PLOT SCALE - 1:200

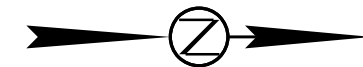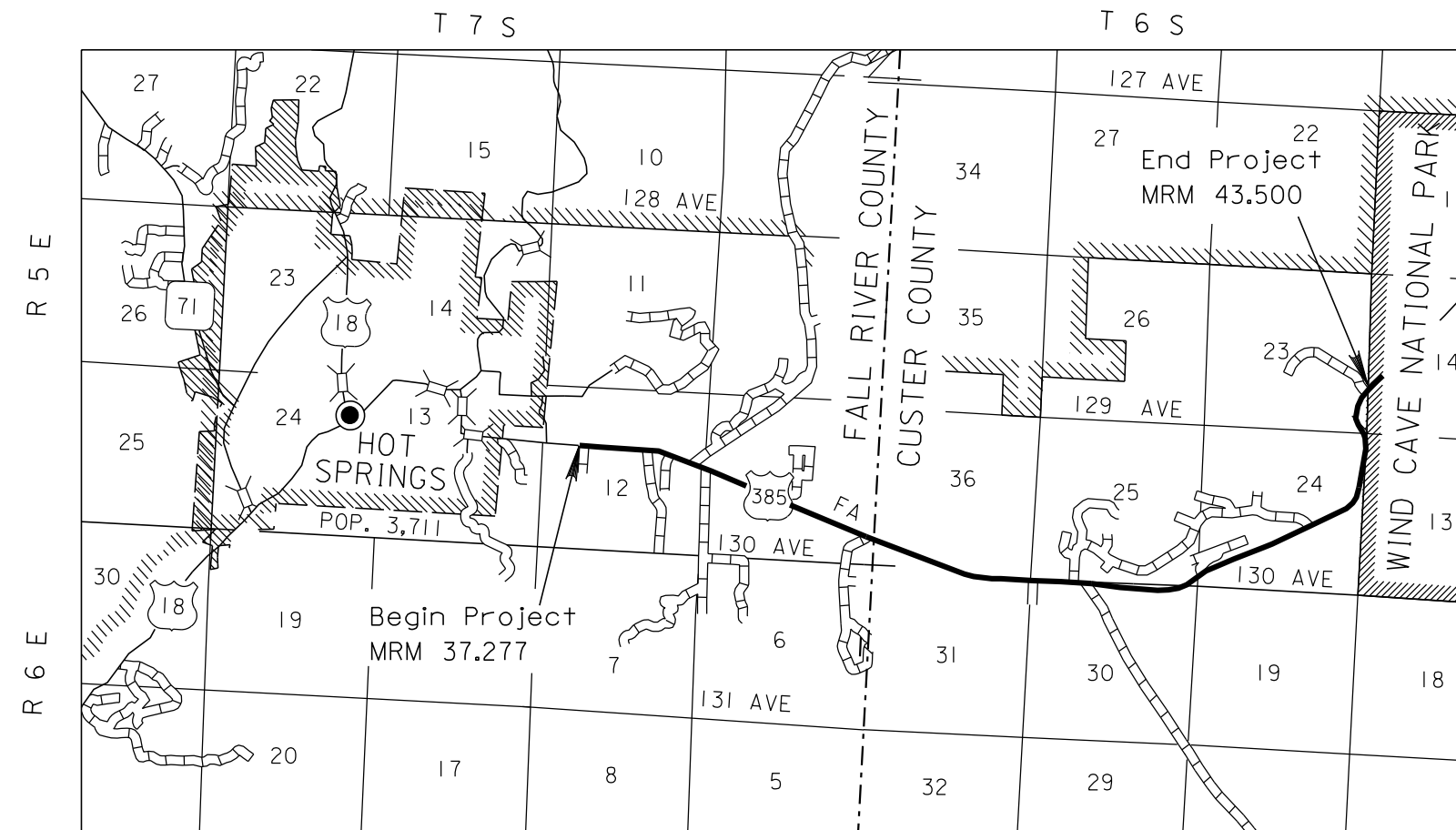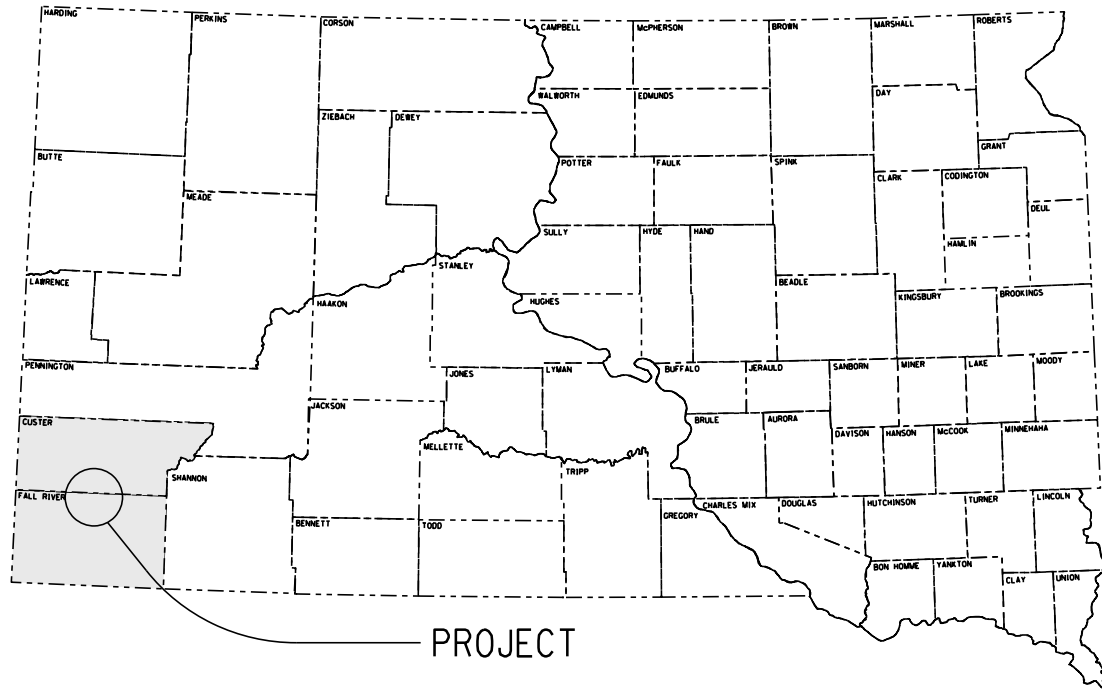# STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION
PLANS FOR PROPOSED

PROJECT 385-492
US HIGHWAY 385
FALL RIVER & CUSTER COUNTIES

ASPHALT SURFACE TREATMENT (SHOULDERS)
PCN i2LC

PROJECT

INDEX OF SHEETS

T 7 S   T 6 S

PLOT NAME - 1

FILE - ...\i2LC_TITLE.DGN

DESIGN DESIGNATION
US 385, MRM 37.277 to MRM 43.500
ADT (2011)   1539
ADT (2031)   1777
DHV   357
D   51%
T DHV   3.1%
T ADT   6.7%
V   65 MPH

Gross Length	32,857.40 FEET	6.223 MILES
Length of Exceptions	0.00 FEET	0.000 MILES
Net Length	32,857.40 FEET	6.223 MILES

PLOTTED FROM - TRRC11951

Storm Water Permit
No Permit Required

ESTIMATE OF QUANTITIES

Bid Item Number	Item	Quantity	Unit
009E0010	Mobilization	Lump Sum	LS
320E0402	Asphalt Repair Mastic Type 2	9,280	Lb
330E0300	SS-1h or CSS-1h Asphalt for Fog Seal	9.3	Ton
360E0020	AE150S Asphalt for Surface Treatment	68.9	Ton
360E1030	Type 2A Cover Aggregate	503.8	Ton
634E0010	Flagging	200	Hour
634E0020	Pilot Car	100	Hour
634E0100	Traffic Control	714	Unit
634E0120	Traffic Control, Miscellaneous	Lump Sum	LS

SPECIFICATIONS

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

SEQUENCE OF OPERATIONS

1. Set up Traffic Control

2. Complete Crack Leveling

3. Complete Asphalt Surface Treatment

4. Complete Fog Seal

5. Remove Traffic Control.

HISTORICAL PRESERVATION OFFICE CLEARANCES

To obtain State Historical Preservation Office (SHPO) clearance, a cultural resources survey may need to be conducted by a qualified archaeologist. In lieu of a cultural resources survey, the Contractor could request a records search from Jim Donohue, State Archaeological Research Center (SARC). Provide SARC 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 no artifacts have been found on the site. The Contractor shall arrange and pay for the cultural resource survey and/or records search.

If any earth disturbing activities occur within the current geographical or historic boundaries of any South Dakota reservation, the Contractor shall obtain Tribal Historical Preservation Office (THPO) clearance. If no THPO exists, the required SHPO clearance shall suffice, with documentation of Tribal contact efforts provided to SHPO.

To facilitate SHPO or THPO responses, the Contractor should submit a records search or cultural resources survey report to the DOT Environmental Engineer, 700 East Broadway Avenue, Pierre, SD 57501-2586 (605-773-3268). Allow 30 days from the date this information is submitted to the Environmental Engineer for SHPO/THPO approval. The Contractor is responsible for obtaining all required permits and clearances for staging areas, borrow sites, waste disposal sites, and all material processing sites. The Contractor shall provide the required permits and clearances to the Engineer at the preconstruction meeting.

WASTE DISPOSAL SITE

The Contractor will be required to furnish a site(s) for the disposal of construction/demolition debris generated by this project.

Construction/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 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/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/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.

ESTIMATED QUANTITIES FOR ASPHALT CONCRETE SHOULDER JOINT LEVELING ALONG PCCP

The quantities of mastic for crack leveling are based off the following criteria:

½" deep x 1' wide x 2000 linear feet of shoulder joint = 80 cubic feet.

A unit weight of 116 lbs./cuft was used for estimating purposes. Provided in the estimate of quantities is 9,280 lbs. of "Asphalt Repair Mastic Type 2". This quantity is for estimating purposes for various locations along the project as directed by the Engineer.

TABLE OF SURFACE TREATMENT QUANTITIES

Highway	Begin	End	Total Length	Width	Type 2A Cover Aggregate	AE150S Asphalt for Surface Treatment	SS-1h or CSS-1h Asphalt for Fog Seal
	MRM	MRM	(ft)	(ft)	(ton)	(ton)	(ton)
US 385	37.277	43.500	32857.4	12	503.8	68.9	9.3

ASPHALT SURFACE TREATMENT RATES OF MATERIALS

US Highway 385, MRM 37.277 to MRM 43.500

AE150S Asphalt for Surface Treatment applied 12 feet wide (2 – 6' wide shoulders), 11.1 tons/mile (Rate = 0.37 gallons per square yard)

Type 2A Cover Aggregate applied 12 feet wide (2 – 6' wide shoulders) 81.0 tons/mile (Rate = 23 pounds per square yard).

SS-1h or CSS-1h Emulsified Asphalt for Fog Seal applied 12 feet wide (2 – 6' wide shoulders), 1.5 tons/mile (0.05 gallons per square yard).

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 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.

BROOMING

The loose material left on the surface shall be lightly broomed off during the cool period of early morning (or as ordered by the Engineer) after a minimum waiting period of 24 hours. Brooming shall be completed within 48 hours from the time of application. All costs for brooming shall be incidental to the other items.

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

CURE TIME FOR CRACK LEVELING

The Contractor shall allow 1 week for the crack leveling material to adequately cure prior to application of the asphalt surface treatment. Any modifications to this curing period shall be approved by the Engineer.

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 385, MRM 37.277 to 43.500 (shoulders)	Badly pocked, porous, and oxidized

ASPHALT FOR SURFACE TREATMENT MIX DESIGN

The asphalt surface treatment will be designed 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.

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:

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 SDDOT Type 2A Cover Aggregate is specified in the plans. 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.
Recommended 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:

$$H = \frac{M}{1.139285 + 0.011506FI}$$

(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:

$$V = 1 - \frac{W}{62.4\,G}$$

(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:

$$E = 1 + \frac{P}{100}$$
(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:

$$C = 46.8\,(1 - 0.4V) \times H \times G \times E$$
(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:

$$B = \frac{2.244 \times H \times T \times V + S + A}{R}$$
(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 1/4 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:

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

Step 5. Determine the loose weight of the aggregate.

A metal cylinder with a volume of 0.014 m³ (0.50 ft³) 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 ©:

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

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/yd²) is used as the starting point in the field.

TRAFFIC CONTROL

Traffic control shall be in accordance with MUTCD Standards, Standard Specifications and these plans.

Work activities shall only be during daylight hours. Daylight hours are considered to be ½ hour before sunrise until ½ hour after sunset.

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.

The bottom of signs on portable or temporary supports shall not be less than seven feet above the pavement in urban areas and one foot above the pavement in rural areas. Portable sign supports may be used as long as the duration is less than 3 days. If the duration is more than 3 days the signs shall be on fixed location, breakaway supports.

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

All vehicles entering and exiting closed lanes of traffic shall display a flashing amber light visible from all directions at a minimum distance of ¼ mile.

All traffic control, materials and equipment shall be moved to a minimum distance of 30 feet from the edge of the traveled lanes during nights, weekends, and other non-working hours.

TRAFFIC CONTROL (CONTINUED)

The quantity of traffic control units paid shall be for the greatest number of signs in place at any one time per highway segment, regardless of the number of set-ups required.

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.

Indiscriminate driving of vehicles within the right-of-way will not be permitted. Any damage to 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.

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

Removing, relocating, covering, salvaging and resetting of existing traffic control devices, including delineation, shall be the responsibility of the Contractor. Cost for this work shall be incidental to the contract unit prices for the various items unless otherwise specified in the plans. Any delineators and signs damaged or lost shall be replaced by the Contractor at no cost to the State.

INVENTORY OF TRAFFIC CONTROL DEVICES

SIGN CODE	SIGN SIZE	DESCRIPTION	#	UNITS PER SIGN	UNITS
G20-2	36" x 18"	END ROAD WORK	2	17	34
W3-4	48" x 48"	BE PREPARED TO STOP	2	34	68
W8-6	48" x 48"	TRUCK CROSSING	2	34	68
W8-7	48" x 48"	LOOSE GRAVEL	2	34	68
W20-1	48" x 48"	ROAD WORK AHEAD	2	34	68
W20-7a	48" x 48"	FLAGGER	2	34	68
W21-2	48" x 48"	FRESH OIL	2	34	68
W21-5	48" x 48"	SHOULDER WORK	2	34	68
W21-5a	48" x 48"	SHOULDER CLOSED	4	34	136
SPECIAL	48" x 48"	MOTORCYCLES USE EXTREME CAUTION	2	34	68

TOTAL UNITS   714

PLOT SCALE - 1:300

PLOT NAME - 2

FILE - ...\ASPHALTSHOULDERREPAIR.DGN

PLOTTED FROM - TRRC11951

Asphalt Concrete Shoulder Joint Leveling along PCCP

Settled areas less than 5/8" will not require
Asphalt Repair Mastic for filling as
directed by the Engineer

Fill Asphalt Repair Mastic to 1/2"
below top of PCCP

Asphalt Surface Treatment

Fill with Asphalt Repair Mastic

Variable Width

Asphalt Surface Treatment

Variable settlement 1/2" to 2"

Asphalt Repair Mastic

Asphalt Shoulder

PCCP

Left Panel — Plate 634.30

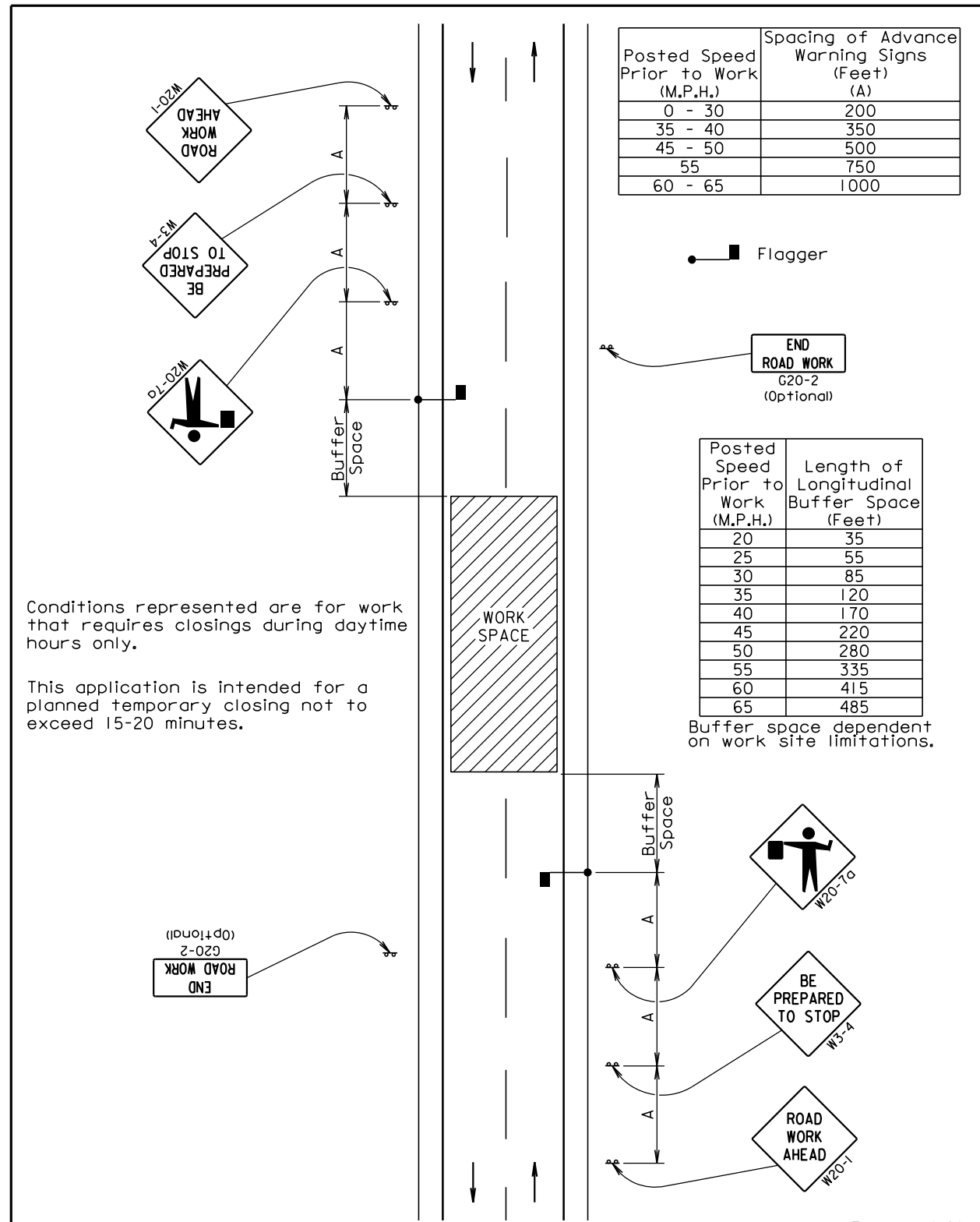| Posted Speed Prior to Work (M.P.H.)	Spacing of Advance Warning Signs (Feet) (A)
0 - 30	200
35 - 40	350
45 - 50	500
55	750
60 - 65	1000

■ Flagger

END ROAD WORK
G20-2
(Optional)

Posted Speed Prior to Work (M.P.H.)	Length of Longitudinal Buffer Space (Feet)
20	35
25	55
30	85
35	120
40	170
45	220
50	280
55	335
60	415
65	485

Buffer space dependent on work site limitations.

ROAD WORK AHEAD W20-1

BE PREPARED TO STOP W3-4

W20-7a

WORK SPACE

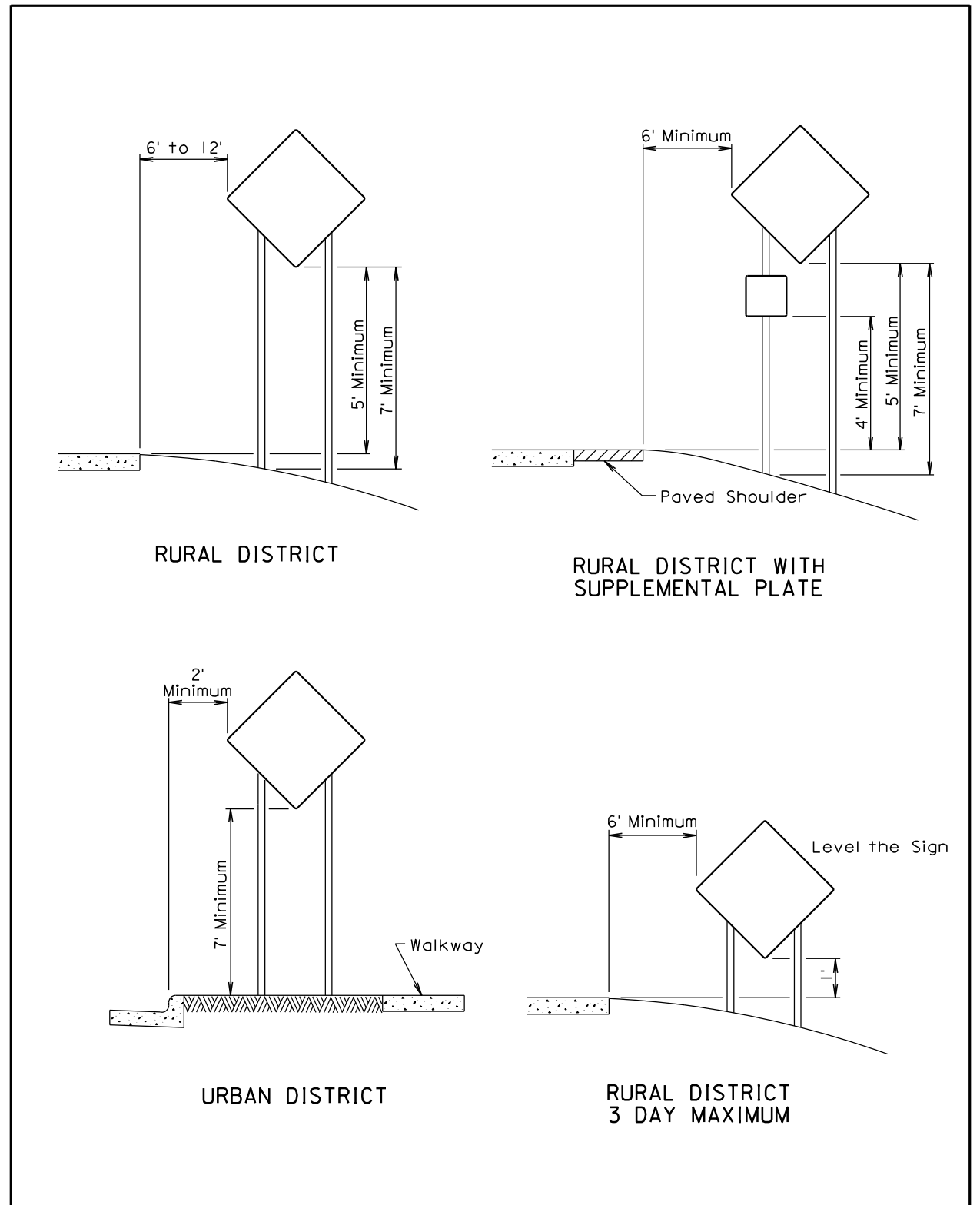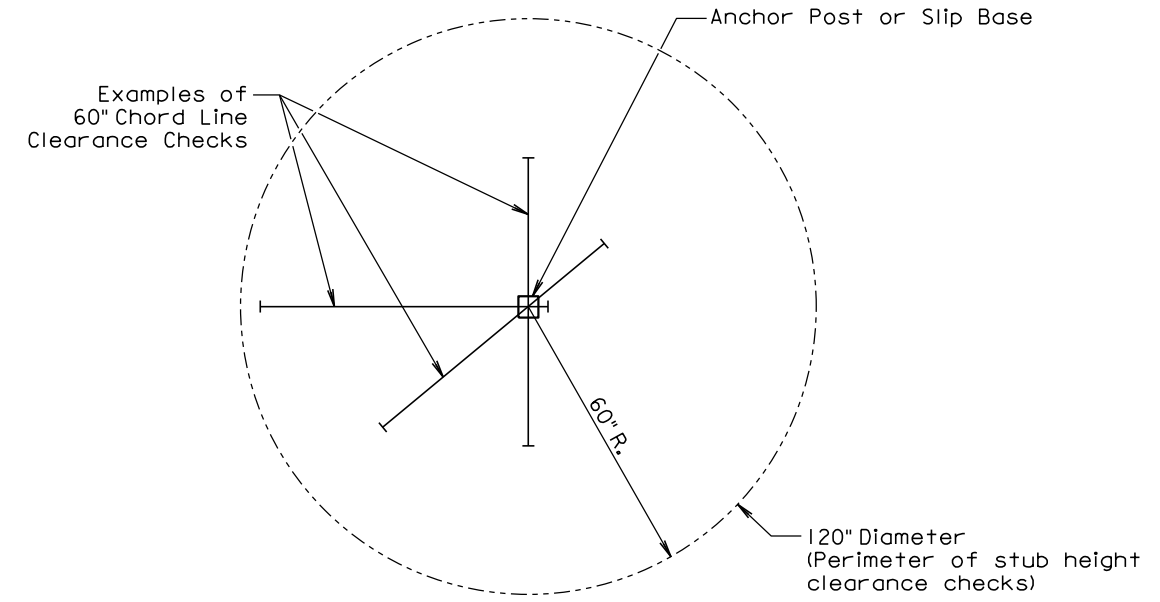Buffer Space

Conditions represented are for work that requires closings during daytime hours only.

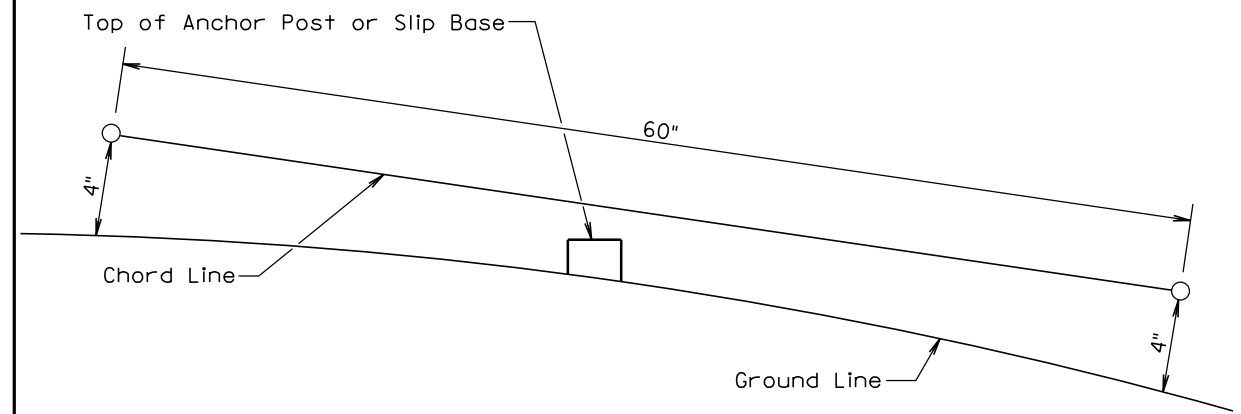This application is intended for a planned temporary closing not to exceed 15-20 minutes.

END ROAD WORK
G20-2
(Optional)

W20-7a

BE PREPARED TO STOP W3-4

ROAD WORK AHEAD W20-1

February 14, 2011

SDDOT	GUIDES FOR TRAFFIC CONTROL DEVICES TEMPORARY ROAD WORK	PLATE NUMBER 634.30
Published Date: 1st Qtr. 2012		Sheet 1 of 1

Right Panel — Plate 634.85

RURAL DISTRICT
6' to 12'
5' Minimum
7' Minimum

RURAL DISTRICT WITH SUPPLEMENTAL PLATE
6' Minimum
4' Minimum
5' Minimum
7' Minimum
Paved Shoulder

URBAN DISTRICT
2' Minimum
7' Minimum
Walkway

RURAL DISTRICT 3 DAY MAXIMUM
6' Minimum
Level the Sign

February 14, 2011

SDDOT	CRASHWORTHY SIGN SUPPORTS (Typical Construction Signing)	PLATE NUMBER 634.85
Published Date: 1st Qtr. 2012		Sheet 1 of 1

Anchor Post or Slip Base

Examples of
60" Chord Line
Clearance Checks

60" R.

120" Diameter
(Perimeter of stub height
clearance checks)

PLAN VIEW
(Examples of stub height clearance checks)

Top of Anchor Post or Slip Base

60"

4"

Chord Line

4"

Ground Line

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: 1st Qtr. 2012

S D D O T

BREAKAWAY SUPPORT STUB CLEARANCE

PLATE NUMBER
634.99

Sheet 1 of 1