protect the pavement marking from oil and aggregates. Tabs shall be placed at the beginning of each masking line to provide a guide for locating the masking material after the seal has been applied.

The masking material shall be placed to the length of that day's surface treatment. Upon the completion of that surface treatment, all pavement markings must be in full compliance, either by removing the pavement marking masking or utilizing temporary pavement markings.

All cost for furnishing, installing, removing, and disposing of the masking materials shall be incidental to the contract unit price for the Pavement Marking Masking contract bid items. The plans shown quantity for Pavement Marking Masking and Temporary Pavement Marking will be the basis for payment unless changes are made by the Engineer. Pavement Marking Masking shall be paid once prior to the installation of the asphalt surface treatment and once prior to the installation of the fog seal.

TYPICAL PAVEMENT MARKING LAYOUT

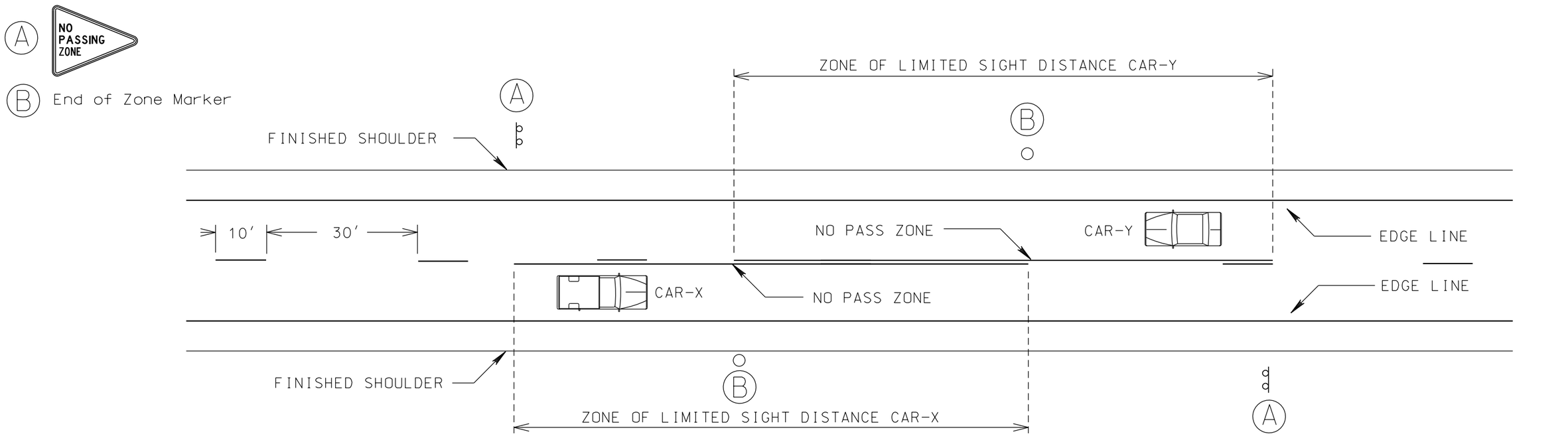
STATE OF SOUTH DAKOTA	PROJECT	SHEET	TOTAL SHEETS
	NH-P 0043(15)	14	18

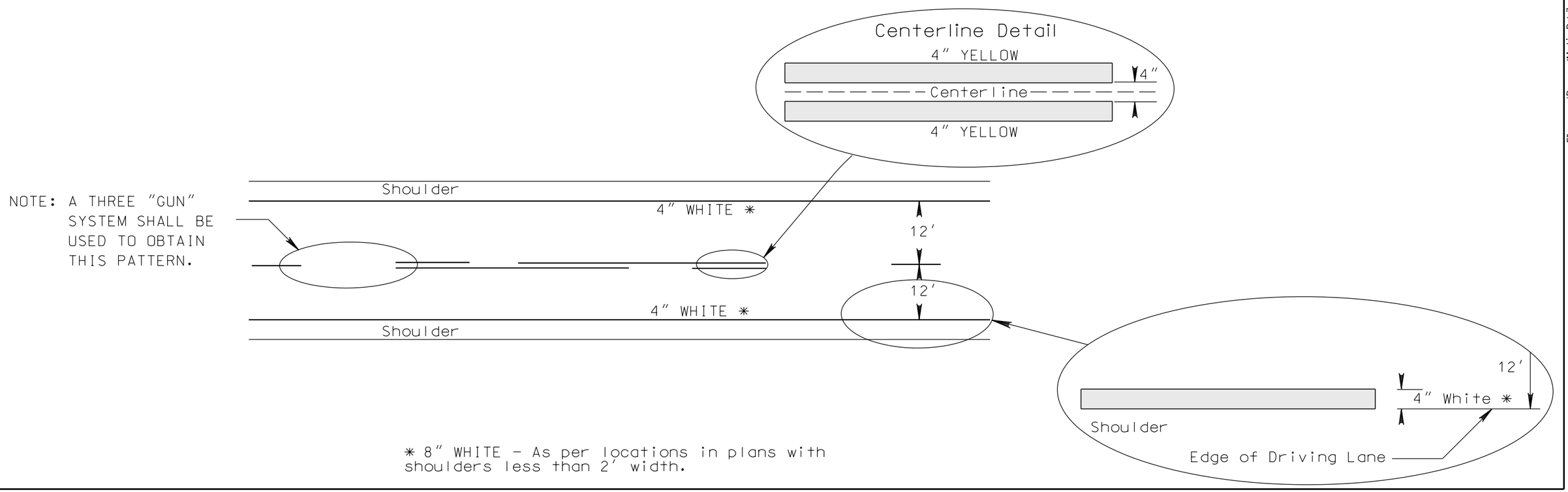
Plotting Date: 12/03/2013

Plot Scale - 1:20

Plotted From - trnc11610

File - ...\PavementMarkingDetails.dgn



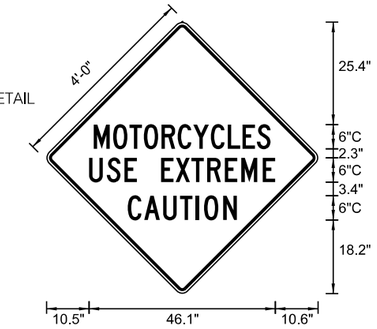


* 8″ WHITE - As per locations in plans with shoulders less than 2′ width.

STATE OF SOUTH DAKOTA	PROJECT	SHEET	TOTAL SHEETS
	NH-P 0043(15)	15	18

Plotting Date: 12/12/2014

SIGN DETAIL
1:25



SIGN NUMBER	Motorcycles
WIDTH x HGHT.	5'-7" x 5'-7"
BORDER WIDTH	1.25"
CORNER RADIUS	3"
MOUNTING	Ground
BACKGROUND	TYPE: Reflective
	COLOR: Orange
LEGEND/BORDER	TYPE: Non-reflective
	COLOR: Black/Black

SYMBOL	ROT	X	Y	WID	HT

Panel Style: construction_warning.ssi
M.U.T.C.D.: 2009 Edition

Panel Style: construction_warning.ssi
Dimensions are in inches.tenths
Letter locations are panel edge to lower left corner

LETTER POSITIONS (X)															LENGTH	SERIES-SIZE
M	O	T	O	R	C	Y	C	L	E	S						C 2000
11.7	16.5	20.5	24.1	28.5	32.5	36.3	40.7	44.9	48.5	52.1					43.8	6
U	S	E		E	X	T	R	E	M	E						C 2000
10.5	14.9	19.3	22.4	28.4	32	35.9	39.8	44.1	48.2	53.5					46.1	6
C	A	U	T	I	O	N										C 2000
20.1	24.2	28.9	33.1	37	39	43.7									27.1	6

Plot Scale - 1:3.125

Plotted From - trrc11951

File - ...\2015\Motorcycles.dgn

Pavement Marking Operations

Shadow and Lead Vehicles shall be positioned at the crest of vertical curves or at loctions of adequate sight distance for approaching vehicles.

Vehicle-mounted signs shall be mounted in a manner such that they are not obscured by equipment or supplies. Sign legends on vehicle-mounted signs shall be covered or turned from view when work is not in progress.

Shadow and Work vehicles shall display high-intensity rotating lights or strobe lights

Vehicle hazard warning signals shall not be used in place of high-intensity rotating, flashing, oscillating, or strobe lights

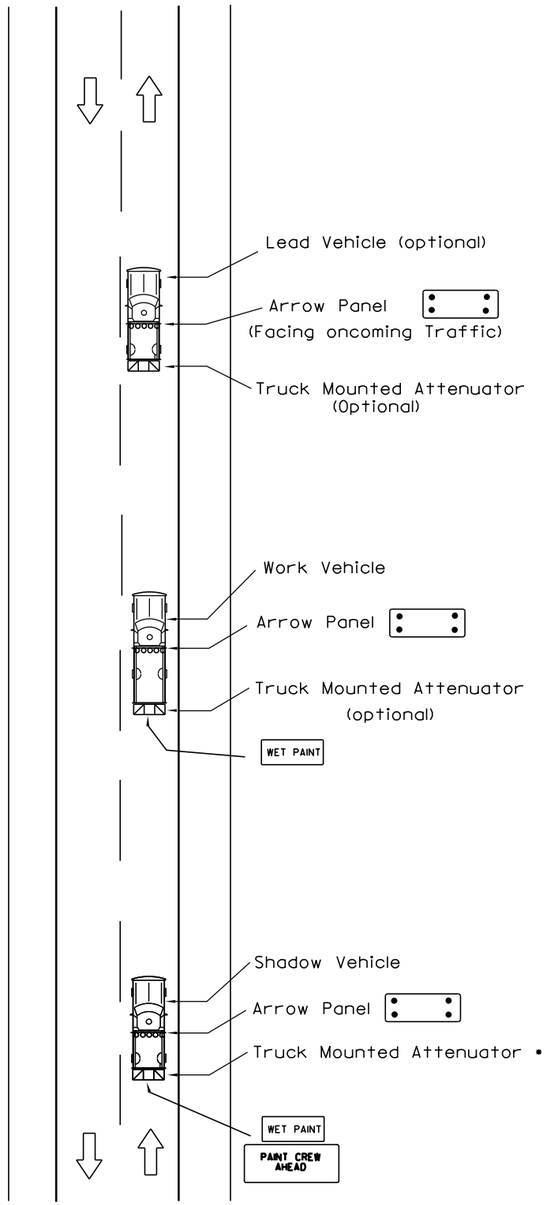
When an arrow panel is used, it shall be used in the caution mode. Marching Diamonds are acceptable.

Arrow panels shall, as a minimum, be Type B, with a size of 60" x 30".

Where practical and when needed, the work and shadow vehicles should pull over periodically to allow motor vehicle traffic to pass.

- If ANY part of the vehicle is within the driving lane, an attenuator is REQUIRED

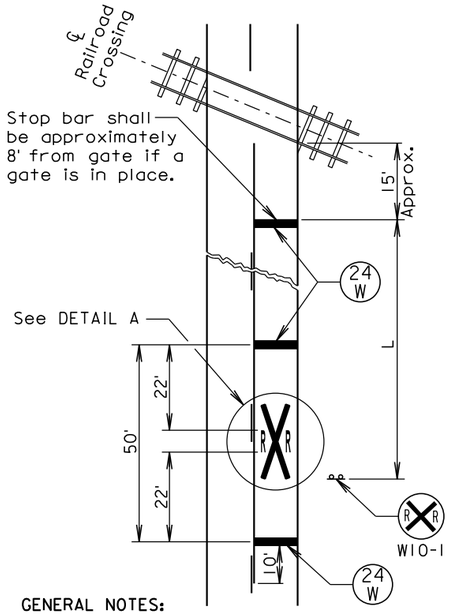
MOBILE: Intermittent and continuous moving.

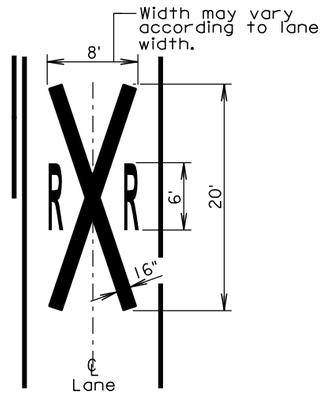


GUIDES FOR TRAFFIC CONTROL DEVICES
MOBILE OPERATIONS ON 2-LANE ROAD

KEY	ITEM
24 W	24" White
	White

Posted Speed Limit (M.P.H.)	L (Ft.)
≤ 30	100
35	100
40	125
45	175
50	250
55	325
60	400
65	475
70	550





DETAIL A

GENERAL NOTES:

The railroad crossing pavement markings shall be placed symmetrically about the centerline of the railroad crossing.

When pavement markings are used, a portion of the RXR symbol shall be placed directly opposite of the advance warning sign W10-1.

On multi-lane roads the transverse bands shall extend across all approach lanes and individual RXR symbols shall be placed in each approach lane.

The railroad crossing pavement markings shall consist of all the transverse bands, stop bars, and RXR symbols.

When pavement marking paint is used for marking the railroad crossing, all costs for furnishing and painting the markings, materials, labor, and necessary equipment shall be incidental to the contract unit price per gallon for "Pavement Marking Paint, White".

When pavement marking tape is used for marking the railroad crossing, all costs for furnishing and placing the markings, materials, labor, and necessary equipment shall be incidental to the contract unit price per each for "Cold Applied Plastic Pavement Marking, Railroad Crossing".

June 26, 2013

Published Date: 4th Qtr. 2014	SDDOT	PAVEMENT MARKINGS AT RAILROAD CROSSING	PLATE NUMBER 633.10
			Sheet 1 of 1

Posted Speed Prior to Work (M.P.H.)	Spacing of Advance Warning Signs (Feet) (A)	Spacing of Channelizing Devices (Feet) (G)
0 - 30	200	25
35 - 40	350	25
45 - 50	500	50
55	750	50
60 - 65	1000	50

Flagger

Channelizing Device

For low-volume traffic situations with short work zones on straight roadways where the flagger is visible to road users approaching from both directions, a single flagger may be used.

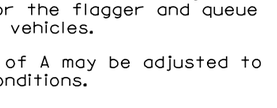
The ROAD WORK AHEAD and the END ROAD WORK signs may be omitted for short duration operations (1 hour or less).

For tack and/or flush seal operations, when flaggers are not being used, the FRESH OIL sign (W21-2) shall be displayed in advance of the liquid asphalt areas.

Flashing warning lights and/or flags may be used to call attention to the advance warning signs.

The channelizing devices shall be drums or 42" cones.

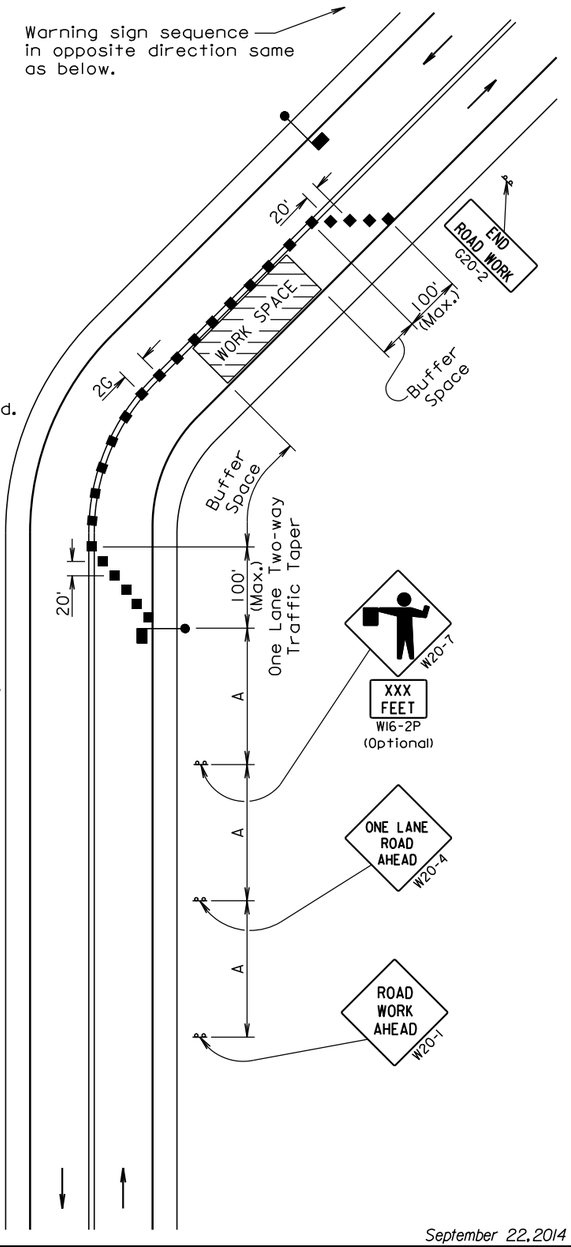
Channelizing devices are not required along the centerline adjacent to work area when pilot cars are utilized for escorting traffic through the work area.



Channelizing devices and flaggers shall be used at intersecting roads to control intersecting road traffic as required.

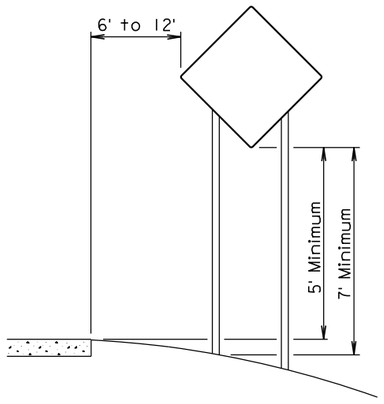
The buffer space should be extended so that the two-way traffic taper is placed before a horizontal or vertical curve to provide adequate sight distance for the flagger and queue of stopped vehicles.

The length of A may be adjusted to fit field conditions.

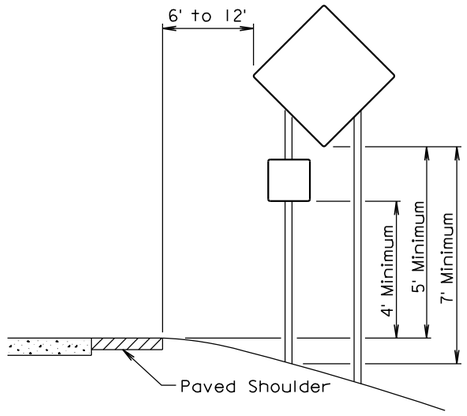


September 22, 2014

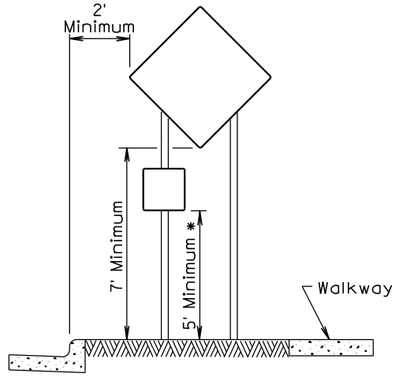
Published Date: 4th Qtr. 2014	SDDOT	GUIDES FOR TRAFFIC CONTROL DEVICES LANE CLOSURE WITH FLAGGER PROVIDED	PLATE NUMBER 634.23
			Sheet 1 of 1



RURAL DISTRICT

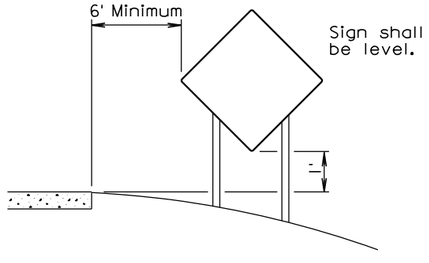


RURAL DISTRICT WITH SUPPLEMENTAL PLATE



URBAN DISTRICT

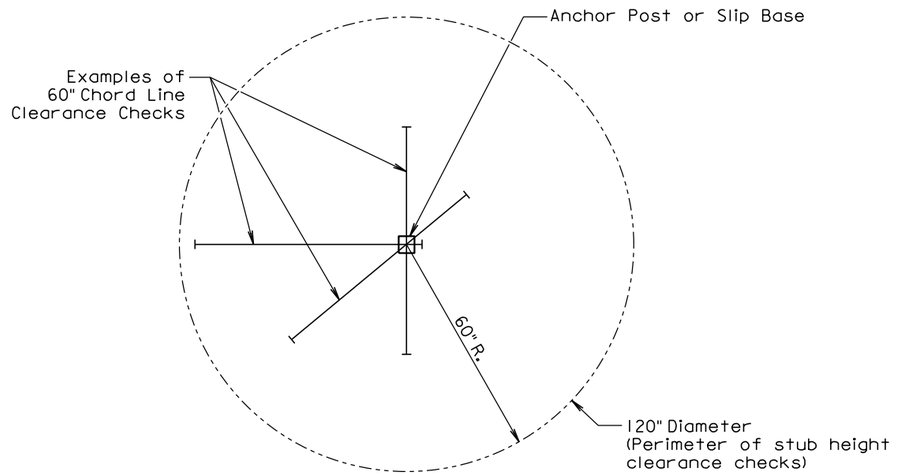
* If the bottom of supplemental plate is mounted lower than 7 feet above a pedestrian walkway, the supplemental plate should not project more than 4" into the pedestrian facility.



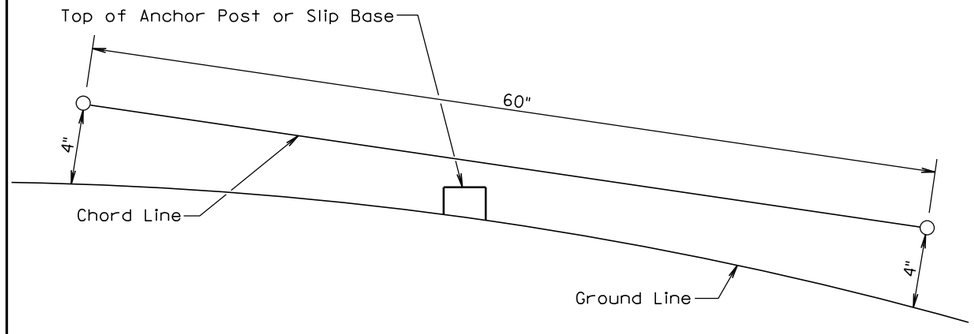
RURAL DISTRICT
3 DAY MAXIMUM
(Not applicable to regulatory signs)

September 22, 2014

Published Date: 4th Qtr. 2014	SDDOT	CRASHWORTHY SIGN SUPPORTS (Typical Construction Signing)	PLATE NUMBER 634.85
			Sheet 1 of 1



PLAN VIEW
(Examples of stub height clearance checks)



ELEVATION VIEW

GENERAL NOTES:

The top of anchor posts and slip bases SHALL NOT extend above a 60" chord line within a 120" diameter circle around the post with ends 4" above the ground.

At locations where there is curb and gutter adjacent to the breakaway sign support, the stub height shall be a maximum of 4" above the ground line at the localized area adjacent to the breakaway support stub.

The 4" stub height clearance is not necessary for U-channel lap splices where the support is designed to yield (bend) at the base.

July 1, 2005

Published Date: 4th Qtr. 2014	SDDOT	BREAKAWAY SUPPORT STUB CLEARANCE	PLATE NUMBER 634.99
			Sheet 1 of 1