

The following examples are intended to demonstrate the procedures used to design the options required by Technical Memo No. 04-19-MAT-02. In some of these design examples the design R-value (average minus one standard deviation) of the native/in-place soil is adjusted to reflect the increase in support provided by the use of select granular material. This adjusted R-value may be used with the *Rigid Pavement Design* program (**RigidPavement.exe**) and the *Flexible Pavement Design* program (**FlexiblePavement.exe**) to determine pavement thickness.

**Web sites:**Software: <http://www.dot.state.mn.us/materials/pvmtdesign/software.html>Pavement Design Manual: <http://www.dot.state.mn.us/materials/pvmtdesign/manual.html>Technical Memos: <http://www.dot.state.mn.us/materials/pvmtdesign/docs>**Design Parameters**

The following parameters will be used in the examples.

**Traffic**

- (a) 20 year design lane BESALs = 4,179,000
- (b) 20 year design lane CESAL = 6,471,000
- (c) 35 year design lane CESAL (12,942,000 x 0.93\*) = 12,036,060  
(\* frozen subgrade effect factor)

**Load Transfer**

For a PCC protected edge design (27' wide): Load Transfer, J =2.6

**Subgrade Support**

Native/in-place sub-grade soil design R-value (average minus one standard deviation) is equal to 12.

**Example No. 1 - Concrete Pavement with Drainage Layer**

- (a) The applicability of this design should be established in accordance with Figure 1 provided in the "Permeable Aggregate Base Drainage System Design Guidelines," dated July 1994.
- (b) The concrete thickness is determined using standard procedures with the **RigidPavement** program.

Enter the following parameters into the **RigidPavement** program:

Soil Characteristic, R-value = 12

Load Transfer, J =2.6 (for protected edge design)

35 year design lane CESAL (12,942,000 x 0.93) = 12,036,060

The **RigidPavement** program calculated thickness is 8.867”.

Reduce the thickness by 0.5” as per “Permeable Aggregate Base Drainage System Design Guidelines”

$$8.867'' - 0.5'' = 8.367''$$

Round the design thickness to 8.5”.

### **Example No. 2 - Concrete Pavement Overlying 12” Select Granular Material**

- (a) Adjust the R-value to account for increase support provided by the 12” select granular material. (The Class 5 Aggregate Base is not included in the adjustment procedure).

The adjustment is made as follows:

1. Use the Bituminous Aggregate Base (BAB) design chart (Figure 5-3.7, *Pavement Design Manual*).
  2. Convert the 12” select granular material to a granular equivalent (GE) by using a granular equivalent factor of 0.5. The GE is 12” x 0.5 = 6”.
  3. Using the BAB design chart, locate on the chart the point x established with design parameters ESALs = 4,179,000 and R = 12. Count upwards 6 GE inches and estimate the R-value at this point. The adjusted R-value is estimated to be approximately equal to 24.
- (b) The concrete thickness is determined using standard procedures with the **RigidPavement** program.

Enter the following parameters into the **RigidPavement** program:

Soil Characteristic, R-value = 24

Load Transfer, J =2.6 (for protected edge design)

35 year design lane CESAL (12,942,000 x 0.93) = 12,036,000

The **RigidPavement** program calculated thickness is 8.661”.

Round the design thickness to 9.0”.

### **Example No.3 - Concrete Pavement with 3/5” Class 5**

This design is used for low volume traffic loads (less than 1,000,000 ESALs). Use the current design procedures (**RigidPavement** program) for determination of the pavement thickness. The minimum concrete thickness is 7”.

**Example No.4 - Bituminous Aggregate Base (BAB Design)**

- (a) Determine the structural thickness using the current design procedure (**FlexiblePavement** or Figure 5-3.7, *Pavement Design Manual*).
- (b) The minimum structural thickness is 30 inches, unless the 20 year BESALs exceed 7 million, in which case, the minimum thickness is increased to 36 inches. The “Z” thickness is the additional material required if the **FlexiblePavement** or Figure 5-3.7 thickness results in a total structural thickness that is less than the minimum 30 (36”) inches. The material that is used to meet the additional required thickness to satisfy the minimum standard thickness may be Select Granular, Class 4, or Class 5 or a combination thereof. However, the final materials selection should be based on an economic analysis and ease of construction.
- (c) If the current design procedure provides a total structural thickness that is greater than the minimum standard thickness, then that total thickness should be incorporated into the design.
- (d) Using the design parameters  $R= 12$  and  $BESALs = 4,179,000$  the **FlexiblePavement** program results in the following:

G.E. = 36.8 inches

1.5” Type 41 Wear  
 2.5” Type 41 Binder  
 2.5” Type 31 Base  
 6.0” Class 6, Aggregate Base  
 6.0” Class 4, Aggregate Base  
 16.5” Class 3, Aggregate Base

- (e) The **FlexiblePavement** program was developed using a previous version of Mn/DOT specifications and Type 41, 61, and 31 bituminous material is no longer specified. Type 31 material used a GE factor of 2.0 and currently all plant-mix bituminous pavement uses a GE factor of 2.25. To adjust the Type 31 thickness to current specifications, multiply it by .889. Type 41 and Type 61 material does not require a thickness adjustment.

2.5” (Type 31 Base) x .889 = 2.225” – round to 2.5”.

The thicknesses in accordance with current Mn/DOT specification 2360 -

4.0” Wearing Course  
 2.5” Non-Wearing Course  
 6.0” Class 6, Aggregate Base  
 6.0” Class 4, Aggregate Base  
 16.5” Class 3, Aggregate Base

The total thickness is 35.0” which is greater than the 30” minimum, so no additional aggregate or granular material is required.

**Example No.5 Bituminous Deep Strength (BDS) Design**

- (a) The design procedure for BDS is an iterative process.
- (b) Determine the structural thickness using the current full-depth design procedure (**FlexiblePavement** or Figure 5-3.8, *Pavement Design Manual*).
- (c) Subtract the thickness determined in (b) plus 3 inch of Class 5 from the 30" minimum depth to determine the estimated "Z" thickness of select granular material.
- (d) Multiply the "Z" x 0.5 to determine the granular equivalent in inches.
- (e) Adjust the in-place/native soil design R-value to account for the increase support provided by the "Z" thickness of select granular material. (The Class 5, Aggregate Base, is not included in the adjustment procedure). The adjustment is made as described under item (a) 3. Design No. 2.
- (f) Using the design parameters  $R = 12$  and  $BESALs = 4,179,000$ .
  1. Full-Depth Design = 12.21 inches (from **FlexiblePavement** or Figure 5-3.8)
  2. Determine depth "Z" inches  
 $30'' - 3'' - 12.0'' = 15''$  of select granular
  3. Determine GE of the select granular  
 $15'' \times 0.5 = 7.5''$  GE
  4. Using the BAB design chart, locate on the chart the point x established with design parameters  $ESALs = 4,179,000$  and  $R = 12$ . Count upwards 7.5 GE inches and estimate the R-value at this point. The adjusted R-value is estimated to be approximately equal to 29.
  5. Determine new BDS thickness using full-depth design chart or *FlexiblePavement* using design parameters  $R = 29$  and  $BESAL = 4,179,000$ . The resulting thickness is 10.6" (round to 10.5").
  6. Trial No. 2 uses 10.5"  
 $"Z" = 30'' - 3'' - 10.5'' = 16.5''$  of select granular  
 $GE = 16.5'' \times 0.5 = 8.25''$   
 Adjusted/new design R-value = 31  
 New Bituminous thickness equals 10.4", use 10.5" (no change from Trial No. 1)  
  
 $10.5''$  (Bituminous) + 3" (Class 5, Aggregate Base) + 17" (select granular) = 31"  
 which is greater than the required 30 inch minimum thickness.

**Example No.6 - BAB/BDS**

- (a) These designs are used for low volume traffic loads (less than 1,000,000 BESALs.)
- (b) The design procedures are the same as examples No. 4 (BAB) and No. 5 (BDS) except that there is no requirement for a minimum total depth. There is a requirement for a minimum of 6" granular treatment (Class 5 Aggregate Base or Select Granular Material.)

**Unbonded Concrete Overlay Design**

The un-bonded concrete overlay thickness should be determined in accordance with the design procedures illustrated in Appendix D, *Pavement Design Manual*.