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16. Abstract <p>Most local agencies in Iowa currently make their pavement treatment decisions based on their limited experience due primarily to lack of a systematic decision-making framework and a decision-aid tool. The lack of objective condition assessment data of agency pavements also contributes to this problem.</p> <p>This study developed a systematic pavement treatment selection framework for local agencies to assist them in selecting the most appropriate treatment and to help justify their maintenance and rehabilitation decisions. The framework is based on an extensive literature review of the various pavement treatment techniques in terms of their technical applicability and limitations, meaningful practices of neighboring states, and the results of a survey of local agencies. The treatment selection framework involves three different steps: pavement condition assessment, selection of technically feasible treatments using decision trees, and selection of the most appropriate treatment considering the return-on-investment (ROI) and other non-economic factors.</p> <p>An Excel-based spreadsheet tool that automates the treatment selection framework was also developed and is covered in this user guide. The Pavement Treatment Selection Tool (PTST) for Local Agencies allows users to enter the severity and extent levels of existing distresses and, then, recommends a set of technically feasible treatments. The tool also evaluates the ROI of each feasible treatment and, if necessary, it can also evaluate the non-economic value of each treatment option to help determine the most appropriate treatment for the pavement.</p> <p>It is expected that the framework, which is detailed in the final report for this project, and the tool will help local agencies improve their pavement asset management practices significantly and make better economic and defensible decisions on pavement treatment selection.</p> <p>This document is intended to be used as an implementation resource.</p>			
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PAVEMENT TREATMENT SELECTION TOOL (PTST) FOR LOCAL AGENCIES

User Guide
October 2015

Principal Investigator

H. David Jeong, Associate Professor
Construction Management and Technology Program, Iowa State University

Co-Principal Investigators

Omar Smadi, Director
Roadway Infrastructure Management and Operations Systems, Iowa State University

Douglas D. Gransberg, Donald F. and Sharon A. Greenwood Professor
Construction Management and Technology Program, Iowa State University

Research Assistant

Ahmed Abdelaty

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A report from
Institute for Transportation
Iowa State University
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664
Phone: 515-294-8103
Fax: 515-294-0467
www.intrans.iastate.edu

TABLE OF CONTENTS

ACKNOWLEDGMENTS	vii
INTRODUCTION	1
Who Should Use the PTST	1
When to Use the PTST	1
Value of Using the PTST	1
Using this Guide	2
PAVEMENT TREATMENT SELECTION FRAMEWORK AND RELEVANT RESOURCES	3
USING THE PTST	6
Manually Assigning Weights to the Factors	11
Using the AHP to Assign Weights to the Factors	14
Reviewing the Final Summary Spreadsheet	18
EXAMPLE OF USING THE PTST	20
Manually Assigning Weights to the Factors	25
Using the AHP to Assign Weights to the Factors	29

LIST OF FIGURES

Figure 1. Pavement treatment selection framework	3
Figure 2. PTST start-up window.....	6
Figure 3. Project Information worksheet	7
Figure 4. Distress Data worksheet for AC pavements	8
Figure 5. Distress Data worksheet for PCC pavements	8
Figure 6. EUAC and ROI Calculations worksheet	9
Figure 7. PTST economic ranking sheet.....	11
Figure 8. PTST factor weight assignment method question	11
Figure 9. Manual weight assignment worksheet.....	12
Figure 10. Scoring worksheet	13
Figure 11. Non-economic ranking sheet.....	14
Figure 12. Pairwise comparison worksheet	15
Figure 13. PTST dropdown list for pairwise comparison.....	16
Figure 14. Additional user input question for pairwise comparisons	16
Figure 15. Scoring worksheet	17
Figure 16. Non-economic ranking sheet.....	18
Figure 17. Summary sheet	19
Figure 18. PTST start-up window.....	20
Figure 19. Example of Project Information worksheet.....	21
Figure 20. Distress Data worksheet for AC pavements	21
Figure 21. Example of Distress Data worksheet showing Potential Actions	22
Figure 22. Example showing user-defined scenarios to compare for economic effectiveness.....	23
Figure 23. Example of economic effectiveness ranking	24
Figure 24. PTST factor weight assignment method question	24
Figure 25. Example of manual factor weight assignment worksheet	25
Figure 26. Example of scoring worksheet	26
Figure 27. Example of non-economic ranking sheet	27
Figure 28. Example of summary sheet	28
Figure 29. Choosing AHP as method for factor weight assignment.....	29
Figure 30. Pairwise comparison worksheet using the AHP for factor weight assignments	30
Figure 31. Additional user input question for AHP pairwise comparisons	31
Figure 32. Scoring sheet with weights calculated using the AHP	32

LIST OF TABLES

Table 1. Distress input parameters for asphalt and concrete pavements	4
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INTRODUCTION

The Pavement Treatment Selection Tool (PTST) for Local Agencies is an Excel-based spreadsheet tool developed by the Data Analytics Laboratory for Project and Infrastructure Management (DALPIM) at Iowa State University.

The PTST was developed to help local agencies in Iowa select technically feasible treatments for both asphalt and concrete pavements when the pavement condition is known and identify which of those treatments is the best economic alternative. It can also be used in considering non-economic factors to help select the most suitable treatment. The tool can help determine the most suitable treatment considering the return on investment (ROI) and other non-economic factors.

Who Should Use the PTST

The PTST can benefit pavement managers of Iowa local agencies who are responsible of making decisions on pavement maintenance and rehabilitation of their local pavements by helping them select the most suitable treatments in terms of technical feasibility, ROI, and other non-economic factors. The PTST tool is applicable for low-volume roads, which are the most common type of roads managed by local agencies.

When to Use the PTST

The PTST can be used to select the most suitable treatments when the pavement history and current condition are known qualitatively or quantitatively.

Value of Using the PTST

- Using different distress data as input values to select technically feasible treatments leads to a data-driven decision-making process
- Provides a means to estimate the ROI for each feasible alternative
- Provides a methodology to evaluate different alternatives from non-economic perspectives
- Saves local agencies effort and time in selecting pavement treatments
- Provides local agencies a defensible treatment selection framework that can be used for external communication
- Helps local agencies make defensible maintenance and rehabilitation decisions for their pavements

Using this Guide

The next chapter includes a brief description of the treatment selection framework, along with some useful resources for users who want to obtain more information about each step. The third chapter provides detailed step-by-step instructions on how to use the PTST. Finally, the last chapter presents a hypothetical project to further demonstrate how the PTST is used to select the most appropriate treatment alternative.

PAVEMENT TREATMENT SELECTION FRAMEWORK AND RELEVANT RESOURCES

The treatment selection framework, which is fully described and discussed in the final report for this project, is divided into three main phases, or steps, as shown in Figure 1.

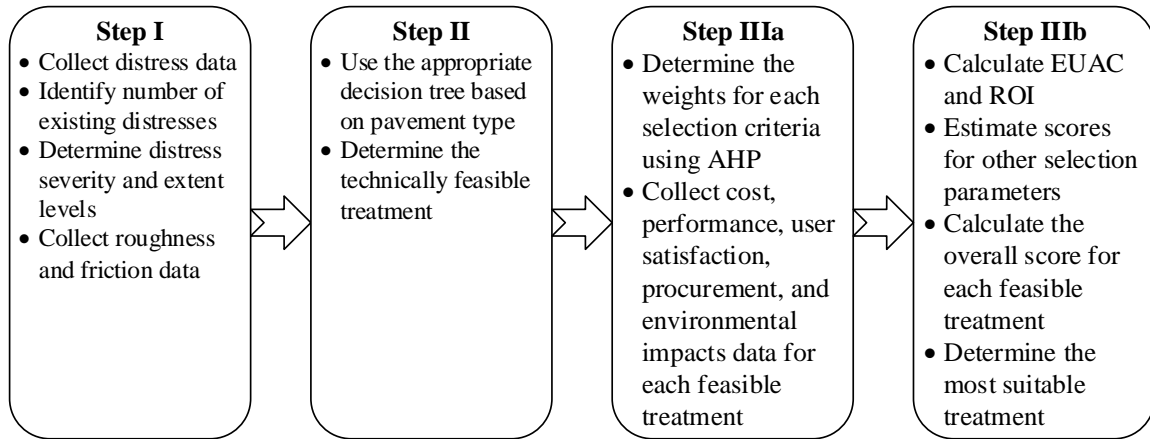


Figure 1. Pavement treatment selection framework

The first step is to collect and identify the existing distresses for the pavement. The second step includes a systematic process for determining the technically feasible treatments. The third and last step in the selection framework involves a scoring method that considers different factors to determine the most effective treatment. This step can be divided into two sub-steps.

The first sub-step includes processes to determine the weights for each selection criteria using the analytic hierarchy process (AHP) and the collection of scoring data for different selection parameters. The second sub-step involves the calculation of cost selection parameters and determination of the overall score for each treatment.

Six distress input parameters were identified for asphalt pavements and seven for concrete pavements as listed in Table 1.

Table 1. Distress input parameters for asphalt and concrete pavements

Asphalt distress input	Concrete distress input
Longitudinal cracking	Longitudinal cracking
Transverse	Transverse cracking
Alligator cracking	D-cracks
Rutting	Joint spalling
Roughness	Faulting
Friction	Roughness
	Friction

For each distress type, the PTST includes a distress identification sheet with a qualitative and quantitative description. Additional information about pavement distresses can be found in this publication:

- [*Distress Identification Manual for the Long-Term Pavement Performance Program*](#)
Miller, John S., and William Y. Billenger. Federal Highway Administration. Washington, DC. 2003.

The PTST uses life-cycle cost analysis (LCCA) to evaluate the economic effectiveness for each alternative. More information about LCCA inputs and procedures can be found in these publications:

- [*Life-Cycle Cost Analysis in Pavement Design*](#)
Walls, James, III, and Michael, R. Smith. Federal Highway Administration, Washington, DC. 1998.
- [*Life-Cycle Cost-Based Pavement Preservation Treatment Design*](#)
Pittenger, Dominique, Douglas D. Gransberg, Musharraf Zaman, and Caleb Riemer. *Transportation Research Record: Journal of the Transportation Research Board*. No. 2235. 2011. pp. 28-35.

The PTST also helps you in considering non-economic factors for treatment selection. To determine the weights for each factor, the PTST uses the analytic hierarchy process (AHP), which is based on pairwise comparisons to calculate the weights for each selection factor. More information about the AHP can be found in these publications:

- [*Decision Making with the Analytic Hierarchy Process*](#)
Saaty, Thomas L. *International Journal of Services Sciences*. Vol.1, No.1, 2008. pp. 83-98.
- [*How to Make a Decision: The Analytic Hierarchy Process*](#)
Saaty, Thomas L. *European Journal of Operational Research*. Vol.48, No.1, 1990. pp. 9-26.

- [What is the Analytic Hierarchy Process?](#)
Saaty, Thomas L. In *Mathematical Models for Decision Support*. NATO ASI Series, Vol. F48. Springer-Verlag Berlin Heidelberg. 1988. pp. 109-121.

USING THE PTST

This chapter covers the step-by-step process of using the PTST.

The PTST was developed in Excel 2007. Users need to make sure they have Excel macros enabled to use the tool.

After obtaining the PTST and saving the tool to the hard disk of your computer, open the tool by double clicking the PTST Excel file. The start-up window appears (see Figure 2).

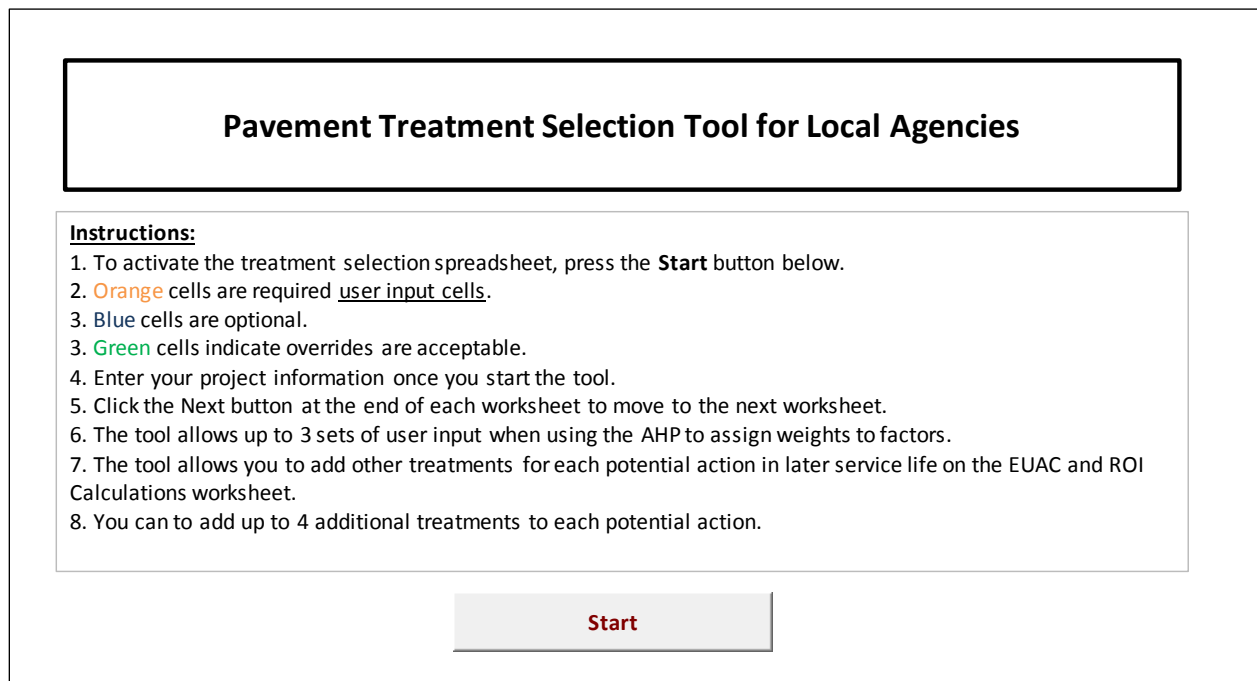


Figure 2. PTST start-up window

Be sure to read the instructions on how to use the PTST. Then, click on the Start button under the Instructions box. Note that different users may have different screen resolutions, so, once you open the PTST, you may need to scroll down to the Start button. The Project Information worksheet appears when you click on the Start button (see Figure 3).

<i>Project Information</i>			
County/City		Date	10/8/2015
Name		Estimated Letting date	
Project Engineer		<u>Location Data</u>	
Project Number		Route	
Accounting ID		Road Type	
		Project Location From	
Pavement Surface Type		Project Location To	
Length (miles)		<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Next>> </div>	
Number of Lanes			
Number of Lane Miles	0		
Surface Area (Sq..)	0		
Total length of cracks (LF)			
Total length of joints (LF)*			
*Required for rigid pavements only			

Figure 3. Project Information worksheet

The Project Information worksheet is where you input the basic project information:

- Information regarding the county/city, project number, accounting ID, letting dates, and location data are optional.
- Information about the project length, number of lanes, and length of cracks are required to calculate the total cost for potential treatments.
- You must select either asphalt concrete (AC) or Portland cement concrete (PCC) as the Pavement Surface Type from the dropdown list in order to proceed.

Click on the Next button and the Distress Data worksheet shown in either Figure 4 or 5, depending on your Pavement Surface Type, appears.

After selecting whether or not a distress exists or not, you'll be able to select the severity and extent level for each existing distress from a dropdown menu. Note that you can open up the Distress Identification Guide by clicking on the button in the top right corner of the window. A list of Potential Actions is automatically generated based on existing distresses and other input.

Distress Data				
	Existence	Severity Level	Extent Level	Class
Longitudinal Cracking				-
Alligator Cracking				-
Transverse Cracking				-
Rutting				-
Roughness				
Friction				
<i>Potential Action(s)</i>				
<i>Action #1</i>	-			
<i>Action #2</i>	-			
<i>Action #3</i>	-			
<i>Action #4</i>	-			
<i>Action #5</i>	-			

[See Distress Identification Guide for Flexible Pavements](#)

<< Back

Next >>

Figure 4. Distress Data worksheet for AC pavements

	Existence	Severity Level	Extent Level	Class
Longitudinal Cracking				-
Transverse Cracking				-
D-Cracks				-
Joint Spalling				-
Faulting (JPCP)				-
Roughness				
Skid Resistance				
Distress Location and Distribution				
Joint Related?				
Distress Distribution				
<i>Potential Action(s)</i>				
<i>Action #1</i>	-	*Diamond grinding should be used in conjunction with load transfer restoration treatment		
<i>Action #2</i>	-			
<i>Action #3</i>	-			
<i>Action #4</i>	-	**Joints should be repaired before an HMA overlay		
<i>Action #5</i>	-			

[See Distress Identification Guide for Rigid Pavements](#)

<< Back

Next >>

Figure 5. Distress Data worksheet for PCC pavements

Click on the Next button and the Equivalent Annual Uniform Cost (EUAC) and ROI Calculations worksheet shown in Figure 6 appears.

<i>EUAC and ROI Calculations</i>								
Pavement Surface Type	0	<i>See Guide for Treatments Life Expectancy and Costs</i>						
Remaining Service Life	0							
Discount Rate	3.00%							
<i>Potential Action</i>	<i>Unit Cost</i>	<i>Unit</i>	<i>Quantity</i>	<i>Initial Cost</i>	<i>Treatment Service Life</i>	<i>Are you combining this action with other treatments in later service life?</i>	<i>How Many?</i>	
Action #1	-	-	-	-	0			
Action #2	-	-	-	-	0			
Action #3	-	-	-	-	0			
Action #4	-	-	-	-	0			
Action #5	-	-	-	-	0			
Action #6 (ROI Calc.)	Planned Reconstruction/Rehab	\$ 575,000.00	Lane mile	0	\$ -	40		
<i>Scenario #1</i>								
<i>Treatment Actions</i>	<i>Year (Ordinal)</i>	<i>Treatment</i>	<i>Unit Cost</i>	<i>Unit</i>	<i>Quantity</i>	<i>Initial Cost</i>	<i>Treatment Service Life</i>	<i>Pavement Service Life</i>
-	0	-	-	-	-	-	0	
-						\$ -	0	
-						\$ -	0	
-						\$ -	0	
-						\$ -	0	

Application year of each, where 0 is the current year.

Select treatments from the drop-down list (includes predefined and user-defined treatments).

Select Yes if considering the application of other treatments in the future. Each Yes answer in this column generates a Scenario in a worksheet below. How Many? can be up to 4 additional.

Figure 6. EUAC and ROI Calculations worksheet

This worksheet helps you to evaluate the economic effectiveness of each alternative. The PTST calculates the EUAC and ROI for each alternative based on the initial costs and expected extended service life for each treatment.

Information about initial costs and life expectancy are stored in a different sheet, which you can view by clicking on the See Guide for Treatments Life Expectancy and Costs button. The tool comes with default values and local agencies are encouraged to modify them to reflect their experience and practices. However, you need to be careful with the unit of initial cost of each treatment when changing these values. The PTST calculates remaining service life for each treatment based on the pavement condition and the expected service life for each potential treatment.

At this point, the PTST can calculate the EUAC and ROI for each potential treatment at a discount rate of 3%. However, you can override the default value of the discount rate (upper left corner of the top worksheet in Figure 6) to reflect your practices and experience.

The PTST allows you to add additional treatments by answering Yes and entering the number of treatment actions (up to 4 additional) in the How Many? column at the far right of the top worksheet in Figure 6. This defines how many treatment actions you want to define for a single scenario, so that you can evaluate the economic effectiveness of the whole lifecycle scenario, which will appear in a numbered Scenario worksheet below the top worksheet (as shown in Figure 6).

This allows you to select up to four additional treatments to consider that were not available in the original list when considering other maintenance scenarios with multiple Treatment Actions over time to extend the service life of the pavement. The Treatment dropdown list for each Scenario worksheet will include the user-defined Treatment Actions.

Note: When applying an overlay treatment that converts the pavement from flexible or rigid to composite, the PTST retains the input that the pavement is AC (flexible) or PCC (rigid) based on the Pavement Surface Type. In these cases, be sure to use user-defined treatment actions to build the scenarios.

Remember: You can change the discount rate, costs, and life expectancies of treatments.

Click on the Next button at the bottom of the EUAC and ROI Calculations sheet and the treatment ranking sheet appears (Figure 7) with a ranking (right column) for each Potential Action based on the ROI value.

	A	B	C	F	G
1		Potential Action	EUAC	ROI	Rank
2		Action #1 -	-	-	-
3		Action #2 -	-	-	-
4		Action #3 -	-	-	-
5		Action #4 -	-	-	-
6		Action #5 -	-	-	-
7					
8		<div style="border: 1px solid black; padding: 5px;"> <p>Would you like to consider other selection criteria such as user satisfaction and environmental sustainability?</p> </div>			
9					
10					
11		<div style="border: 1px solid black; padding: 5px;"> <input type="text"/> </div>			
12		<div style="border: 1px solid black; padding: 5px;"> <input type="text"/> </div>			
13		<input style="background-color: #cccccc;" type="button" value=" << Back "/>		<input style="background-color: #cccccc;" type="button" value=" Next >> "/>	
14					
15					
16					
17					
18					
19					

Figure 7. PTST economic ranking sheet

At this point, you can choose whether or not to consider other selection factors. If you select No, a summary sheet appears and the selection process is over. If you select Yes, you will be able to continue the selection process, which involves the evaluation of non-economic factors.

Click on the Next button and the tool asks whether to use AHP or a manual assignment method for weight calculation of each factor (see Figure 8).

Would you like to assign selection parameters weights manually or use AHP to calculate the selection parameters weights?

Figure 8. PTST factor weight assignment method question

Manually Assigning Weights to the Factors

If you select Manual Assignment from the dropdown list and then click on the Next button, the manual assignment worksheet shown in Figure 9 appears.

<u>Category</u>	<u>Selection Criteria</u>	<u>Average Global Weight</u>
Performance	Pavement Structure Improvement	
	Performance Under Heavy Traffic Loading	
	Performance Under Average Daily Traffic	
User Satisfaction	Facility Downtime	
	Impact on Roughness	
	Impact on Friction	
	Noise	
Procurement and Contracts	Availability of Qualified Contractors	
	Availability of Quality Materials	
Environmental Sustainability	Negative Environmental Impact	
<i>Sum of Weights</i>		<i>0.00%</i>
<input style="border: 1px solid black; padding: 5px;" type="button" value=" << Back "/>		<input style="border: 1px solid black; padding: 5px;" type="button" value=" Next >> "/>

Figure 9. Manual weight assignment worksheet

On this sheet, you must assign a relative weight to each factor and the sum of the weights assigned must equal 100%.

Click on the Next button and the scoring worksheet (Figure 10) appears.

			Scores					Weighted Scores				
Category	Selection Criteria	Average Global Weight	-	-	-	-	-	-	-	-	-	-
Performance	Pavement Structure Improvement	#N/A						-	-	-	-	-
	Performance Under Heavy Traffic Loading	#N/A						-	-	-	-	-
	Performance Under Average Daily Traffic	#N/A						-	-	-	-	-
User Satisfaction	Facility Downtime	#N/A						-	-	-	-	-
	Impact on Roughness	#N/A						-	-	-	-	-
	Impact on Friction	#N/A						-	-	-	-	-
	Noise	#N/A						-	-	-	-	-
Procurement and Contracts	Availability of Qualified Contractors	#N/A						-	-	-	-	-
	Availability of Quality Materials	#N/A						-	-	-	-	-
Environmental Sustainability	Negative Environmental Impact	#N/A						-	-	-	-	-
Total Score								0.00	0.00	0.00	0.00	0.00
								0.00	0.00	0.00	0.00	0.00
								<< Back		Next >>		

Figure 10. Scoring worksheet

On this scoring worksheet, you will see and check the different factors and their assigned weights. Each treatment alternative will appear in one of the Scores columns. You will then assign scores to the different factors for each alternative.

Scores should be from 0 to 10, where 0 represents the lowest improvement or the highest negative impact and 10 represents the highest improvement or the highest positive impact. The PTST takes the assigned scores and their weights and calculates the weighted scores in the rightmost columns, along with totals at the bottom for each pavement treatment alternative.

Click on the Next button and a ranking sheet appears (see Figure 11) to show the rank of the Potential Actions under consideration based on the non-economic factors.

Potential Actions		
Action	Total Score	Rank
-	0.00	-
-	0.00	-
-	0.00	-
-	0.00	-
-	0.00	-

<< Back

Go to Summary Sheet

Figure 11. Non-economic ranking sheet

Using the AHP to Assign Weights to the Factors

If you prefer to use the AHP method to determine the weight of each factor instead of the manual assignment method, select AHP from the dropdown list shown in Figure 8 and click on the Next button. The pairwise comparison worksheet appears (see Figure 12).

Note: When calculating weights using the AHP, input from at least two users is recommended. The PTST allows you to enter up to three sets of user input for the pairwise comparisons.

<i>1. High Level Weighing Process</i>				
<i>Category</i>	Performance	Procurement and Contracts	Environmental Sustainability	User Satisfaction
Performance				
Procurement and Contracts				
Environmental Sustainability				
User Satisfaction				
Overall Consistency	-	Review pair wise comparison		

Figure 12. Pairwise comparison worksheet

This worksheet is where you enter pairwise comparisons to indicate the level of importance of each factor over another using the dropdown lists (see Figure 13).

1. High Level Weighing Process			
Category	Performance	Procurement and Contracts	Environmental Sustainability
Performance			
Procurement and Contracts			
Environmental Sustainability			
User Satisfaction			
Overall Consistency	-		

Figure 13. PTST dropdown list for pairwise comparison

For example, if performance is considered 7 times more important than Procurement and Contracts in terms of selecting the right pavement treatment on this project, you would select Very strong importance (7) from the dropdown list. On the other hand, if Procurement and Contracts is 5 times more important than Performance, you would select R-Strongly important (1/5) from the dropdown list. The same concept is applied to the other pairwise comparisons.

The PTST checks the overall consistency of the pairwise comparisons. If not consistent, the tool warns you and recommends that you revise the pairwise comparisons. After finishing, the PTST asks if another user wants to provide input to conduct another pairwise comparison (see Figure 14).

Is there another user input?

<< Back

Next >>

Figure 14. Additional user input question for AHP pairwise comparisons

The tool allows input from up to three users for the same project. After the pairwise comparisons are completed, the tool averages the weights generated from the user input. Click on the Next button and the scoring worksheet appears (see Figure 15).

			Scores					Weighted Scores				
Category	Selection Criteria	Average Global Weight	-	-	-	-	-	-	-	-	-	-
Performance	Pavement Structure Improvement	#N/A						-	-	-	-	-
	Performance Under Heavy Traffic Loading	#N/A						-	-	-	-	-
	Performance Under Average Daily Traffic	#N/A						-	-	-	-	-
User Satisfaction	Facility Downtime	#N/A						-	-	-	-	-
	Impact on Roughness	#N/A						-	-	-	-	-
	Impact on Friction	#N/A						-	-	-	-	-
	Noise	#N/A						-	-	-	-	-
Procurement and Contracts	Availability of Qualified Contractors	#N/A						-	-	-	-	-
	Availability of Quality Materials	#N/A						-	-	-	-	-
Environmental Sustainability	Negative Environmental Impact	#N/A						-	-	-	-	-
Total Score								0.00	0.00	0.00	0.00	0.00
								0.00	0.00	0.00	0.00	0.00
								<< Back		Next >>		

Figure 15. Scoring worksheet

On this scoring worksheet, you will see and check the different factors and their assigned weights. Each treatment alternative will appear in one of the Scores columns. You will then assign scores to the different factors for each alternative.

Scores should be from 0 to 10, where 0 represents the lowest improvement or the highest negative impact and 10 represents the highest improvement or the highest positive impact. The PTST takes the assigned scores and their weights and calculates the weighted scores in the rightmost columns, along with totals at the bottom for each pavement treatment alternative.

Click on the Next button and a ranking sheet appears to show the rank of alternatives under consideration based on the non-economic factors (see Figure 16).

Potential Actions		
Action	Total Score	Rank
-	0.00	-
-	0.00	-
-	0.00	-
-	0.00	-
-	0.00	-

<< Back

Go to Summary Sheet

Figure 16. Non-economic ranking sheet

Reviewing the Final Summary Spreadsheet

Click on the Go to Summary Sheet button and a final summary sheet appears showing the project information, existing distresses, potential actions, and ranking of pavement alternatives in terms of ROI values and non-economic values (see Figure 17).

Click on the Print Summary Sheet button in the lower right corner to print the information.

Project Information							
County/City		0	Date	10/9/2015			
Name		0	Estimated Letting date	1/0/1900			
Project Engineer		0	Location Data				
Project Number		0	Route		0		
Accounting ID		0	Road Type		0		
			Project Location From		0		
Pavement Surface Type		0	Project Location To		0		
Length (miles)		0					
Number of Lanes		0					
Distress Data							
	Existence	Severity Level	Extent Level	Class			
Longitudinal Cracking	0	0	0	-			
Alligator Cracking	0	0	0	-			
Transverse Cracking	0	0	0	-			
Rutting	0	0	0	-			
Roughness	0						
Friction	0						
Distress Distribution							
Surface Age	0						
Distress Distribution	0						
Cost Ranking	Non-Cost Ranking	Potential Action(s)		NPV	EUAC	ROI	Service Life
-	-	Action #1	-	-	-	-	0
-	-	Action #2	-	-	-	-	0
-	-	Action #3	-	-	-	-	0
-	-	Action #4	-	-	-	-	0
-	-	Action #5	-	-	-	-	0
Method of Weights Assignment		0					
Scoring Sheet							
Category	Selection Criteria	Average Global Weight	Weighted Scores				
Performance	Pavement Structure Improvement	#N/A	-	-	-	-	-
	Performance Under Heavy Traffic Loading	#N/A	-	-	-	-	-
	Performance Under Average Daily Traffic	#N/A	-	-	-	-	-
User Satisfaction	Facility Downtime	#N/A	-	-	-	-	-
	Impact on Roughness	#N/A	-	-	-	-	-
	Impact on Friction	#N/A	-	-	-	-	-
	Noise	#N/A	-	-	-	-	-
Procurement and Contracts	Availability of Qualified Contractors	#N/A	-	-	-	-	-
	Availability of Quality Materials	#N/A	-	-	-	-	-
Environmental Sustainability	Negative Environmental Impact	#N/A	-	-	-	-	-
Total Score			0.00	0.00	0.00	0.00	0.00

Print Summary Sheet

Figure 17. Summary sheet

EXAMPLE OF USING THE PTST

This final chapter illustrates use of the PTST to help select most appropriate pavement treatment with a hypothetical project. The user first sees the PTST start-up window when they open the file to start using the tool (see Figure 18).

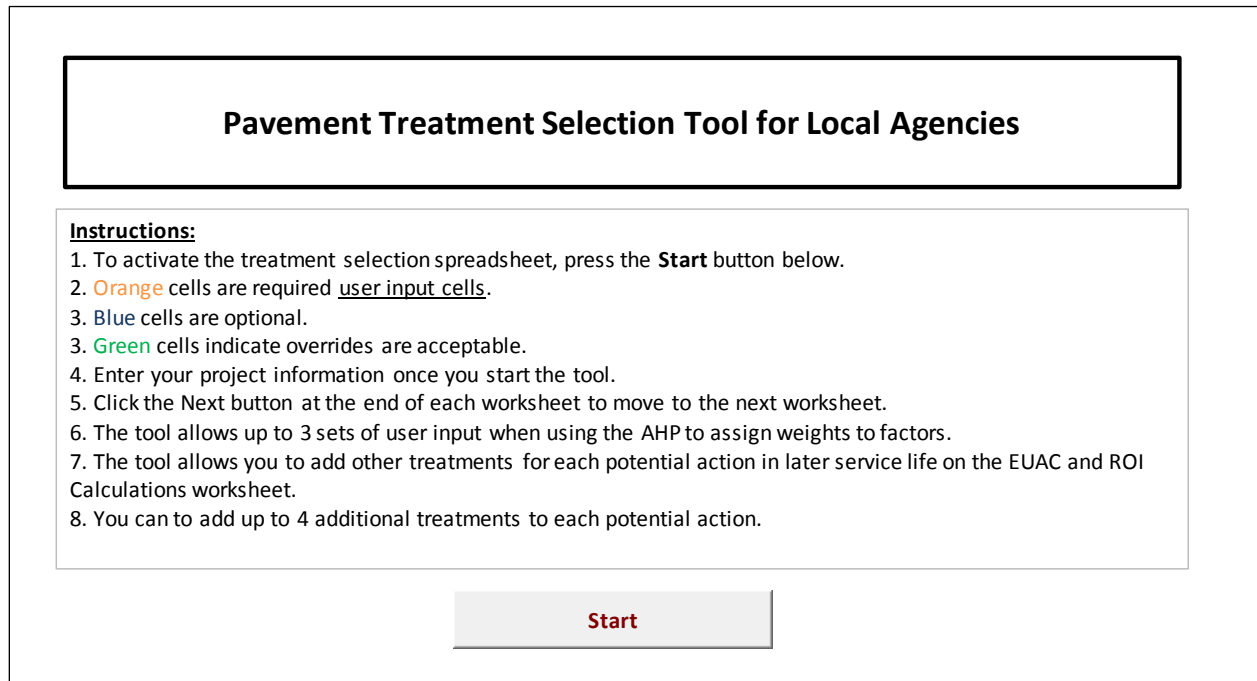


Figure 18. PTST start-up window

After clicking on the Start button, the user will enter the basic project information (see Figure 19).

<u>Project Information</u>			
County/City	XYZ	Date	9/3/2015
Name	-	Estimated Letting date	5/1/2016
Project Engineer	John	<u>Location Data</u>	
Project Number	DCM-12-5628	Route	
Accounting ID	19-129-463	Road Type	
Pavement Surface Type	AC	Project Location From	
Length (miles)	1	Project Location To	
Number of Lanes	1	Next>>	
Number of Lane Miles	1		
Surface Area (Sq.ft.)	63360		
Total length of cracks (LF)	0		
Total length of joints (LF)*	0		
*Required for rigid pavements only			

Figure 19. Example of Project Information worksheet

In this example, the pavement is AC and the length of the pavement is one lane mile. The Distress Data worksheet appears when the user clicks on the Next button (see Figure 20).

Distress Data				
	Existence	Severity Level	Extent Level	Class
Longitudinal Cracking				-
Alligator Cracking				-
Transverse Cracking				-
Rutting				-
Roughness				
Friction				
<u>Potential Action(s)</u>				
<u>Action #1</u>	-			
<u>Action #2</u>	-			
<u>Action #3</u>	-			
<u>Action #4</u>	-			
<u>Action #5</u>	-			

See Distress Identification Guide for Flexible Pavements

<< Back

Next >>

Figure 20. Distress Data worksheet for AC pavements

In this example, the pavement has exhibited a moderate severity level and low extent level of longitudinal cracking and a low severity level and low extent level of transverse cracking. Pavement roughness is high and friction is good. Upon entering these values on the Distress Data

worksheet, the list of treatments under Potential Actions is automatically generated (see Figure 21).

Distress Data				
	Existence	Severity Level	Extent Level	Class
Longitudinal Cracking	Yes	Moderate	Low	3
Alligator Cracking				-
Transverse Cracking	Yes	Low	Low	3
Rutting				-
Roughness	High			
Friction	Good			
<i>Potential Action(s)</i>				
<i>Action #1</i>	Microsurfacing			
<i>Action #2</i>	Chip seal			
<i>Action #3</i>	-			
<i>Action #4</i>	-			
<i>Action #5</i>	-			

See [Distress Identification Guide for Flexible Pavements](#)

<< Back

Next >>

Figure 21. Example of Distress Data worksheet showing Potential Actions

For this hypothetical project, microsurfacing and chip seal were determined to be technically feasible. When the user clicks on the Next button, the EUAC and ROI Calculations worksheet appears, automatically populated from the Distress Data worksheet and the treatment life expectancy and costs worksheet. (Information about initial costs and life expectancy are stored in a different sheet, which the user can view by clicking on the See Guide for Treatments Life Expectancy and Costs button.)

In this example, the user wants to compare two lifecycle management scenarios to each other (see Figure 22). The first scenario is to apply microsurfacing, thin hot-mix asphalt (HMA) overlay, and chip seal at years 0, 8, and 16, respectively. The second scenario is to apply chip seal and thick HMA overlay at years 0 and 7 respectively.

The user can change the discount rate, costs, and life expectancies of treatments if desired.

<i>EUAC and ROI Calculations</i>								
Pavement Surface Type	AC	<i>See Guide for Treatments Life Expectancy and Costs</i>						
Remaining Service Life	10							
Discount Rate	3.00%							
<i>Potential Action</i>	<i>Unit Cost</i>	<i>Unit</i>	<i>Quantity</i>	<i>Initial Cost</i>	<i>Treatment Service Life</i>	<i>Are you combining this action with other treatments in later service life?</i>	<i>How Many?</i>	
Action #1 Microsurfacing	\$ 17,948.90	Lane mile	1	\$ 17,948.90	6	Yes	2	
Action #2 Chip seal	\$ 11,600.00	Lane mile	1	\$ 11,600.00	5	Yes	1	
Action #3 -	-	-	-	-	0			
Action #4 -	-	-	-	-	0			
Action #5 -	-	-	-	-	0			
Action #6 (ROI Calc.) Planned Reconstruction/Rehab	\$ 600,000.00	Lane mile	1	\$ 600,000.00	20			
<i>Scenario #1</i>								
<i>Treatment Actions</i>	<i>Year (Ordinal)</i>	<i>Treatment</i>	<i>Unit Cost</i>	<i>Unit</i>	<i>Quantity</i>	<i>Initial Cost</i>	<i>Treatment Service Life</i>	<i>Pavement Service Life</i>
1	0	Microsurfacing	\$ 17,948.90	Lane mile	1	\$ 17,948.90	6	6
2	8	Thin HMA overlay	\$ 86,130.00	Lane mile	1	\$ 86,130.00	8	14
3	16	Chip seal	\$ 11,600.00	Lane mile	1	\$ 11,600.00	5	19
-			-	-	-	\$ -	0	
-			-	-	-	\$ -	0	
<i>Scenario #2</i>								
<i>Treatment Actions</i>	<i>Year (Ordinal)</i>	<i>Treatment</i>	<i>Unit Cost</i>	<i>Unit</i>	<i>Quantity</i>	<i>Initial Cost</i>	<i>Treatment Service Life</i>	<i>Pavement Service Life</i>
1	0	Chip seal	\$ 11,600.00	Lane mile	1	\$ 11,600.00	5	5
2	7	Thick HMA overlay	\$ 160,000.00	Lane mile	1	\$ 160,000.00	15	20
-			-	-	-	\$ -	0	
-			-	-	-	\$ -	0	
-			-	-	-	\$ -	0	

Figure 22. Example showing user-defined scenarios to compare for economic effectiveness

When the user clicks on the Next button at the bottom of the EUAC and ROI Calculations sheet, the EUAC and ROI information appears (see Figure 23).

Potential Action	EUAC	ROI	Rank
Action #1 Microsurfacing	\$ 6,504.52	10.00	1
Action #2 Chip seal	\$ 11,534.22	4.80	2
Action #3 -	-	-	-
Action #4 -	-	-	-
Action #5 -	-	-	-

Would you like to consider other selection criteria such as user satisfaction and environmental sustainability?

<< Back

Next >>

Figure 23. Example of economic effectiveness ranking

At this point, the user can see that the first scenario is more economical compared to the second alternative. The ROI score is calculated based on the difference or savings between the EUAC of a proposed scenario and the EUAC of the do nothing scenario. The alternative that generates the highest savings receives a score of 10 and the other scenarios receive a lower score calculated with respect to the best alternative score.

At this point, the user can end the process and generate the final summary sheet by selecting No from the dropdown menu and clicking on the Next button, or they can consider other non-economic selection factors by selecting Yes and clicking on the Next button. When the user selects Yes for this hypothetical example, the next step is to select the method of factor weight assignment (see Figure 24).

Would you like to assign selection parameters weights manually or use AHP to calculate the selection parameters weights?

<< Back

Next >>

Figure 24. PTST factor weight assignment method question

We show each of the two methods—manual and AHP—on the following pages.

Manually Assigning Weights to the Factors

Using the manual assignment method, the weight of each factor is determined based on user experience and preference (see Figure 25).

<i>Category</i>	<i>Selection Criteria</i>	<i>Average Global Weight</i>
Performance	Pavement Structure Improvement	30.00%
	Performance Under Heavy Traffic Loading	15.00%
	Performance Under Average Daily Traffic	15.00%
User Satisfaction	Facility Downtime	10.00%
	Impact on Roughness	10.00%
	Impact on Friction	10.00%
	Noise	3.00%
Procurement and Contracts	Availability of Qualified Contractors	1.00%
	Availability of Quality Materials	1.00%
Environmental Sustainability	Negative Environmental Impact	5.00%
<i>Sum of Weights</i>		<i>100.00%</i>
<input style="border: 1px solid gray;" type="button" value=" << Back "/>		<input style="border: 1px solid gray;" type="button" value=" Next >> "/>

Figure 25. Example of manual factor weight assignment worksheet

On this worksheet, the user assigned the relative weight to each factor (in the rightmost column) with the sum of the weights equaling 100% (bottom right) as required. When the user clicks on the Next button, the scoring worksheet appears with the factor weights automatically populated. At this point, the user assigns scores for each treatment in the center part of the worksheet (see Figure 26).

			Scores					Weighted Scores				
Category	Selection Criteria	Average Global Weight	Microsurfacing	Chip seal	-	-	-	Microsurfacing	Chip seal	-	-	-
Performance	Pavement Structure Improvement	30.00%	8.0	10.0				2.40	3.00	0.00	0.00	0.00
	Performance Under Heavy Traffic Loading	15.00%	8.0	10.0				1.20	1.50	0.00	0.00	0.00
	Performance Under Average Daily Traffic	15.00%	8.0	10.0				1.20	1.50	0.00	0.00	0.00
User Satisfaction	Facility Downtime	10.00%	7.0	10.0				0.70	1.00	0.00	0.00	0.00
	Impact on Roughness	10.00%	10.0	10.0				1.00	1.00	0.00	0.00	0.00
	Impact on Friction	10.00%	10.0	10.0				1.00	1.00	0.00	0.00	0.00
	Noise	3.00%	10.0	10.0				0.30	0.30	0.00	0.00	0.00
Procurement and Contracts	Availability of Qualified Contractors	1.00%	10.0	10.0				0.10	0.10	0.00	0.00	0.00
	Availability of Quality Materials	1.00%	10.0	10.0				0.10	0.10	0.00	0.00	0.00
Environmental Sustainability	Negative Environmental Impact	5.00%	10.0	10.0				0.50	0.50	0.00	0.00	0.00
Total Score								8.50	10.00	0.00	0.00	0.00
								8.50	10.00	0.00	0.00	0.00

<< Back
Next >>

Figure 26. Example of scoring worksheet

The score for each scenario solely depends on the experience of the users. (Additional information regarding the performance for each treatment can be found in the Literature Review chapter in the final report for this project.) When the user clicks on the Next button, the non-economic ranking of the alternatives appear (see Figure 27).

Potential Actions		
Action	Total Score	Rank
Microsurfacing	8.50	2
Chip seal	10.00	1
-	0.00	-
-	0.00	-
-	0.00	-

Figure 27. Example of non-economic ranking sheet

Finally, the user can go to the summary sheet (Figure 28) by clicking on the Go to Summary Sheet button.

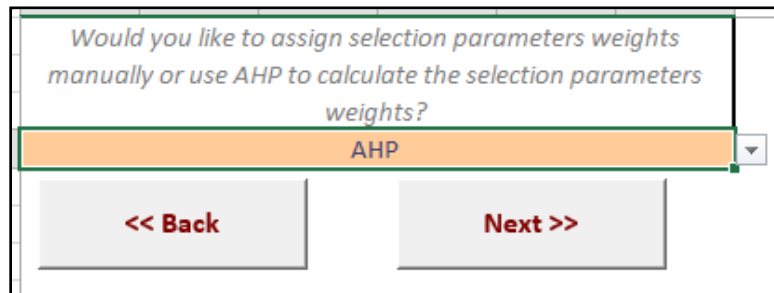
Project Information							
County/City	XYZ	Date	10/9/2015				
Name	-	Estimated Letting date	5/1/2016				
Project Engineer	John	Location Data					
Project Number	DCM-12-5628	Route	0				
Accounting ID	19-129-463	Road Type	0				
Pavement Surface Type	AC	Project Location From	0				
Length (miles)	1	Project Location To	0				
Number of Lanes	1						
Distress Data							
	Existence	Severity Level	Extent Level	Class			
Longitudinal Cracking	Yes	Moderate	Low	3			
Alligator Cracking	0	0	0	-			
Transverse Cracking	Yes	Low	Low	3			
Rutting	0	0	0	-			
Roughness	High						
Friction	Good						
Distress Distribution							
Distress Distribution	0						
Cost Ranking	Non-Cost Ranking	Potential Action(s)		NPV	EUAC	ROI	Service Life
<u>1</u>	<u>2</u>	<u>Action #1</u>	<u>Microsurfacing</u>	\$93,169.45	\$6,504.52	10.00	19
<u>2</u>	<u>1</u>	<u>Action #2</u>	<u>Chip seal</u>	\$171,600.00	\$11,534.22	4.80	20
-	-	<u>Action #3</u>	-	-	-	-	0
-	-	<u>Action #4</u>	-	-	-	-	0
-	-	<u>Action #5</u>	-	-	-	-	0
Method of Weights Assignment		AHP					
Scoring Sheet							
Category	Selection Criteria	Average Global Weight	Weighted Scores				
			Microsurfacing	Chip seal	-	-	-
Performance	Pavement Structure Improvement	0.1	0.9	1.1	0.0	0.0	0.0
	Performance Under Heavy Traffic Loading	0.1	0.8	0.9	0.0	0.0	0.0
	Performance Under Average Daily Traffic	0.1	1.0	1.3	0.0	0.0	0.0
User Satisfaction	Facility Downtime	0.0	0.3	0.5	0.0	0.0	0.0
	Impact on Roughness	0.1	0.8	0.8	0.0	0.0	0.0
	Impact on Friction	0.1	0.9	0.9	0.0	0.0	0.0
	Noise	0.1	0.7	0.7	0.0	0.0	0.0
Procurement and Contracts	Availability of Qualified Contractors	0.1	0.9	0.9	0.0	0.0	0.0
	Availability of Quality Materials	0.1	0.9	0.9	0.0	0.0	0.0
Environmental Sustainability	Negative Environmental Impact	0.2	2.1	2.1	0.0	0.0	0.0
Total Score			9.20	10.00	0.00	0.00	0.00

Print Summary Sheet

Figure 28. Example of summary sheet

Using the AHP to Assign Weights to the Factors

Using the same hypothetical example, after finishing the ROI evaluation (back with Figure 22) and clicking on the Next button, the user instead selects AHP as the method of determining the factor weights (see Figure 29).



The screenshot shows a dialog box with a white background and a thin black border. At the top, there is a text prompt: "Would you like to assign selection parameters weights manually or use AHP to calculate the selection parameters weights?". Below this prompt is a dropdown menu with a light orange background and the text "AHP" in the center. To the right of the dropdown is a small downward-pointing arrow. At the bottom of the dialog, there are two buttons: " << Back " on the left and " Next >> " on the right, both in a light gray box with red text.

Figure 29. Choosing AHP as method for factor weight assignment

When the user clicks on the Next button, the pairwise comparison worksheet appears where the user enters pairwise comparisons of the factors (see Figure 30).

<u>1. High Level Weighing Process</u>				
<i>Category</i>	Performance	Procurement and Contracts	Environmental Sustainability	User Satisfaction
Performance		Strongly important (5)	Moderately important (3)	Equally important (1)
Procurement and Contracts			Equally important (1)	R-Strongly important (1/5)
Environmental Sustainability				Equally important (1)
User Satisfaction				
Overall Consistency	Consistent			
<u>1.1 Performance Parameters Weighing Process</u>				
	Pavement Structure Improvement	Performance Under Heavy Traffic Loading	Performance Under Average Daily Traffic	
Pavement Structure Improvement		Equally important (1)	Equally important (1)	
Performance Under Heavy Traffic			R-Equally to moderately (1/2)	
Performance Under Average Daily				
Overall Consistency	Consistent			
<u>1.2 User Satisfaction Parameters Weighing Process</u>				
	Facility Downtime	Impact on Roughness	Impact of Friction	Noise
Facility Downtime		R-Moderately important (1/3)	R-Moderately important (1/)	R-Moderately important (1/3)
Impact on Roughness			Equally important (1)	Equally important (1)
Impact of Friction				Moderately important (3)
Noise				
Overall Consistency	Consistent			
<u>1.3 Procurement and Contracts Parameters Weighing Process</u>				
	Availability of Qualified Contractors	Availability of Quality Materials		
Availability of Qualified Contractors		Equally important (1)		
Availability of Quality Materials				
Is there another user input?	No			

Figure 30. Pairwise comparison worksheet using the AHP for factor weight assignments

The user indicates the importance of each factor with respect to another by selecting an option from the dropdown list. The PTST calculates the consistency of the pairwise comparisons and recommends repeating them if they are inconsistent.

After finishing, the PTST asks the user if another user wants to provide input (see Figure 31).

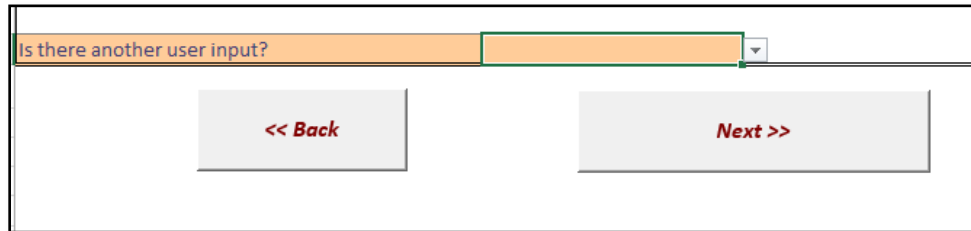
The image shows a screenshot of a web application interface. At the top, there is a horizontal bar with an orange background containing the text "Is there another user input?". Below this bar, there are two buttons: a grey button on the left with the text "<< Back" and a grey button on the right with the text "Next >>".

Figure 31. Additional user input question for AHP pairwise comparisons

The tool allows three sets of user input for the each project and input from at least two users is recommended when calculating weights using the AHP.

After the pairwise comparisons are completed, the tool averages the weights generated from the user input. When the user clicks on the Next button, the scoring sheet appears (see Figure 32).

The scoring sheet contains the technically recommended actions at the top of the sheet. In addition, the global weights for each factor are automatically populated based on the pairwise comparisons.

Based on the pairwise comparisons from the user in this example, negative environmental impacts, performance under average daily traffic, and pavement structure improvement have the highest weights. On the other hand, facility downtime and noise received the lowest weights.

			Scores					Weighted Scores				
Category	Selection Criteria	Average Global Weight	Microsurfacing	Chip seal	-	-	-	Microsurfacing	Chip seal	-	-	-
Performance	Pavement Structure Improvement	10.82%	8.0	10.0				0.87	1.08	0.00	0.00	0.00
	Performance Under Heavy Traffic Loading	9.47%	8.0	10.0				0.76	0.95	0.00	0.00	0.00
	Performance Under Average Daily Traffic	12.51%	8.0	10.0				1.00	1.25	0.00	0.00	0.00
User Satisfaction	Facility Downtime	4.69%	7.0	10.0				0.33	0.47	0.00	0.00	0.00
	Impact on Roughness	7.81%	10.0	10.0				0.78	0.78	0.00	0.00	0.00
	Impact on Friction	9.33%	10.0	10.0				0.93	0.93	0.00	0.00	0.00
	Noise	6.81%	10.0	10.0				0.68	0.68	0.00	0.00	0.00
Procurement and Contracts	Availability of Qualified Contractors	8.70%	10.0	10.0				0.87	0.87	0.00	0.00	0.00
	Availability of Quality Materials	8.70%	10.0	10.0				0.87	0.87	0.00	0.00	0.00
Environmental Sustainability	Negative Environmental Impact	21.18%	10.0	10.0				2.12	2.12	0.00	0.00	0.00
Total Score								9.20	10.00	0.00	0.00	0.00
								9.20	10.00	0.00	0.00	0.00

<< Back
Next >>

Weights calculated using the pairwise comparisons

Figure 32. Scoring sheet with weights calculated using the AHP