

# PaveSafe v1.0.2

# Mechanistic Load Restriction Decision Platform for Pavement Systems Prone to Moisture Variations

# 12/24/2020

# **User Manual**

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The software development was sponsored by National Road Research Alliance (NRRA) under MnDOT Contract# 1034192 and supported by the University of New Hampshire.

For updates please visit <a href="http://mypages.unh.edu/pavesafe/">http://mypages.unh.edu/pavesafe/</a>

**Reference Papers:** 

To be added.

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### **REQUIREMENTS AND INSTALLATION PROCEDURE**

The toolkit "PaveSafe" is currently at version v1.0.2. The toolkit requires MATLAB Compiler Runtime (MCR) to be installed on the host system.

MCR inherits identical system requirements as of the MATLAB version used to build the toolkit. MATLAB 2019b Update 3 has been used for toolkit development.

General MCR requirements are listed below:

- 1. For Macintosh systems: <u>https://www.mathworks.com/content/dam/mathworks/mathworks-dot-com/support/sysreg/files/system-requirements-release-2019b-macintosh.pdf</u>
- 2. For Windows systems: <u>https://www.mathworks.com/content/dam/mathworks/mathworks-dot-com/support/sysreq/files/system-requirements-release-2019b-windows.pdf</u>
- 3. For Linux systems: <u>https://www.mathworks.com/content/dam/mathworks/mathworks-dot-</u> <u>com/support/sysreq/files/system-requirements-release-2019b-linux.pdf</u>

#### **Installation Procedure:**

**Step 1:** The toolkit package is provided in two folders:

- PaveSafe Application
- MyAppInstaller

Users can choose to use the PaveSafe Application folder which contains the toolkit to run the application, given, MCR already configured in the host system.

If MCR is not configured on the host system, users may need to use the MyAppInstaller folder and launch the contained installer file "MyAppInstaller\_web". Detailed installation procedure using the installer is mentioned in the following steps

	11/23/2020 7:35 PM	File folder
PaveSafe Application	11/23/2020 7:35 PM	File folder

**Step 2:** Open the MyAppInstaller\_web installer.

PaveSafe Installer				×
Connec	ction Settings			
PaveSafe 1.0.1			/	
		•		
				V.
< Back Next >	Cancel			

**Step 3:** Select the application installation folder.

Installation Options				×
Choose installation folder:				
C:\Program Files\PaveSafe	B <u>r</u> ov	vse		
	Restore Default Fo	lder		
Add a shortcut to the desktop				
		_		
< <u>B</u> ack <u>N</u> ext >	Cance	el		

**Step 4:** Installer will detect if the MRC is installed on the host computer. If it is not already configured, a prompt for choosing the installation folder appears.



**Step 5:** Accept the license agreement, confirm and wait until installation is completed.

License Agreement	-		×
The MathWorks, Inc.			^
MATLAB RUNTIME LICENSE			
IMPORTANT NOTICE BY CLICKING THE "YES" BUTTON BELOW. YOU ACCEPT THE TERMS OF THIS LICENSE. IF YOU ARE NOT	WILLING	TO DO	
SO, SELECT THE "NO" BUTTON AND THE INSTALLATION WILL BE ABORTED.			
<ol> <li>LICENSE GRANT. Subject to the restrictions below, The MathWorks, Inc. ("MathWorks") hereby grants you are an individual or an entity, a license to install and use the MATLAB Runtime ("Runtime"), solely a the purpose of running software created with the MATLAB Compiler (the "Application Software"), and purpose. This license is personal, nonexclusive, and nontransferable.</li> </ol>	to you, v and expre for no ot	vhether essly for her	
2. LICENSE RESTRICTIONS. You shall not modify or adapt the Runtime for any reason. You shall not disa decompile, or reverse engineer the Runtime. You shall not alter or remove any proprietary or other leg-conies of the Runtime. Unless used to run Application Software you shall not rent lease or loan the Runtime.	assemble al notices intime, til	, s on or in me share	
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## INTRODUCTION

The toolkit PaveSafe v1.0.2 is password protected via password protected window and requires the user to provide inputs across 5 panels after correct password has been provided. In addition to these sections, the toolkit offers the Menu Tab on top of the PaveSafe application window. In the version PaveSafe v1.0.2 we have added the flexibility for user to select SI Units or use US Customary instead.

The application collectively contains the following sections:

- Password Protection Window
- SI Units vs US Customary Selection Stage
- Project Information Panel
- Pavement Structure Panel
- Subgrade Properties Panel
- Hydrological Information Panel
- Results Panel
- Menu Tab

These panels and windows are described in more detail in the upcoming sections.

#### PASSWORD PROTECTION MENU

Inherently, MATLAB does not provide a password protection for the generated applications. A password protection window that secures the app from unauthorized access is prepared as first line of defense.

Disclaimer: Please note that there is no underlying encryption mechanism which protects the application from people who have intentions to misuse the application. Simple methods such as brute force (example – John the Ripper password cracking software) can still break the password. It is advised to share the application with the intended users only. In workspaces, users should be trained to be aware of attacks such as Shoulder Surfing, Tailgating, Phishing and other forms of Social Engineering attacks. The host systems can be secured by using anti-virus and setting up appropriate firewall settings. These preventive measures along with provided password protection can reduce the risk of misuse. We do not guarantee complete protection against hackers or take accountability for any misuse of the application. It is the responsibility of the intended users to keep the application secure.

On launch, a password protection screen pops out and requires the users to enter the password. After providing the password it is requires to press the "Check Password" button in order to proceed.

Ressword Protection	-	×
		1
		-
Password		-
Check Pacsword		
Check Password		

In the event of providing an incorrect password, a wrong password alert box appears on the screen. You may choose to close the alert box or press "OK" to proceed.



In the event of providing a correct password, a correct password alert box appears on the screen. You must choose to close the alert box by pressing "OK", "Cancel" or closing the alert box by clicking the "X" on top right side of the alert box to proceed working with the PaveSafe application.



## SI UNITS VS US CUSTOMARY UNITS SELECTION STAGE

In this stage, user is required to select the units of measurement.

We have the following units of measurements in place:

- SI Units
- US Customary

A dialogue box will appear requiring the user to select the desired units of measurement. If user chooses to close the dialogue box without selection, SI Units will be default.

承 Me	asuring System Selection -	-		×
?	Please select a measurement system below. The default is SI. If you choose any system, the default profile is active.	u do no	ət	

#### **PROJECT INFORMATION PANEL**

On launch of the application post selecting the desired units of measurement, Project Information panel appears in the application which has the following optional inputs to be provided by the user:

- Project Name:
- Engineer Name:
- Route:
- City:
- Date:
- Notes: Any additional notes to be saved for future reference.

PaveSafe v1.0.1	- 0 )
About Help Export Data	
	Project Information
Asphalt Concrete Base subbase	
Pavement Structure	
subgrade	Project Name Engineer Name
GW	
Subgrade Properties	
	Date
Hydrological Information	Notes
Results	NRRAA National Road Research Alliance

The Pavement Structure, Subgrade Properties, Hydrological Information and Results Panels can be accessed by pressing the individual buttons on the left-hand side of the application screen. If these buttons are pressed again then the button is de-selected, and it brings the users back to the Project Information Panel.

#### **PAVEMENT STRUCTURE PANEL**

The Pavement Structure panel requires the user to input thickness (in units of cm or inch), resilient modulus (in units of MPa or ksi) and saturated hydraulic conductivity (in units of m/hour or ft/s) for Asphalt Concrete, Base and Subbase layers. Please note that it is not required to provide saturated hydraulic conductivity for the Asphalt Concrete layer. The users may choose to use the default values provided. The field "Type" was added in PaveSafe v1.0.2 and it provides the user 2 dropdowns to choose default values for AASHTO or MnDOT Class with respect to Base and Subbase selection (if other agencies provide us with their default materials and corresponding properties, those will be added to the selection drop-box). Note that, the units will change when US Customary is selected.



In order to remove Base and Subbase layers from calculations in case those layers do not exist, users may opt to uncheck the respective selection check boxes. By default, these layers are selected for calculations.

## SUBGRADE PROPERTIES PANEL

		Subg	rade Properties
Asphalt Concrete Base			
Subbase Pavement Structure			
	Soil Type	Coarse Grained 🔻	Saturated Hydraulic Conductivity
	Soil Category	A-2-4	Input Value  • Estimate
subgrade			Void Ratio, e 0.6
GW	Resilient Modu at OMC (MPa)	alus 65	Effective Grain Size, D10 (mm) 0.02
Subgrade Properties			Ks saturated (m/hour) 0.002
	van Genuchter	n's SWRC parameters	
	$\alpha vG(1/m)$	90	Estimate Ks
Hydrological	nvG (-)	3	
Information			
			University of
Results			NICC // New Hampshire
			National Road Research Alliance
PaveSafe v1.0.1 About Help Export Data			- 🗆 X
		Sub	grade Properties
Asphalt Concrete		Sub	grade Properties
Asphalt Concrete Base subbase Pavement Structure		Sub	grade Properties
Asphalt Concrete Base subbase Pavement Structure	Soil Type	Sub Fine Grained V	grade Properties Saturated Hydraulic Conductivity
Asphalt Concrete Base subbase Pavement Structure	Soil Type Soil Category	Fine Grained       ▼       A-4	grade Properties           Saturated Hydraulic Conductivity           Input Value         Estimate
Asphalt Concrete Base subbase Pavement Structure	Soil Type Soil Category	Sub Fine Grained V A-4 V	Saturated Hydraulic Conductivity
Asphalt Concrete Base subbase Pavement Structure	Soil Type Soil Category Resilient Mod at OMC (MPa)	Sub Fine Grained A-4 40	grade Properties          Saturated Hydraulic Conductivity         Input Value       • Estimate         Void Ratio, e       0.8         Liquid Limit (%)       10
Asphalt Concrete Base subbase Pavement Structure	Soil Type Soil Category Resilient Mod at OMC (MPa)	Sub Fine Grained A-4 ulus 40	grade Properties Saturated Hydraulic Conductivity Input Value  Estimate Void Ratio, e 0.8 Liquid Limit (%) 10 Ks saturated (m/hour) 0.0002
Asphalt Concrete Base subbase Pavement Structure	Soil Type Soil Category Resilient Mod at OMC (MPa)	Sub Fine Grained A-4 ulus 40	grade Properties Saturated Hydraulic Conductivity Input Value •Estimate Void Ratio, e 0.8 Liquid Limit (%) 10 Ks saturated (m/hour) 0.0002
Asphalt Concrete Base subbase Pavement Structure	Soil Type Soil Category Resilient Mod at OMC (MPa) van Genuchte guG (1/m)	Subj Fine Grained A-4 ulus 40 n's SWRC parameters	grade Properties Saturated Hydraulic Conductivity Input Value • Estimate Void Ratio, e 0.8 Liquid Limit (%) 10 Ks saturated (m/hour) 0.0002 Estimate Ks
Asphalt Concrete Base subbase Pavement Structure	Soil Type Soil Category Resilient Mod at OMC (MPa) <i>van Genuchte</i> αvG (1/m)	Sub Fine Grained  Fine Graine	grade Properties Saturated Hydraulic Conductivity Input Value • Estimate Void Ratio, e 0.8 Liquid Limit (%) 10 Ks saturated (m/hour) 0.0002 Estimate Ks
Asphalt Concrete Base subbase Pavement Structure wbgrade Subgrade Properties Flydrological Information	Soil Type Soil Category Resilient Mod at OMC (MPa) van Genuchte ανG (1/m) nνG (-)	Subj Fine Grained A-4 ulus 40 n's SWRC parameters 1.6 1.4	grade Properties Saturated Hydraulic Conductivity Input Value • Estimate Void Ratio, e 0.8 Liquid Limit (%) 10 Ks saturated (m/hour) 0.0002 Estimate Ks
Asphalt Concrete Base subbase Pavement Structure Subgrade Properties Subgrade Properties Hydrological Information	Soil Type Soil Category Resilient Mod at OMC (MPa) van Genuchte ανG (1/m) nvG (-)	Sub Fine Grained A-4 ulus 40 n's SWRC parameters 1.6 1.4	grade Properties Saturated Hydraulic Conductivity Input Value • Estimate Void Ratio, e 0.8 Liquid Limit (%) 10 Ks saturated (m/hour) 0.0002 Estimate Ks
Asphalt Concrete Base subbase Pavement Structure wbgrade Subgrade Properties Hydrological Information	Soil Type Soil Category Resilient Mod at OMC (MPa) van Genuchte αvG (1/m) nvG (-)	Subj Fine Grained A-4 ulus 40 n's SWRC parameters 1.6 1.4	grade Properties          Saturated Hydraulic Conductivity         Input Value       • Estimate         Void Ratio, e       0.8         Liquid Limit (%)       10         Ks saturated (m/hour)       0.0002         Estimate Ks
Asphalt Concrete Base subbase Pavement Structure Subgrade Properties Hydrological Information	Soil Type Soil Category Resilient Mod at OMC (MPa) van Genuchte αvG (1/m) nvG (-)	Sub Fine Grained A-4 ulus 40 n's SWRC parameters 1.6 1.4	grade Properties          Saturated Hydraulic Conductivity         Input Value       • Estimate         Void Ratio, e       0.8         Liquid Limit (%)       10         Ks saturated (m/hour)       0.0002         Estimate Ks
Asphalt Concrete Base subbase Pavement Structure Understand Subgrade Properties Hydrological Information	Soil Type Soil Category Resilient Mod at OMC (MPa) van Genuchte αvG (1/m) nvG (-)	Subj Fine Grained A-4 ulus 40 n's SWRC parameters 1.6 1.4	saturated Hydraulic Conductivity   Input Value   Koid Ratio, e   Uoid Ratio, e   Liquid Limit (%)   10   Ks saturated (m/hour)   Estimate Ks   Estimate Ks

The default screen for the Subgrade Properties Panel has the following appearance:

The Soil Type dropdown menu controls the Soil Category dropdown and default values of other inputs appearing on the screen. The default value of Soil Type dropdown menu is "Coarse Grained" and can be changed to "Fine Grained".

After the selection of the Soil Type, Soil Category based on AASHTO soil classification system must be selected. Based on the Soil Category default values of other inputs on the screen are populated. Users always have an option to change these values including resilient modus at optimum moisture content (in units of MPa or ksi), van Genuchten's SWRC fitting parameters, void ratio, effective grain size (D10) (in units of mm or inch).

The saturated hydraulic conductivity will be estimated based on either the default soil parameters or the input values, by pressing "Estimate Ks" button. If this button is not pressed, then a default value will be assigned, which may not exactly reflect the Soil Category.

Also, there is an option provided for the user to directly input saturated hydraulic conductivity via selecting the "Input value" radio button under the Saturated Hydraulic Conductivity box, if such value is available (in units of m/hour or ft/s).

A PaveSafe v1.0.1						– 🗆 X
About Help Export Data						
Asphalt Concrete Base subbase			Subgrade Pr	operties		
Pavement Structure						
	Soil Type	Fine Grained	V	Saturated Hydraul	lic Conductivity	
	Soil Category	A-4	V	● Input Value	○ Estimate	
subgrade GW Subgrade Properties	Resilient Modu at OMC (MPa)	ılus 40		Ks saturated (m/hour)	0.0002	
	van Genuchter	's SWRC parameters				
	<i>ανG</i> (1/m)	1.6				
Hydrological Information	nvG (-)	1.4				
Results				NRRAA National Road Research Alliance	Univer New H	sity of ampshire

## HYDROLOGICAL INFORMATION PANEL

Hydrological Information Panel has the following required inputs:

- Period of Analysis (in hour): By default, this value is set to be for 10 days of analysis i.e. 240 hours.
- Input Climatic Data: The precipitation events can be provided as input to the application by first selecting the "Precipitation Event" checkbox and then providing the starting and ending hour values with the rate of precipitation (in units of cm/hour or inch/hour). However, if the box assigned for each precipitation event is not checked, that event would not be considered in the analysis.
- Initial Ponded Water Height (in units of m or ft): By default, we assume there is no ponded water above the ground hence default value is 0.
- Evaporation Rate (in units of m/hour or ft/hour): The default value set inside the application is 0.005 m/hour; however, if there is no ponded water above the ground, there will be no evaporation in the calculations.
- Water Runoff (as % of precipitation): This input is the percentage of precipitation water that runs off from the ground.
- Initial Ground Water Depth (in units of m or ft): This is the depth at which ground water table exists. By default, 3 meters is taken as input value.
- Initial Saturation Condition: The users can select the initial saturation condition of the ground above the water table to be hydrostatic or fully saturated. The default value set is hydrostatic condition above the water table, meaning linear suction profile with depth.

The default screen appears as below:

PaveSafe v1.0.1 About Help Export Data				- 0	×
			Hydrologica	al Input	
Asphalt Concrete Base	Period of Analysis (hour)	240			
subbase Pavement Structure	Precipitati	ion Data Method Se	election		
	<ul> <li>Input Climatic Data</li> </ul>	O Import Precip	litation Time History		
	Precipitation S	Start End	Rate		
subgrade	Event (h	hour) (hour)	(cm/hour)		
GW		0 0	0		
Subgrade Properties		0 0	0		
		0 0	0		
		0	0		
	Initial Ponded Water Height (m)	0	]		
Information	Evaporation Rate (m/hour)	0.005			
	Water Runoff (% of Precipitation	i) 0 3	1	Schematic Help View Plot Clear Plot	
	mitial Ground Water Depth (m)	5			
~~~	Initi	ial Saturation Condition		NDD A University of	
Results	Hydrosta	atic Condition $\bullet$			nire
				National Road Research Alliance	

After providing the precipitation event data, the user can view the plot of precipitation data by clicking "View Plot" button and "Clear Plot" to clear the plot from the screen. A view plot example is as shown below:

About Help Export Data		Hydrologi	cal Input
Asphalt Concrete Base subbase Pavement Structure	Period of Analysis (hour) Precipitation Dat	240 a Method Selection	
subgrade Properties	<ul> <li>● Input Climatic Data</li> <li>Precipitation Start Event (hour)</li> <li>○</li> <li>○</li> <li>○</li> <li>○</li> <li>○</li> <li>○</li> <li>○</li> </ul>	End         Rate           (hour)         (cm/hour)           10         0.0!           0         0           0         0           0         0           0         0	Precipitation vs Time
Hydrological Information	0 Initial Ponded Water Height (m) Evaporation Rate (m/hour) Water Runoff (% of Precipitation) Initial Ground Water Depth (m)	0 0 0.005 0 3	0 50 100 150 200 250 0 50 100 150 200 250 Time (hour) Schematic Help View Plot Clear Plot
Results	Initial Satu Conditi Hydrostatic Con	ration on dition ▼	NRRAA Netional Road Research Alliance University of New Hampshire

Note that currently the option to import precipitation time histories are disabled as this feature is projected to be accommodated in future release.

In PaveSafe v1.0.2, a "Schematic Help" button was introduced explaining the underlying model. The schematic help is mentioned below for reference.



#### **RESULTS PANEL**



By default, the results panel has the following appearance:

The users can opt to select the desired vehicle class and a representative image of that vehicle class will appear on the screen.

As input to the application, users can set the Pavement Surface Deflection Threshold for Road Caution and Road Closure (in mm or inch). By default, these values are set to 1 mm (0.04 inch) and 1.5 mm (0.06 inch) for Road Caution and Road Closure, respectively.

After the inputs are provided or retained, the application is ready to run. To run the application please press the "Run" button appearing on the screen.

While the model is running the "Run" button turns Yellow in color and users must wait until the model has completed the run cycle. The running state appears as below:



Once the model has finished its run cycle, the "Run" button turns **Green** and the deflection results are displayed on the figure at the top as a graph. A bell sound alerts the user of completed run. Also, safe passage information is visible at the bottom of the graph giving information about the condition of the road with respect to the selected vehicle class. **Green** Passage means the vehicle is safe to pass, **Yellow** means it is a caution zone and **Red** means completely unsafe. After the run cycle the Results Panel appears as below:



The users are provided the freedom to change the Road Caution and Road Closure values to view the effect on safe passage with the new values. Users must keep in mind that it is required to change the vehicle class to reflect changes with new Road Caution and Road Closure values. Also, any change in the application inputs (excluding changes to Project Information Panel) turns the "Run" button to Gray, which means a new analysis and run are needed.

Note that, users are also provided with a feature to export the analysis data. This feature is available in the Menu Tab and will be explained in detail in the following section.

#### **MENU TAB**

The Menu Tab appears at the top of the application and contains the following options:

- About
- Help
- Export Data

The About menu brings up details about the application in the default browser. It is a pdf file and it has a possibility to be opened within the default pdf viewer on the system.

The Help menu brings up the User Manual for detailed information about the application.

The Export Data menu brings down "Export Excel File" dropdown. When this dropdown is clicked, it asks the users to provide the location where the generated file would be saved. Also, an alert box appears on the screen informing the user about the file generation process. Users may close this alert box, but they must wait until "File Generated" alert appears on the screen before they continue to interact with the application. The output file generated is a Microsoft Excel Worksheet with name "PaveSafe\_ExportData".









📭 PaveSafe\_ExportData

11/23/2020 11:34 PM Microsoft Excel Worksheet 494 KB