



Use of Foreslope Rounding by Departments of Transportation

Prepared for
Bureau of Project Development

Prepared by
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WisDOT Research & Library Unit
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Request for Report

To enhance driver safety, departments of transportation sometimes round the foreslopes of highway shoulders at the intersection of the shoulder and its side slope. WisDOT was interested in learning about foreslope rounding practices used by other DOTs, including how slope rounding is shown in cross sections, whether design software can accommodate slope rounding and whether slope rounding is visible after construction.

Summary

This report is divided into two sections:

- Related Guidance and Research
- Survey Results

We found little guidance in design manuals or elsewhere about foreslope rounding practices. An online search produced one research study—a 1993 Texas Transportation Institute study sponsored by the Minnesota Department of Transportation and recommended by FHWA Safety Engineer Frank Julian. This study includes foreslope rounding guidelines.

We distributed a survey to members of the AASHTO Technical Committee on Roadside Safety and the TRB Committee on Roadside Safety Design. The survey consisted of the following questions:

1. Does your agency engage in foreslope rounding on roadsides?
2. How is slope rounding shown in cross sections? Please provide links to design standards, specifications and detail drawings for slope rounding.
3. Can your agency's design software accommodate slope rounding?
4. Is the slope rounding shown in plans clearly visible in the actual construction of foreslopes?

Staff at 28 state and province DOTs responded to this survey. According to survey results, almost half of DOTs use foreslope rounding, which is usually visible in the field but rarely shown in cross sections. While about two-thirds of DOTs using foreslope rounding have design software (InRoads) that could accommodate it, half of the DOTs in this group noted they do not use this functionality. Key findings include:

- **Use**
 - Twelve DOTs use foreslope rounding.
 - One DOT (North Carolina) used foreslope rounding until recently.
 - Four DOTs do not prescribe foreslope rounding, but construction practices generally lead to some rounding.
 - Eleven DOTs do not use foreslope rounding.
- **Visibility in cross sections**
 - Of the 13 DOTs that use or have used foreslope rounding, only three—Delaware, Nebraska and Washington—show it explicitly in their cross sections; in two others, rounding is not explicitly shown but is called out (via a tick mark for New Hampshire DOT and text for New York DOT).
- **Design software**
 - Of those DOTs that use or have used foreslope rounding, eight said they have a software package—typically InRoads (with one exception)—that can accommodate foreslope rounding. However, four of these states noted they do not use this functionality, finding manual design less cumbersome.
 - Three DOTs that do not use foreslope rounding (Arizona, Georgia and Virginia) noted that their software can accommodate rounding in general.
 - Software packages other than InRoads mentioned by respondents included Geopak, CAiCE and Civil 3D; none of these can accommodate foreslope rounding, although CAiCE may be programmed to do so. Indiana DOT uses a CADD system that accommodates foreslope rounding.
- **Visibility in the field**
 - Of those DOTs that use or have used foreslope rounding:
 - Nine said it is visible in the field. Kentucky Transportation Cabinet noted that it would be visible to the expert but not the average driver, and Kansas DOT provided a photo of visible rounding in the field. (See [Appendix B.2.](#))
 - Two (New York and Washington) said it was sometimes visible in the field.
 - Two (North Carolina and Indiana) said it was not visible in the field.
 - Two states that use other forms of rounding (Arizona and Virginia) noted that it is visible in the field, and South Dakota noted that rounding due to construction practices is visible.

See **Survey Results** beginning on page 2 of this report for the full text of these survey responses.

Related Guidance and Research

Evaluating the Benefits of Slope Rounding, H.E. Ross, R.P. Bligh, J. Liu, Texas Transportation Institute, Minnesota Department of Transportation, June 1993.

<http://tti.tamu.edu/documents/TTI-1993-ID19661.pdf>

This study addresses the problem of evaluating the benefits of rounding the hinge at the intersection of the shoulder and side slope, and includes rounding guidelines.

Contact: Frank Julian, Safety Engineer, FHWA, frank.julian@dot.gov.

Survey Results

The full text of each survey response is provided below. For reference, we have included an abbreviated version of each question before the response; for the full question text, please see the **Summary** on page 1 of this report.

Alabama

Contact: Carey Kelly, Assistant State Design Engineer, Alabama Department of Transportation, (334) 242-6118, kellyc@dot.state.al.us.

1. Agency use

Yes, assuming that foreslope rounding is rounding the top of the slope at the shoulder break point.

2. Design standards, specifications and detail drawings

Slope rounding is not shown on the cross sections. Our view is that it is impossible to construct the sharp shoulder point break as shown on the cross sections and the rounding is the most natural way to dress the slopes during construction.

3. Design software

ALDOT uses Microstation and InRoads. I assume that it would handle slope rounding; however as I said previously we do not try to show rounding on the foreslopes. We do show rounding at the top of our backslopes.

4. Visibility

Not shown in the plans, but clearly visible in the actual construction of the foreslopes.

Alberta

Contact: Bill Kenny, Director, Design, Project Management and Training, Technical Standards Branch, Alberta Transportation, (780) 415-1048, bill.kenny@gov.ab.ca.

1. Agency use

No.

2. Design standards, specifications and detail drawings

N/A.

3. Design software

N/A.

4. Visibility

Our cross-section details are shown in standard plans contained in Chapter C of Alberta's Highway Geometric Design Guide at this link: <http://www.transportation.alberta.ca/951.htm>.

Arizona

Contact: Chris Cooper, Manager, Roadway Design Section, Arizona Department of Transportation, (602) 712-8493, ccooper@azdot.gov.

1. Agency use

No. We only apply rounding to the top of cut backslopes, and in the foreslope to backslope break on depressed urban freeways.

2. Design standards, specifications and detail drawings

See ADOT Construction Standard Drawings C-02.10, C-02.20 and C-02.30 at http://www.azdot.gov/highways/Roadway_Engineering/Roadway_Design/Construction_Standards/Drawings_Curent/PDF/2007ConstructionStandardDrawings.pdf; and the ADOT Roadway Design Guidelines, Figure 302.2A at http://www.azdot.gov/highways/Roadway_Engineering/Roadway_Design/Guidelines/Manuals/PDF/RoadwayDesignGuidelines.pdf.

3. Design software

We don't currently include the slope rounding on our design surfaces. Our software is able to round tops of cuts, but we're still working on the rounding between foreslope and backslope for our depressed urban sections.

4. Visibility

Yes. See:

- http://www.azdot.gov/highways/Roadway_Engineering/Roadway_Design/Construction_Standards/Drawings_Current/PDF/2007ConstructionStandardDrawings.pdf
- http://www.azdot.gov/highways/Roadway_Engineering/Roadway_Design/Guidelines/Manuals/PDF/RoadwayDesignGuidelines.pdf.

Arkansas

Contact: Mike Fugett, Division Head, Roadway Design, Arkansas State Highway and Transportation Department, (501) 569-2525, mike.fugett@arkansashighways.com.

1. Agency use

The Arkansas Highway and Transportation Department does not engage in foreslope rounding on its roadsides.

2. Design standards, specifications and detail drawings

N/A.

3. Design software

N/A.

4. Visibility

N/A.

Delaware

Contact: Thad McIlvaine, Project Manager, Delaware Department of Transportation, (302) 760-2349, thad.mcilvaine@state.de.us.

1. Agency use

Yes.

2. Design standards, specifications and detail drawings

See Figure 4-3 ([Appendix A.1](#)) and Standard Construction Details B1-3 ([Appendix A.2](#)) for design standards and construction details. Figure 4-3 is from the DelDOT Road Design Manual regarding cross section side slopes; B1-3 is from the DelDOT Standard Construction Details for guardrail applications. For us, the guardrail application is the application where slope rounding is used the most.

3. Design software

Yes, DelDOT currently uses Bentley InRoads XM as our design/modeling software and it is capable of slope rounding.

4. Visibility

Yes, the rounding if called out in the plans is typically visible in construction. The degree of visibility may vary from project to project depending on the slopes being rounded and contractor performing the work.

Florida

Contact: David C. O'Hagan, State Roadway Design Engineer, Florida Department of Transportation, (850) 414-4283, david.ohagan@dot.state.fl.us.

1. Agency use

Florida DOT does not foreslope rounding. We typically get enough rain that "Mother Nature" does this for us eventually.

2. Design standards, specifications and detail drawings

N/A.

3. Design software

Not that I'm aware of.

4. Visibility

N/A.

Georgia

Contact: Daniel G. Pass, Engineering Division—Design Policy and Support Office, Georgia Department of Transportation, (404) 631-1651, dpass@dot.ga.gov.

1. Agency use

GDOT does not specify or implement any form of foreslope rounding.

2. Design standards, specifications and detail drawings

N/A.

3. Design software

We are currently migrating our civil design software from CAiCE to InRoads. InRoads can be used to reflect slope rounding. My understanding is that CAiCE does not have this direct capability but that a “fragment” within CAiCE could be programmed to do so.

4. Visibility

N/A.

Illinois

Contact: Michael Brand, Bureau of Design & Environment, Illinois Department of Transportation, (217) 782-7651, michael.brand@illinois.gov.

1. Agency use

IDOT is not currently using rounded foreslopes.

2. Design standards, specifications and detail drawings

N/A.

3. Design software

We use Geopak by Microstation; not sure [it] would handle this or not.

4. Visibility

N/A.

Indiana

Contact: John E. Wright, Director of Highway Design & Tech Support, Office of Production Management, Indiana Department of Transportation, (317) 232-5147, jwright@indot.in.gov.

1. Agency use

Yes.

2. Design standards, specifications and detail drawings

Slope rounding is not shown in our Design Manuals; nor is it stated in our Standards Specification.

3. Design software

Our CADD system has the ability to provide for a rounded foreslope.

4. Visibility

No, however, as a safety measure all our foreslopes are constructed rounded despite of how they are shown on plans.

Iowa

Contact: Chris Poole, Roadside Safety Engineer, Office of Design, Iowa Department of Transportation, (515) 239-1864, chris.poole@dot.iowa.gov.

1. Agency use

Iowa DOT does not design for foreslope rounding.

2. Design standards, specifications and detail drawings

N/A.

3. Design software

N/A.

4. Visibility

N/A.

Kansas

Contact: James Brewer, Bureau of Road Design, Kansas Department of Transportation, (785) 296-3901, jbrewer@ksdot.org.

1. Agency use

We do round the shoulder on the high of superelevated sections. We accomplish rounding on the graded portion with a plan note “to soften and round for a pleasing appearance.” See rd600 for a typical section ([Appendix B.1](#)). Also, see the 2004 AASHTO Green Book, pages 313, 316, 326-330.

2. Design standards, specifications and detail drawings

We do not show rounding on slope intersections on the cross sections (see [Appendix B.1](#)). It is impractical to do so. Under normal grading operations, the slope intersections for the earthwork will be rounded as a normal course of operations by the grading contractor, seeding contractor, or natural events such as rainfall.

3. Design software

If we wanted to show rounding on the cross sections (which we don't), we have not been able to have GEOPAK to do it satisfactorily.

4. Visibility

Yes. See the photo of a recently completed project ([Appendix B.2](#)).

Kentucky

Contact: Keith Caudill, Division of Highway Design, Roadway Design Branch, Kentucky Transportation Cabinet, (502) 564-3280 x3364, keith.caudill@ky.gov.

1. Agency use

Yes.

2. Design standards, specifications and detail drawings

We do not typically show this on the cross-sections. We have a Standard Drawing that details the slope rounding. We reference this drawing on our plans and our resident (field) engineers ensure that this is done in the field by the contractors. See the KYTC Standard Drawing showing the Rounding of Slopes:
<http://transportation.ky.gov/Highway-Design/Standard%20Drawing%20%20Sepia%20PDFs/Roadway-SERIES2008.pdf#rgx001-05>.

3. Design software

KYTC uses InRoads to model our roadway designs and it is my understanding that InRoads can accommodate slope rounding.

4. Visibility

It is noticeable in the field, if you know what you are looking for. The average driver probably would not notice it at normal operating speeds.

Massachusetts

Contact: Luciano Rabito, Highway Division, Massachusetts Department of Transportation, (617) 973-7729, rabito@mhd.state.ma.us.

1. Agency use

Our PD&DG makes references to the rounding of slopes. However, we don't design them as round but as an angle point. (5-28 PD&DG; 5-27 - Exhibit 5-13 Usable Shoulder). During construction we have a construction standard drawing: 103.1.0 Method of Rounding Slopes. (See [Appendix C.](#))

2. Design standards, specifications and detail drawings

Our cross sections show it as an angle point.

3. Design software

I do not believe so since assemblies in Civil 3D are joined by lines and not curves.

4. Visibility

We do not show it on plans as rounding but as two intersecting lines.

Michigan

Contact: Carlos A. Libiran, Design Standards Engineer, Design Division, Michigan Department of Transportation, (515) 335-1904, libiranc@michigan.gov.

1. Agency use

Michigan DOT does not use contoured slopes but does round the cross section slope breaks. The slope itself is linear (as opposed to contoured). The top and bottom cross section break points are rounded.

2. Design standards, specifications and detail drawings

Cross sections show the break points with sharp angles but it is understood and stated by specification (see [Appendix D.1](#) and [Appendix D.2](#)) that the break points are rounded in construction.

3. Design software

Contoured slopes would be cumbersome and slope rounding would be possible but we have not pursued or considered it.

4. Visibility

No.

Montana

Contact: Paul Ferry, Pre-construction Design Engineer, Montana Department of Transportation, (406) 444-6244, pferry@mt.gov.

1. Agency use

Don't use.

2. Design standards, specifications and detail drawings

N/A.

3. Design software

N/A.

4. Visibility

N/A.

Nebraska

Contact: Phil TenHulzen, Design Standards Engineer, Nebraska Department of Roads, (402) 479-3951, phil.tenhulzen@nebraska.gov.

1. Agency use

The Nebraska Department of Roads designs a “barn roof” style foreslope with a 2'@4% (shoulder slope), 1V:6H to the clear zone hinge point and then break to 1V:3H to meet the existing ground. The break points are disked, harrowed or raked 3" depth, which avoids sharp breaks.

2. Design standards, specifications and detail drawings

The “barn roof” is shown on typical cross sections and earthwork cross sections. The specifications book explains the disked, harrowed or raked procedure in section 803 seeding: <http://www.nebraskatransportation.org/ref-man/specbook-2007.pdf>.

3. Design software

I don't know.

4. Visibility

This is spelled out in the specifications book and the elimination of sharp breaks is usually visible.

New Hampshire

Contact: Mike Hazlett, Senior Supervisor, Final Design Section, New Hampshire Department of Transportation, (603) 271-1599, mhazlett@dot.state.nh.us.

1. Agency use

For slopes steeper than 6V to 1 H we use both foreslope and backslope rounding except for specific special instances where constraints dictate otherwise. We do not use roundings in our narrow ditch sections but do use it in our wider ditch sections. See:

<http://www.nh.gov/dot/org/projectdevelopment/highwaydesign/designmanual/documents/HDMtypicalsectionsplans.pdf>

2. Design standards, specifications and detail drawings

A tick mark is shown on the section where the slope rounding would end vs. the simple intersection of the slope with the existing ground.

3. Design software

We have not utilized software for doing the rounding but were doing it manually; we have come to the conclusion that it is too labor intensive vs. the value of the results achieved.

4. Visibility

The slope lines on the plans indicate the actual rounded limits.

New Jersey

Contact: Fred Azimi, Principal Engineer, Program Management Office, New Jersey Department of Transportation, fred.azimi@dot.state.nj.us.

1. Agency use

Yes.

2. Design standards, specifications and detail drawings

See our Roadway Design Manuals: <http://www.state.nj.us/transportation/eng/documents/RDM/sec5.shtm>.

3. Design software

Yes.

4. Visibility

Yes.

New Mexico

Contact: Joe Garcia, Bureau Chief, Survey and Lands Engineering, New Mexico Department of Transportation, (505) 827-5419, joe.s.garcia@state.nm.us.

1. Agency use

We do not use this technique in NM.

2. Design standards, specifications and detail drawings

N/A.

3. Design software

N/A.

4. Visibility

N/A.

New York

Contact: Terry Hale, Specifications and Standards Section, New York State Department of Transportation, (518) 485-7009, thale@dot.state.ny.us.

1. Agency use

Yes. We have long urged slope intersection rounding at the shoulder break. We recently began urging rounding of concave slope intersections where a vehicle would be likely to nose into the next slope. This could be for exposed transverse embankments or for the toe of slope intersections.

2. Design standards, specifications and detail drawings

Typically, we only call out “round to 1.2 m vertical curve” or “round to 4' v.c.”

3. Design software

Our drafters are capable of drawing the sections to show the rounding, and do occasionally.

4. Visibility

Not as often as it should be.

North Carolina

Contact: Glenn W. Mumford, Assistant State Roadway Design Engineer, North Carolina Department of Transportation, (919) 707-6200, gmumford@ncdot.gov.

1. Agency use

NCDOT has, until very recently, rounded our ditches for interstates, freeways, expressways and other four lane facilities. See the sketch from our Roadway Design Manual that shows the vertical curves we utilized for this rounding ([Appendix E.1](#)).

2. Design standards, specifications and detail drawings

This rounding was shown on our roadway typical sections, but was not reflected in our cross sections. (See [Appendix E.1](#).)

3. Design software

Our agency’s software does not accommodate the slope rounding and we have always ignored it when laying out our cross sections. Additionally, since NCDOT is in the process of transitioning into the development of 3-D surface models for our proposed earthwork, we have actually modified our ditch guidelines to remove the ditch rounding requirement altogether; see Proposed2012Standard.pdf ([Appendix E.2](#)).

4. Visibility

Our proposed ditch slopes for freeway type facilities are so flat anyway (6:1) that it is difficult to visually discern rounding in the completed construction. Up until now our ditches have been rounded during construction, but I

would have to say that our round bottom dimensions were more of a general guidance than actually something the motor grader operators followed exactly to round off the bottom of the roadway ditch.

North Dakota

Contact: Roger Weigel, North Dakota Department of Transportation, (701) 328-4403, rweigel@nd.gov.

1. Agency use

No. Although there may be some rounding during construction.

2. Design standards, specifications and detail drawings

We do not show slope rounding.

3. Design software

Yes, by drawing a rounded corner. But we do not use foreslope rounding.

4. Visibility

N/A.

Ohio

Contacts: Michael Bline, Standards Engineer, Ohio Department of Transportation, (614) 644-1203, michael.bline@dot.state.oh.us.

Dirk B. Gross, Office of Roadway Engineering Services, Ohio Department of Transportation, (614) 752-5576, dirk.gross@dot.state.oh.us.

1. Agency use

Yes. See figure 307-1E to 307-5E and the associated reference sections:

http://www.dot.state.oh.us/Divisions/Engineering/Roadway/roadwaystandards/Location%20and%20Design%20Manual/Section_300_April_2011.pdf.

2. Design standards, specifications and detail drawings

Not shown on cross sections. The Typical Sections are to show the rounding to be applied during construction. Section 307.2.3 discusses rounding and references the figures that show details.

See Volume 3 Section 1304.4: Rounding of slopes shall be shown on each typical section where applicable. See General Note G101

(http://www.dot.state.oh.us/Divisions/Engineering/Production/volume3/Volume3/1300_0711.pdf):

G101 – ROUNDING

THE ROUNDING AT SLOPE BREAKPOINTS SHOWN ON THE TYPICAL SECTIONS APPLIES TO ALL CROSS-SECTIONS EVEN THOUGH OTHERWISE SHOWN.

Designer Note: When appropriate, the Typical Sections should show rounding at the slope breakpoints in accordance with the Location and Design Manual, Volume 1. Since rounding is not shown on the cross sections, the above plan note should be used on all plans where rounding is called for on the Typical Sections.

3. Design software

No. Earthwork is calculated to the slope break points. GEOPAK can't accommodate slope rounding on cross sections.

4. Visibility

Yes.

South Dakota

Contact: Bernie Clocksin, Office of Road Design, Division of Planning and Engineering, South Dakota Department of Transportation, (605) 773-6646, bernie.clocksin@state.sd.us.

1. Agency use

No, but contractors provide some foreslope rounding due to construction practices.

2. Design standards, specifications and detail drawings

None.

3. Design software

Yes, but how would a person stake this in the field and construct to the designer's tolerances?

4. Visibility

We don't provide it in plans, but see a natural rounding due to construction practices.

Virginia

Contact: George T. Rogerson, Jr., Policies & Procedures Section Manager, Virginia Department of Transportation, (804) 786-8287, george.rogerson@vdot.virginia.gov.

1. Agency use

No, backslope rounding is provided only.

2. Design standards, specifications and detail drawings

Backslope rounding is provided in accordance with Section 700 of the VDOT Road and Bridge Standards, available at: http://www.virginiadot.org/business/locdes/2008_road_and_bridge_standards_table_of_contents.asp.

3. Design software

Yes, backslope rounding is projected onto the cross-sections and reflected in the plan construction limits and computed quantities.

4. Visibility

Foreslope rounding is not provided. Backslope rounding is evident in final construction.

Washington

Contact: Dave Olson, Design Policy, Standards, & Research Manager, Washington State Department of Transportation, (360) 705-7952, olsonda@wsdot.wa.gov.

1. Agency use

Yes.

2. Design standards, specifications and detail drawings

We show this in our Standard Plans (Plan A-20.10.00):

- <http://www.wsdot.wa.gov/Design/Standards/Plans.htm>
- http://www.wsdot.wa.gov/publications/fulltext/Standards/english/PDF/a20.10-00_e.pdf

Additional direction is provided in our Standard Specifications, section 2-03.3(5):

2-03.3(5) Slope Treatment

The tops of all Roadway cut slopes, except solid rock cuts, shall be rounded in accordance with the Standard Plan. Unless otherwise noted in the Plans or Special Provisions, Class A slope treatment shall be utilized. If a layer of earth covers a rock cut, the slope shall be rounded above the rock as if it were an earth slope. When the Contractor removes stumps or any embedded material from the rounded area, the void shall be backfilled and stabilized to prevent erosion. All Work required to complete slope treatment, including excavation, haul, and slope rounding, shall be included in the unit Bid price for Roadway excavation.

3. Design software

InRoads. There is no standard tool to do this. We understand that with some programming, it could be an added function, but we haven't taken that step.

4. Visibility

That is highly dependent on the slopes. Where the algebraic difference is small, the rounding is not very obvious with only 6" of material (depth) displaced. With steeper slopes, the results are more obvious.

West Virginia

Contact: Todd West, Engineering Division, West Virginia Department of Transportation, (304) 558-9738, todd.g.west@wv.gov.

1. Agency use

Yes.

2. Design standards, specifications and detail drawings

WVDOH does not show rounding on the cross sections. We do show rounding on typical sections per DD-601 which can be found here:

<http://www.transportation.wv.gov/highways/engineering/DD/2006%20DD%20Manual%20MASTER.pdf>

3. Design software

The WVDOH uses InRoads software which I believe can accommodate rounding. I don't believe we utilize this function for shoulder rounding.

4. Visibility

Yes, in most cases.

Wyoming

Contact: William B. Wilson, Architectural and Highway Standards Engineer, Wyoming Department of Transportation, bill.wilson@wyo.gov.

1. Agency use

The Wyoming DOT does not require slope rounding for foreslopes.

2. Design standards, specifications and detail drawings

We do have a detail shown in our standard plans for back slope blending, but it does not show up in the cross-sections. You may refer to the following link for our standard plan on earthwork construction:

[http://www.dot.state.wy.us/webdav/site/wydot/shared/Engineering_Services/Standard%20Plans/203-2A%20%20\(MAR_2009\).pdf](http://www.dot.state.wy.us/webdav/site/wydot/shared/Engineering_Services/Standard%20Plans/203-2A%20%20(MAR_2009).pdf)

3. Design software

N/A.

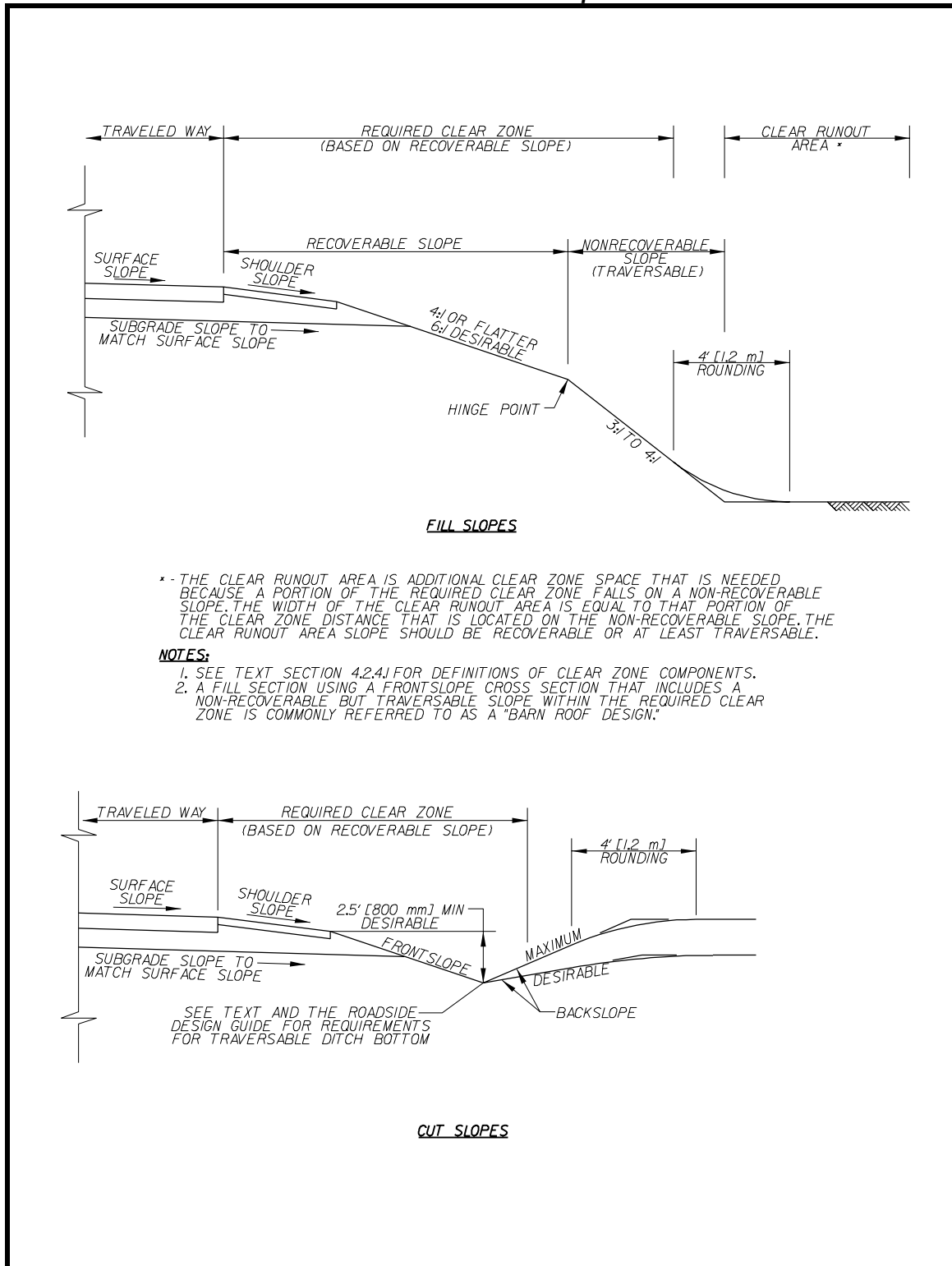
4. Visibility

N/A.

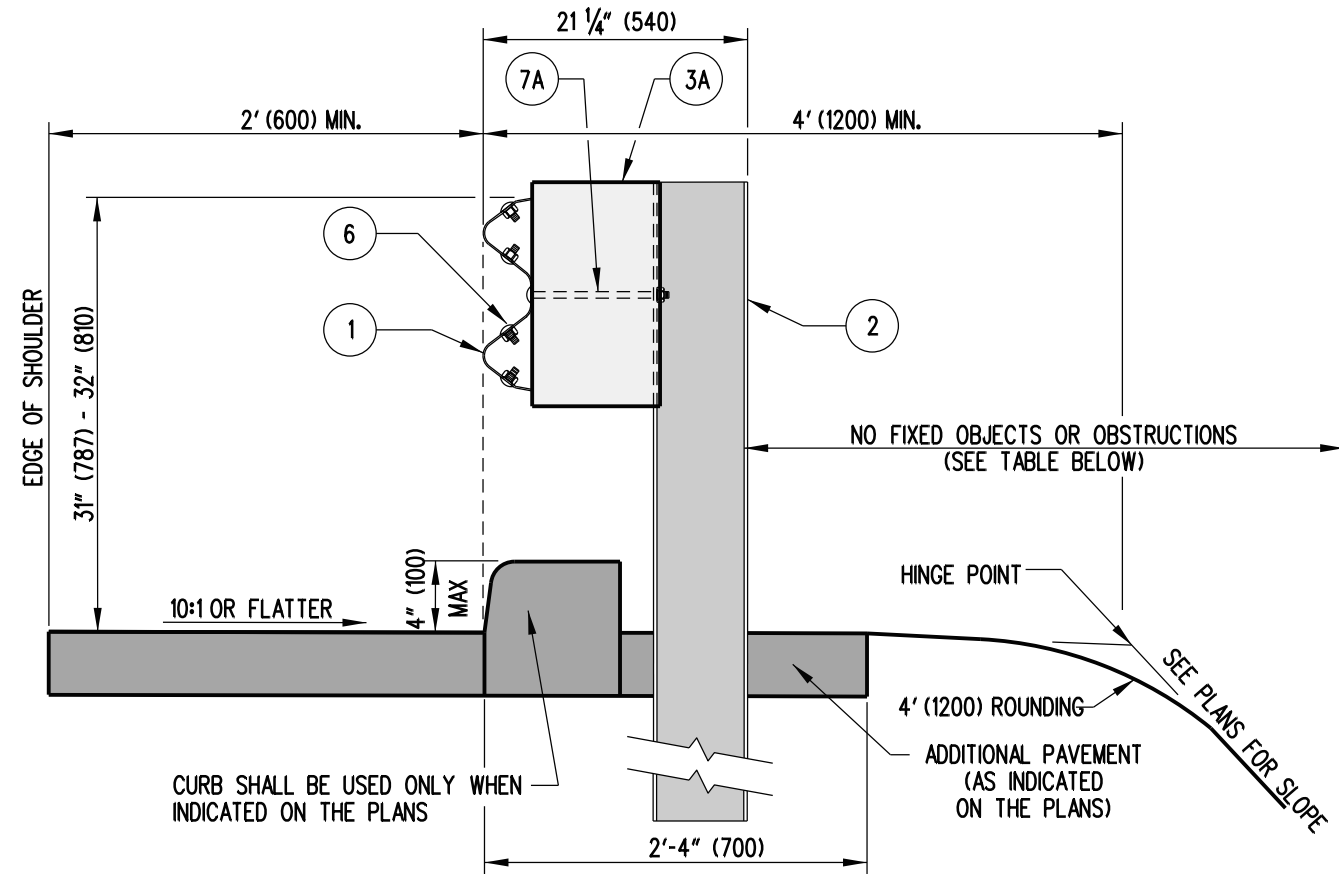
Appendix A.1

De/IDOT Road Design Manual

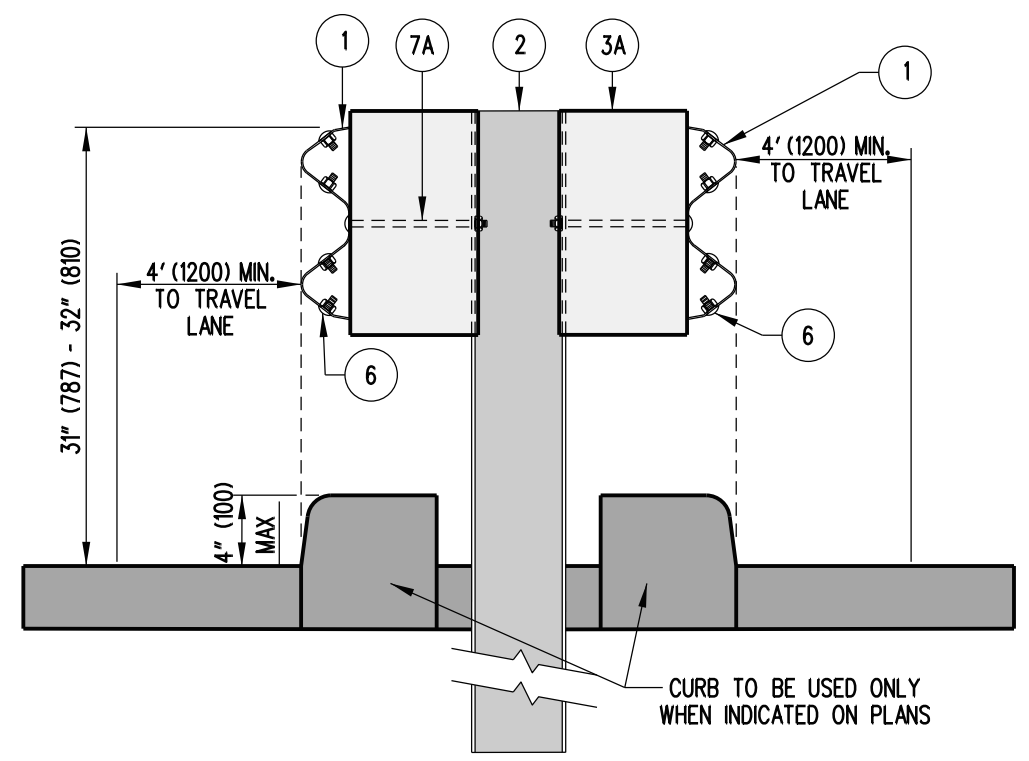
Figure 4-3
Cross Section Side Slopes



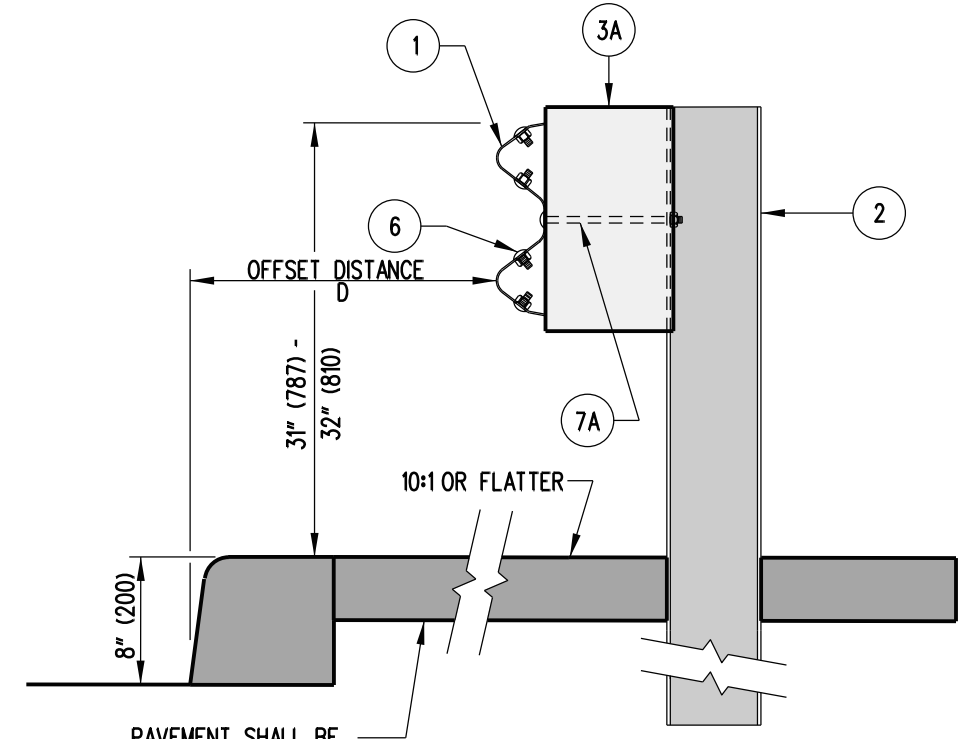
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GUARDRAIL SECTION
RURAL SHOULDER APPLICATION



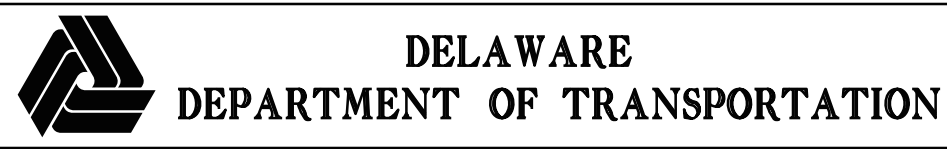
GUARDRAIL SECTION
MEDIAN APPLICATION



GUARDRAIL SECTION
URBAN SHOULDER APPLICATION

TYPE	POST SPACING	CLEAR AREA BEHIND POST
1	6'-3" (1905)	3'-0" (900) MIN
2	3'-1 1/2" (952.5)	2'-0" (600) MIN

DESIGN SPEED	D
< 50 MPH (80 km/h)	8'-0" (2400)
> 50 MPH (80 km/h)	13'-0" (3900)



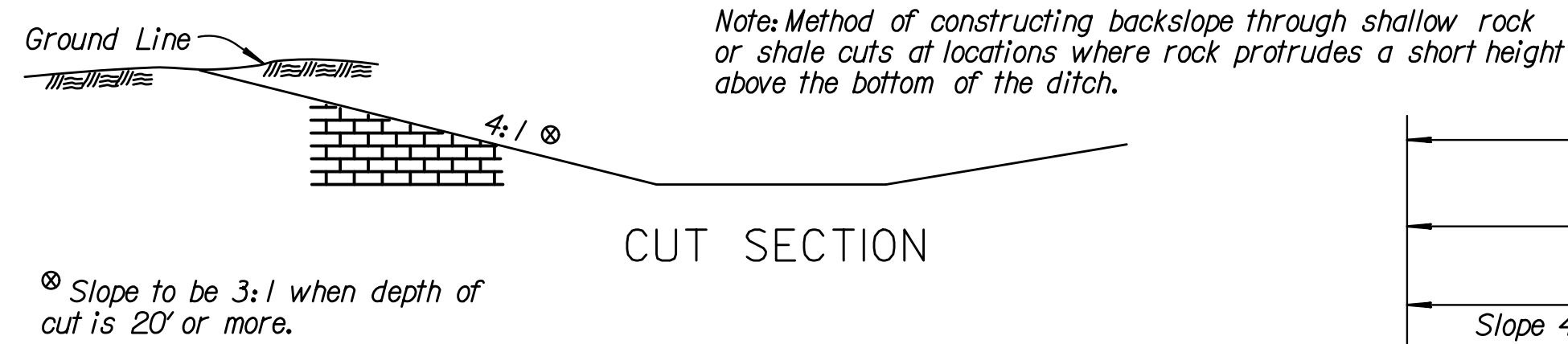
TYPES 1-31, 2-31, AND 3-31 GUARDRAIL APPLICATIONS

STANDARD NO. **B-1 (2010)** SHT. **3** OF **3**

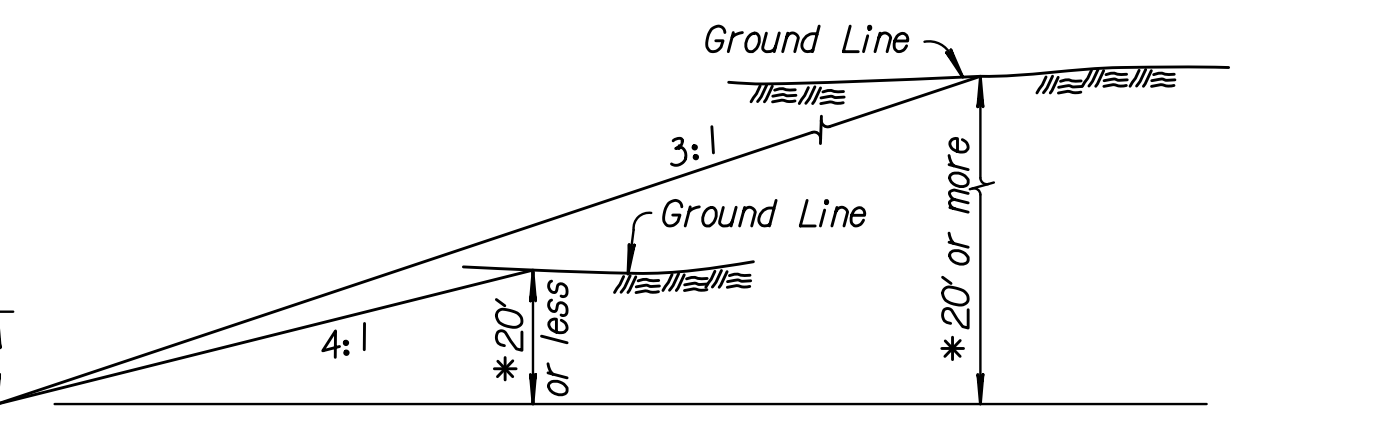
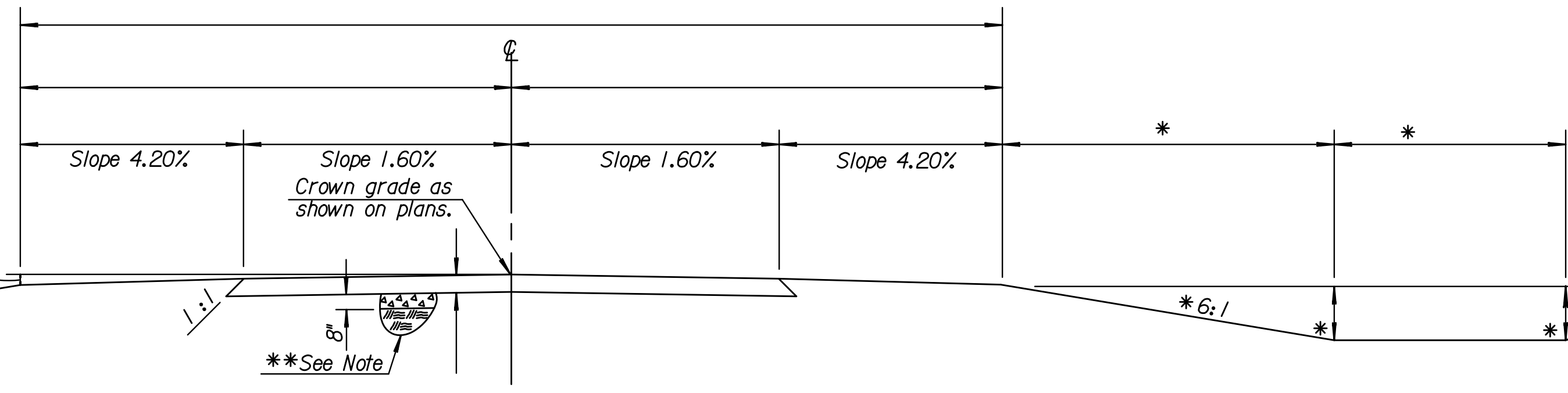
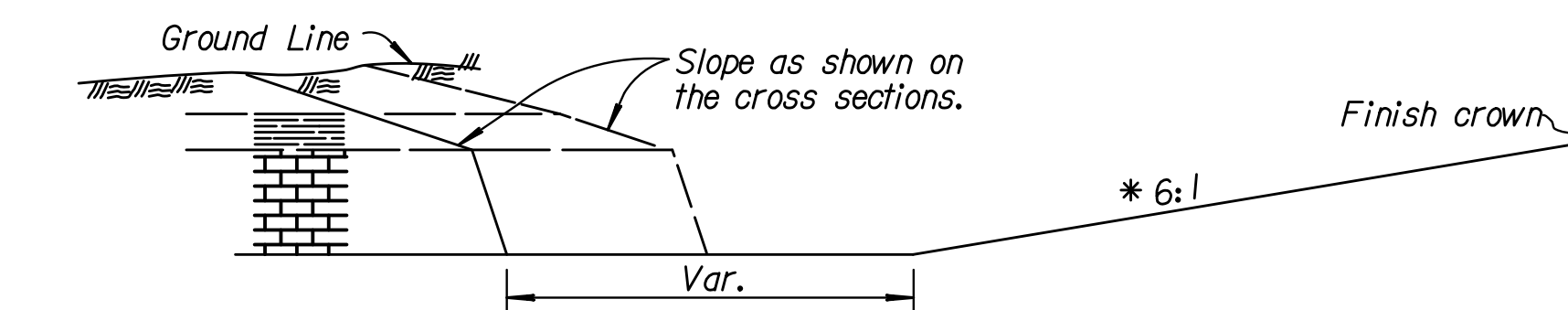
APPROVED _____ SIGNATURE ON FILE _____ 12/28/2010
CHIEF ENGINEER DATE

RECOMMENDED _____ SIGNATURE ON FILE _____ 12/27/2010
DESIGN ENGINEER DATE

STATE	PROJECT NO.	YEAR	SHEET NO.	TOTAL SHEETS
KANSAS				



Guide to designer: Use this sheet when subgrading in rock or shale is not required. See Soils and Geology Reports for additional plan notes.

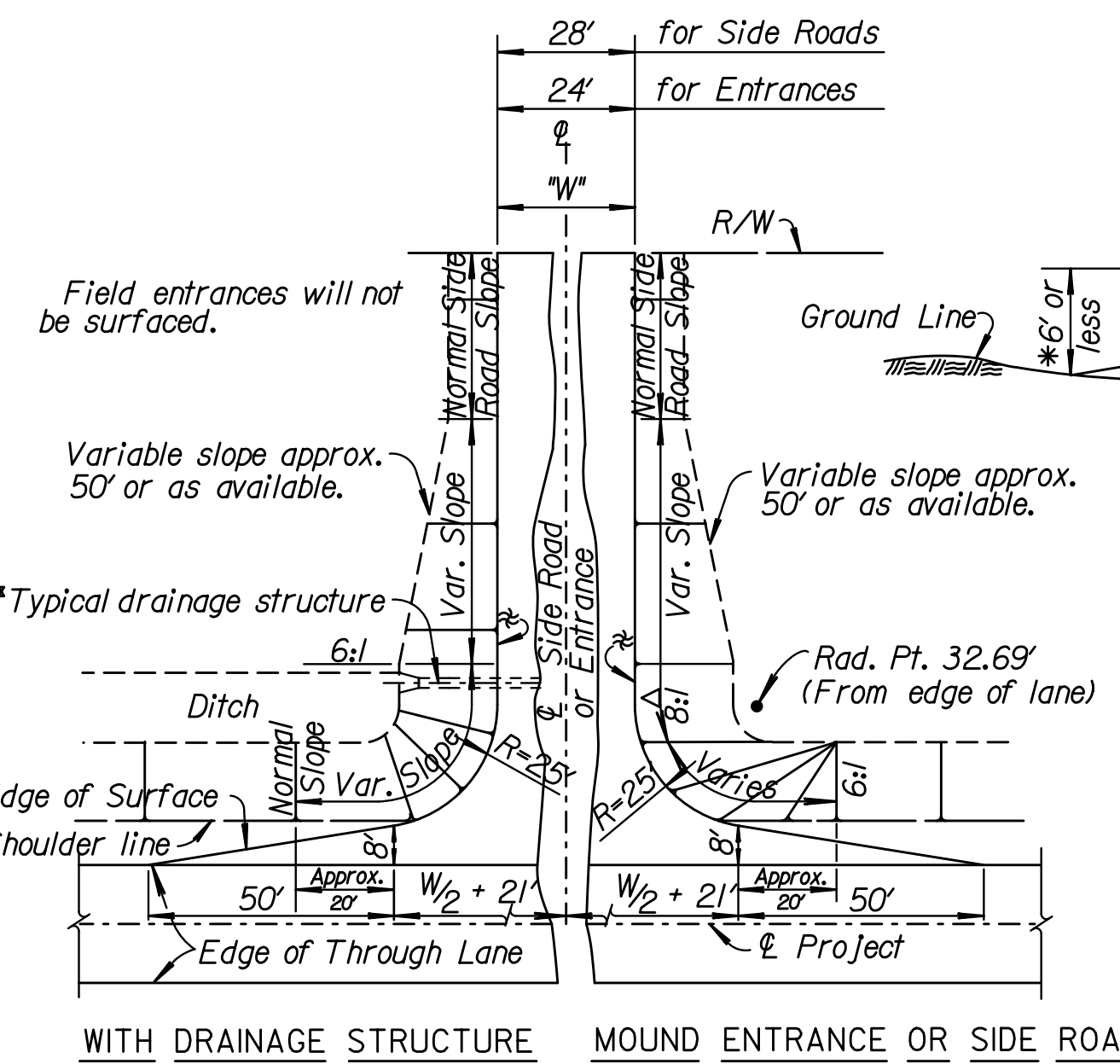


**Overbreakage in limestone or sandstone rock shall be brought to within 8" of the subgrade line with crushed stone, shot rock, and/or rock rubble, properly compacted, and then brought to the subgrade line with crushed stone meeting the requirements for "Crushed Stone for Backfill" in accordance with the Standard Specifications. Layers of earth or shale will not be permitted for backfill up to the bottom of the crushed stone. Overbreakage in shale or in rock where shale is exposed shall be backfilled with low permeability soils listed as useable for subgrade construction in the Soils Report. All materials, equipment, and labor for this work shall not be paid for directly, but shall be subsidiary to other items of the contract.

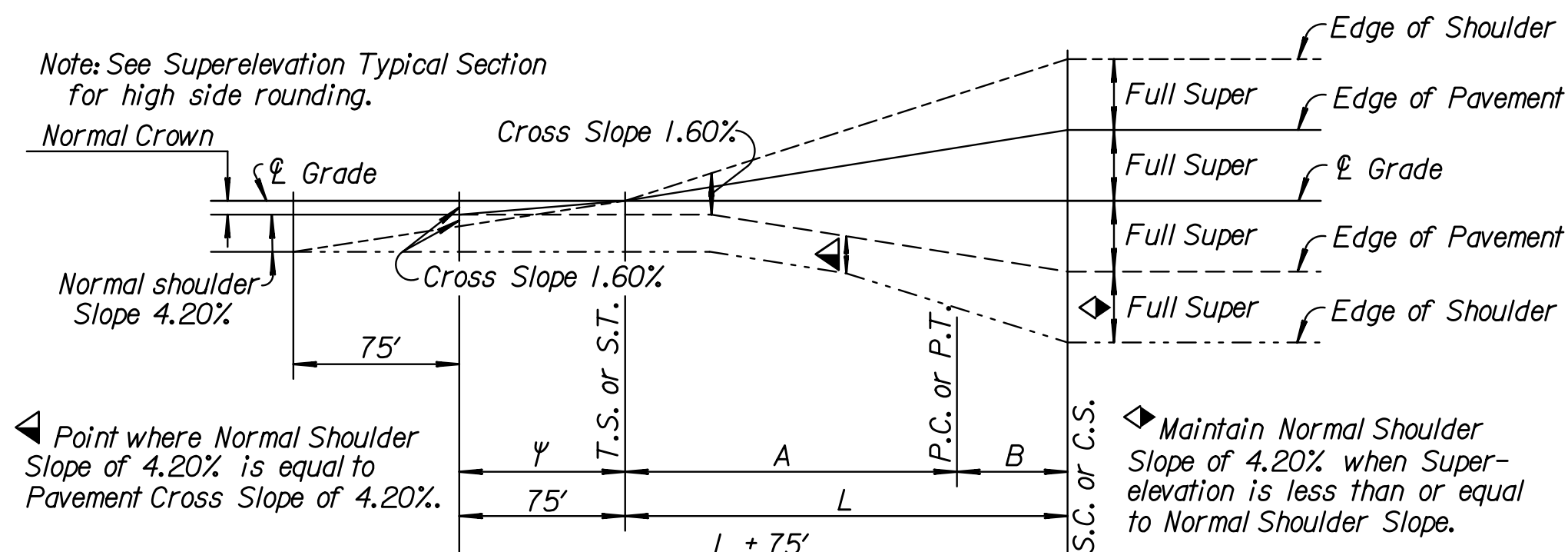
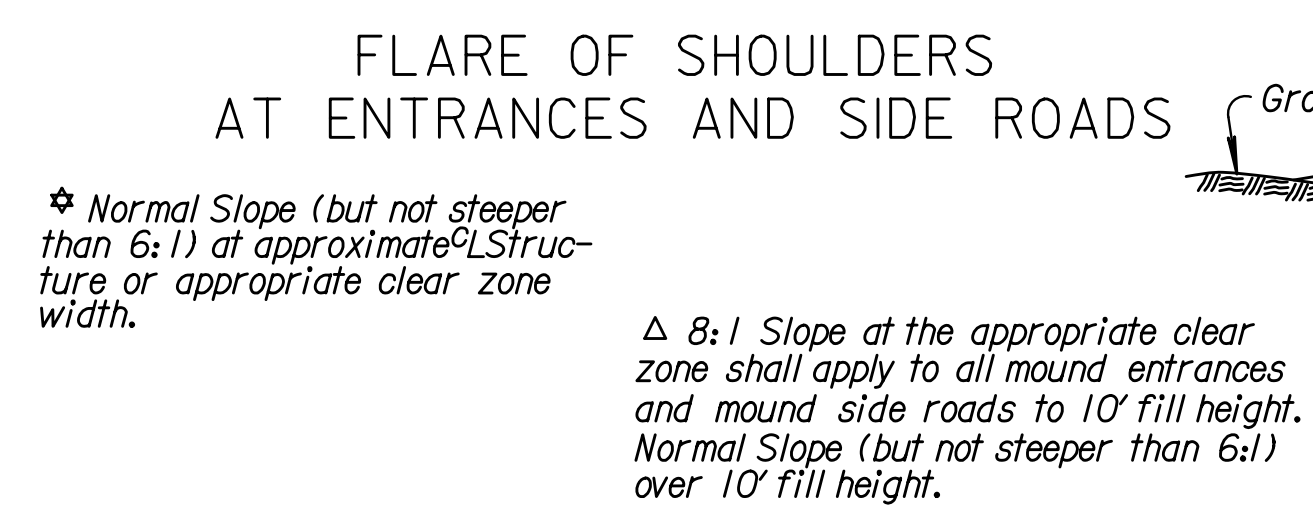
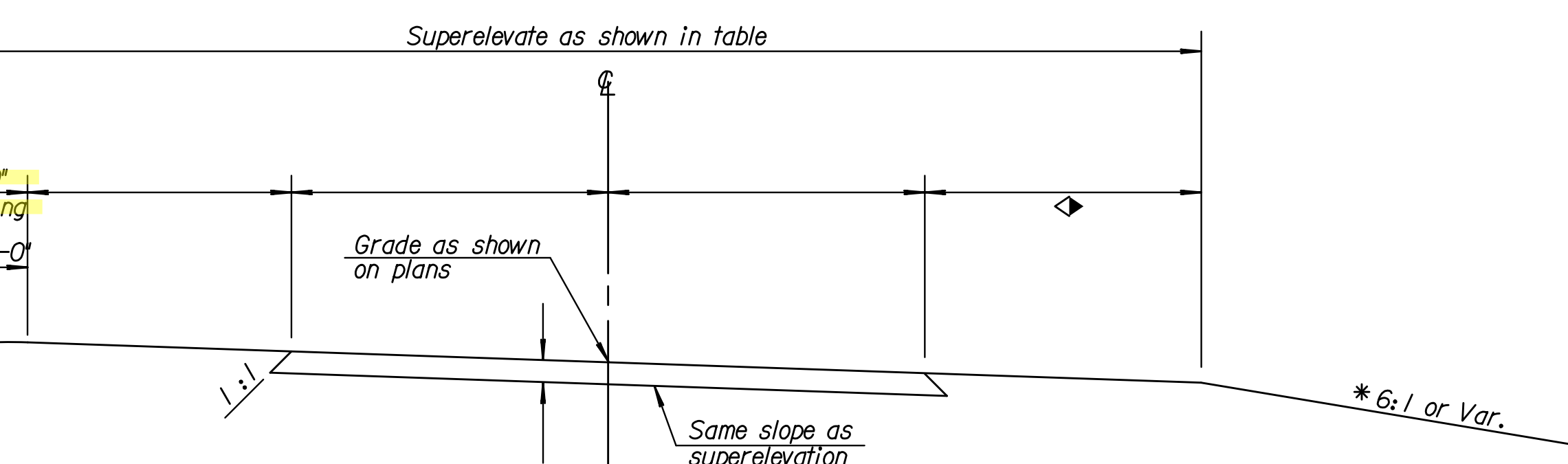
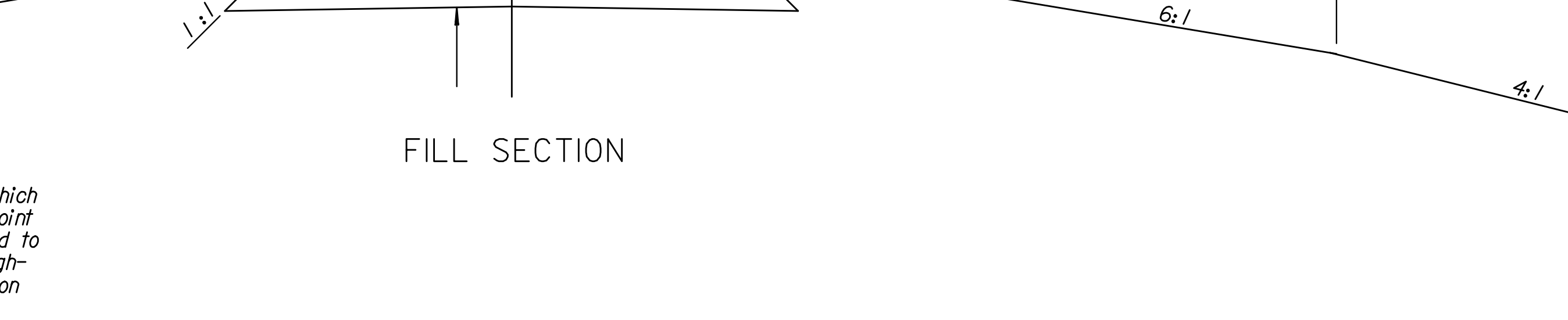
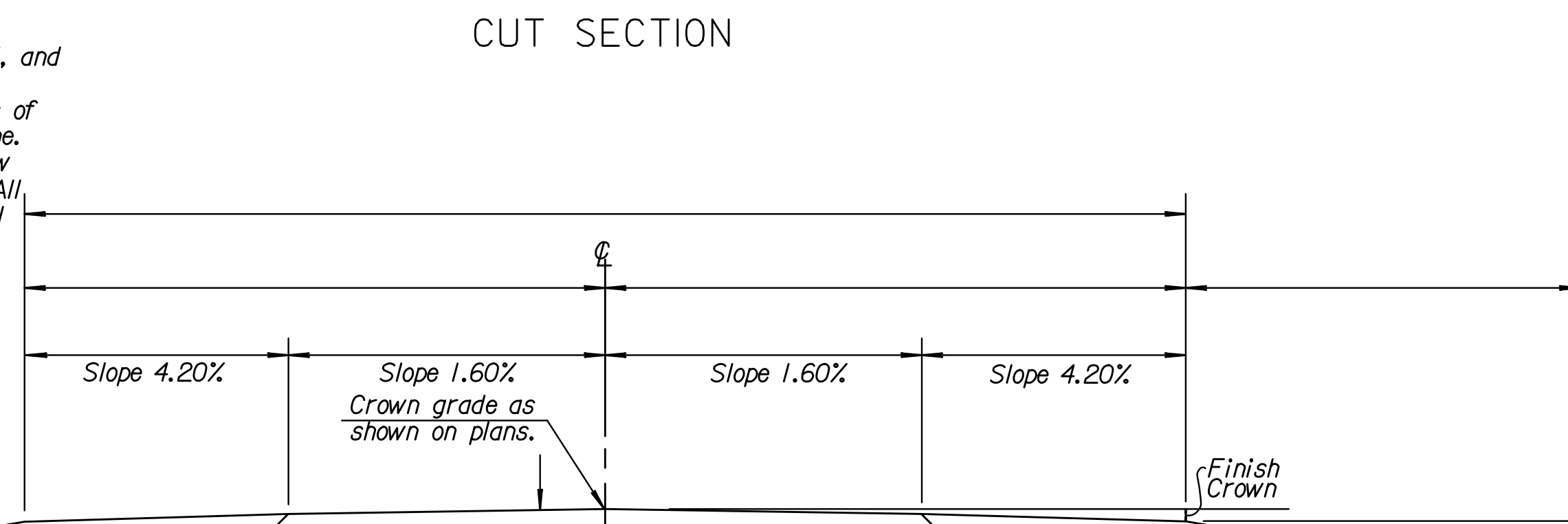
* Dimensions and slopes for standard ditches and fills. See plan and cross-sections for variations.

Note: Intersection of all slope lines shall be softened and rounded for pleasing appearance.

Ditch Plugs within the appropriate clear zone shall have side slopes of 10:1 or flatter.



* On side roads and entrances which slope toward the highway, a low point approx. 6" deep shall be constructed to divert surface drainage into the highway ditch, unless otherwise shown on the plans.



Sta. P.I. Curve	Radius	Design Speed	Super %	Transition - (Lin.Ft.)		
				L	A	B

NO.	DATE	REVISIONS	BY	APP'D
20	5-20-09	8 1/2' over 10' fill mound ent./s.d.r.d.	S.W.K.	J.O.B.
19	11-10-04	Changed slope labels to percent	S.W.K.	J.O.B.
18	5-10-00	Rev. Ditch Plug Slope 10:1	R.J.S.	J.O.B.
17	2-10-98	Rev. s.d.r.d.&ent. det.& fill foreslope	R.J.S.	J.O.B.

KANSAS DEPARTMENT OF TRANSPORTATION

TYPICAL SECTION GRADING & SURFACING

RD600

DESIGNED	6-30-09	APP'D. James O. Brewer
DESIGN CK.	DETAIL CK.	QUAN. CK.

KDOT Graphics Certified 07-22-2010

Plotted : 22-JUL-2010 18:22
Drawn By : marks
File : rd600.dgn (rd600)

KDOT Graphics Certified



4:1

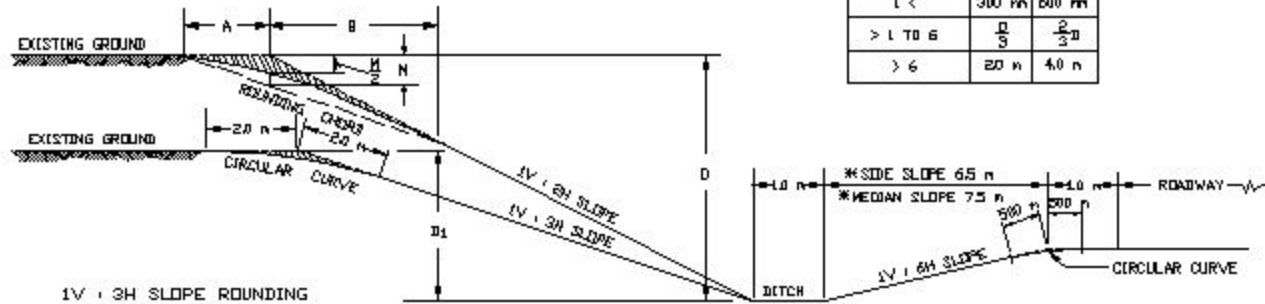
6:1

Appendix C

METHOD OF ROUNDING CUT SLOPES

ROUNDING TABLE FOR 1V : 2H SLOPE

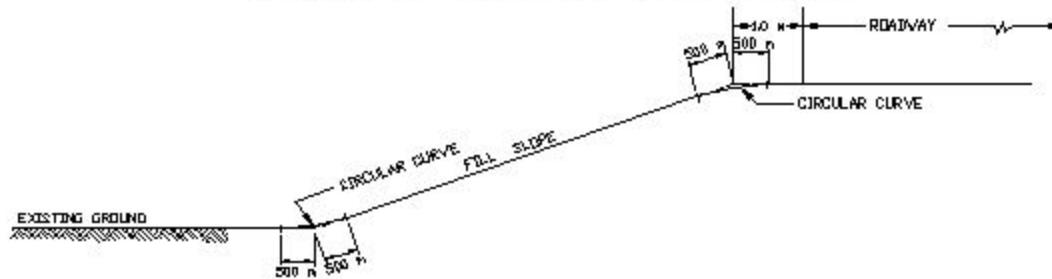
D METERS	A	B
L <	300 m	600 m
> L TO 6	$\frac{D}{3}$	$\frac{2}{3}D$
> 6	20 n	4.0 n



1V : 3H SLOPE ROUNDING

- A. WHEN "D1" IS 500 m OR MORE ROUND AS SHOWN IN TABLE ABOVE.
- B. WHEN "D1" IS LESS THAN 500 m ROUND FULL LENGTH OF SLOPE.

METHOD OF ROUNDING FILL SLOPES



* USE SLOPE LENGTHS FOR LIMITED ACCESS OR HIGH SPEED ROADWAYS.

NOTE:

1. THE DIMENSIONS SHOWN FOR ROUNDING CUT AND FILL SLOPES ARE APPROXIMATE; THEY ARE TO BE USED AS GUIDES.

205.03

For granular blanket, Type 2, dress the excavated area with a nominal 3-inch layer of Class II granular material before placing the drainage layer. Construct the drainage layer using one of the following:

1. A 2-inch layer of open-graded aggregate with geotextile blanket above and below;
2. A three-dimensional mesh with geotextile blanket above and below;
3. Other geocomposite section approved by the Engineer.

Place at least a 12-inch layer of Class II granular material on the drainage layer to bring the slope and ditch section to the required elevation and cross section.

Construct underdrains adjacent to, or as a part of the slope protection, in accordance with section 404.

N. Trimming and Finishing Earth Grade. Construct the earth grade to the required grade. Remove exposed stones and rocks with a diameter greater than 3 inches.

Trim the subgrade to the grade shown on the plans. If a subbase is required, trim the subgrade to within ± 1 inch of the required grade. If a subbase is not required, trim the subgrade to within $\pm \frac{3}{4}$ inch of the required grade.

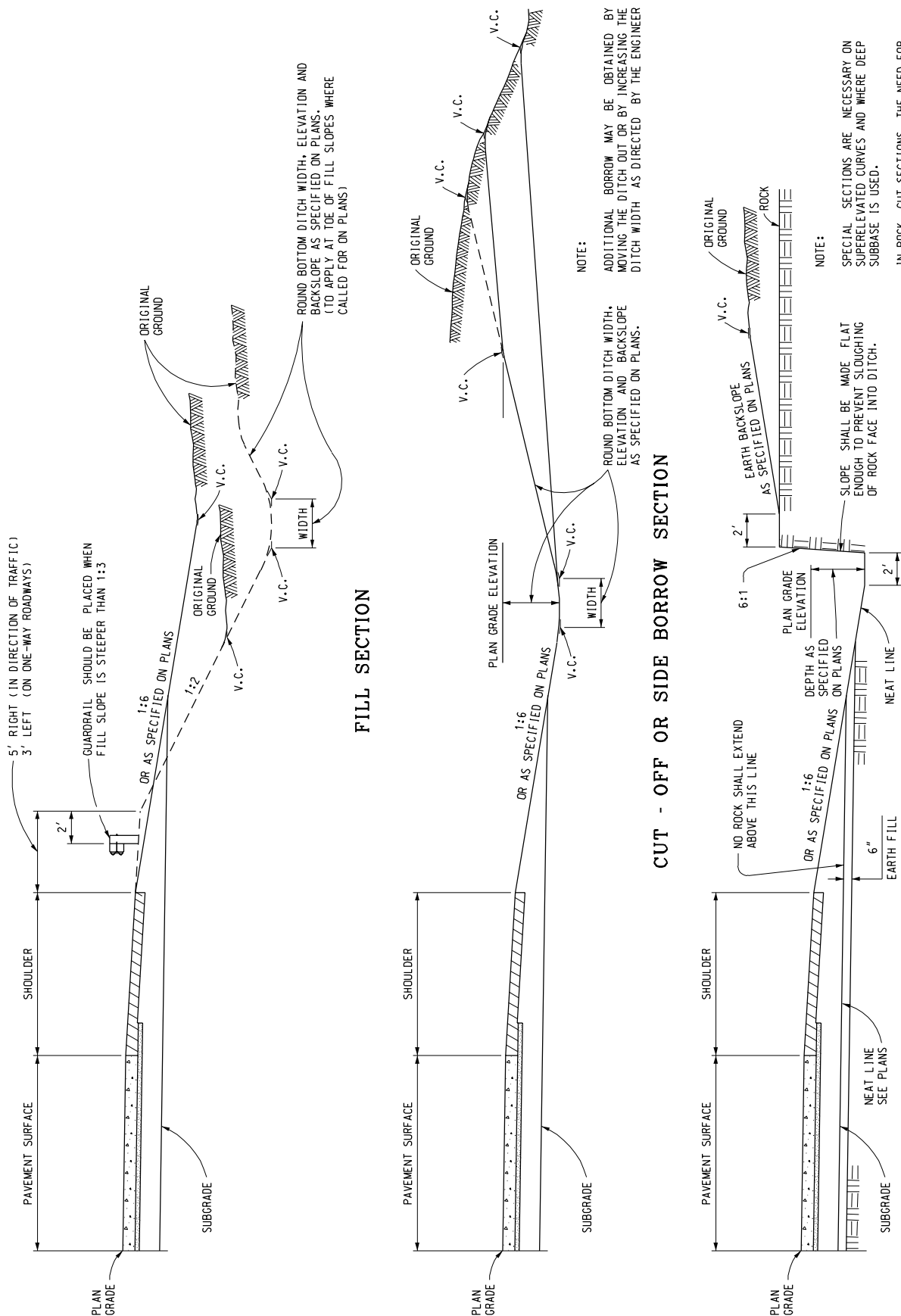
Trim and shape the earth grade outside the subgrade to the required lines, grades, and cross sections. Finish slopes to Class B tolerance unless Class A tolerance is required.

Finish Class A slopes to within ± 1 inch of the average slopes shown on the plans. Make measurements at right angles to the slope.

Finish Class B backslopes to within ± 6 inches of the average slopes shown on the plans. Make measurement at right angles to the slope. Do not leave abrupt variations in the finished surface. Remove debris and unsuitable material.

Finish Class B fill slopes to within $\pm 2\frac{1}{2}$ inches of the required grade and cross section, from the outside shoulder line for 3 feet down the slope. Measure at right angles to the slope. Finish the remainder of the fill slope the same as Class B backslope.

If trees or other obstacles do not interfere, round the tops of backslopes, bottoms of fill slopes, and other angles in the lines of the cross section, to form vertical curves as shown on the plans or as directed by the Engineer. Make vertical curve transitions gradual and present a uniform and attractive appearance. The Contractor may omit vertical curves if constructing ditches in peat.



FILL SECTION

CUT - OFF OR SIDE BORROW SECTION

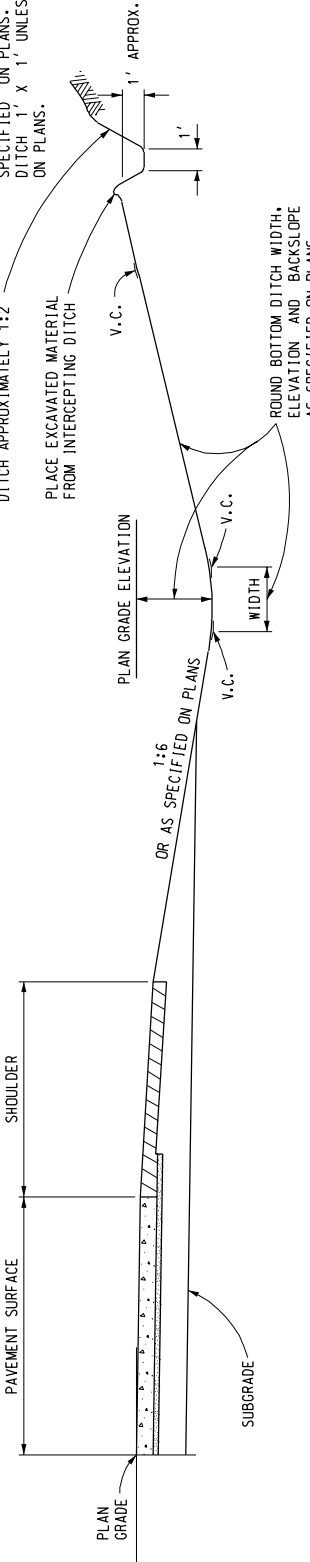
ROCK CUT SECTION

	ENGINEER OF CONSTRUCTION & TECHNOLOGY		MICHIGAN DEPARTMENT OF TRANSPORTATION BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR	
	ENGINEER OF MAINTENANCE		GRADING CROSS-SECTIONS	
PREPARED BY DESIGN SUPPORT AREA	ENGINEER OF DESIGN SUPPORT AREA DEPARTMENT DIRECTOR Gloria J. Jeff			
DRAWN BY: <u>B.L.T.</u>	ENGINEER OF DEVELOPMENT		11-14-2003 F.H.W.A. APPROVAL	6-19-2002 PLAN DATE
CHECKED BY: <u>W.K.P.</u>	ENGINEER OF TRAFFIC AND SAFETY		R-105-D	
			SHEET 1 OF 6	

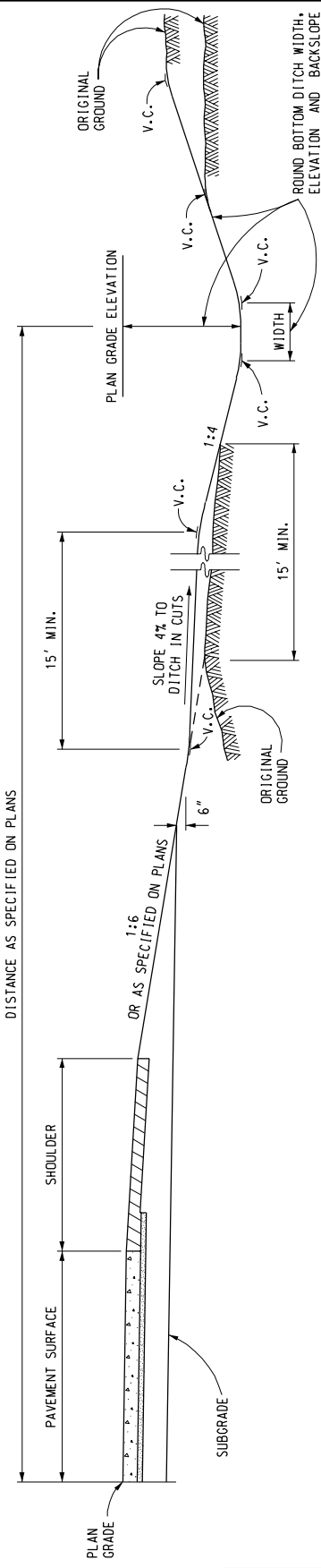
NOTE: THIS PLAN IS NOT A LEGAL ENGINEERING DOCUMENT BUT AN ELECTRONIC DUPLICATE. THE ORIGINAL SIGNED COPY APPROVED FOR PUBLICATION, IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.

INTERCEPTING DITCH TO BE CONSTRUCTED WHERE SPECIFIED ON PLANS. MAKE INTERCEPTING DITCH 1' X 1' UNLESS OTHERWISE SPECIFIED ON PLANS.

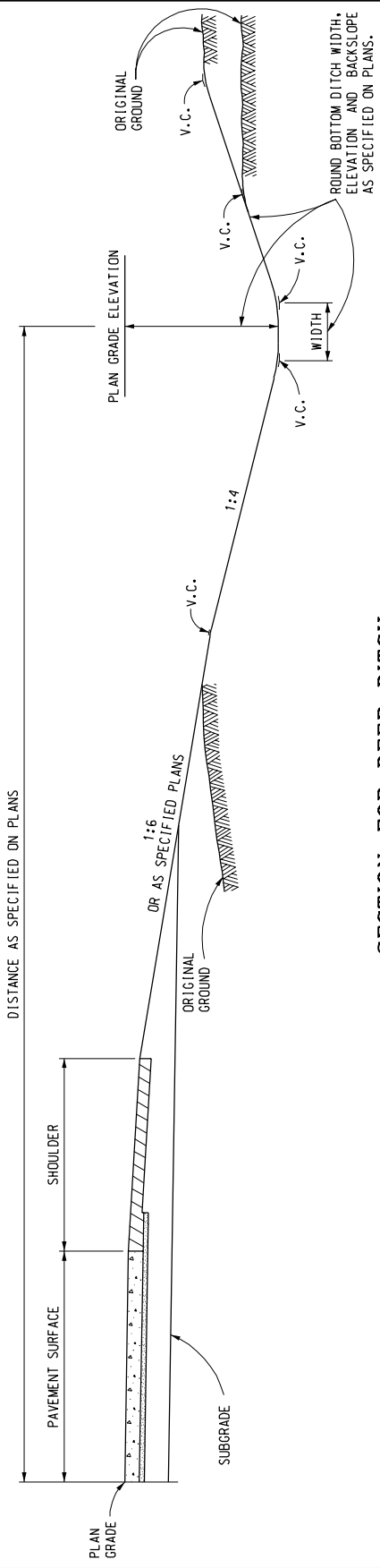
MAKE SLOPES OF INTERCEPTING DITCH APPROXIMATELY 1:2. PLACE EXCAVATED MATERIAL FROM INTERCEPTING DITCH



ROUND BOTTOM DITCH SECTION



BERM OR SWAMP DITCH SECTION



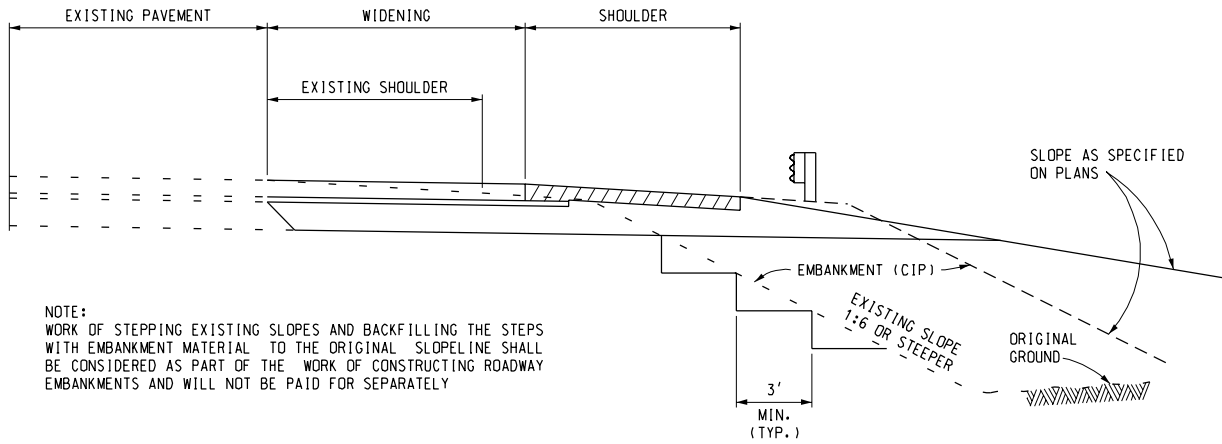
SECTION FOR DEEP DITCH

MICHIGAN DEPARTMENT OF TRANSPORTATION
 BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR

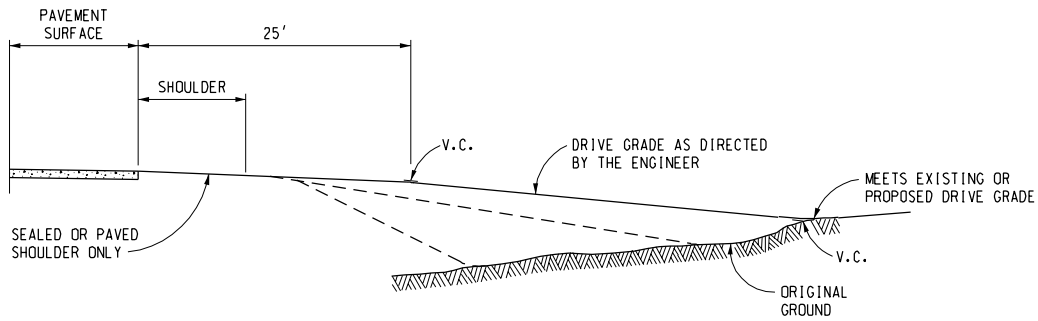
GRADING CROSS-SECTIONS

11-14-2003 F.H.W.A. APPROVAL	6-19-2002 PLAN DATE	R-105-D	SHEET 2 OF 6
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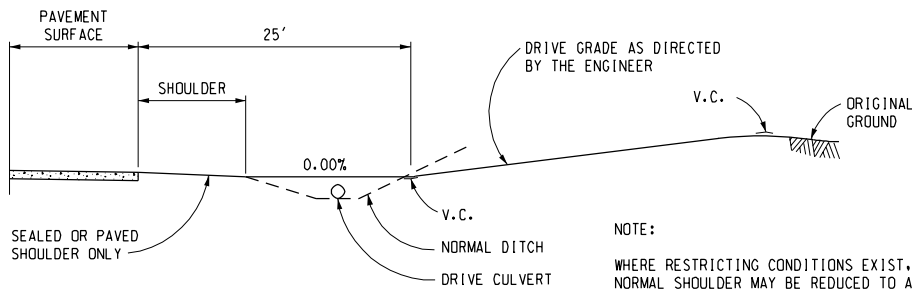
NOTE: THIS PLAN IS NOT A LEGAL ENGINEERING DOCUMENT BUT AN ELECTRONIC DUPLICATE. THE ORIGINAL SIGNED COPY APPROVED FOR PUBLICATION, IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.



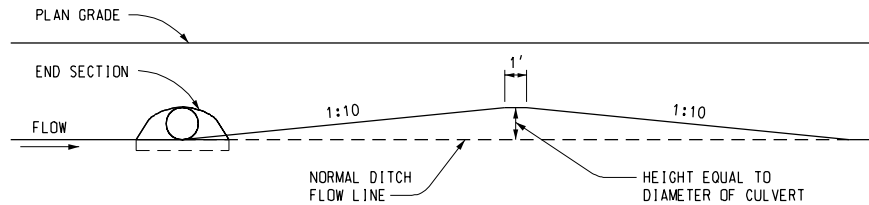
ADDING EMBANKMENT TO EXISTING SLOPES



GRADING OF DRIVES IN FILL SECTIONS



GRADING OF DRIVES IN CUT SECTIONS



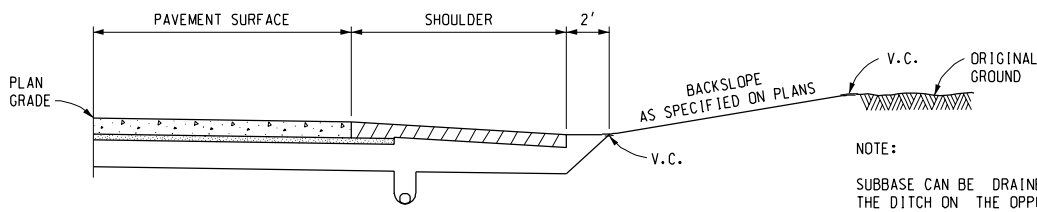
DIKE IN DITCH SECTION

MICHIGAN DEPARTMENT OF TRANSPORTATION
 BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR

GRADING CROSS-SECTIONS

11-14-2003 F.H.W.A. APPROVAL	6-19-2002 PLAN DATE	R-105-D	SHEET 3 OF 6
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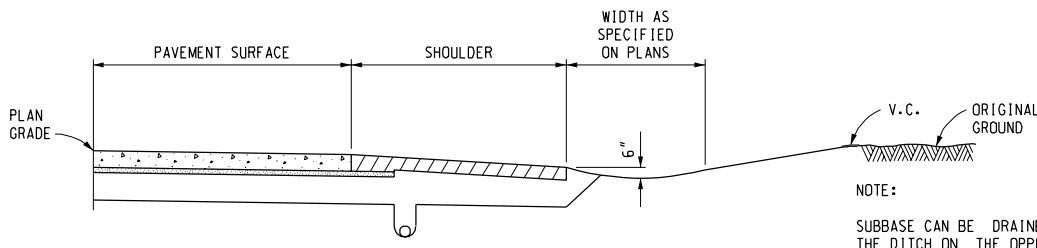
NOTE: THIS PLAN IS NOT A LEGAL ENGINEERING DOCUMENT BUT AN ELECTRONIC DUPLICATE. THE ORIGINAL SIGNED COPY APPROVED FOR PUBLICATION, IS KEPT ON FILE AT THE MICHIGAN DEPARTMENT OF TRANSPORTATION.



NO DITCH SECTION

NOTE:

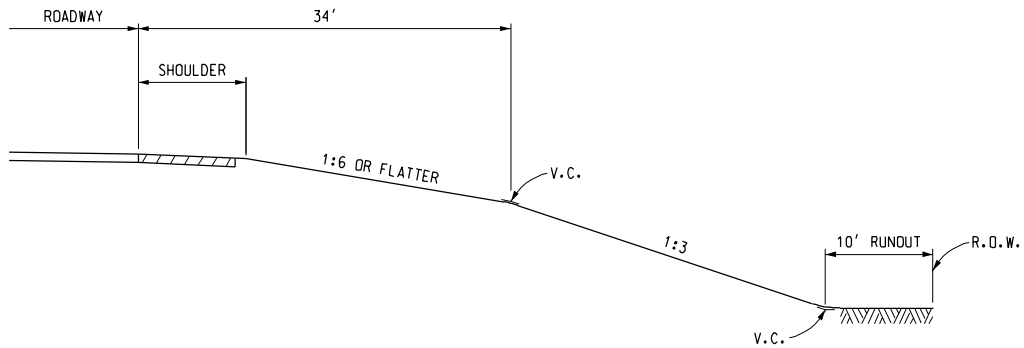
SUBBASE CAN BE DRAINED WITH UNDER DRAIN OR ONE-WAY TO THE DITCH ON THE OPPOSITE SIDE. SHORT SECTIONS CAN BE DRAINED LONGITUDINALLY. SEE STANDARD PLAN R-80-SERIES.



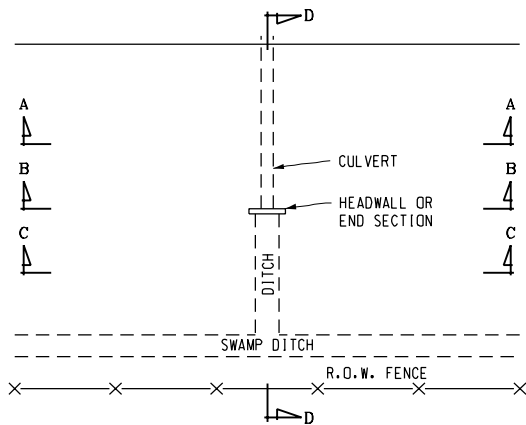
VALLEY DITCH SECTION

NOTE:

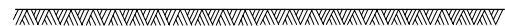
SUBBASE CAN BE DRAINED WITH UNDER DRAIN OR ONE-WAY TO THE DITCH ON THE OPPOSITE SIDE. SHORT SECTIONS CAN BE DRAINED LONGITUDINALLY. SEE STANDARD PLAN R-80-SERIES.



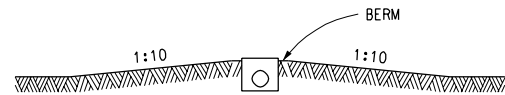
BARN ROOF FILL SECTION
(TO APPLY ON TANGENT SECTIONS ONLY)



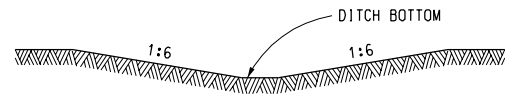
OUTLET CULVERT IN BERM OR SWAMP DITCH SECTION



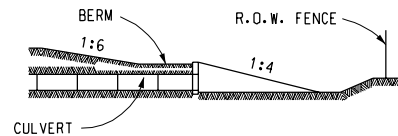
SECTION A - A



SECTION B - B



SECTION C - C



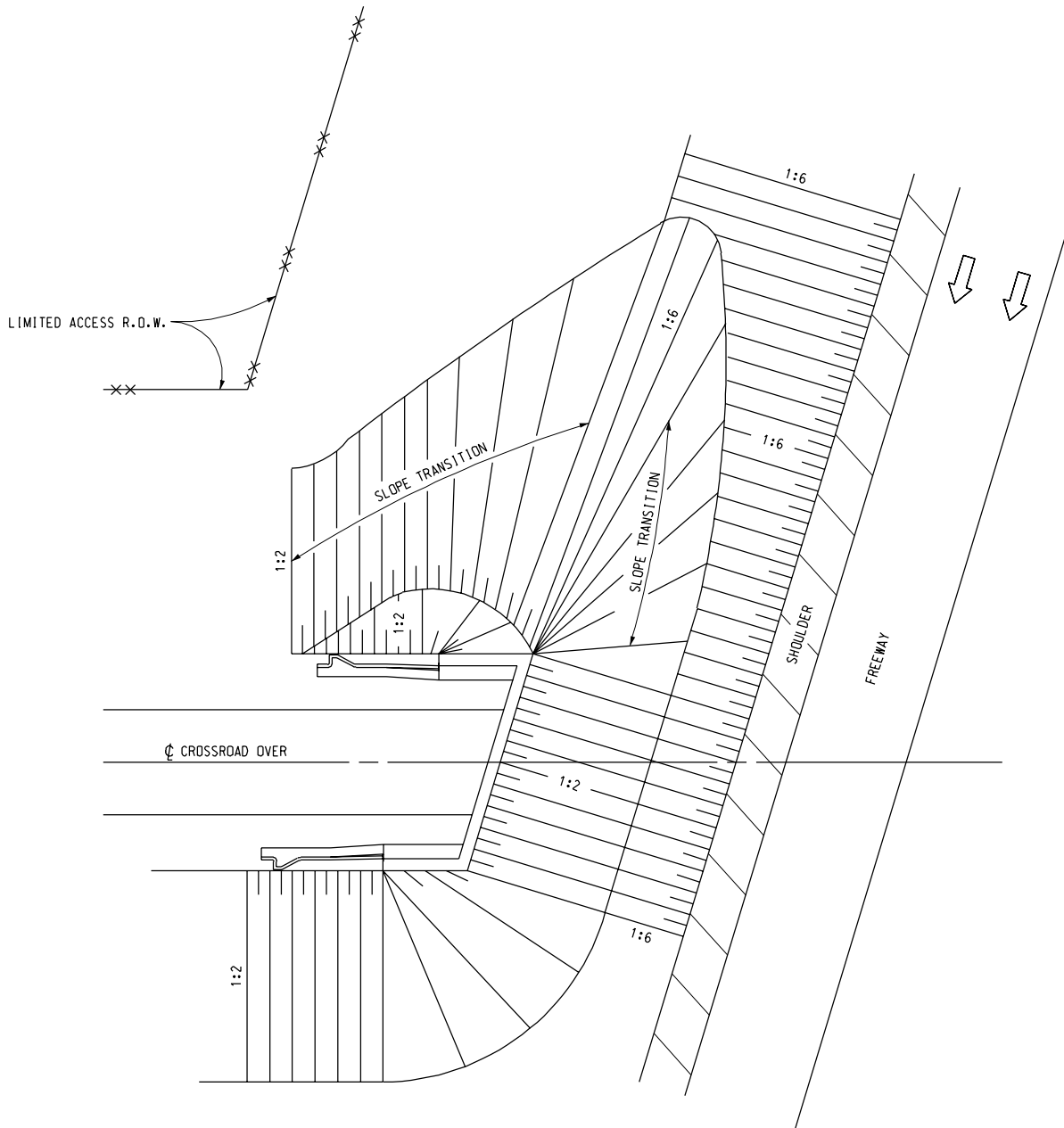
SECTION D - D

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR

GRADING CROSS-SECTIONS

11-14-2003 F.H.W.A. APPROVAL	6-19-2002 PLAN DATE	R-105-D	SHEET 4 OF 6
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NOTE:

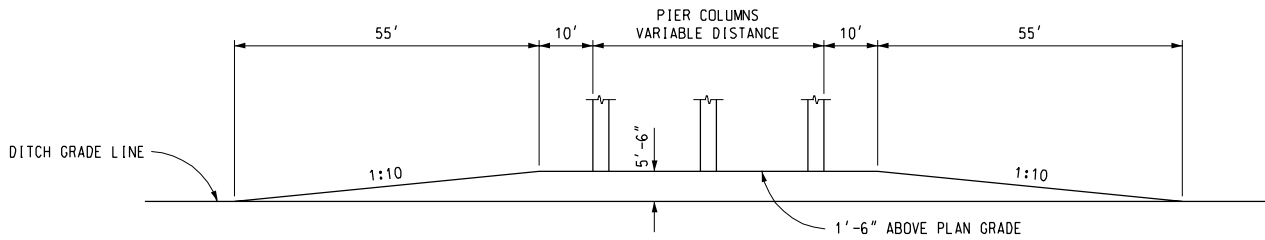
THE 1:6 SLOPE FACING FREEWAY TRAFFIC SHOULD BE USED ON ALL NEW CONSTRUCTION UNLESS THE DISTANCE FROM THE EDGE OF THE NEAREST FREEWAY THROUGH LANE TO THE TOE OF THE 1:2 SLOPE UNDER THE BRIDGE EXCEEDS THE CLEAR ZONE.

GRADING DETAILS FOR FLATTENING LONG SLOPE AT BRIDGE APPROACH FILLS FACING ONCOMING TRAFFIC

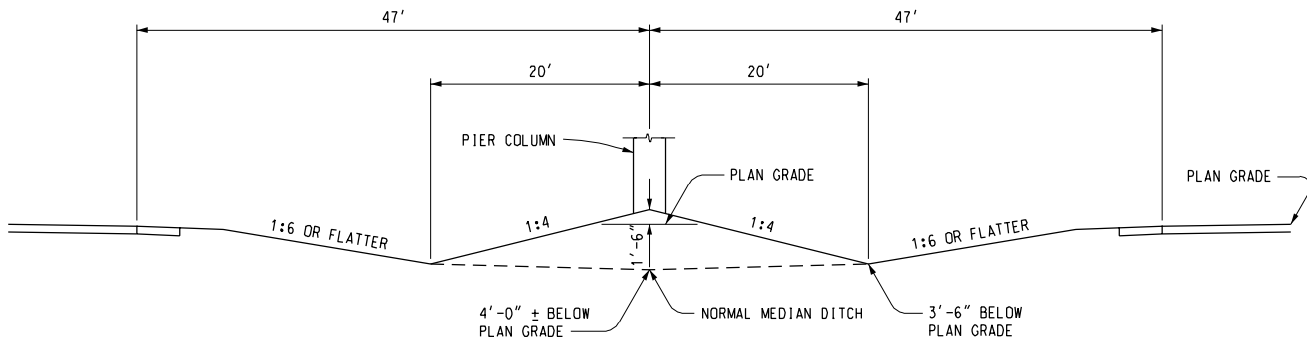
MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR

GRADING CROSS-SECTIONS

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LONGITUDINAL SECTION ALONG MEDIAN



TRANSVERSE SECTION AT STRUCTURES

TYPICAL GRADING DETAILS AROUND PIERS FOR MEDIANS 94' OR WIDER

NOTES:

THIS STANDARD APPLIES PRINCIPALLY FOR VARIOUS DITCH TYPES AND FOR THE ROUNDING OF SLOPES. THE SUBGRADE WILL BE SPECIFIED ON THE PLANS. SLOPES OTHER THAN THOSE SPECIFIED ON THIS PLAN MAY BE USED WHEN THEY ARE SPECIFIED ON THE PROJECT PLANS. IN THE EVENT OF A DISCREPANCY BETWEEN THIS PLAN AND THE PROJECT PLANS, THE PROJECT PLANS WILL GOVERN.

SEE CURRENT STANDARD PLAN R-107-SERIES FOR SUPERELEVATED SECTIONS.

DITCHES SHOULD ALWAYS BE DEEP ENOUGH TO GRAVITY DRAIN THE SUBBASE, WHERE SUBBASE IS USED.

THE SUBGRADE SHOULD BE SLOPED TO DRAIN TO THE OUTSIDE DITCH IF THE MEDIAN ON DUAL ROADWAYS IS OF INSUFFICIENT WIDTH TO ALLOW DITCHES DEEP ENOUGH TO DRAIN THE SUBBASE.

THE TOP OF BACKSLOPES AND THE BOTTOM OF FILL SLOPES SHALL BE ROUNDED WITH VERTICAL CURVES AS FOLLOWS, PROVIDED TREES OR OTHER RESTRICTIONS DO NOT INTERFERE:

1. USE 4' VERTICAL CURVE ON CUTS OR FILLS LESS THAN 4'.
2. USE 8' TO A MAXIMUM 16' VERTICAL CURVE ON CUTS OR FILLS 4' TO 16'.
3. USE A MAXIMUM 16' VERTICAL CURVE ON CUTS OR FILLS GREATER THAN 16'.

ALL TRANSITIONS IN LENGTH OF VERTICAL CURVES SHALL BE GRADUAL AND GRADED TO PRESENT A UNIFORM AND ATTRACTIVE APPEARANCE.

WHEN 1:6 OR FLATTER SLOPES CANNOT BE CONSTRUCTED WITHIN THE EXISTING R.O.W., THE BARN ROOF FILL SECTION MAY BE USED TO ELIMINATE THE NEED FOR ADDITIONAL R.O.W.. THEY WILL BE USED ONLY WHERE SPECIFIED ON THE PLANS.

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY DEVELOPMENT STANDARD PLAN FOR

GRADING CROSS-SECTIONS

11-14-2003
F.H.W.A. APPROVAL

6-19-2002
PLAN DATE

R-105-D

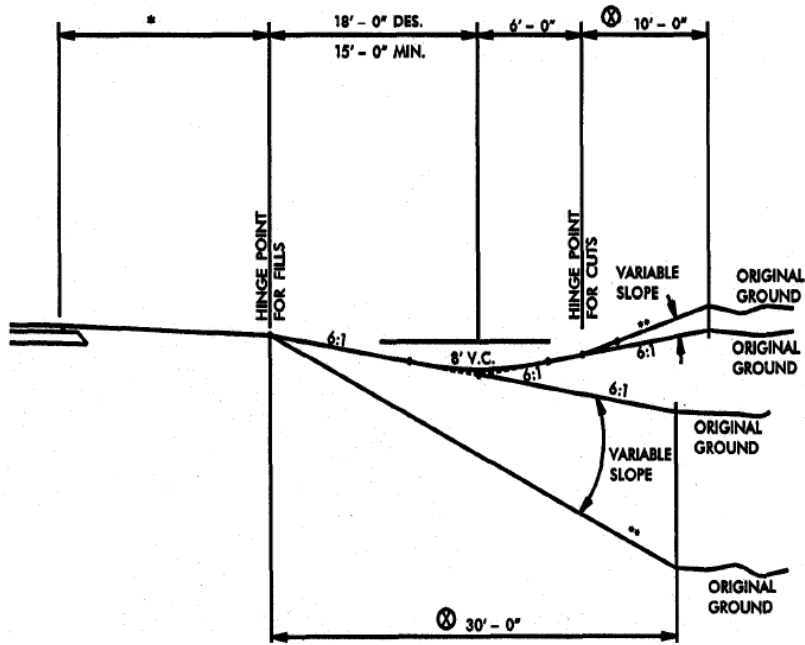
SHEET
6 OF 6

(A) INTERSTATES, FREEWAYS, EXPRESSWAYS & OTHER FOUR LANE FACILITIES

1 - 2A

(ROUND BOTTOM DITCH WITH HINGE POINT SLOPES)

F - 1



⊗ WHEN SLOPE-STAKE POINT FALLS OUTSIDE THE HINGE POINT DISTANCE, MAINTAIN APPROPRIATE MAXIMUM OR MINIMUM SLOPE.

