ACCESS SPACING GUIDELINES

INTERSECTING HIGHWAY		RURAL ARTERIAL UNDER STUDY					
Type	Design Year-ADT	Freeway	Expressway	Principal Arterial	Minor Arterial		
					>5000	1000-5000	<1000
Freeway		A	B	B	B	B	B
Expressway		B	B	B	B	C	C
Principal Arterial	>3000	B	B	B	B	C	C
	<3000	B	B	C	C	D	D
Minor Arterial	>5000	B	B	B	B	C	C
	3000-5000	B	B	C	C	C	D
	<3000	B	C	C	D	D	D
Major Collector		B	C	C	D	D	D
Minor Collector		B	D	D	D	D	E
Local		N/A	D	D	D	D	E
Private	>100	N/A	D	E	E	E	E
	<100	N/A	E	E	E	F	F

Recommended Spacing Between Access Points:

A = 5 miles

B = 2 miles

C = 1 mile

D = 2000 feet

E = 1000 feet

F = 500 feet

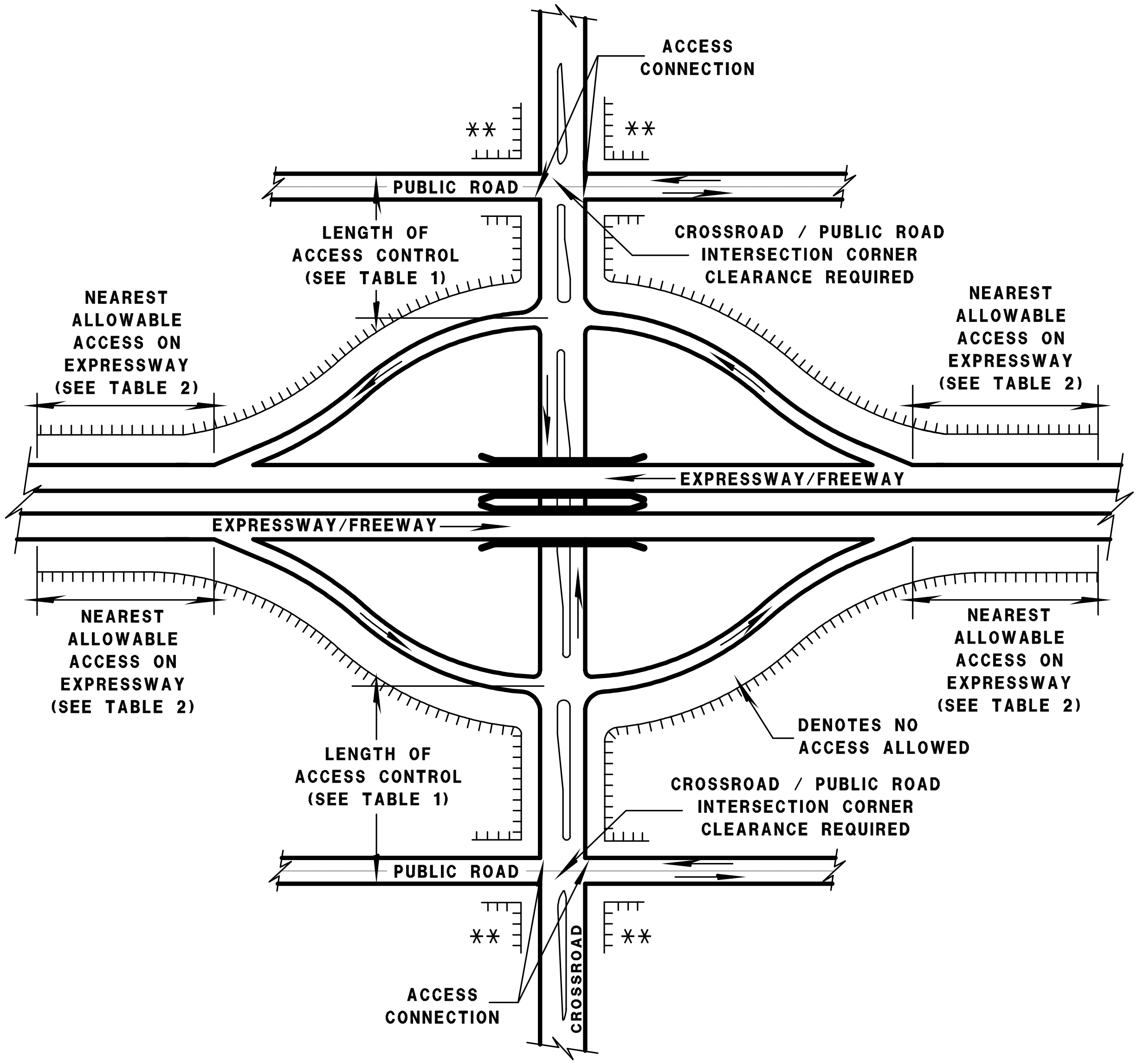


TABLE 1 - Distance of Access Control on Crossroad

Area Type	Upper Minimum	*Lower Minimum
Rural or Urban	1,320 ft	1,000 ft (1200-ft if location is or is likely to be signalized)

TABLE 2 - Distance of Access Control on Expressways

Area Type	Median opening at at-grade intersection	Upper Minimum	* Lower Minimum
Rural or Urban	**None** (intersection is right-in or right-out or both)	2,640 ft	1,500 ft
	Full or restricted (allows left-in, left-out, thru movements, or any combination of the three	2,640 ft	2,640 ft

* An approved traffic impact analysis is required to justify a less than upper minimum distance of access control. See text.

**Access control here is based on the functional area of the intersection. See FDM 11-25-1.

The following are two examples of earthwork calculations:

Example 1

Given:	Cut	= 3,250 CY
	Fill	= 33,992 CY
	Fill expansion	= 1.25
	Rock excavation	= 1,395 CY
	Rock expansion	= 1.1
	Marsh excavation	= 343 CY
	Marsh expansion	= 1.5

Common excavation is clean sand and will be used to backfill marsh.

Marsh will be wasted and will not be included in the fill.

Step 1

Identify all excavation and fill volumes as well as the expansion/reduction

Factors for each material.

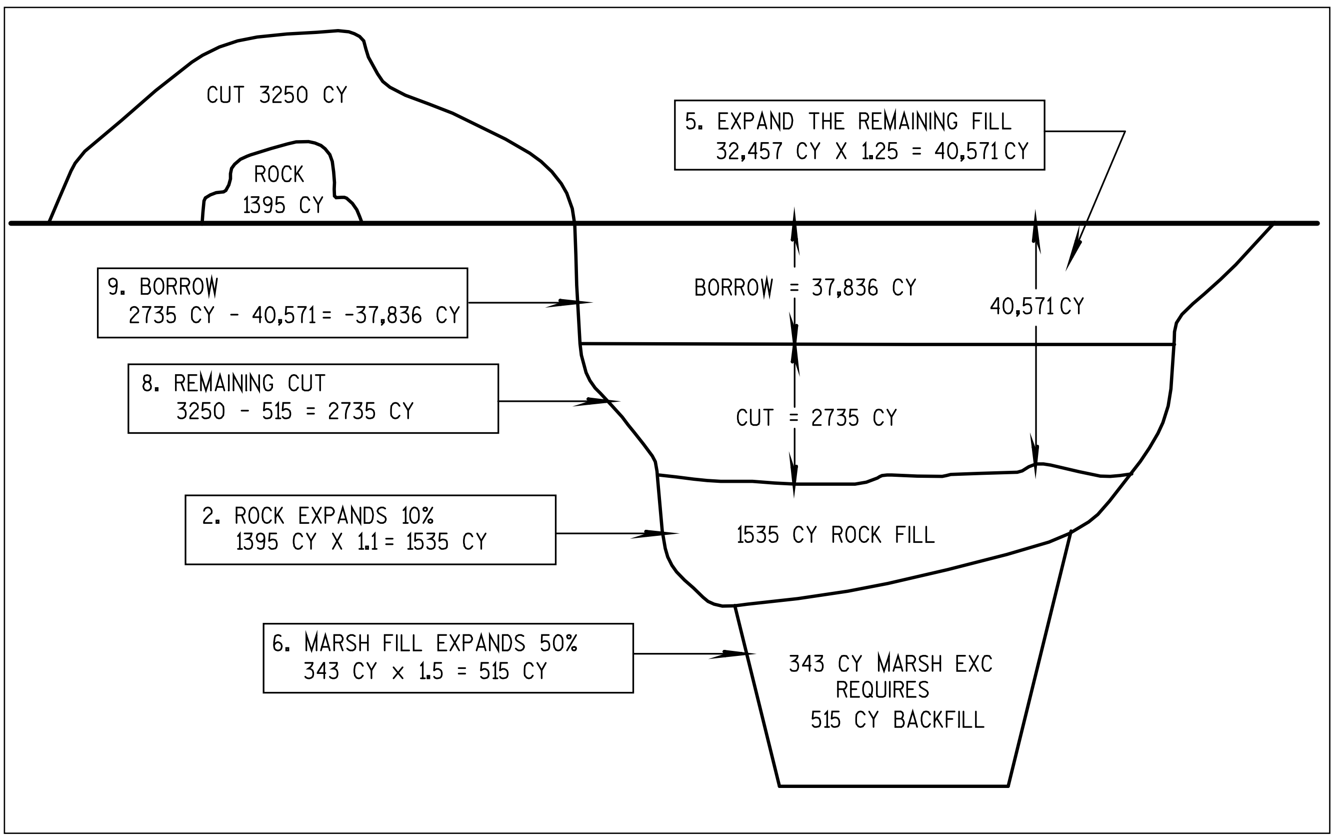


Figure 1. Schematic Earthwork Volume Sketch

Step 2

Expand the rock and deduct this from the unexpanded fill.

(Note: The 1.1 expansion factor means that the excavated rock will expand to fill a volume of 110 % in the new fill.)

1,395 CY x 1.1 = 1,535 CY

This means that the rock will expand to fill a volume of 1,535 CY in the fill.

Deduct the rock fill from the unexpanded fill.

(Note: The rock fill volume is the true volume of rock after it is excavated and placed in the fill. This rock fill must be deducted prior to expanding the fill. Remember that fill expansion does not actually occur and is only a

visualization to account for the shrinkage of the cut and borrow excavation. If the rock fill would be deducted from the expanded fill, a significant error would occur because the fill expansion factor is intended to account for only the shrinkage of the cut and borrow).

33,992 CY – 1,535 CY = 32,457 CY

This indicates that, after the rock excavation is placed in the fill, there is still 32,457 more CY of material needed, in place, to complete the fill. This is the true volume of fill, in place, and does not account for the shrinkage of the cut and borrow excavation.

Step 3

Not applicable, marsh will not be used in the embankment.

Step 4

Not applicable, EBS will not be used in the embankment.

Step 5

Expand the remaining fill.

(Note: The 1.25 expansion factor means that the fill is visualized to expand to 125 % of its true volume in order to account for the shrinkage of the cut and borrow excavation).

32,457 CY x 1.25 = 40,571 CY

This indicates that 40,571 CY of cut and borrow excavation, measured in its original location, will be needed to complete the fill.

Step 6

Determine the volume of marsh backfill.

(Note: The 1.50 expansion factor means that the marsh excavation is visualized to expand to 150 % in order to account for both the displacement of the marsh and the shrinkage of the material placed as marsh backfill. If granular backfill or select borrow would be specified as backfill, this would also include the one foot of granular backfill or select borrow placed above the marsh).

343 CY x 1.5 = 515 CY

This indicates that 515 CY of cut, borrow, select borrow or granular backfill, measured in its original location, will be needed to backfill the marsh excavation.

Step 7

Not applicable, no EBS is identified.

Step 8

Determine the volume of cut remaining after the marsh is backfilled.

In this example, cut will be used to backfill the marsh, so this reduces the amount of cut available in the remaining fill. If granular backfill would be specified as marsh backfill, the material to backfill the marsh would be paid for under the item of granular backfill and would not affect the volume of cut that is available for the fill.

3,250 CY - 515 CY = 2,735 CY

This indicates that 2,735 CY of cut will be available as fill after the marsh is backfilled.

Step 9

Determine the required borrow (minus value) or waste (plus value) by subtracting the expanded fill from the remaining cut.

2,735 CY - 40,571 CY = -37,836 CY

Note: The value is "- 37,836 CY", so 37,836 CY of borrow is required.

In the following example, the marsh and EBS are backfilled with granular backfill and the marsh and EBS are used in the fill outside of the 1:1 slope.

Example 2

Given:	Cut	= 250,001 CY
	Salvaged asphalt pavement in cut	= 1,111 CY
	Fill	= 150,001 CY
	Fill expansion	= 1.25
	Rock excavation	= 25,000 CY
	Rock expansion	= 1.1
	Marsh excavation	= 15,001 CY
	Marsh backfill expansion	= 1.5
	Marsh fill Reduction	= 0.6
	EBS	= 7,500 CY
	EBS backfill expansion	= 1.3
	EBS fill reduction	= 0.8

Step 1

Determine the usable volumes of all excavation and fill materials as well as the expansion/reduction factors for each material.

Determine the usable volume of cut.

250,001 CY – 1,111 CY. = 248,890 CY

Step 2

Expand the rock and deduct the rock fill from the unexpanded fill

Rock fill = 25,000 CY. x 1.1 = 27,500 CY

Remaining fill = 150,001 CY. – 27,500 CY. = 122,501 CY

Step 3

Deduct the marsh fill from the remaining fill

Marsh fill = 15,001 CY. x 0.60 = 9,000 CY.

Remaining fill = 122,501 CY. – 9,000 CY. = 113,501 CY

Step 4

Deduct EBS fill from the remaining fill

EBS fill = 7,500 CY. x 0.8 CY = 6,000 CY

Remaining fill = 113,501 CY – 6,000 CY = 107,501 CY

Step 5

Expand the remaining fill.

107,501 CY. x 1.25 = 134,375 CY

Step 6

Determine the volume of material needed to backfill the marsh.

15,001 CY x 1.5 = 22,501 CY

Note: This is the volume of granular backfill required to backfill the marsh. This does not affect the cut or fill and is not used in the mass ordinate computations.

Step 7

Determine the volume of material needed to backfill the EBS.

7,500 CY x 1.3 = 9,750 CY

Note: This is the volume of granular backfill required to backfill the EBS. This does not affect the cut or fill and is not used in the mass ordinate computations.

Step 8

Not applicable, granular backfill is specified to backfill the marsh and EBS, so this does not affect the volume of cut that is available.

Step 9

Determine the volume of borrow (minus value) or waste (plus value) by deducting the remaining expanded fill from the usable volume of cut.

248,890 CY – 134,375 CY = + 114,515 CY

There is 114,515 CY of waste.

COMPACTION OF SOILS

One of the essential functions of geotechnical engineering is to ensure that adequate density of the soil or rock exists to provide satisfactory performance. If this required density does not exist in the soil, either in place or after reworking by excavation and placement, compactive effort (applied energy) is necessary to increase the density. Regardless of any terminology applied, compaction means applying energy to secure a given unit weight, usually in our usage pounds per cubic foot or kilograms per cubic meter. A moisture content of the material may also be specified. For most Wisconsin soils, any concern for moisture is largely for a means to attain required density with minimum energy.

There are numerous properties of soils that affect its performance as a construction material. Fortunately, soil density has been found to be a good indicator of the properties that yield desirable results. Therefore, an effort should be made to achieve proper soil density.

In the past, density measurements were made in both old and new fills. Data from these investigations indicated a reasonable balance of desired performance properties with densities. This work found the densities achieved were in a range of what is now known as 90 to 100% of the AASHTO T-99 maximum density. Continuing studies since Proctor's work in 1923 have determined that density in the range of 90 to 95% AASHTO T-99 is desirable and adequate for most work. Later studies have recognized that special problems may require greater density. AASHTO T-180 may be required for air fields, high embankments, or heavy footing loads. Of course, there are also a few isolated special cases, which may warrant lower densities. These include expansive soils being compacted to lower density and higher moisture contents or silts being compacted at lower moistures.

Moisture content is usually more of a means to achieve density than a desired property within itself. For example, a heavy clay compacted considerably dry of optimum will be compacted only with tremendous compaction energy, say four to five times normal compactive effort. A 2% increase in moisture content would allow the clay to be compacted with normal effort. Silts compacted at or above optimum moisture usually cannot be brought up to the desirable density.

Other properties of soils are also affected to a degree by moisture content. For example, a clay compacted fairly wet will have slightly less consolidation but slightly greater strength than it would exhibit if compacted rather dry. These changes for Wisconsin soils are usually less than the effects from different rollers or differences in laboratory compaction versus field methods. One check should always be made where moisture is of concern, either in drying a wet soil or wetting a dry material. Soil does not supersaturate, so the relation of density-moisture to the zero air voids line should be checked.

If a certain density is needed, it should make no difference to a contractor what compaction inspection method is called for if he is achieving the density specified. If a contractor objects to a specific specification, one might assume he feels he can achieve and have accepted a lesser density with another method.

These preliminary remarks lead to the fact that the soil engineer should recommend the method used to determine that the needed density is achieved. Ordinarily in Wisconsin this means a recommendation of either Standard Compaction or Special Compaction. The use of QMP Earthwork generally calls for the contractor to perform the density/moisture testing on a project. In Wisconsin, the terms Special Compaction and Standard Compaction have absolutely nothing to do with the desired density. These terms are merely methods set out for checks or observations to ensure the desired density is being achieved. Having nothing to do with these terms at all, some special cases may make modification in density or additional controls necessary. The advantages and disadvantages of each method are outlined below:

Special Compaction:

Advantages	Disadvantages
Specific data at specific site.	Difficult to select standard lab density.
Enforceable in specific language.	Impossible or largely judgmental in highly variable soils.
Allows more control on problem soils such as; fat clay, silts, organics, etc.	Largely unneeded on granular soils.
Easily documented.	Requires more equipment to be effective.
Better confidence in design for high fills, plastic soils in subgrade or similar critical uses.	Process often too slow to effectively control lifts: i.e., additional lifts go on before testing is complete.

Standard Compaction:

Advantages	Disadvantages
Less testing equipment.	Experienced personnel needed.
Allows broader enforcement in highly visible soils.	Judgmental.
Adequate for many soils, particularly granular.	Poorer coverage and lift thickness control.
Simplified record keeping.	Misleading in dry cohesive soils.
	Ambiguous specification.
	Less confidence in design.
	Misleading in clod-type soils.

A study by the Region Soils Engineer of the soils encountered, along with design, construction, and service needs, should weigh these advantages and disadvantages. From this study, a recommendation on appropriate compaction control should be given to the designer as a part of the project Soils Survey Report.

The advantages and disadvantages noted above must be considered and applied to the combination of local soil conditions, the design parameters, and performance requirements. As these factors vary in significantly, no exact criteria can be specified. However, the guidelines can be applied that should set up the recommendations made in the Soil Survey Report.

While no exact criteria may exist, some broad guides are possible.

For plastic soils with liquid limits (LL) greater than or equal to 45, special compaction should be recommended. For soils with LL less than or equal to 25, standard compaction should give satisfactory performance. On some very bony soils, density tests of any type are virtually impossible. On these soils, no density requirements are expected and fortunately rarely needed.

Fill height should also be criterion. Fills with heights exceeding 35 feet should have a controlled compaction specification and fills in excess of 50 feet should mandate both density and moisture controls. Silts in higher fills should have moisture controls and always be compacted 2 to 5% below optimum moisture. Fills with heights exceeding 50 feet, if built of silts or clay, should have analyses based on tests to give design parameters. Also, low height fills of material having a liquid limit greater than 45 should have controlled compaction.

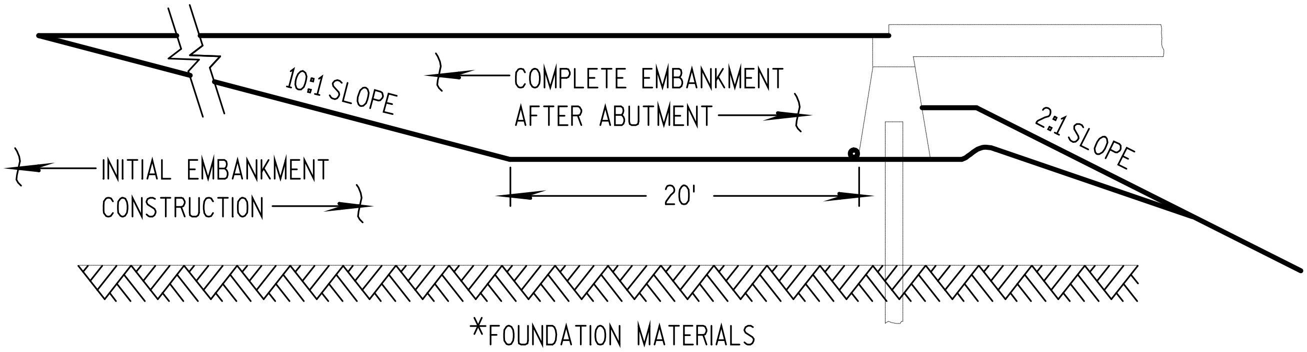
With considerable amount of current construction being on short fills that are inherently difficult to compact, the soil engineer should give special attention to these situations.

It is intended that a check density test be made on each 25,000 yards of soil in all embankments regardless of the acceptance method. On projects of smaller quantities, one or more density tests should be made.

The consequences of future settlements should be weighed. A higher fill will settle more than a shallow fill. For example, often a 25-foot fill will cause foundation settlement much more than 2-1/2 times that of a 10-foot fill. Also, the soil engineer should relate anticipated future settlement in the foundation to design. If there is to be a future settlement of, say, 1 foot in the foundation soil than 3 inches of settlement in the fill due to lack of compaction may not be of primary concern.

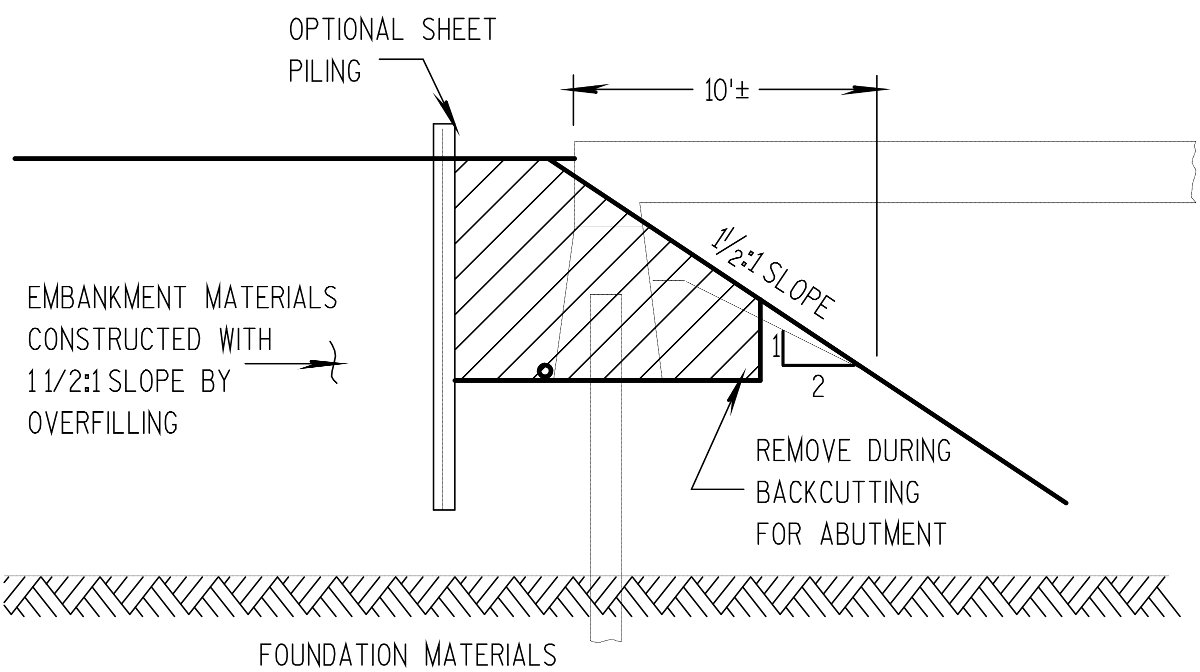
Admittedly this leaves non-specific areas in soil properties, fill height, side slope, and pavement performance where controls are still judgmental. As long as there are two compaction acceptance procedures that should achieve the same result, there must be judgments in preparing a Soil Survey Report that considers fill height, bridge end bumps, resilient modulus of subgrades, and placement conditions.

For optimum field results, it should be emphasized that standard compaction without adequate overall control can be difficult. For example, a clay soil compacted 5 or 6 percent dry of optimum will not show evidence of low density. However, when it attains the normal 90-95 percent saturation under a pavement in 3 to 5 years, severe problems develop. Similarly, grade inspections using controlled methods should never depend on tests alone to control compaction. The tests are to verify and assist in verifying desired density, but observation for and enforcement of coverage, lift thickness, and uniformity is always essential.



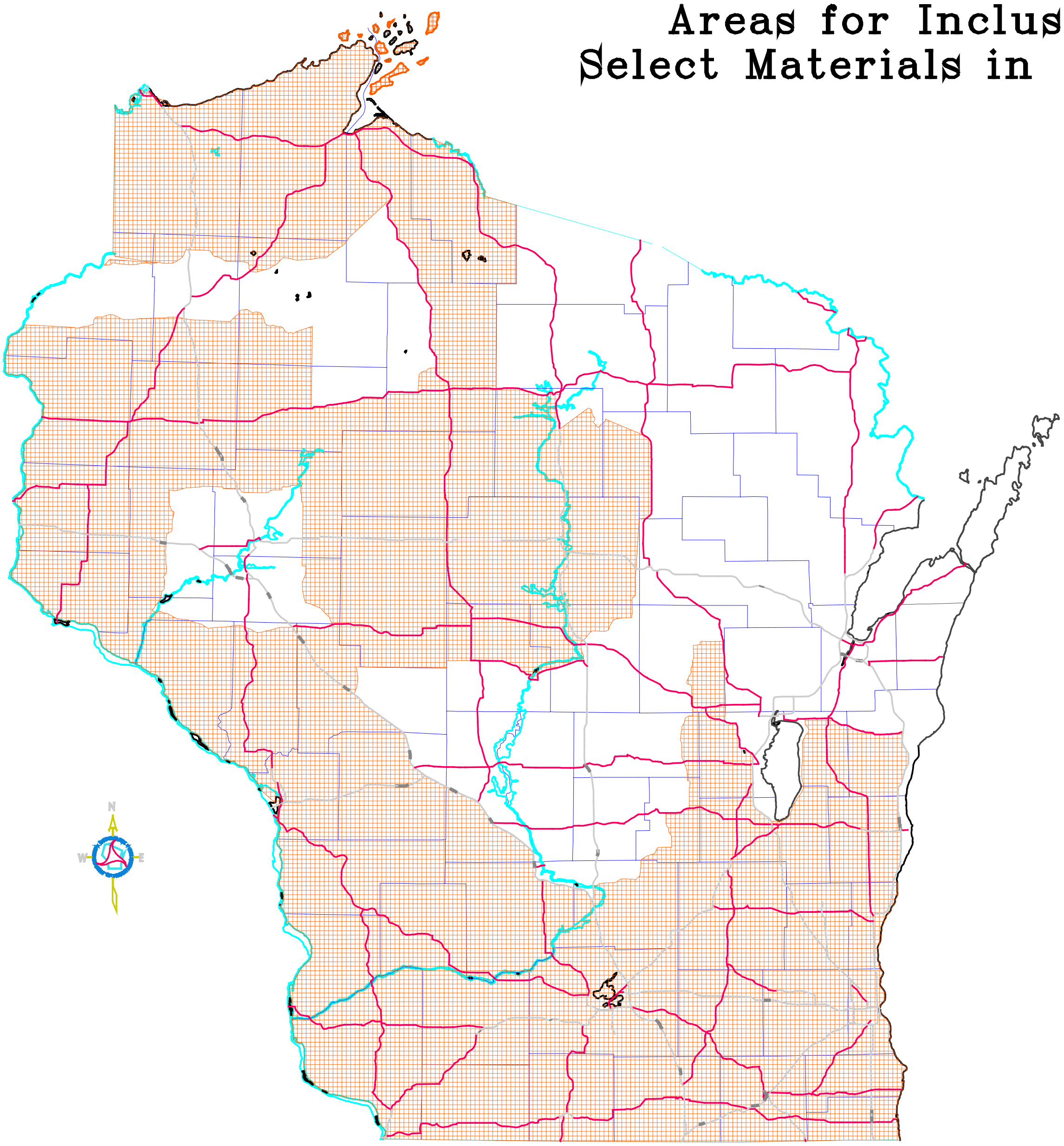
* When designing an embankment, the designer should consider the effect that the embankments weight will have on the foundation materials. This matter should be discussed with the region soils engineer.

Detail A: Recommended Embankment Construction Method



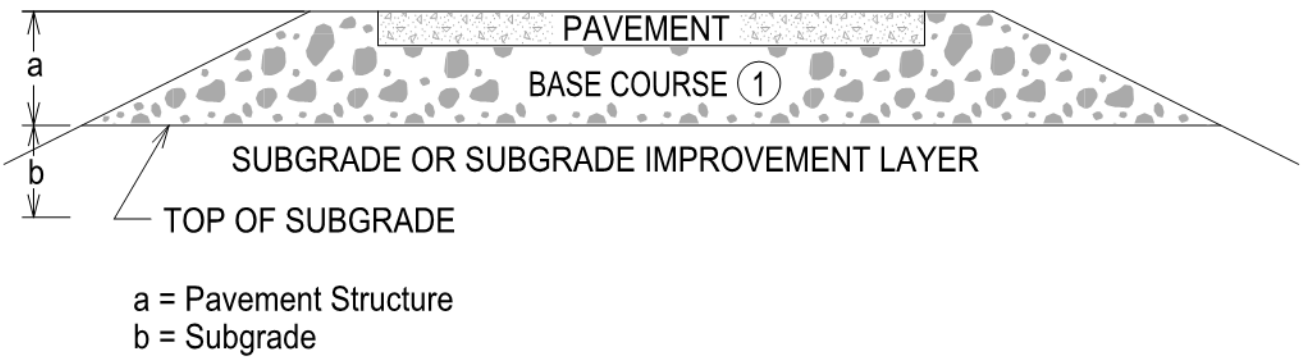
Detail B: Alternate Embankment Construction Method

Areas for Inclusion of Select Materials in Subgrades

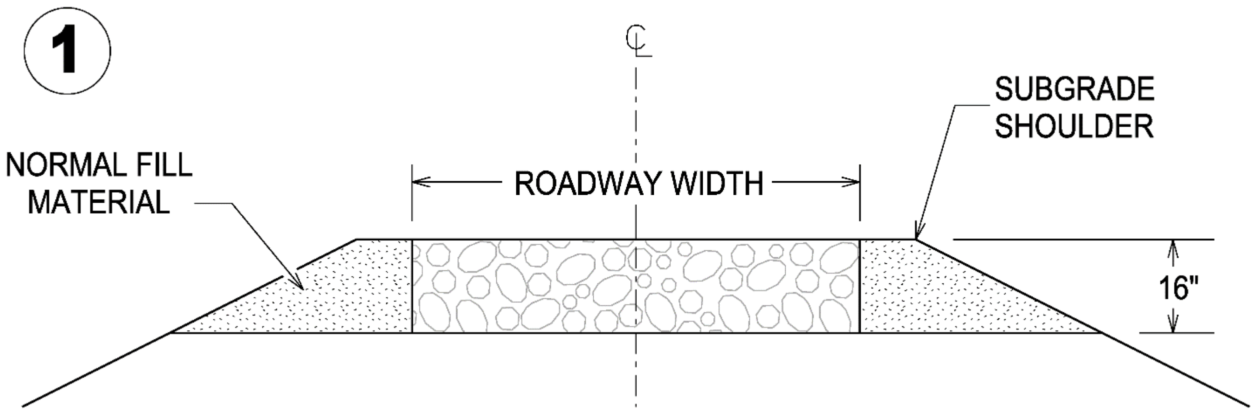


Standard Non-inclusion Areas

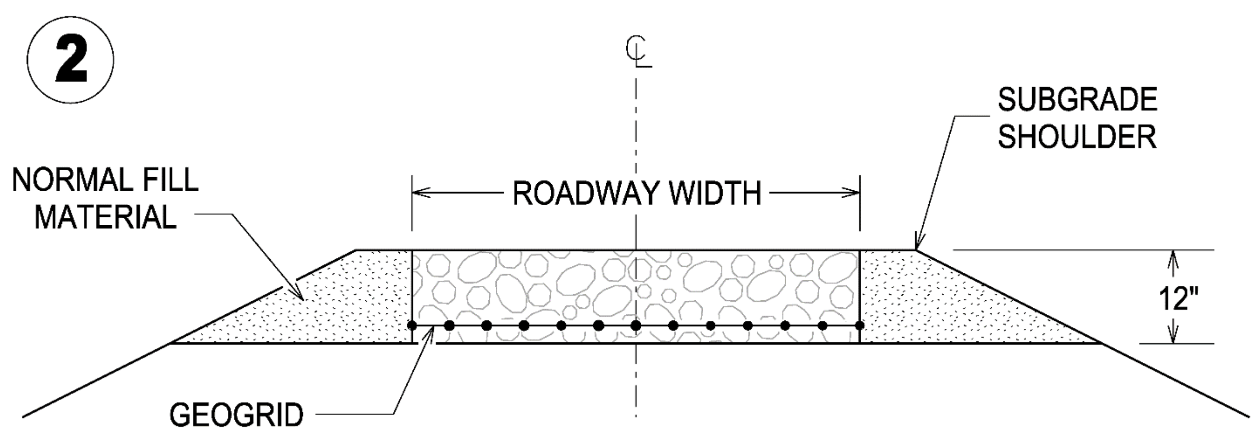
Standard Inclusion Areas



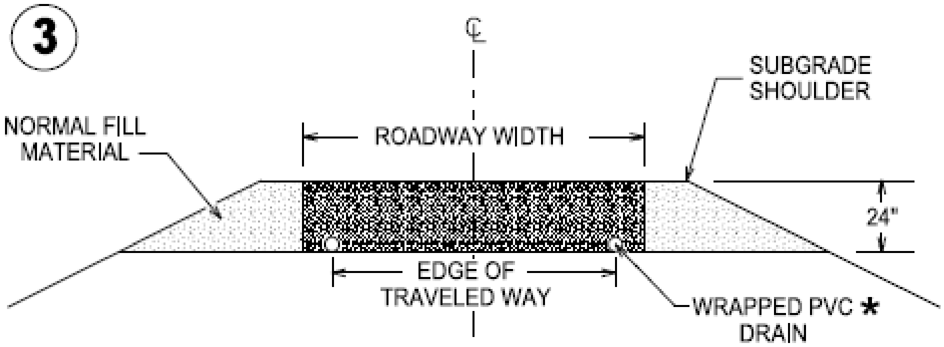
(1) BASE COURSE MATERIALS INCLUDE ¾ INCH / 1¼ INCH / 3 INCH DENSE GRADED BASE AS DEFINED IN WI STANDARD SPEC SECTION 301 AND 305



BREAKER RUN STONE

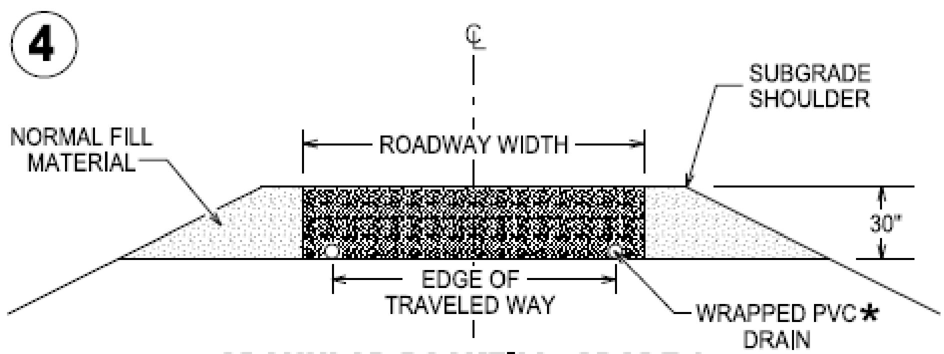


BREAKER RUN STONE WITH GEOGRID



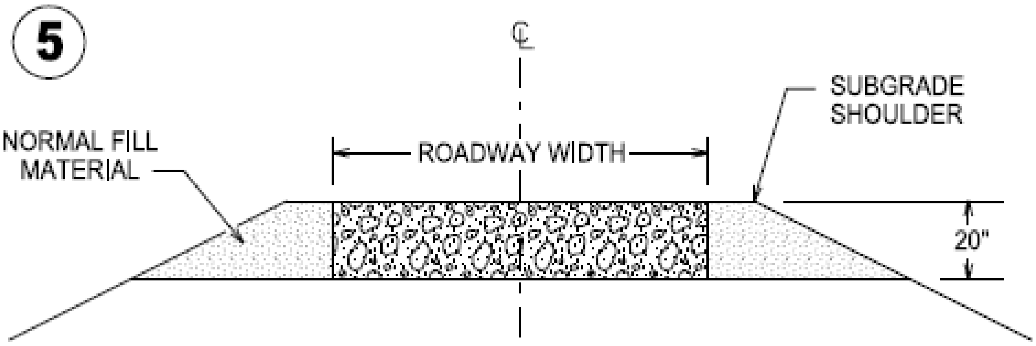
GRANULAR BACKFILL, GRADE 1

* MAY BE ELIMINATED IF GRANULAR BACKFILL SLOPES ARE COVERED WITH 3"- 4" OF BASE AGGREGATE DENSE

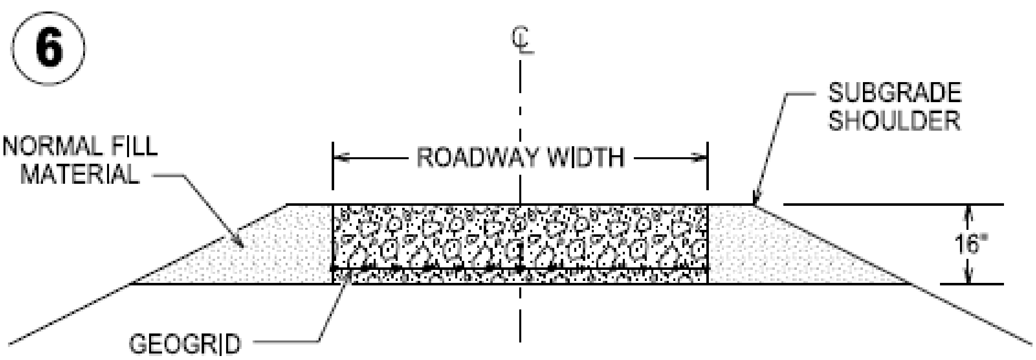


GRANULAR BACKFILL, GRADE 2 OR SELECT BORROW

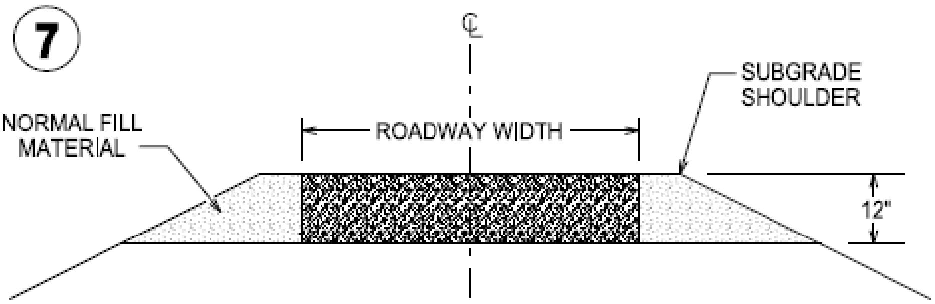
* MAY BE ELIMINATED IF GRANULAR BACKFILL SLOPES ARE COVERED WITH 3"- 4" OF BASE AGGREGATE DENSE



PIT RUN SAND & GRAVEL

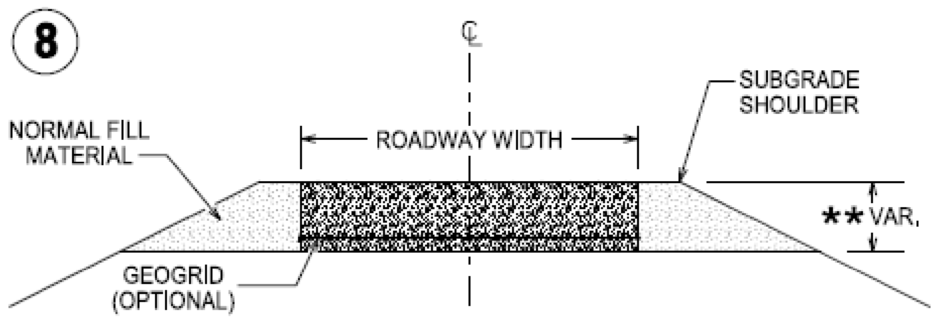


PIT RUN SAND & GRAVEL
WITH GEOGRID



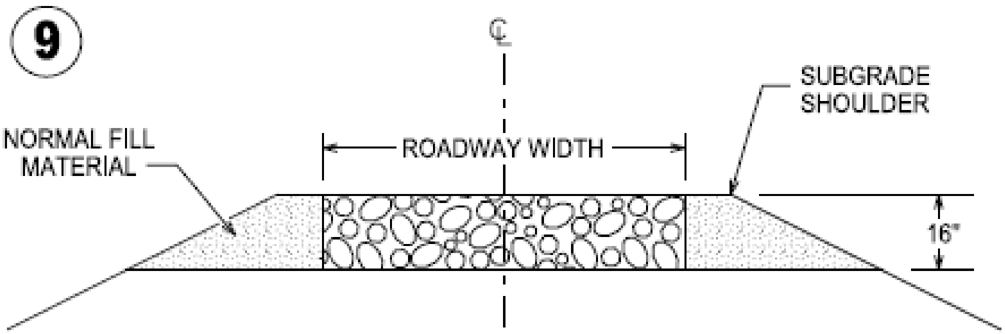
LIME, FLYASH, OR CEMENT STABALIZED SOIL

(APPLIES ONLY TO SUBGRADE SOILS CLASSIFIED AS CLAY SOILS)

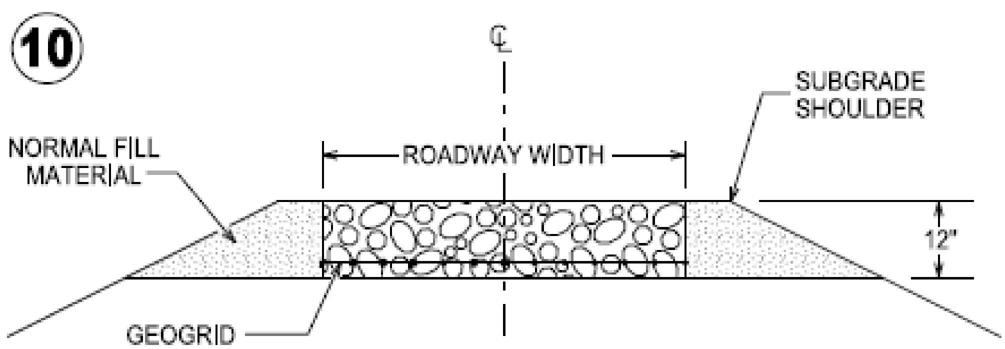


RECYCLED CONCRETE, STEEL SLAG, FOUNDRY SLAG, BOTTOM ASH, RECYCLED ASPHALTIC PAVEMENT WITH GEOGRID

** SEE RECOMMENDATION IN SOILS REPORT



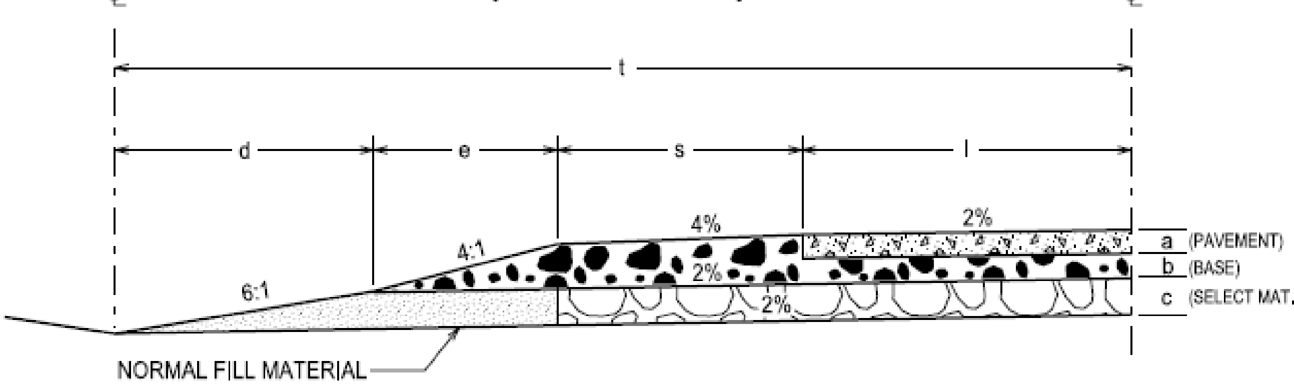
SELECT CRUSHED MATERIAL



**SELECT CRUSHED MATERIAL
WITH GEOGRID**

THE RELIEF TRENCH DETAIL SHOWN IN FDM 11-5 ATTACHMENT 15.3 SHALL BE USED IN CONJUNCTION WITH ALL THE SELECT MATERIAL SYSTEMS EXCEPT #7.

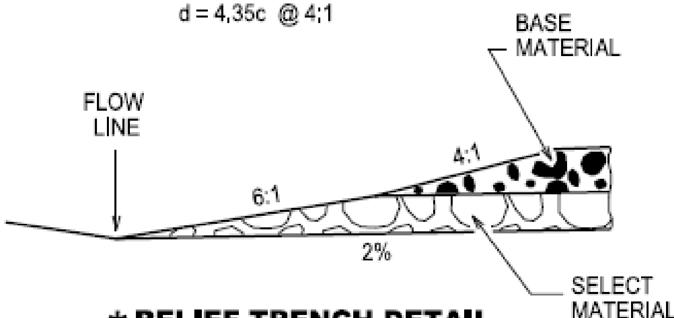
TYPICAL HALF SECTION WITH SELECT MATERIALS (OUTSIDE DITCH)



e = 4.35 (a + b - .02s)

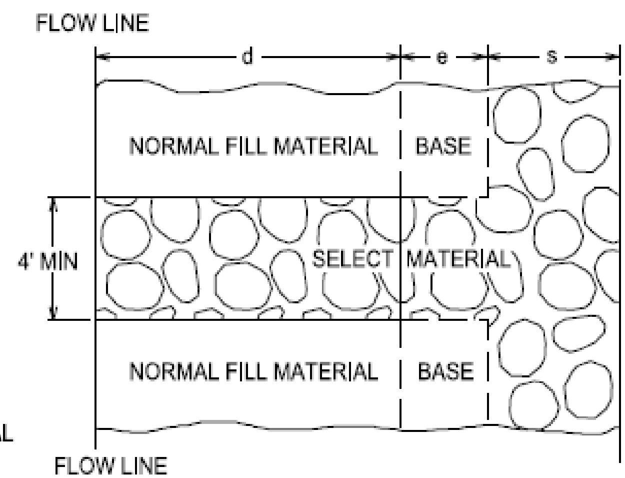
d = 6.82c @ 6:1

d = 4.35c @ 4:1



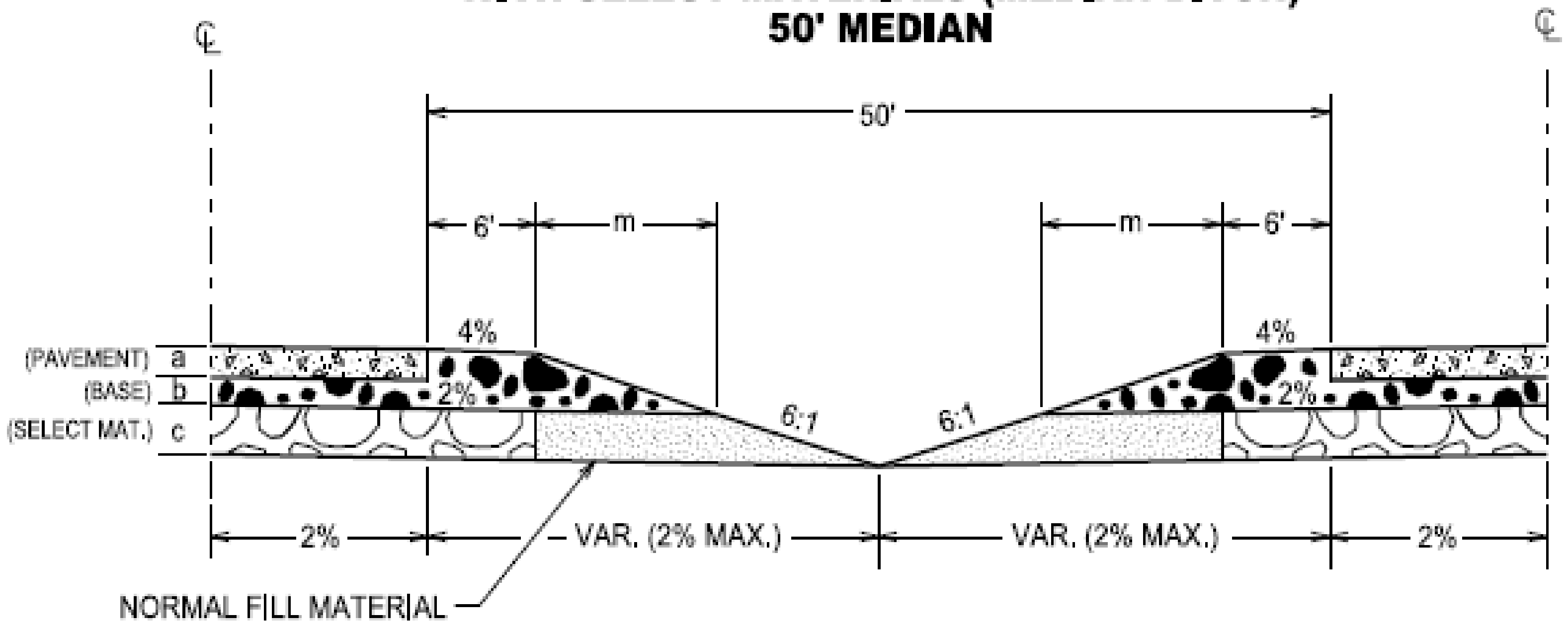
* RELIEF TRENCH DETAIL PROFILE VIEW

* Construct relief trench at sag points or every 250 feet



RELIEF TRENCH DETAIL PLAN VIEW THROUGH SELECT MATERIAL

TYPICAL HALF SECTION FOR FOUR LANE DIVIDED HIGHWAYS WITH SELECT MATERIALS (MEDIAN DITCH) 50' MEDIAN



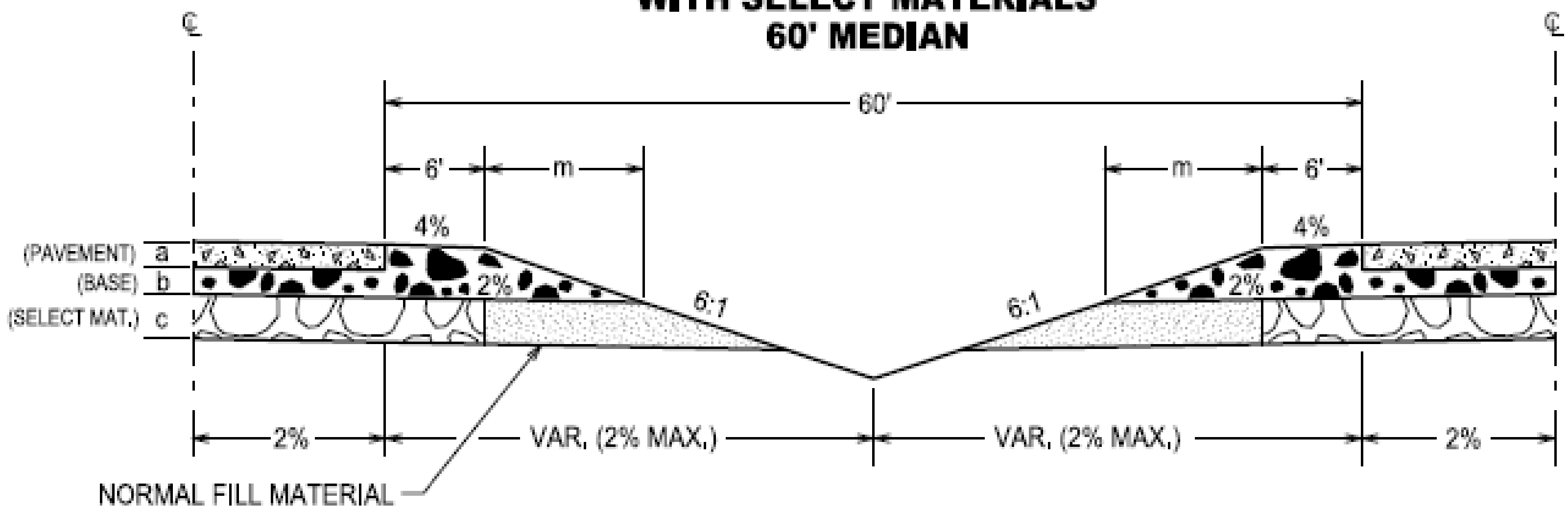
$m = 6.82\ (a + b - 0.12)$

WITH 2% SLOPE: $C_{max} = 2.91 - (a + b)$

WITH FLAT SLOPE: $C_{max} = 3.41 - (a + b)$

NOTE: Construct relief trenches as shown in FDM 11-5 Attachment 15.3 at ditch sag points or every 250 feet

TYPICAL HALF SECTION FOR FOUR LANE DIVIDED HIGHWAYS WITH SELECT MATERIALS 60' MEDIAN



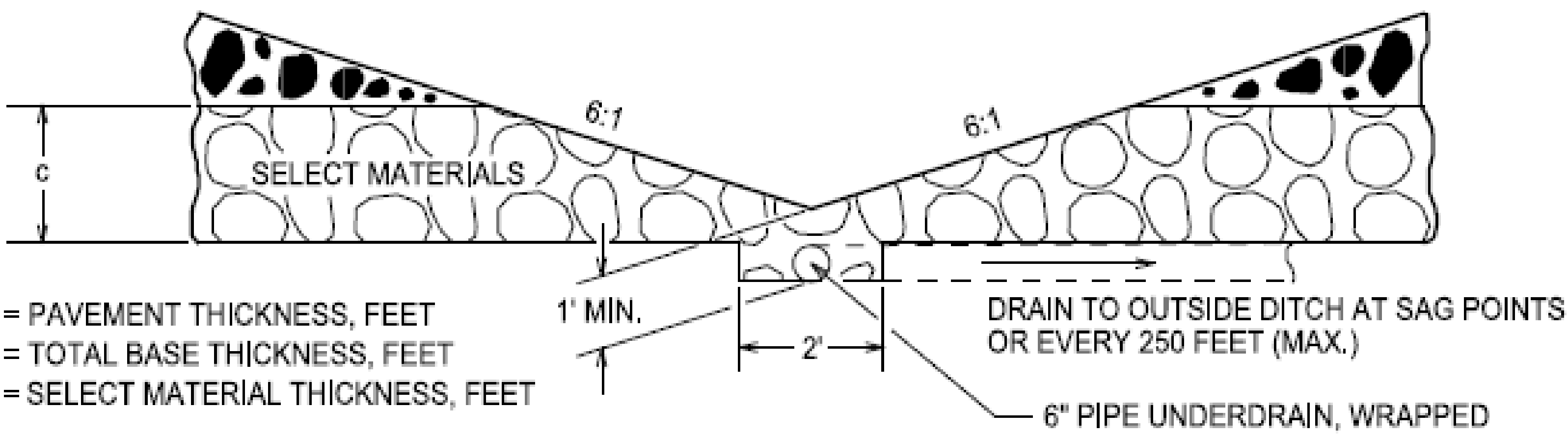
NOTE: Construct relief trenches as shown in FDM 11-5 Attachment 15.3 at ditch sag points or every 250 feet

$m = 6.82\ (a + b - 0.12)$

WITH 2% SLOPE: $C_{max} = 3.64 - (a + b)$

WITH FLAT SLOPE: $C_{max} = 4.24 - (a + b)$

MEDIAN DRAIN DETAIL FOR SELECT MATERIALS LAYERS GREATER THAN C_{max}

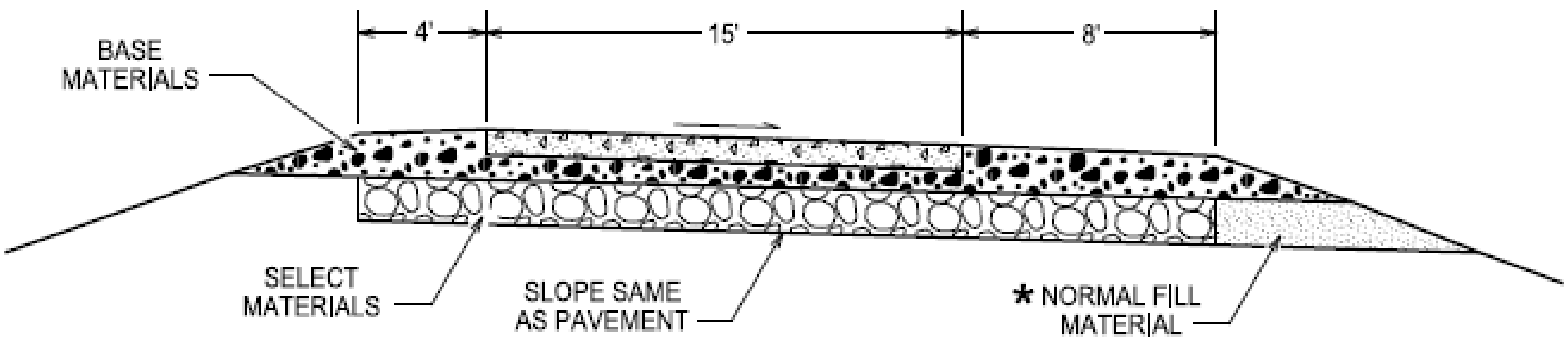


a = PAVEMENT THICKNESS, FEET
b = TOTAL BASE THICKNESS, FEET
c = SELECT MATERIAL THICKNESS, FEET

FOR A 50' MEDIAN: $C_{max} = 3.41 - (a + b)$

FOR A 60' MEDIAN: $C_{max} = 4.24 - (a + b)$

TYPICAL SECTION FOR ONE LANE RAMP WITH SELECT MATERIALS



* NOTE: Construct relief trenches as shown in FDM 11-5 Attachment 15.3 every 250 feet