1.1 General
Soils information should come from the soils report. In lieu of the report, standard correlations between pavement parameters are listed in Table 1.1.

Table 1.1 Soil Parameters for Pavement Design

<table>
<thead>
<tr>
<th>Material</th>
<th>AASHTO</th>
<th>Soil Support Value</th>
<th>Wisconsin Design Group Index</th>
<th>Subgrade K</th>
</tr>
</thead>
<tbody>
<tr>
<td>I – well sorted</td>
<td>A-1-a</td>
<td>5.5-5.4</td>
<td>0-2</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>A-1-b</td>
<td>5.3-5.2</td>
<td>3-4</td>
<td>275</td>
</tr>
<tr>
<td></td>
<td>A3</td>
<td>5.1-5.0</td>
<td>5-6</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>A-2-4</td>
<td>4.9-4.7</td>
<td>7-8</td>
<td>225</td>
</tr>
<tr>
<td></td>
<td>A-2-4/A-4</td>
<td>4.6-4.5</td>
<td>9-10</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>A-4/A-6</td>
<td>4.4-4.2</td>
<td>11-12</td>
<td>175</td>
</tr>
<tr>
<td>II – poorly sorted</td>
<td>A-4</td>
<td>4.2</td>
<td>12</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>A-4/A-6</td>
<td>4.1-3.8</td>
<td>13-15</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>A-7-6</td>
<td>3.7-3.5</td>
<td>16-17</td>
<td>100</td>
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<tr>
<td></td>
<td>A-7-5</td>
<td>3.3-3.0</td>
<td>18-20</td>
<td>75</td>
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</tbody>
</table>

Design Group Index as it relates to Frost Index

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>F-0 to F-1</td>
</tr>
<tr>
<td>1-6</td>
<td>F-2</td>
</tr>
<tr>
<td>6-15</td>
<td>F-3</td>
</tr>
<tr>
<td>15-20</td>
<td>F-4</td>
</tr>
</tbody>
</table>

5.1 Subgrade Improvement Impact on Pavement Thickness Design
The Bureau of Technical Services has implemented a statewide policy that incorporates the use of select material in the pavement design process. The philosophy is that the subgrade is improved through the use of select material. Therefore, the support value of the improved subgrade must be increased to include the influence of the select material.

Regardless of the material used to improve the subgrade, it is still considered subgrade and should be given no additional credit in the structural design process beyond what is stated in this procedure.

Note: The use of a sub-base layer is still acceptable.
5.2 Policy

5.2.1 Concrete Pavements
When select material is placed according to FDM 11-5-15, the modulus of subgrade reaction (k) should be increased to 375. This increase is based on the development of a composite k per the AASHTO 1993 Guide for Design of Pavement Structures. One value has been established to cover all circumstances when a select material is used, the input values needed to determine a composite k are resilient modulus of the subgrade and elastic modulus of the subbase (select material).

5.2.2 Hot Mix Asphalt (HMA) Pavements
When select material is placed according to FDM 11-5-15, the Design Group Index(DGI)/Soil Support Value (SSV) chart (Attachment 5.1) includes a second reference line that is to be used to establish a SSV of an improved subgrade. This second reference line is for DGI values from 8 to 20.

LIST OF ATTACHMENTS
Attachment 5.1 Soil Support Value vs. Design Group Index

FDM 14-5-10 Base Aggregate Dense May 15, 2019

10.1 General
The Department uses a base aggregate that meets the specifications of Standard Spec 301.
Adequate moisture in base aggregate dense is required to prevent segregation and ensure proper compaction. Include bid item 624.0100 Water, MGal with base aggregate dense material. The application rates for water vary widely but may be estimated at a rate of approximately 10 - 20 gallon/ton of base aggregate dense. Refer to FDM 19-21-10 if the special provision for QMP base aggregate dense 1 1/4-inch compaction is required.

10.2 Paving Platform
10.2.1 Concrete Pavements
A standard 6-inch base aggregate dense should be used. When using base aggregate open graded, refer to FDM 14-5-15.

10.2.2 Traditional HMA Pavements
A ratio of 1:2 or 1:3 HMA pavement depth to base aggregate dense depth.
Example: 5 inches of HMA pavement over 10 to 15 inches of base aggregate dense.
When using base aggregate open graded, refer to FDM 14-5-15.

10.2.3 Deep-Strength or Perpetual HMA Pavements
A standard 6-inch base aggregate dense should be used. When using base aggregate open graded, refer to FDM 14-5-15.

10.2.4 Design Thicknesses
Calculate the design thickness of base aggregate layers to the nearest 1-inch.

10.3 Design Guidance
The Standard Specifications contain bid items for base aggregate dense that are referenced by their maximum size: 3-inch, 1 1/4-inch, and 3/4-inch.
The following figures show how these base materials would typically be incorporated into pavement sections according to the Standard Specifications. Standard Spec 305.2.2.1 allows the contractor the option of using 3-inch base in the lower layer. If designers leave this option in the contract, they should use Figure 10.1 as guidance to label typical sections or to prepare a similar plan detail.

10.3.1 Base Aggregate Dense 3/4-Inch on Foreslopes
With the option of the 3-inch base in the lower layer, the 3/4-inch base should be used from the edge of paved shoulder to the edge of the base portion of the foreslope. The 3-inch base should be covered with the 3/4-inch base to avoid future maintenance problems. If the use of the 3-inch base is excluded, then 3/4-inch base on the foreslope is not necessary.
10.3.2 Base Under the Finished Shoulder
Both the 3/4-inch base and the 1 1/4-inch base are acceptable under the paved shoulder and the adjacent finished shoulder. Designers should show this note on their plans and not restrict the shoulder construction to just one material. There are cost advantages to allowing both materials in this area. While both bases are allowed in this area, designers should include the quantity of this material in the bid item of Base Aggregate Dense 3/4-Inch.

10.3.3 Use of Base Aggregate Dense 3-Inch
The 3-inch base has a top size of 3 inches and is well graded through the remainder of the sieve ranges. It is a coarse material intended for use only in the lower portion of the base layer. The coarse size and maximum density-based gradation make it a very stable material with superior load carrying and load distribution properties. However, it is unsuited for use as base surface material or as shoulder material since the coarse size will make it difficult to finish. When produced from a quarry, it is expected to have a lower unit cost than 1 1/4-inch base, since less crushing effort will be required.

Quarries are the most logical source of 3-inch base. Producing this material from a gravel pit would be problematic due to both the size of the material and the requirement for 58% fracture on one face of the material retained on the No. 4 sieve.

As previously stated, the Standard Specifications allow the contractor the option of using 3-inch base in the lower layer. However, designers may require the use of the 3-inch base, or they may preclude it and instead require the use of the 1 1/4-inch base, as shown on Figure 10.2 and Figure 10.3. Designers should use these details as guidance to label typical sections or to prepare similar plan details.
The designer may require 3-inch base in the typical section under these conditions.

1. The total thickness of the base layer under the pavement is 10 inches or greater. Given the required 4-inch minimum layer of 1 1/4-inch base, 6 inches or more of the 3-inch base course would be required.

2. The project is in an area where quarries are the normal source of aggregates. The region soils engineer can provide guidance on specific projects, but the limestone regions that form an arc through the western, southern, and eastern portions of the state would have the most potential for economic production of 3-inch base. This would include most of the SW and SE regions and parts of the NW and NE regions.
3. A project contains items for the removal and the disposal of relatively large volumes of concrete pavement that would be suitable for crushing.

The use of 3-inch base is not recommended in areas where gravel pits are the primary source of base materials. The cost of production will be excessive, unless the pit contains large amounts of cobbles or boulders. Areas where this restriction would apply include nearly all of the NW and NC regions along with portions of the NE region. The region soils engineer can provide project specific information.

Do not allow the use of the 3-inch base if the total base thickness under the pavement is less than 10 inches.

FDM 14-5-15 Base Aggregate Open Graded (BAOG)  
May 15, 2019

15.1 General
The Department uses only one type of Base Aggregate Open Graded. The following elements are essential to ensure maximum performance of a drained pavement structure.

1. A permeable Base Aggregate Open Graded (BAOG)
2. A filter layer
3. A longitudinal edge drain collector system

15.2 BAOG Filter Layer
The target permeability of BAOG is 1,000 ft/day.

BAOG can be used in two different applications; the first is placed directly on the subgrade when the subgrade soils are coarse-grained, sandy soils with AASHTO classifications of A-1, A-3, and possibly some A-2 classifications. These soils are naturally permeable and can help drain the pavement structure. However, the subgrade soils must be analyzed to ensure they are compatible with the BAOG based upon the filter criteria. The particle size of the soil and BAOG must meet the following three filter criteria as shown in Figure 15.1.

The symbol "D" represents the diameter of the particle at the indicated percent passing on the grain size distribution curve of each material. All three criteria must be met to ensure that the subgrade does not contaminate the BAOG. Contamination of the layer will result in a decrease in permeability, a loss of structural support, and clogging of the edge drains. If the filter criteria are not met, it is not a good practice to increase the thickness of the BAOG layer with the assumption that only part of the layer will be lost to contamination. Research has shown that the pumping action of water will continue to move the contamination through the entire depth of the layer.

If the subgrade soil has an AASHTO classification of A-1, A-3 or A-2, BAOG should be proposed on the project, and placed directly on the subgrade. The subgrade soil type will be identified in the Soils Report. That report will also furnish the necessary inputs to perform the filter criteria analysis, provide a range of subgrade permeability values and make a recommendation for the use of this material. The minimum thickness of the BAOG layer,
when placed directly on subgrade, is 8 inches regardless of pavement type (refer to sheet ‘c’ of SDD 8D15). This thickness is required to provide enough hydraulic capacity to obtain a good level of drainage as per the criteria outlined by AASHTO and FHWA.

The other condition for use of BAOG is when the filter criteria cannot be met. In this situation, a filter layer of 6 inches of crushed aggregate base course is required to protect the BAOG layer from contamination. A geotextile can also be considered if it can be economically justified and construction operations will facilitate its use. A minimum thickness of 4 inches is required for the BAOG layer (refer to sheet ‘b’ of SDD 8D15).

15.3 Use of BAOG
The use of BAOG does not depend on ESALs. The designer will determine if BAOG is to be used. Situations, such as sag areas, should be considered. The feasibility and necessity of BAOG is still being researched.

15.4 Stabilization
There could potentially be cost and constructability advantages to stabilizing BAOG. Stabilization will be at the contractor’s discretion with no additional cost to the Department.

The effect of stabilization should not be factored into the design of the pavement structure and the strength coefficients for unstabilized open graded base course should be used.

15.5 Edge Drains
An edge drain system is required for installation with BAOG. The edge drain used shall be a conventional circular pipe underdrain with a 6-inch diameter. The advantage to these edge drains is their flow capacity and, more importantly, their ability to be maintained. For proper performance, edge drains must be maintained. The edge drain should not be wrapped with geotextile fabric due to the potential for the fabric to become plugged and/or reduce the hydraulic capacity of the system. Refer to FDM 13-40-1 and the edge drain detail series SDD 8D15.

Interchanges have proven to be difficult locations for the placement of BAOG edge drains and outlets. Pavement drainage must be maintained through the interchange. The base aggregate open graded layer should be extended out to drain the ramp tapers and gore. The edge drain should also be moved out and placed at the edge of the ramp taper and gore pavements so that they can be maintained. Outlets must be strategically placed such that all water entering the pavement can drain.

Note: Edge drains should not be retrofit under concrete pavements with dense graded base course. The Department’s experience indicates concrete pavements do not receive any benefit from this combination of features.

15.5.1 Trench
In an urban situation, it is recommended that the edge drain and trench be located under the concrete curb and gutter to protect the system from utilities and other activities that take place within the right-of-way area.

To ensure proper drainage, connect the edge drains to inlets, manholes, or catch basins of the storm sewer system (refer to sheet ‘a’ of the SDD 8D15).

15.5.2 Outlet Pipe
Careful attention must be given to the location of the outlet pipes such that outlets are placed at the sags of vertical curves and prior to bridge abutments. For maintenance purposes, the practical maximum spacing between outlets is 250 feet. To prevent damage to the outlet, the location of the endwall should be marked with a flexible marker post or some other method for easy identification by county maintenance forces.

Refer to the SDDs, titled "Reinforced Concrete Apron Endwall for Pipe Underdrain" and “Edgedrain Outlet and Outfall Markers".