DESIGN EXAMPLES

Example 1 – Aggregate Base Design

Location: Metro, Ramsey County

Design parameters: The predominant soil type is Clay Loam, ESALs = 4,179,000. The minimum depth required is 30 inches (ESALs greater than 1,000,000) unless chart gives greater thickness.

Grading: A 12 inch compaction subcut will be constructed.

R-value Design

The design chart gives a GE requirement of 36.8 inches and the following minimum thickness: 6.5 inches HMA, 6.0 inches Class 6 base, 6 inches Class 4, and 16.5 inches Class 3. The total thickness of these is over 30 inches so go with this.

MnPAVE Design

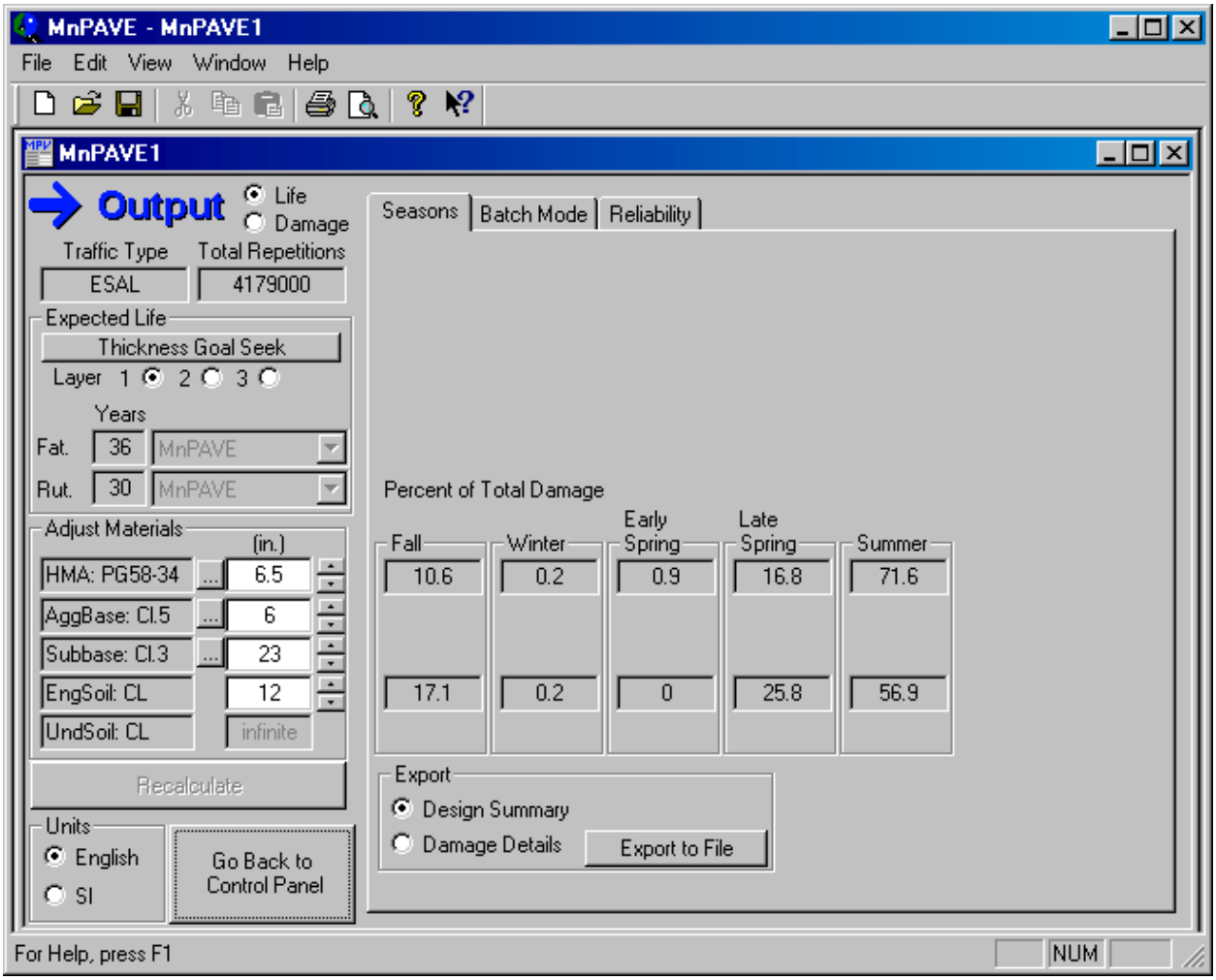
1. Fill in the project information under Project Information window (see attached design summary report).

2. Open Climate window, click on Ramsey county.

3. Open Structure window; Input the above pavement structure obtained from the R-value design into MnPAVE (substitute Class 3 for Class 4). In this case, since the R-value of subgrade soils is unknown, Basic level is used for the design. Select Clay Loam for Engineered Soil and Undisturbed Soil. Engineered Soil is used to model the compacted subcut soil.

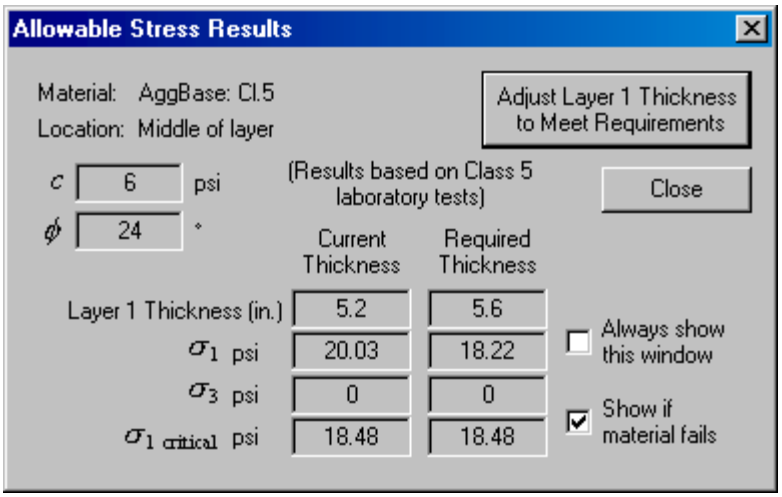
4. Input design ESALs of 4,179,000 in Traffic window.

5. The output is shown below:

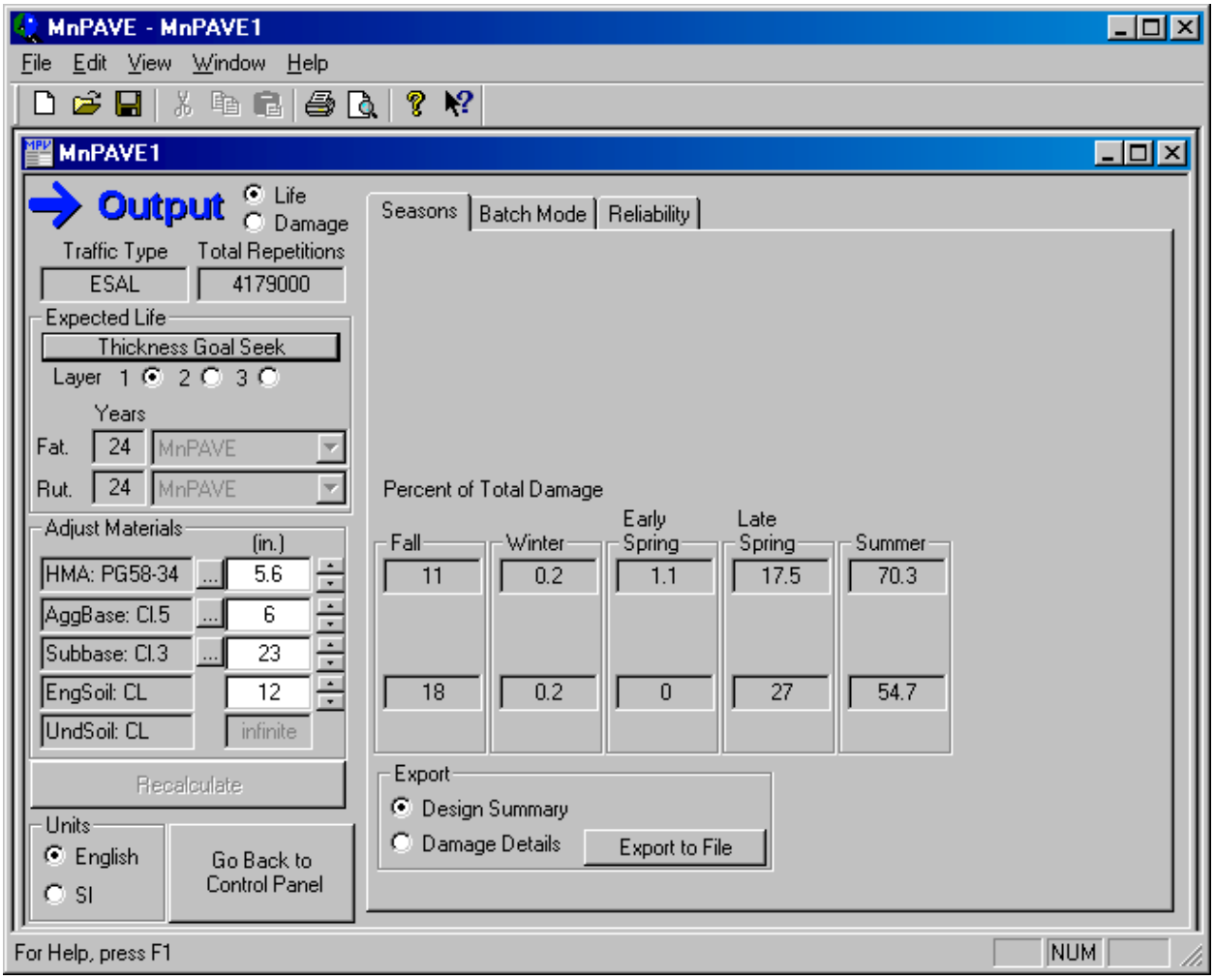


MnPAVE gives a fatigue design life of 36 years and rutting life of 30 years. Since the pavement design life is 20 years, this design is conservative.

6. Now, use the “Thickness Goal Seek” function and select the “Layer 1” option to obtain HMA layer thickness such that one of the design lives reaches 20 years. In this case, the Bearing Capacity check is exceeded as shown below. MnPAVE will automatically dimension the HMA layer such that the stress levels are satisfied.

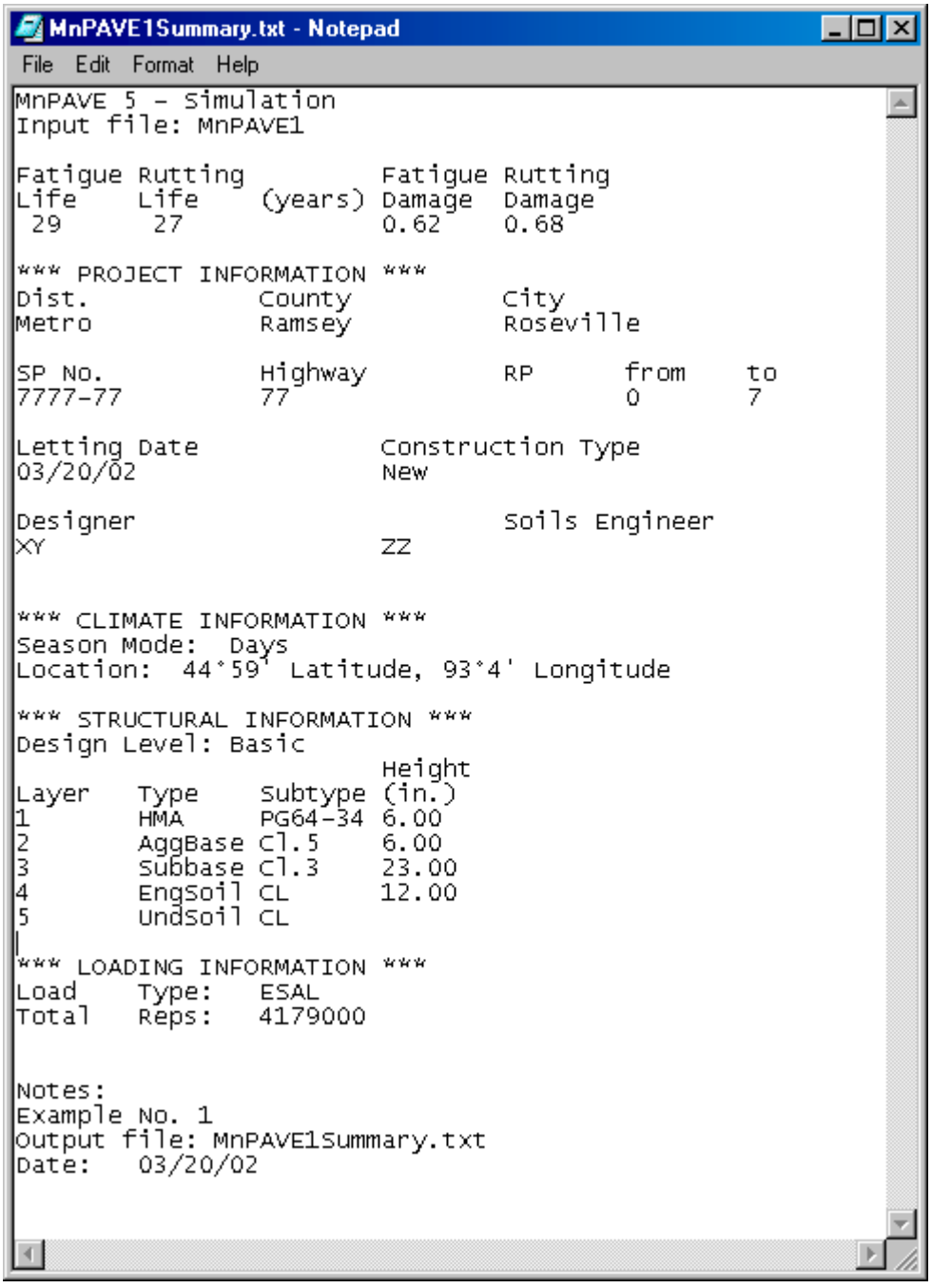


7. Select the "Adjust Layer 1 Thickness" button to automatically change the HMA thickness. The resulting output is obtained.



At this point the designer may round the HMA thickness up to 6.0 inches which results in a design that still appears to be conservative. These results were obtained with the default base failure load criteria. The designer should evaluate the validity of these loads for the particular job they are designing for.

8. MnPAVE is also capable of exporting results of varying detail. Below is an example of the Design Summary output. This is obtained by selecting "Design Summary" in the "Export" window and clicking the "Export to File" button.



MnPAVE1Summary.txt - Notepad

File Edit Format Help

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MnPAVE 5 - Simulation
Input file: MnPAVE1

Fatigue Rutting          Fatigue Rutting
Life    Life    (years)  Damage  Damage
 29      27              0.62    0.68

*** PROJECT INFORMATION ***
Dist.           County          City
Metro           Ramsey          Roseville

SP No.          Highway         RP      from    to
7777-77         77                      0       7

Letting Date            Construction Type
03/20/02                New

Designer                        Soils Engineer
XY                      ZZ


*** CLIMATE INFORMATION ***
Season Mode:  Days
Location:  44°59' Latitude, 93°4' Longitude

*** STRUCTURAL INFORMATION ***
Design Level: Basic
                        Height
Layer   Type    Subtype (in.)
1       HMA     PG64-34 6.00
2       AggBase Cl.5    6.00
3       Subbase Cl.3    23.00
4       EngSoil CL      12.00
5       UndSoil CL

*** LOADING INFORMATION ***
Load    Type:   ESAL
Total   Reps:   4179000


Notes:
Example No. 1
Output file: MnPAVE1Summary.txt
Date:   03/20/02
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Example 2 –Full Depth / Deep Strength Design

Location: District 8, Redwood County

Design parameters: The predominant soil type encountered is Clay Loam. The design R-value is 12, ESALs = 4,179,000. Total depth required is 30 inches (ESALs greater than 1,000,000) unless chart gives greater thickness.

Grading: A 12 inch compaction subcut will be constructed.

Full Depth Design

The initial thickness is determined from the full-depth design chart (12.2 inches HMA). Determine the "Z" depth (30 – 3 – 12 = 15 inches select granular). Determine GE of this (15 x 0.5 = 7.5 inches). Next, adjust the R-value (using R-value chart this is found to be 29). Determine the new full-depth thickness with this adjusted R-value (10.6 inches, use 10.5). The new "Z" depth is 30 – 3 – 10.5 = 16.5 inches select granular. The final design is: 10.5 inches HMA, 3 inches Class 5, and 17 inches select granular.

MnPAVE Design

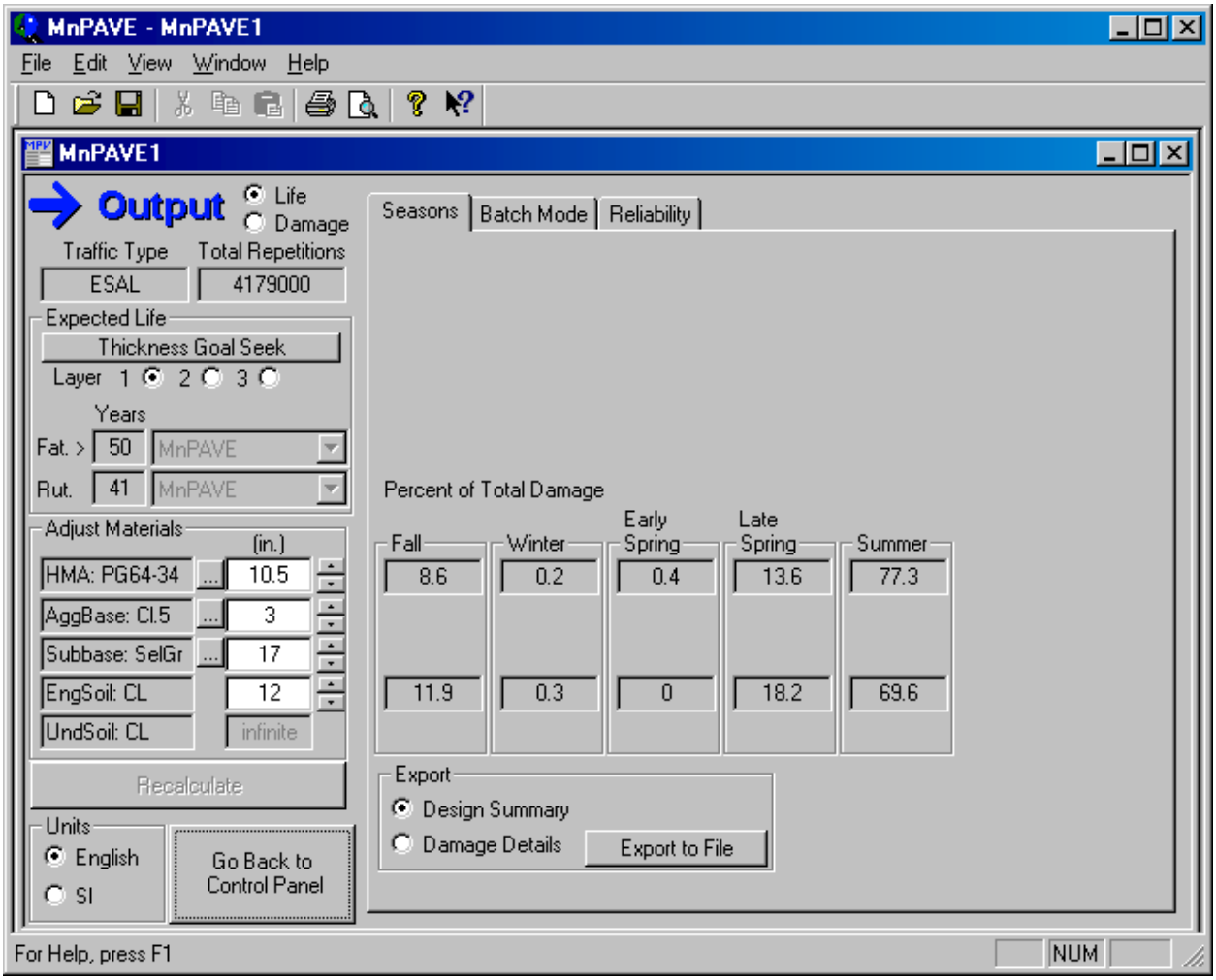
1. Fill project information under Project Information window.

2. Open the Climate window, click on Redwood County in District 8.

3. Open Structure window; Input the above pavement structure obtained from the R-value design into MnPAVE. Since the design R-value of the engineered soil is known, the Intermediate level can be used for design. Input R=12 for Engineered Soil under Intermediate window.

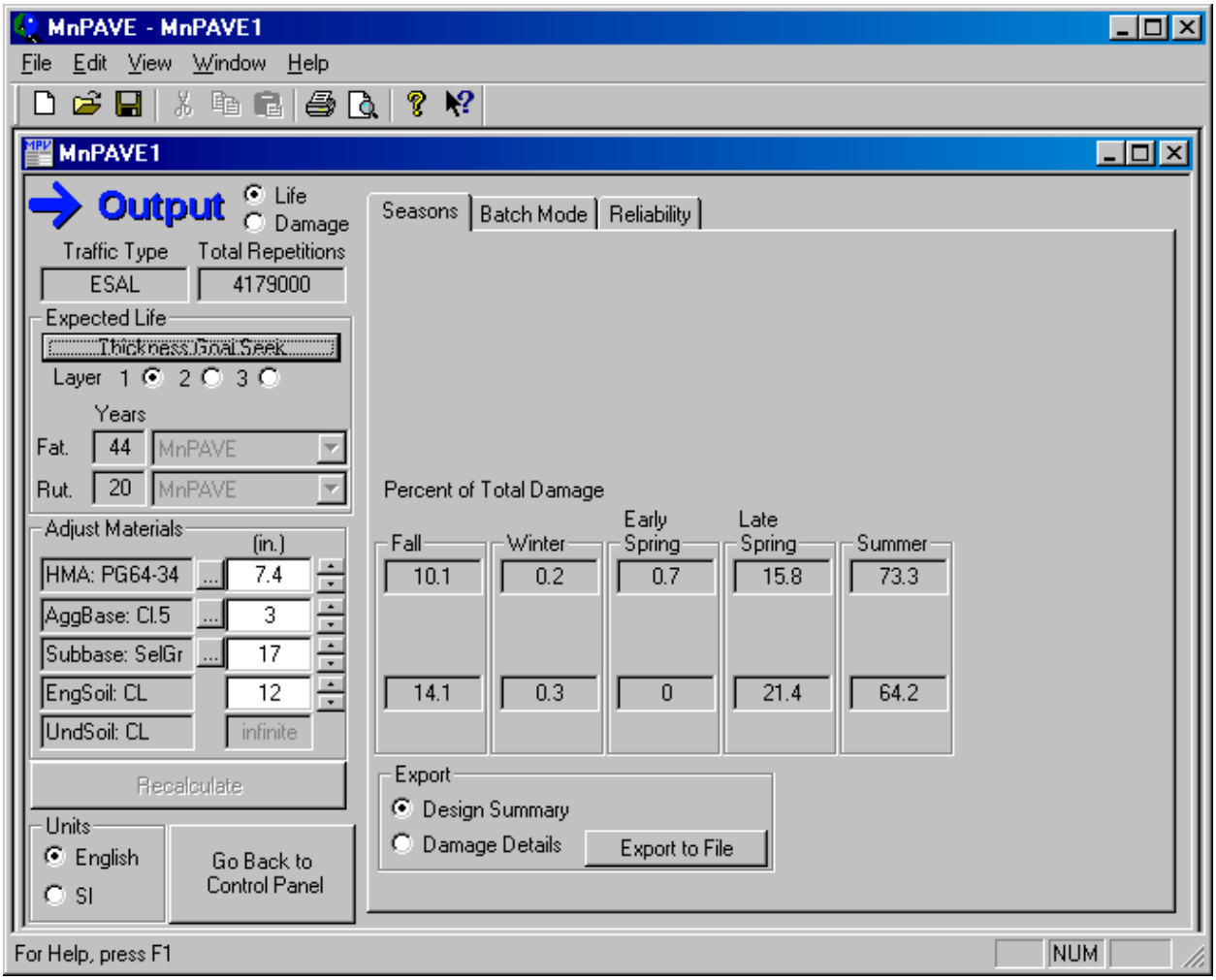
4. Input design ESALs of 4,179,000 under the Traffic window.

5. The output is shown below:



As can be seen the deep strength thickness results in an extremely conservative design compared to the aggregate base thickness shown in the previous example.

6. Now select “Thickness Goal Seek” for the HMA layer to obtain:



This results in a total structural thickness that is less than the minimum required 30 inches so if this were an actual design you would need to add several inches of Select Granular.

Example 3 – Mn/DOT project (Aggregate Base Design)

Location: District 6, Fillmore County

Soil Type(s): Silt loam.

Available test data: A total of 10 samples were tested for R-value. The mean value was 13 with a standard deviation of 3.

Given information: Design ESALs = 1,905,000. Construct top 2 feet of grading subgrade with Select Granular.

R-Value Design

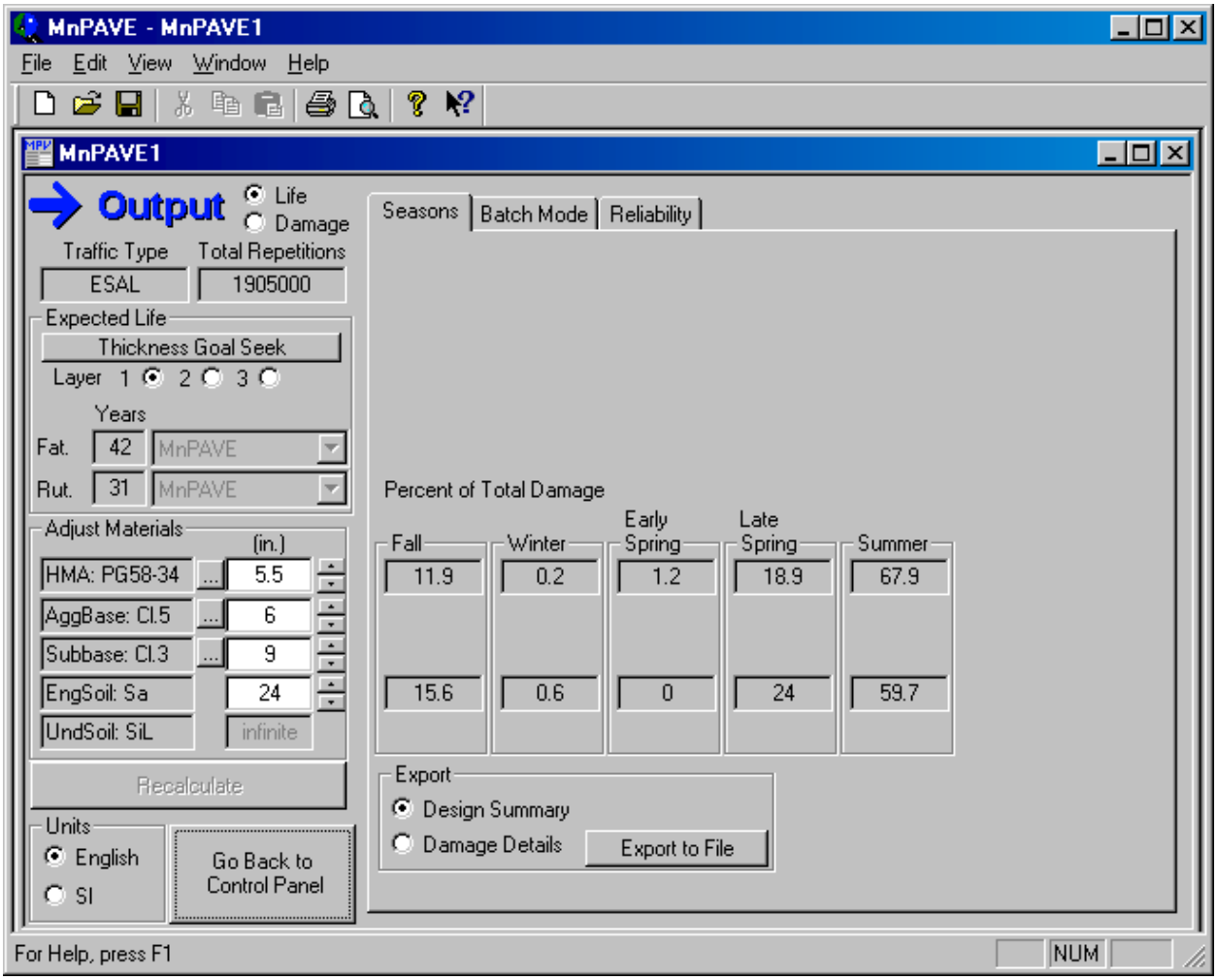
The design chart gives the following minimum thicknesses: 5.4 inches HMA, 6.0 inches Class 6, 6.0 inches Class 4, and 19.1 inches Class 3. Convert part of the Class 3 to Select Granular which leaves approximately 3 inches of Class 3. The final design is: 5.5 inches HMA, 6.0 inches Class 6, 6.0 inches Class 4, 3.0 inches Class 3, and 24 inches Select Granular.

MnPAVE Design

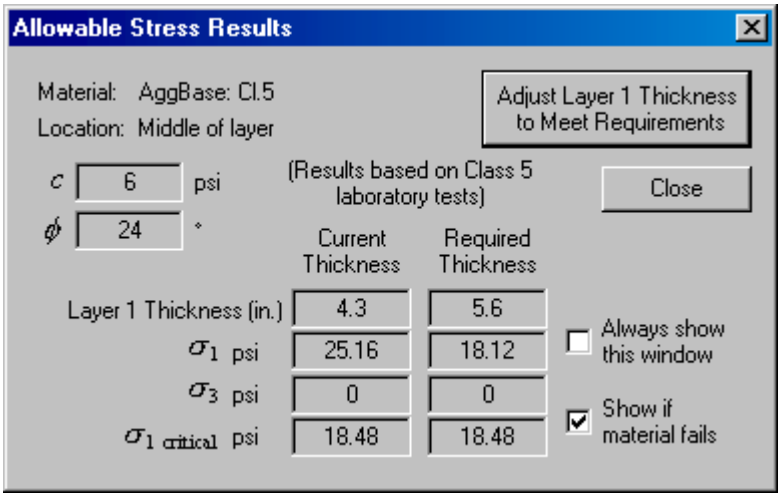
1. Since R-value is known, the designer can use Intermediate level. Input R-value=10 in the Intermediate window. Combine 6.0 inches Class 4 and 3 inches Class 3 to 9 inches Class 3 and use Sand as Engineered Soil to model Select Granular.

2. In the Traffic window, input design ESALs of 1,905,000.

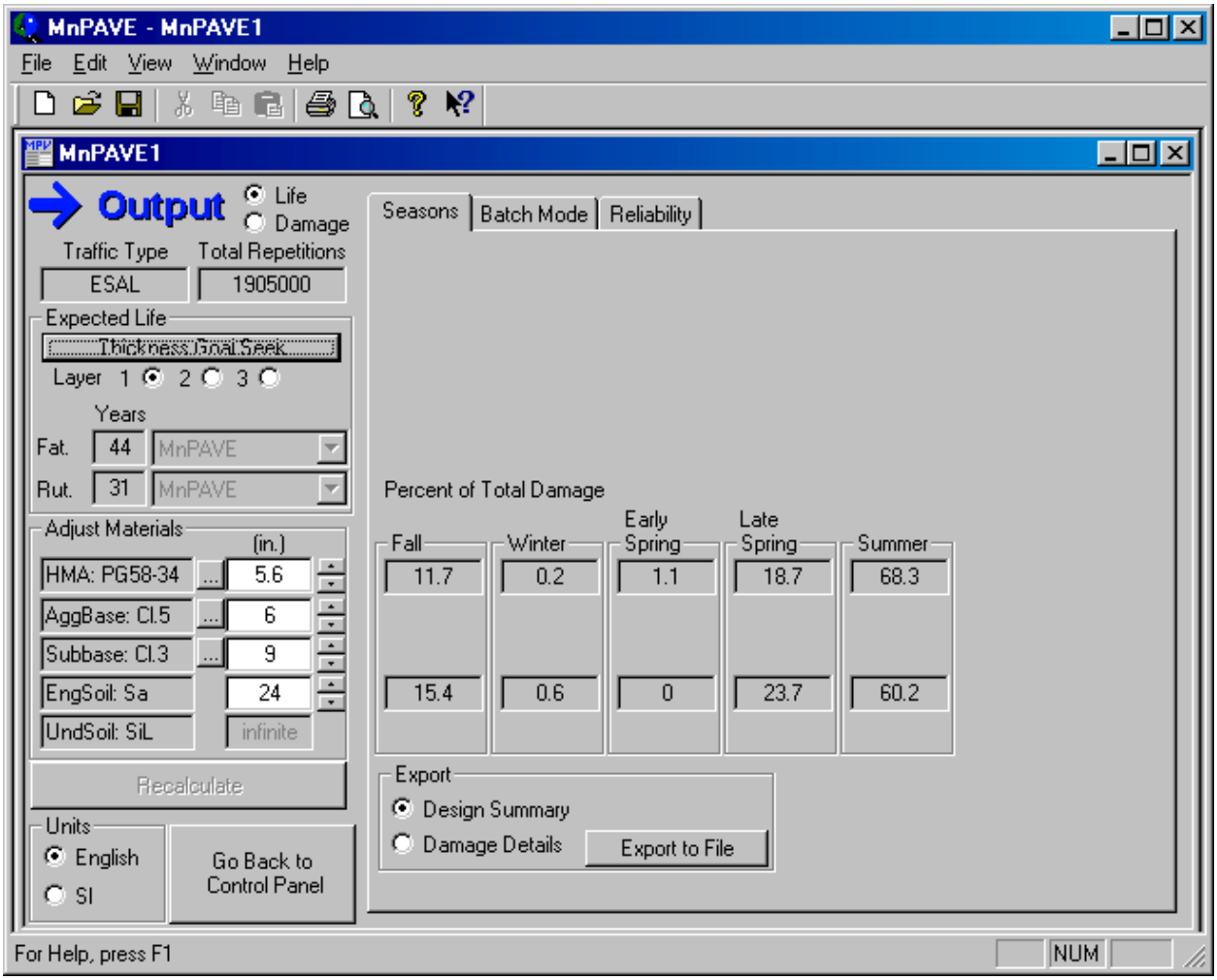
3. The output is shown below:



4. Since the design is conservative try using "Thickness Goal Seek" to refine the design. This results in the following warning for base bearing capacity:

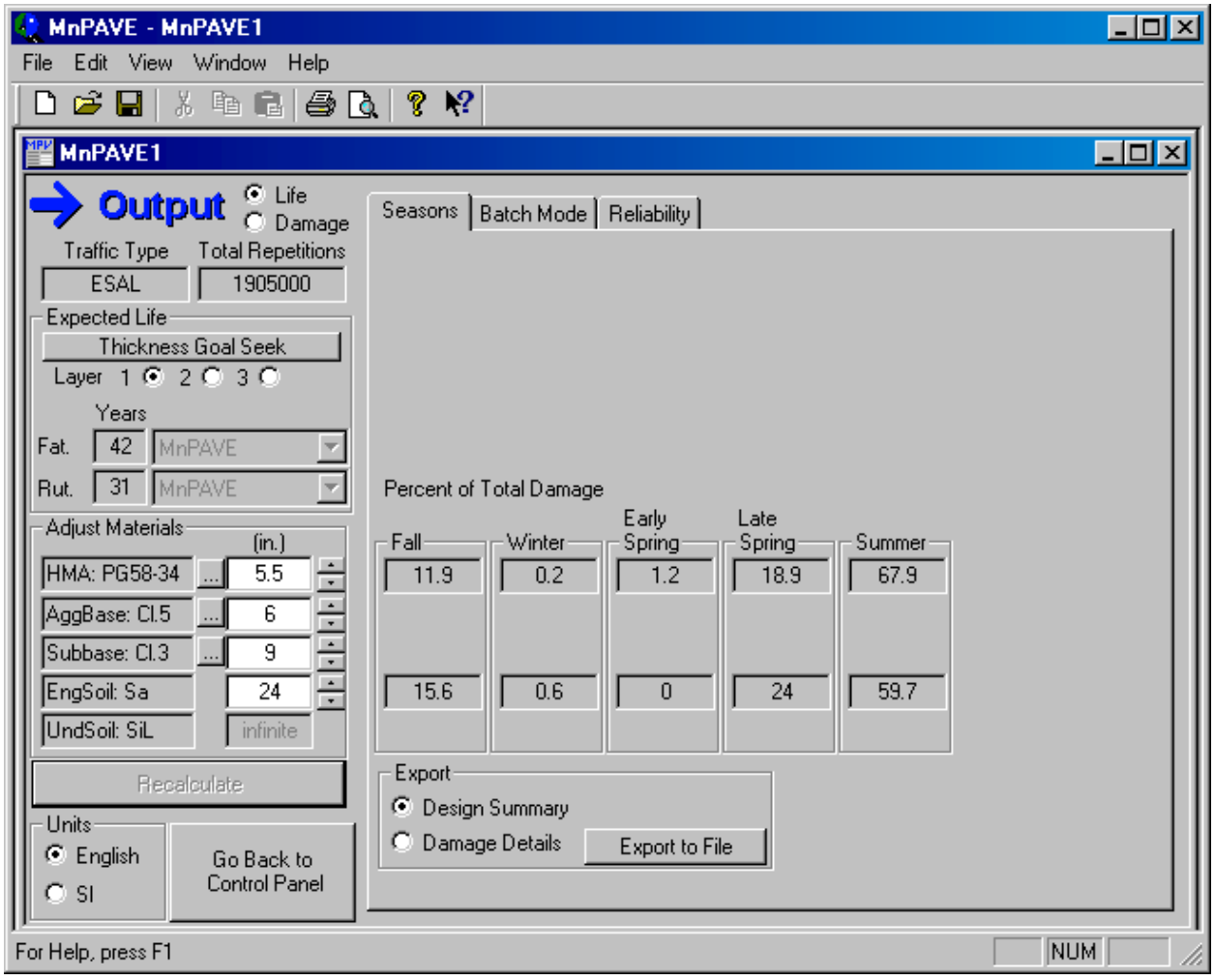


If the HMA layer is adjusted to meet the requirements we obtain the following result:



5. Now try rounding the HMA thickness up or down to 6 or 5.5 inches. As it turns out, a thickness of 5.5 inches, even though it is less than the recommended 5.9 inches, still satisfies the base bearing capacity requirements. This example demonstrates the multiple levels of failure criterion of the procedure. In this case, the bearing capacity of the aggregate base controls the design.

DESIGN EXAMPLES



Example 4 – Soil Factor Design

Location: Metro County

Soil Type: Clay loam, A-6

Available test data: Samples indicate this project has a Soil Factor of 100.

Given Information: Design HCAADT = 450 and measured ESALs = 629,000, Urban section – construct top 2 feet of grading subgrade with Select Granular.

Analysis: The design soil factor is 100.

Soil Factor Design

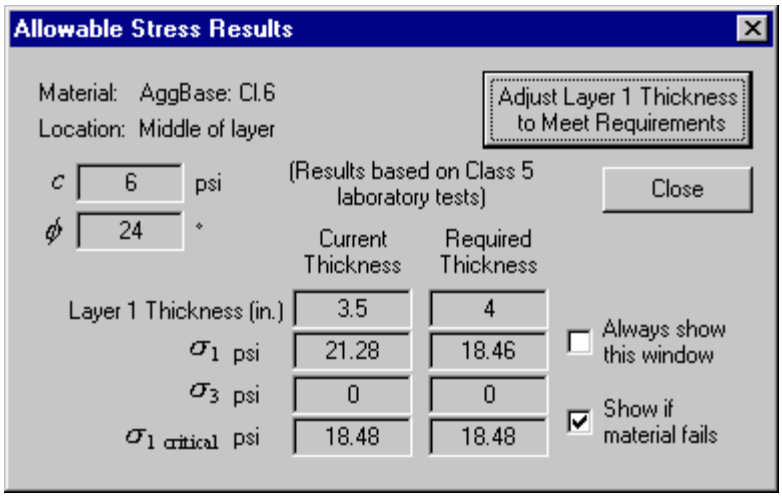
The design chart gives the following minimum thicknesses: 3.5 inches HMA, 6.0 inches of Class 6, 15.0 inches of Class 4 subbase.

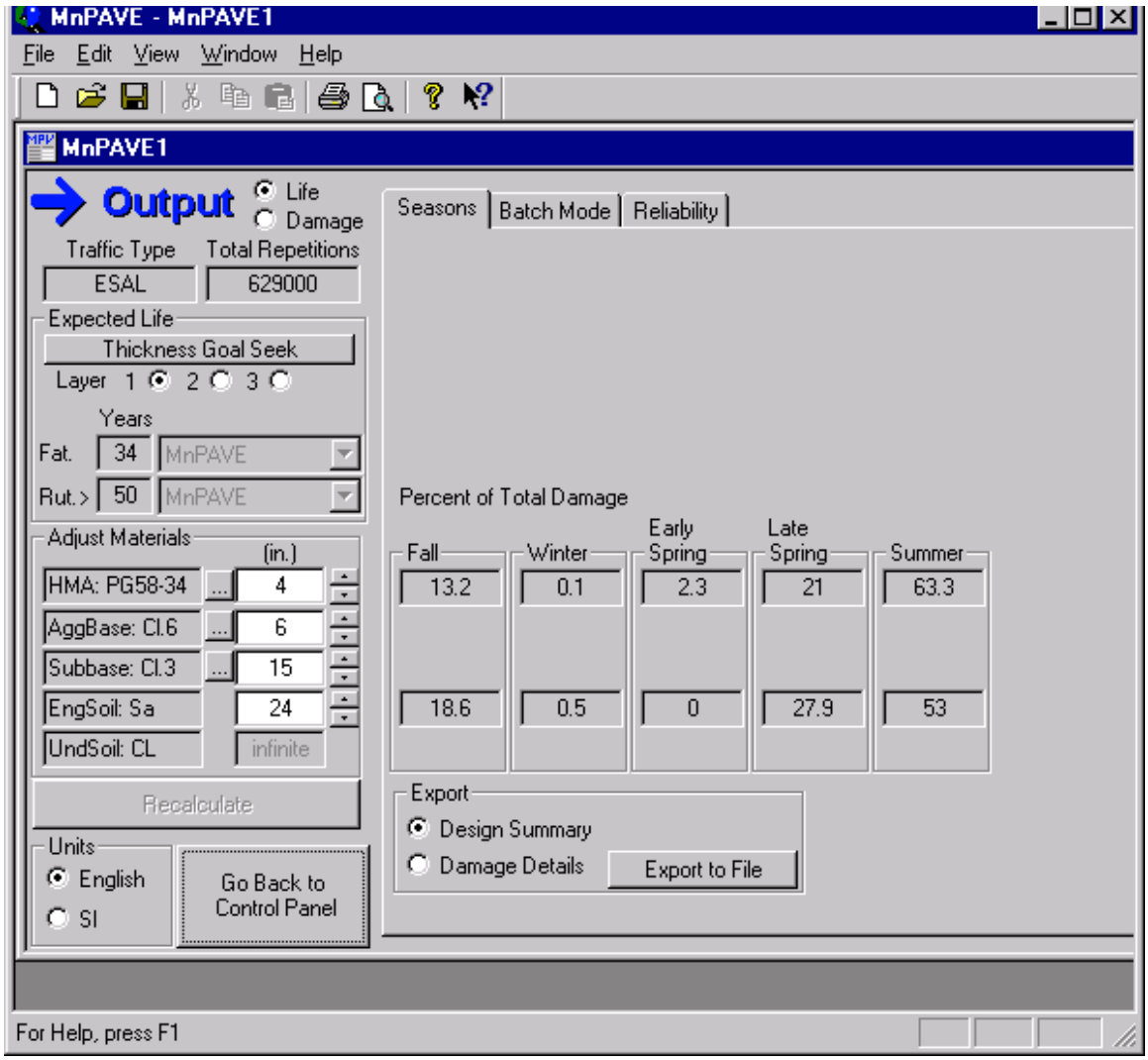
MnPAVE Design

1.Since the R-value of subgrade soil is unknown, use Basic level for the design. Input the above pavement structure into MnPAVE and use Sand to model Select Granular. Substitute Class 4 by Class 3.

2.In the Traffic window, input the design ESALs of 629,000, estimated annual growth rate of 3% and the expected heaviest axle weight. In this case, the heaviest single tire axle weight is 12,000 lbs and the heaviest dual tire axle weight is 20,000 lbs.

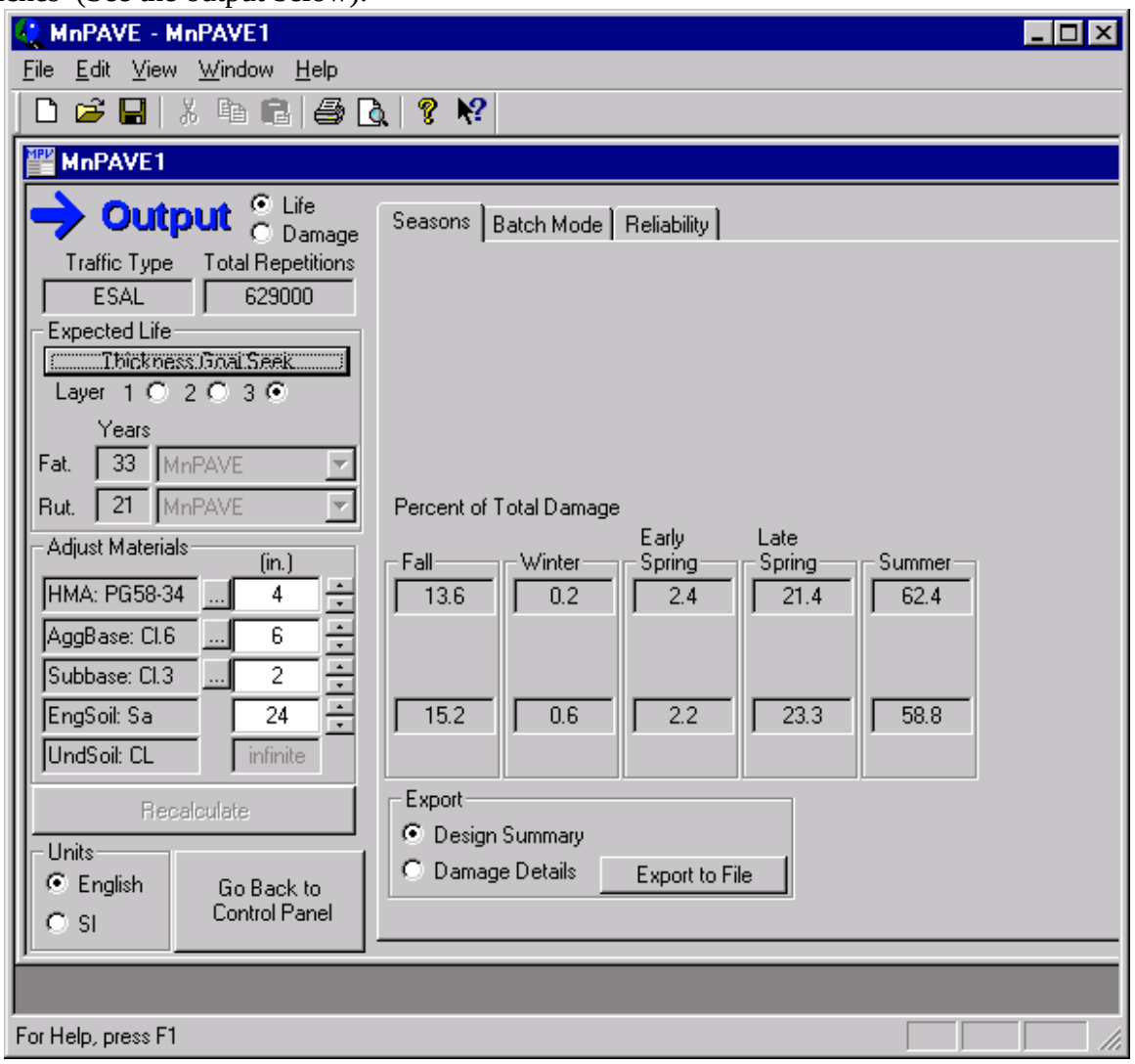
3. MnPAVE gives the following warning and shows that the required minimum HMA thickness is 4 inches. The designer may use the required thickness suggested by MnPAVE by click on " Adjust Layer 1 Thickness to Meet Requirements." However, if the designer does not want to use the required thickness, the designer can ignore this warning by click on "Close." In this case, the minimum 4 inches of HMA thickness suggested by MnPAVE is used and the design is shown below.


Allowable Stress Results
Material: AggBase: Cl.6
Location: Middle of layer
Adjust Layer 1 Thickness to Meet Requirements
c 6 psi
ϕ 24 °
(Results based on Class 5 laboratory tests)
Close
Current Thickness
Required Thickness
Layer 1 Thickness (in.) 3.5 4
σ1 psi 21.28 18.46
σ3 psi 0 0
σ1 critical psi 18.48 18.48
Always show this window
Show if material fails


MnPAVE - MnPAVE1
File Edit View Window Help
MnPAVE1
Output
Life
Damage
Traffic Type
Total Repetitions
ESAL
629000
Expected Life
Thickness Goal Seek
Layer 1 2 3
Years
Fat. 34 MnPAVE
Rut.> 50 MnPAVE
Adjust Materials
(in.)
HMA: PG58-34 4
AggBase: Cl.6 6
Subbase: Cl.3 15
EngSoil: Sa 24
UndSoil: CL infinite
Recalculate
Units
English
SI
Go Back to Control Panel
Seasons
Batch Mode
Reliability
Percent of Total Damage
Fall
Winter
Early Spring
Late Spring
Summer
13.2
0.1
2.3
21
63.3
18.6
0.5
0
27.9
53
Export
Design Summary
Damage Details
Export to File
For Help, press F1

MnPAVE shows that the design rutting life is greater than 50 years. So, this design is conservative. The designer can try to adjust Class 3 thickness so that the rutting life is close to 20 years.

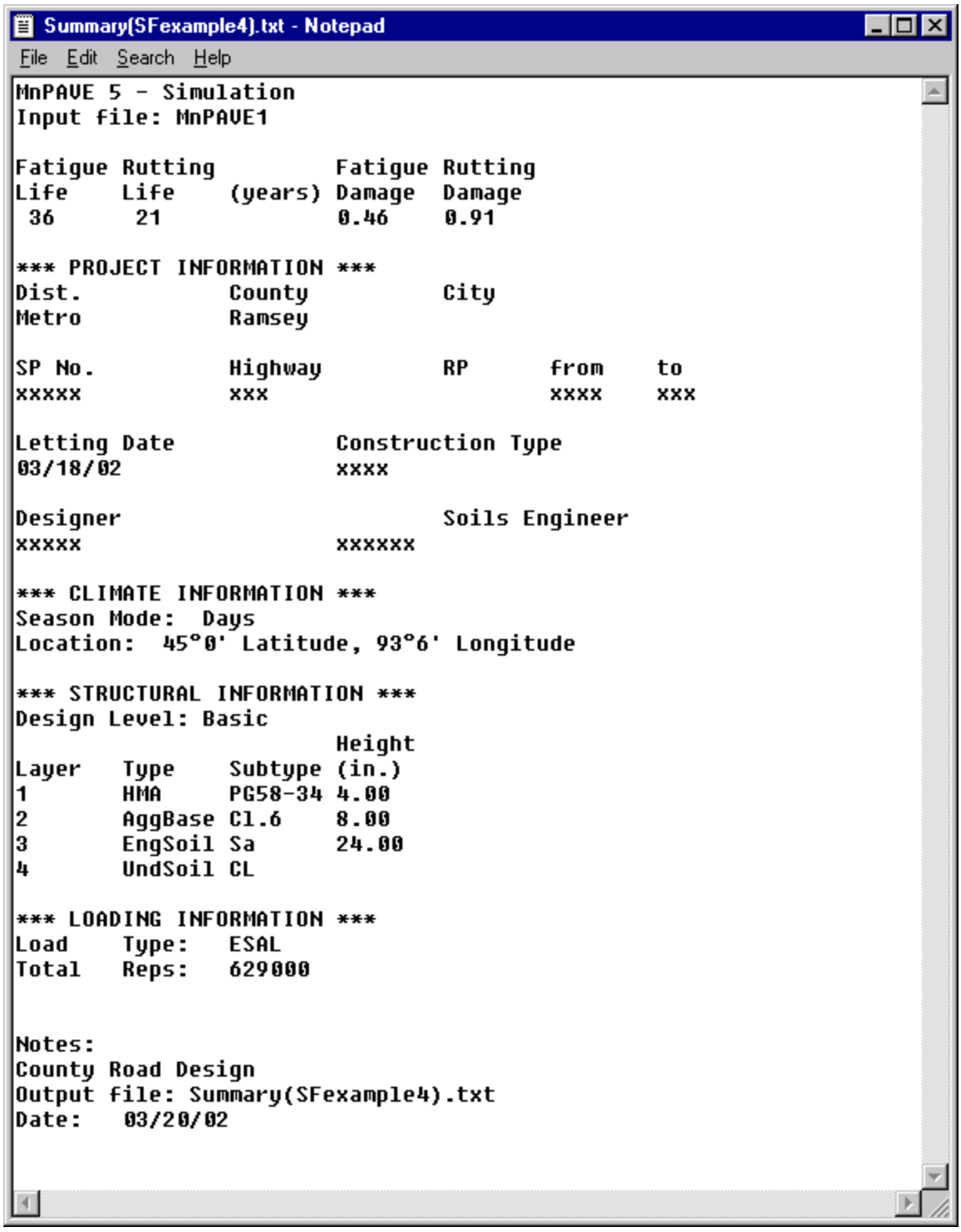
4. Now, use "Thickness Goal Seek" function and select "Layer 3" to obtain the thickness of Class 3 layer. In this case, the rutting life has reached 20 years when Class 3 layer thickness is 2 inches (See the output below).



5. Check the required minimum pavement structural thickness of 30 inches (if it is required)

4+6+2+24 = 38 inches > 30 inches. OK.

6. Considering construction feasibility, the designer may convert 2 inches of Class 3 to 2 inches of Class 6, which results in a conservative design. See the design summary below for the final design. Attach the design summary to your design recommendation.



Summary(SFexample4).txt - Notepad

File Edit Search Help

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MnPAVE 5 - Simulation
Input file: MnPAVE1

Fatigue Rutting          Fatigue Rutting
Life    Life    (years)  Damage  Damage
 36      21              0.46    0.91

*** PROJECT INFORMATION ***
Dist.           County          City
Metro           Ramsey

SP No.          Highway         RP      from    to
xxxxx           xxx                     xxxx    xxx

Letting Date            Construction Type
03/18/02                xxxx

Designer                        Soils Engineer
xxxxx                   xxxxxx

*** CLIMATE INFORMATION ***
Season Mode:  Days
Location:  45°0' Latitude, 93°6' Longitude

*** STRUCTURAL INFORMATION ***
Design Level: Basic
                        Height
Layer   Type    Subtype (in.)
1       HMA     PG58-34 4.00
2       AggBase Cl.6    8.00
3       EngSoil Sa      24.00
4       UndSoil CL

*** LOADING INFORMATION ***
Load    Type:   ESAL
Total   Reps:   629000


Notes:
County Road Design
Output file: Summary(SFexample4).txt
Date:   03/20/02
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Example 5 – Soil Factor Design

Location: Metro County

Soil Type: Clay loam, A-6

Available test data: Samples indicate this project has a Soil Factor of 100.

Given Information: Design HCAADT = 450 and measured ESALs = 629,000, A 2.5 feet compaction subcut will be constructed.

Analysis: The design soil factor is 100.

Soil Factor Design

The design chart gives the following minimum thicknesses: 3.5 inches HMA, 6.0 inches of Class 6, 15.0 inches of Class 4 subbase.

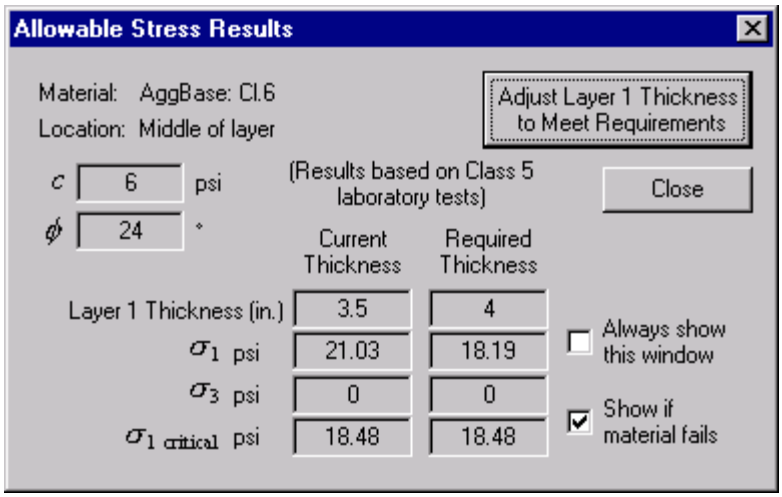
MnPAVE Design

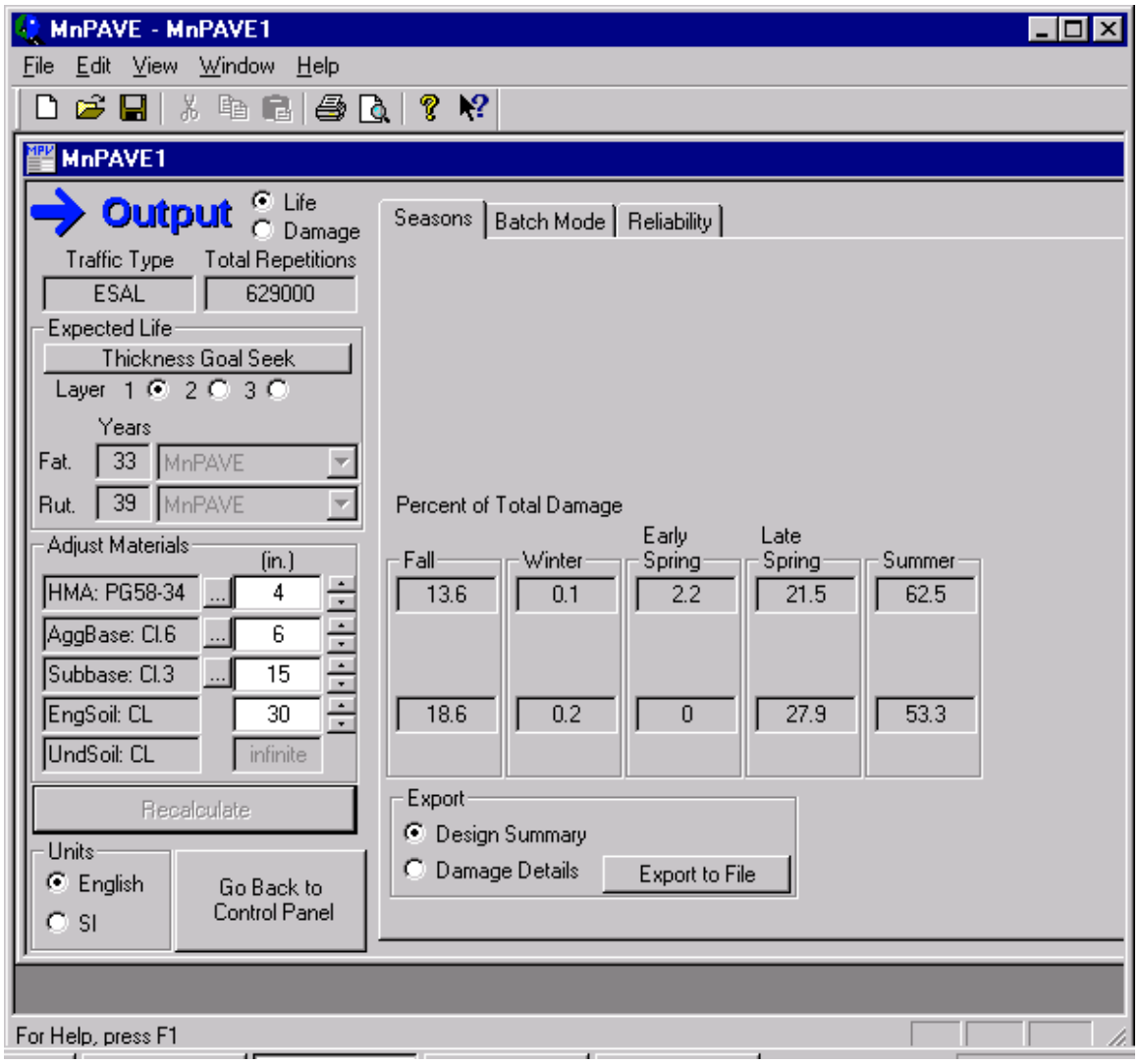
1.Since the R-value of subgrade soil is unknown, use Basic level for the design. Input the above pavement structure into MnPAVE. Substitute Class 4 by Class 3.

2.In the Traffic window, input the design ESALs of 629,000, estimated annual growth rate of 3% and the expected heaviest axle weight. In this case, the heaviest single tire axle weight is 12,000 lbs and the heaviest dual tire axle weight is 20,000 lbs.

3. MnPAVE gives the following warning and shows that the required minimum HMA thickness is 4 inches. The designer may use the required thickness suggested by MnPAVE by clicking on " Adjust Layer 1 Thickness to Meet Requirements." However, if the designer does not want to use the required thickness, the designer can ignore this warning by click on "Close." In this case, the minimum 4 inches of HMA thickness suggested by MnPAVE is used and the design is shown below.

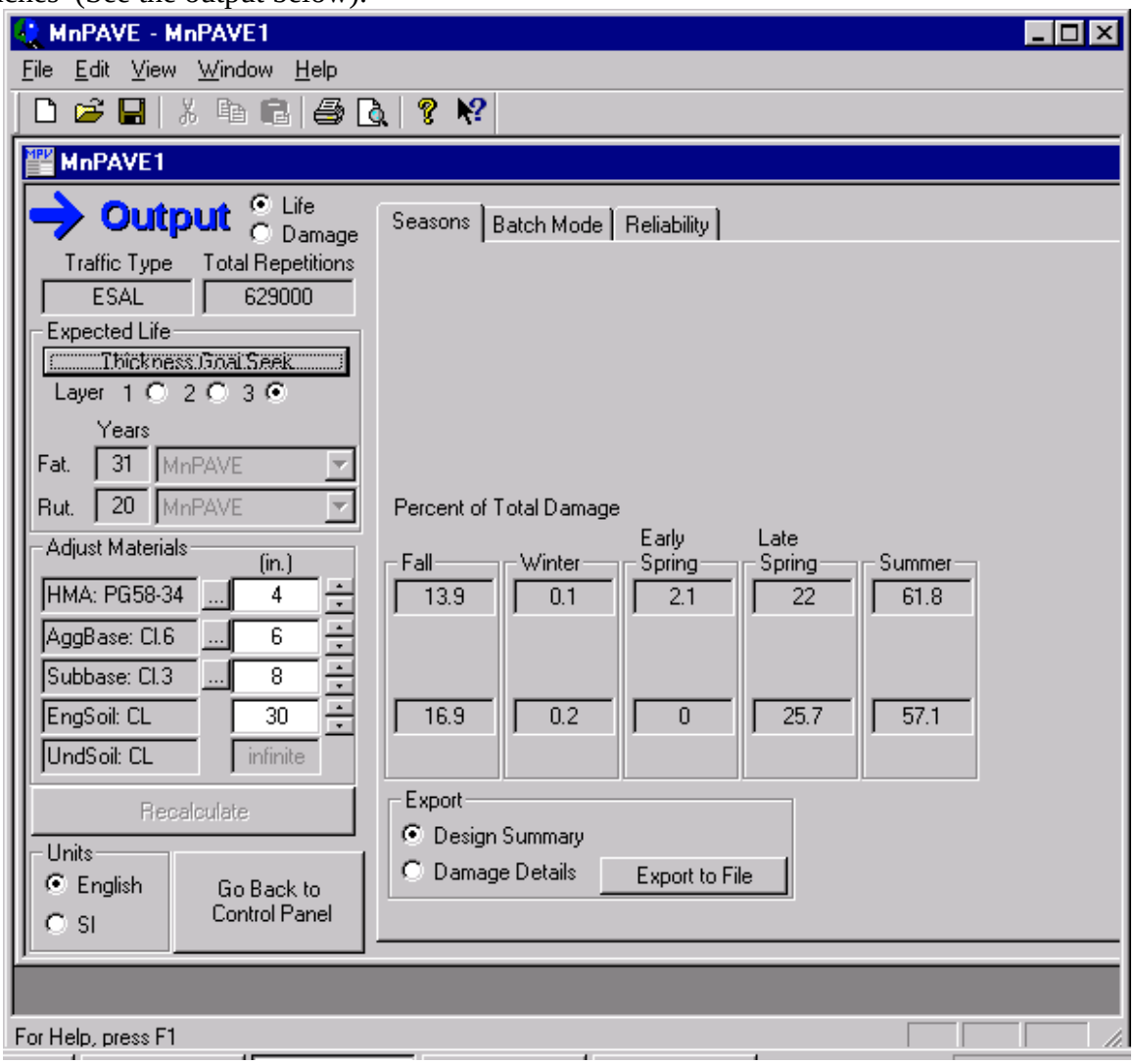
DESIGN EXAMPLES



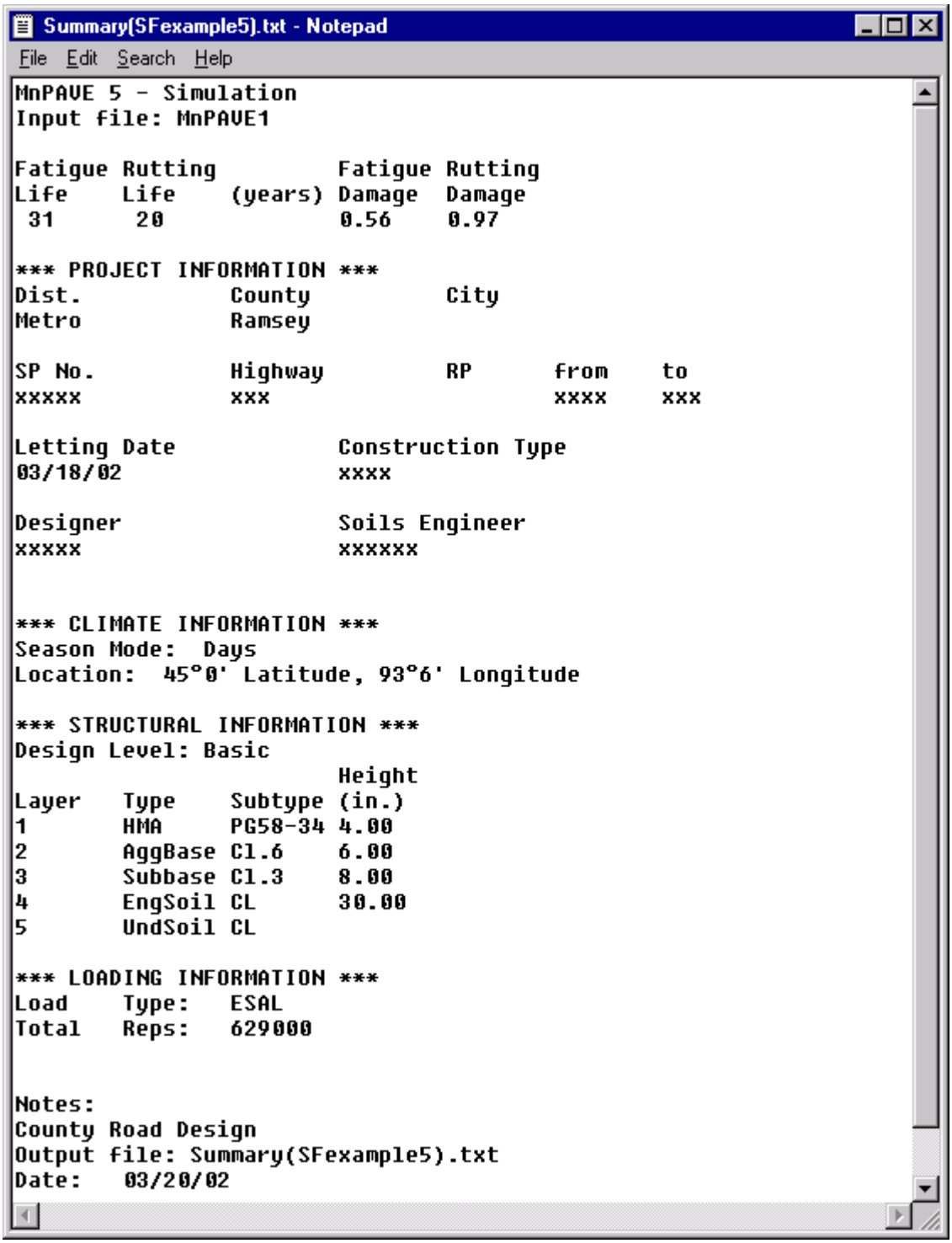


MnPAVE shows that the design rutting life is 39 years. So, this design is conservative. The designer can try to adjust Class 3 thickness so that the rutting life is close to 20 years.

4. Now, use "Thickness Goal Seek" function and select "Layer 3" to obtain the thickness of Class 3 layer. In this case, the rutting life has reached 20 years when Class 3 layer thickness is 8 inches (See the output below).



6. See the design summary for the final design. Attach the design summary to your design recommendation.



Summary(SFexample5).txt - Notepad

File Edit Search Help

```
MnPAVE 5 - Simulation
Input file: MnPAVE1

Fatigue Rutting          Fatigue Rutting
Life    Life    (years)  Damage  Damage
 31      20              0.56    0.97

*** PROJECT INFORMATION ***
Dist.           County          City
Metro           Ramsey

SP No.          Highway         RP      from    to
xxxxx           xxx                     xxxx    xxx

Letting Date            Construction Type
03/18/02                xxxx

Designer                Soils Engineer
xxxxx                   xxxxxx


*** CLIMATE INFORMATION ***
Season Mode:  Days
Location:  45°0' Latitude, 93°6' Longitude

*** STRUCTURAL INFORMATION ***
Design Level: Basic
                        Height
Layer   Type    Subtype (in.)
1       HMA     PG58-34 4.00
2       AggBase Cl.6    6.00
3       Subbase Cl.3    8.00
4       EngSoil CL      30.00
5       UndSoil CL

*** LOADING INFORMATION ***
Load    Type:   ESAL
Total   Reps:   629000


Notes:
County Road Design
Output file: Summary(SFexample5).txt
Date:   03/20/02
```