# SHRP2 Renewal Project R23
# PAVEMENT RENEWAL SOLUTIONS


**Pavement Design Section**

**Roadway Engineering Group**

**Arizona Department of Transportation**

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ADOT

**ABSTRACT**

One of the goals for the creation of the second Strategic Highway Research Program (SHRP2) was to find strategic solutions to improve methods for renewing roads. This program focused on four areas: safety, renewal, reliability and capacity. This program carried out more than hundred research projects and produced reports and products. One such research, in the area of "renewal", is R23 which dealt with the rapid renewal of roadway pavement while incorporating existing pavements and achieving long life at the same time. This research produced a report titled "Using Existing Pavement in Place and Achieving Long Life" and developed a Web-based Scoping Tool, also known as the "*rePave* Scoping Tool".

In 2014, Federal Highway Administration (FHWA) selected Arizona Department of Transportation (ADOT) as one of the states to take part in the "Implementation Assistance Program" for R23. This report discusses the efforts made by ADOT to find out if "*rePave* Scoping Tool" can be adequately used for scoping a pavement rehabilitation project within Arizona.

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# Chapter 1

# Introduction

In early 2014, ADOT was selected as one of the Lead Adopter States for the implementation of *Pavement Renewal Solutions*. Following a nationwide teleconference on the R23 product in February of 2015, NCE, the subject matter expert and FHWA consultant, introduced and showcased the R23 product to ADOT through a webinar on *Pavement Renewal Solutions*.

In July of 2015, as part of the Agency Assessment process, NCE and FHWA visited ADOT for two days and met with the management teams of ADOT's Pavement Design, Pavement Management and Pre-Design sections. One of the objectives of this visit was to discuss current agency processes related to the identification, prioritization, funding, design, and finally, the construction of pavement rehabilitation & reconstruction projects. Another important objective was to find out how the *Pavement Renewal Solutions* product can be implemented within the agency process. Later, in November of 2015, NCE provided a short, yet concise, training course on the *rePave Scoping Tool* to ADOT Pavement Design and ADOT Pavement Management Sections.

ADOT also implemented the *Pavement Renewal Solutions'* long-life concept on one of its pavement preservation projects. This project, located on US 191 between MP 113.50 and MP 117.30, was initially proposed as a candidate project as part of the application to FHWA for the SHRP2 Implementation Assistance Program. Instead of a routine 10 year rehabilitation design, ADOT Pavement Design Section proposed a 30 year (long life) pavement rehabilitation design for this project.

## *1.1 Problem Statement*

Each year, ADOT Pavement Design Section engineers routinely design and recommend treatments for existing, deteriorated pavement sections throughout the state of Arizona. These deteriorated pavements are located on State Routes, US Highways, and six Interstate Highways which pass through the state. These roadway sections get identified early in the planning phase (pre-scoping and scoping phase) by ADOT Pavement Management Section engineers in consultation with the ADOT Engineering and Maintenance District personnel and are given a very preliminary rehabilitation recommendation. A construction budget is usually prepared based on this preliminary recommendation. During the design phase, where more project-specific data (such as pavement coring and falling weight deflectometer results) become available, ADOT Pavement Design Section engineers use various pavement design tools to refine and finalize the rehabilitation recommendation.

In Arizona, the overwhelming majority of pavements which receive rehabilitation each year are Asphaltic Concrete (AC) type pavements. One very common method of asphaltic pavement rehabilitation is milling of the existing pavement and replacing it with an overlay of new asphaltic concrete pavement. This treatment happens to be one of the flexible pavement renewal approaches described in the SHRP2 R23 research report titled, "Using the Existing Pavement In-Place and Achieving Long Life." Often times, it is found that the final rehabilitation recommendation during the design phase varies from what had been recommended during the planning and scoping stage which triggers changes in the final construction budget. In many cases, this can result in project funding challenges.

With the availability of the *rePave Scoping Tool*, which is at the core of SHRP2 R23 product, ADOT engineers would like to compare this tool's rehabilitation recommendation with those they acquire from standard ADOT design tools for pavement rehabilitation. If it is determined that the results from the *rePave Scoping Tool* are comparable to those obtained from ADOT's standard design tools, more accurate planning may be possible, resulting in fewer project funding issues.

### *1.2 Methodology for the rePave Scoping Tool Implementation within ADOT*

To accomplish this, five (5) pavement rehabilitation projects on interstate highways were initially identified for which the design data (such as FWD) were available. These are as follows:

1) Pavement Section on I-8 between MP 20.0 and MP 29.0
2) Pavement Section on I-10 between MP 363.0 and MP 367.0
3) Pavement Section on I-17 between MP 232.0 and MP 245.0
4) Pavement Section on I-19 between MP 32.0 and MP 42.0
5) Pavement Section on I-40 between MP 166.0 and MP 179.0

However, due to some unavoidable reasons, the pavement section on I-40 was later dropped from this list. As part of collecting the input parameters for the rePave software, pavement core exploration was conducted by ADOT Geotechnical Services crews on the above-mentioned highways to find out if existing cracks were full-depth or top-down. In addition, pavement distress surveys were also conducted to determine the severity and extent of existing pavement distresses such as cracking and rutting. Finally, the collected data was used in the analysis of the pavement rehabilitation using the *rePave Scoping Tool*.

The following objectives were expected to be met during this project implementation effort:

1) ADOT Pavement Design Section engineers would gain experience using the rePave software and would become familiar with other resources available on the website.
2) Although rePave is a scoping software, for comparison purposes, results from this tool would be compared with those from regular ADOT's standard pavement design methods.
3) Once comfortable with the implementation of the rePave tool, ADOT Pavement Design Section would introduce this scoping software to ADOT Pre-Design Section who prepares and/or reviews scoping documents for State Highway System (SHS) pavement rehabilitation projects. The goal is to implement the rePave software in the development process as early as possible.
4) In the future, ADOT Pavement Management Section and ADOT Multimodal Planning Division may consider using this tool during the pre-scoping of pavement rehabilitation projects.

### *1.3 rePave Scoping Tool Implementation Approach*

A comprehensive background study was conducted to collect existing information on four (4) pavement rehabilitation project sites mentioned above. This information included review of record drawings, past pavement design reports, traffic data, geotechnical data etc. Visits were made to these sites to conduct visual distress survey, and also, to collect data from pavement coring operation. Finally, these data were used to run the rePave software and results were compared with those from commonly-used ADOT pavement design & rehabilitation tools.

# Chapter 2

## Background Data Collection

This chapter presents a review of existing information on four (4) pavement sections indicated in Chapter 1. It includes information on existing pavement configuration, existing traffic information, and existing subgrade soil data for these pavement sections. This information is necessary, as input parameters, for the rePave software as well as ADOT pavement design tools.

### *2.1 Existing Pavement Configuration*

Table 2.1 below shows the interstate highway pavement sections chosen for the analysis. ADOT Engineering Records and ADOT's Data Warehouse were used to obtain record drawings (for the pavement rehabilitation/construction projects) for these sections dating back to the initial construction of these sections. These drawings provided useful information such as pavement layers originally constructed, types of pavement layer materials along with the layer depths, dates of initial construction and any subsequent rehabilitation.

**Table 2.1: Interstate Highway Sections**

| Interstate | Direction | Beginning MP | Ending MP |
|---|---|---|---|
| ***I-8*** | WB | 20.0 | 29.0 |
| ***I-10*** | EB/WB | 363.0 | 367.0 |
| ***I-17*** | NB | 232.0 | 245.0 |
| ***I-19*** | SB | 32.0 | 42.0 |

The Pavement Management System Database, as maintained by ADOT's Pavement Management Section, was also consulted to verify the details found in the record drawings. Figure 2.1 shows the current pavement structures, at these highway sections chosen for the analysis, with all the pavement layers along with the year of construction and/or rehabilitation. It is important to note here that Figure 2.1 may not show all the rehabilitation performed at each site since the initial construction. However, it shows the pavement layers that currently exist.

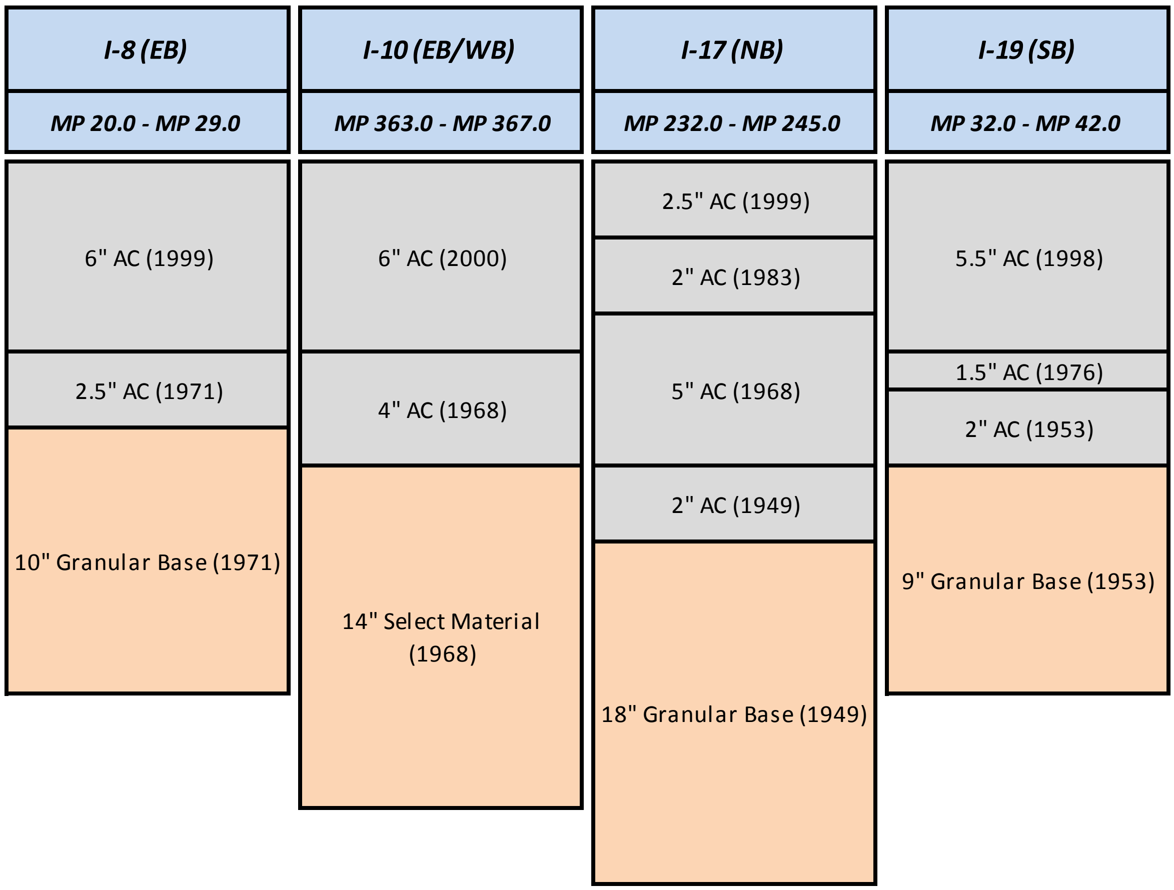


**Figure 2.1: Existing Pavement Structures at Highway Sections**

For example, the highway section on I-10 (between MP 363.0 and MP 367.0) was originally constructed in 1968 with 8 inches of AC over 14" of Select Material. Although this section received an overlay of 2 inches of AC in 1985, this 2 inch overlay along with 4 inches of AC (from the initial 1968 construction) was milled and replaced with 6 inches of AC in 2000 as part of a pavement rehabilitation project. For any rehabilitation project, ADOT performs a design for a 10 year rehabilitation period. However, in most cases, a subsequent rehabilitation of the pavement is not performed in 10 years because of limited pavement rehabilitation funding.

### *2.2 Existing Traffic Information*

Exiting traffic data was collected from ADOT's Multimodal Planning Division database at each of these four (4) locations. Traffic data is typically uploaded to ADOT's website on an annual basis. For the highway sections used in this analysis, traffic data ranging from 2010 to 2014 were used to calculate the ESALs required to run the rePave analysis. Table 2.2 presents traffic data as well as calculated 30 year accumulated ESALs at these highway locations.

**Table 2.2: Traffic Information**

| | Interstate | | | |
|---|---|---|---|---|
| | ***I-8 (EB)*** | ***I-10 (EB/WB)*** | ***I-17 (NB)*** | ***I-19 (SB)*** |
| | **MP 20.0 - MP 29.0** | **MP 363.0 - MP 367.0** | **MP 232.0 - MP 245.0** | **MP 32.0 - MP 42.0** |
| ***Data Year*** | 2014 | 2014 | 2013 | 2012 |
| ***AADT*** | 12,848 | 12,388 | 37,223 | 31,400 |
| ***Single Trucks (%)*** | 771 | 483 | 967 | 1,184 |
| ***Combo Trucks (%)*** | 2,595 | 4,336 | 3,758 | 1,600 |
| ***Growth Rate (%)*** | 1.94 | 2.87 | 2.10 | 1.30 |
| ***1 Year Design ESALs (in millions)*** | 0.763 | 1.207 | 1.102 | 0.504 |
| ***30 Year Design ESALs (in millions)*** | 30.675 | 56.233 | 45.397 | 18.357 |

***2.3 Subgrade Soil Information***

Subgrade soil characteristics, such as type and strength, were collected from a historical database showing resilient modulus values all across the state. Table 2.3 below shows the approximate existing resilient modulus values at the highway sections as well as the resilient modulus values selected for the analysis. It is important to mention here that the rePave tool only allows for the choice among 5,000 psi, 10,000 psi, or 20,000 psi, and therefore, the historical modulus value closest to one of these three (3) values was selected for the analysis.

**Table 2.3: Subgrade Modulus**

| | Interstate | | | |
|---|---|---|---|---|
| | ***I-8 (EB)*** | ***I-10 (EB/WB)*** | ***I-17 (NB)*** | ***I-19 (SB)*** |
| | **MP 20.0 - MP 29.0** | **MP 363.0 - MP 367.0** | **MP 232.0 - MP 245.0** | **MP 32.0 - MP 42.0** |
| ***Historical Resilient Modulus Value (psi)*** | 15,900 | 18,100 | 13,800 | 14,900 |
| ***Design Resilient Modulus Value (psi)*** | 20,000 | 20,000 | 10,000 | 20,000 |

# Chapter 3

## Field Data Collection

This chapter presents a review of field data collection effort on the pavement sections indicated in Chapter 1. During the field visit, two goals were accomplished: the first one was an in-depth visual distress survey of the existing pavement surface, and the second one was to take a look at the pavement sub-surface condition through the analysis of pavement cores.

### *3.1 Visual Distress Survey*

A distress evaluation form was prepared and used during each field visit. The purpose of the form was to collect existing pavement distress information which would later be used to run the rePave software. Figure 3.1 below shows the completed distress evaluation form during I-10 field visit (between MP 363.0 and MP 367.0).

**DISTRESS EVALUATION FOR SHRP R23 PROJECT**

Project Number: M516101X Project Name: WB & EB I-10 (MP 363 to MP 367) Date: 7/26/2016

| CORE INFORMATION | | | | | | | | | | PAVEMENT CONDITION | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Core No | Milepost | Dir | Lane # | R* C L | Depth (inch) | Core Condition ** | Crack Type*** (A-T-L) | Crack Top down or Bottom up | Crack Depth (inch) | Fatigue Cracking % (wheel path) Low | Med. | High | Patching (%) (w.p.) | Rutting (inch) | Transverse Cracking (#/100ft) | Stripping (Depth & Location) | Comments |
| 1 | 363 | EB | 2 | R | 10 | | A | B | 10 | 60 | 20 | | | 0.2 | 20 | | Not recovered |
| 2 | 364 | | 2 | | 11.5 | | T | T | | | | | | | 13 | | |
| 3 | 364 | | 2 | | 12 | | A | Both | | 40 | | | | | | | 5" bottom up; 3" top down; debonded at 3" from top |
| 4 | 364 | | 1 | R | 11.5 | S | A | B | 9 | | | | | | | | |
| 6 | 365 | | 2 | R | 10 | | A | B | | 20 | 5 | | | | 15 | | |
| 7 | 365 | | 2 | C | 10.5 | | L | T | 7 | | | | | | | | |
| 8 | 366 | | 2 | | 10 | | A | Both | | 50 | | | | | | | 3" bottom up; 2.5" top down |
| 9 | 366 | | 2 | | 11 | | T | B | | | | | | | 21 | | |
| 10 | 366 | | 1 | R | 7.5 | S | A | B | 5 | | | | | | | | |
| 11 | 367 | | 2 | R | 12.5 | | A | T | | 40 | 30 | | | | 15 | | |
| 2 | 365 | WB | 2 | R | 10 | | A | B | | 10 | | 20 | | 0.2 | 7 | | Broken pieces - not recovered |
| 3 | 365 | | 2 | R | 10.5 | Intact | NC | | | | | | | | | | |
| 4 | 365 | | 1 | L | 12 | B | A | T | 4 | | | | | | | | |
| 5 | 364 | | 2 | R | 10.5 | | A | T | 4 | 60 | 30 | | | | 16 | | |
| 6 | 364 | | 2 | | 11 | | T | B | | | | | | | | | |
| 7 | 363 | | 2 | R | 10.5 | | A | B | | 50 | 5 | | | | 5 | | |

* RCL: R=Right Wheel path; C=Center of the lane; L=Left Wheel path
** Core Condition: I= Intact; B=Broken; S=Stripped
*** Crack Type: A=Aligator; T=Transverse; L=Longitudinal; NC=No Crack

**Figure 3.1: Completed Distress Evaluation Form for I-10 (MP 363.0 to MP 367.0)**

Figure 3.1 also shows pertinent pavement core information collected for this study. The information includes the location and depth of the core, type and extent of existing pavement cracks, rutting and relevant core-specific comments. Within the project limits, a 100 foot roadway segment at each milepost was initially identified prior to performing the visual distress survey, as seen in Figure 3.2.

**Figure 3.2: 100' Roadway Segment Identification for the Distress Evaluation Survey**

Within the 100 foot roadway segment, the extent and severity of alligator cracks, the number of transverse cracks, rutting depth and extent of patching were measured. Alligator cracks in the wheel paths were evaluated and measured using three levels of severity (Low, Medium and High). This information was later used as inputs for the rePave tool. Figure 3.3 and Figure 3.4 show some of the distress evaluation activities during the field visits.

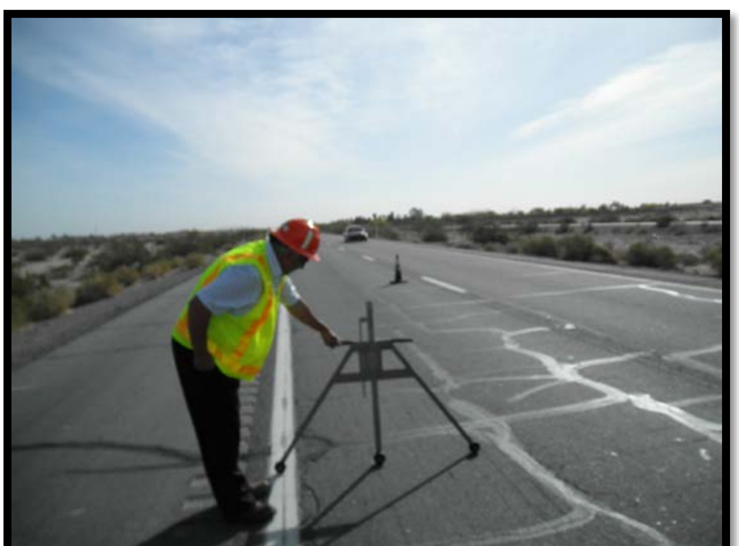

**Figure 3.3: Rut Measurement on I-8**


**Figure 3.4: Low (Top) & High (Bottom) Severity Alligator Crack**

### *3.2 Pavement Coring Operation*

The same distress evaluation form was also used to record pavement core information obtained at each site. Pavement designers, in collaboration with ADOT's Geotechnical Exploration Services and District Traffic Control Section, performed pavement core extractions. At each milepost, two or three pavement coring locations were identified. Coring was performed at crack locations to represent transverse cracks, alligator cracks, longitudinal cracks, and also, at some non-crack locations. During coring operation, the depth of each crack, whether it was either top-down or full depth, was determined because this information is an important input parameter for the rePave software. Figure 3.5 and Fig 3.6 show the step by step procedure for the pavement coring operation at a crack location on I-19 which included the identification/marking of the core location, actual coring operation by ADOT personnel, measurement and analysis. The AC layer thickness at this location was measured to be 8 inches and the crack was found to be full depth.

**Figure 3.5: Marked Location on I-19 (for Core #10)**


**Figure 3.6: Pavement AC Layer Depth Measurement and Analysis**

An example of the coring operation on I-10 (Core # 2) is shown in Figure 3.7 thru Figure 3.9. High severity alligator cracks were noticed at this location in the right wheel path of the travel lane and the core depth was measured to be approximately 10 inches.


**Figure 3.7: Marked Location on I-10 (WB) for Core #2 (MP 365)**

Since the core could not be recovered intact, it was necessary to measure the existing AC layer thickness using the extraction hole with a measuring tape. This core provided information such as signs of stripping within the asphaltic layer.

**Figure 3.8: AC Core Depth Measurement on I-10 (WB)**

**Figure 3.9: Signs of "Stripped" AC Layer on I-10 (WB)**

A third example of the coring operation is shown in Figure 3.10 and 3.11. This core location was also on I-10 (Core #3), however, coring was performed on a non-crack location (very close to Core #2). Similar to Core #2, this core location was also selected on the right wheel path of the travel lane in order to compare the impact of distresses on underlying pavement layers at the same location (MP 365).

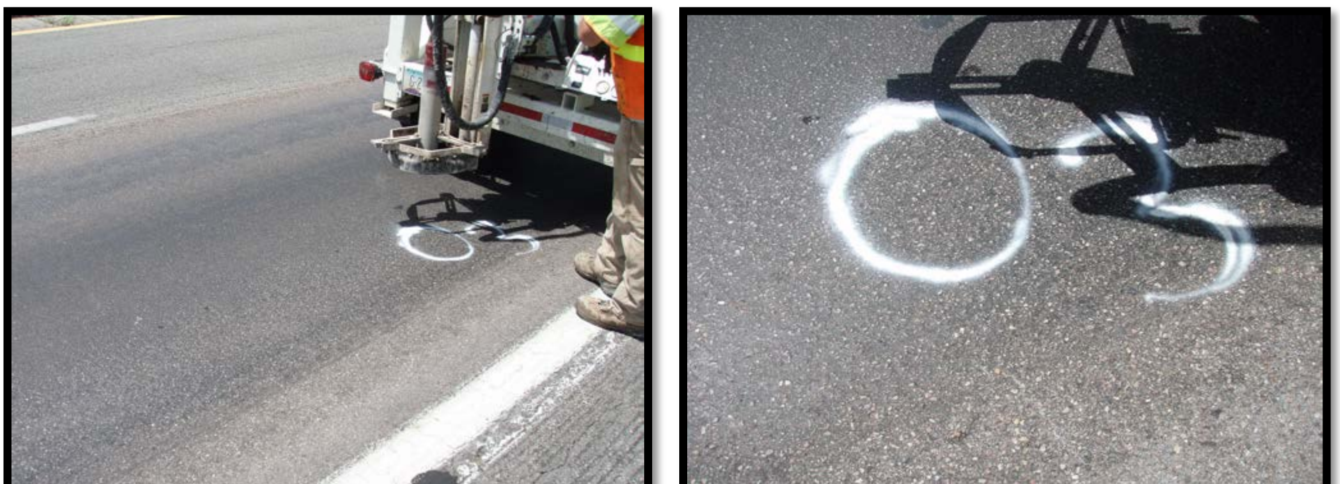

**Figure 3.10: Marked Location on I-10 (WB) for Core #3 (MP 365)**

Upon extraction of this core, it was determined that the sub-surface pavement at this location was in excellent condition with no stripping and the pavement core was found to be entirely intact (Figure 3.11).

**Figure 3.11: Measurement of Core #3 on I-10 (WB)**

The interesting finding here was the dramatic difference between the sub-surface conditions of existing pavement layers at approximately the same location, however, one location *with* and the other *without* any alligator cracks.

# Chapter 4

## Data Analysis with the rePave Scoping Tool

Pavement related data, as discussed in the previous two chapters, were collected and used to perform analysis using the *rePave Scoping Tool*. As the visual distress data and core information varied along the highway at each milepost, data collected from each 100 foot segment (at each milepost of highway section) was carefully reviewed by the designer, and finally, a particular milepost location was selected which would best represent the entire section of the highway.

For flexible pavements, the *rePave Scoping Tool* proposes three (3) alternatives which include the following: 1) Pulverizing of the existing AC and overlaying with new AC, 2) Pulverizing and treating the existing AC and overlaying with AC, and 3) Milling existing pavement and replacing with an overlay of AC.

This scoping tool primarily proposes reconstruction for highly deteriorated pavements, yet very few pavements in Arizona qualify to be a candidate for reconstruction. However, in Arizona, several asphaltic pavement rehabilitation projects take place each year with the most typical treatment being "Mill & replace existing asphaltic concrete with or without an AC overlay". Therefore, in order to compare this scoping tool with ADOT's Standard Design Tools, the "Milling existing pavement partially and replacing with an overlay of AC" alternative was chosen for rehabilitation.

In addition, a hypothetical scenario, where the existing AC layer could be completely removed and reconstructed with a new AC layer, was also analyzed. In reality, as indicated earlier, it does not usually happen because of the fact that the majority of Arizona pavements are relatively new and do not usually call for reconstruction.

In summary, the following two scenarios were analyzed for comparison:

1) *Reconstruction*: Reconstruction of the pavement by removing the existing asphaltic concrete completely and replacing it with a new asphaltic concrete layer to carry the design traffic

2) *Rehabilitation*: Rehabilitation of the pavement by milling the existing asphaltic concrete layer partially and replacing with a new asphaltic concrete layer to carry design traffic

In both cases, a design life of 30 years (long life) has been used.

### *4.1 Reconstruction*

Under this scenario, the goal was to completely remove the existing AC layer and reconstruct with new AC layer while keeping the existing base materials in place. As an example, Figure 4.1 shows one of the first inputs required to run the rePave software (e.g. details of existing pavement section configuration for the I-17 project). The user interface for the rePave software is very easy to navigate and requires little time to enter the input parameters.

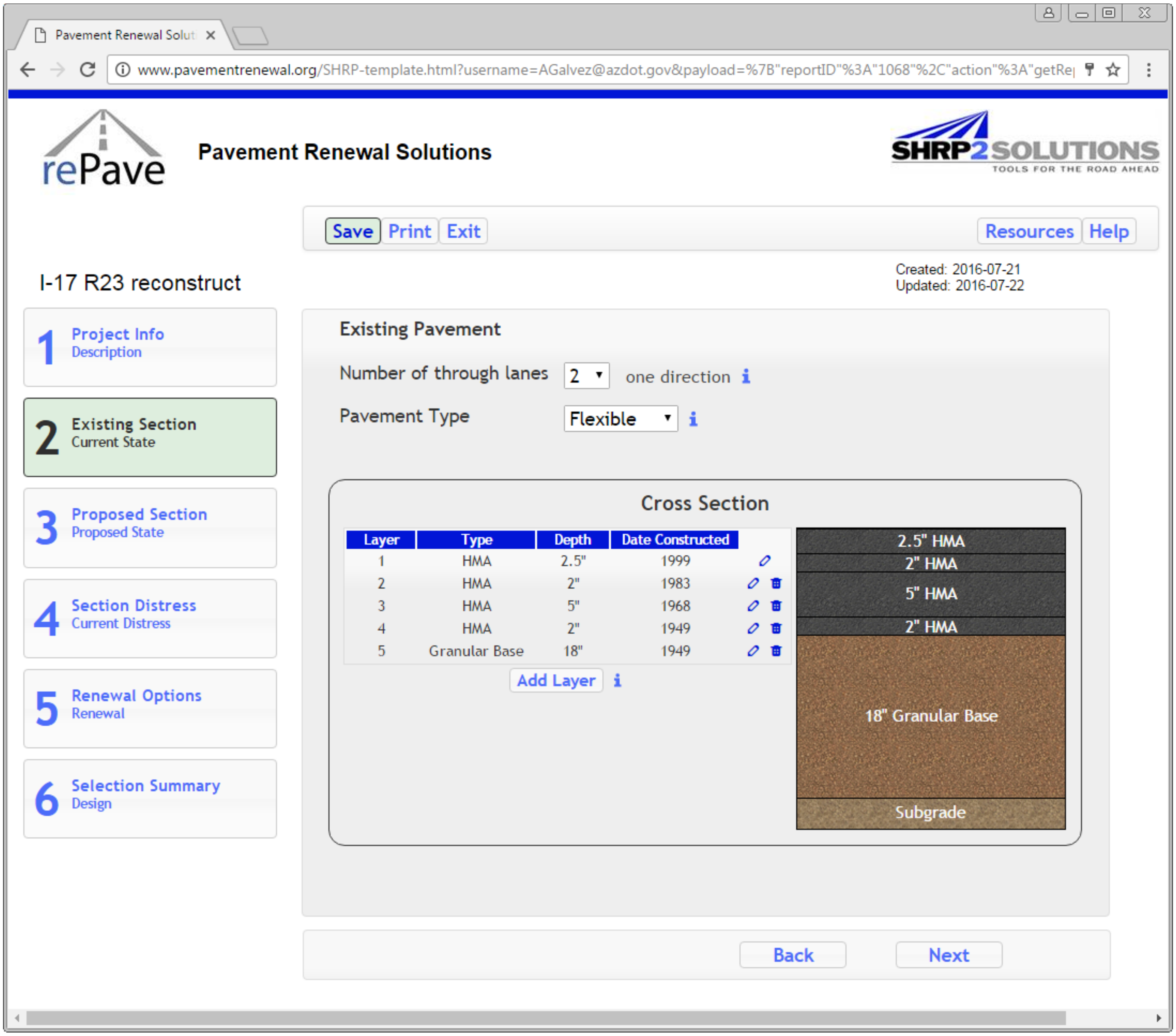


**Figure 4.1: rePave User Interface for Existing Pavement Section Inputs**

These inputs included information regarding design period, existing subgrade modulus, ESALs for the first year, growth rate, current ADT, the number of through lanes and whether or not there were height restrictions. Distress information such as fatigue cracking, patching, rutting, transverse cracking, and stripping, noted on the distress evaluation survey forms, were also used in the analysis**.** One important observation to note here is that the *rePave Scoping Tool* always proposes that the existing AC layer be completely removed in cases where the existing AC layer is either completely stripped or the exiting pavement has full depth fatigue cracks greater than 10% or the pavement shows the presence of even a single transverse crack. Figure 4.2 below shows that the third "Recommended Action" was chosen for this analysis.

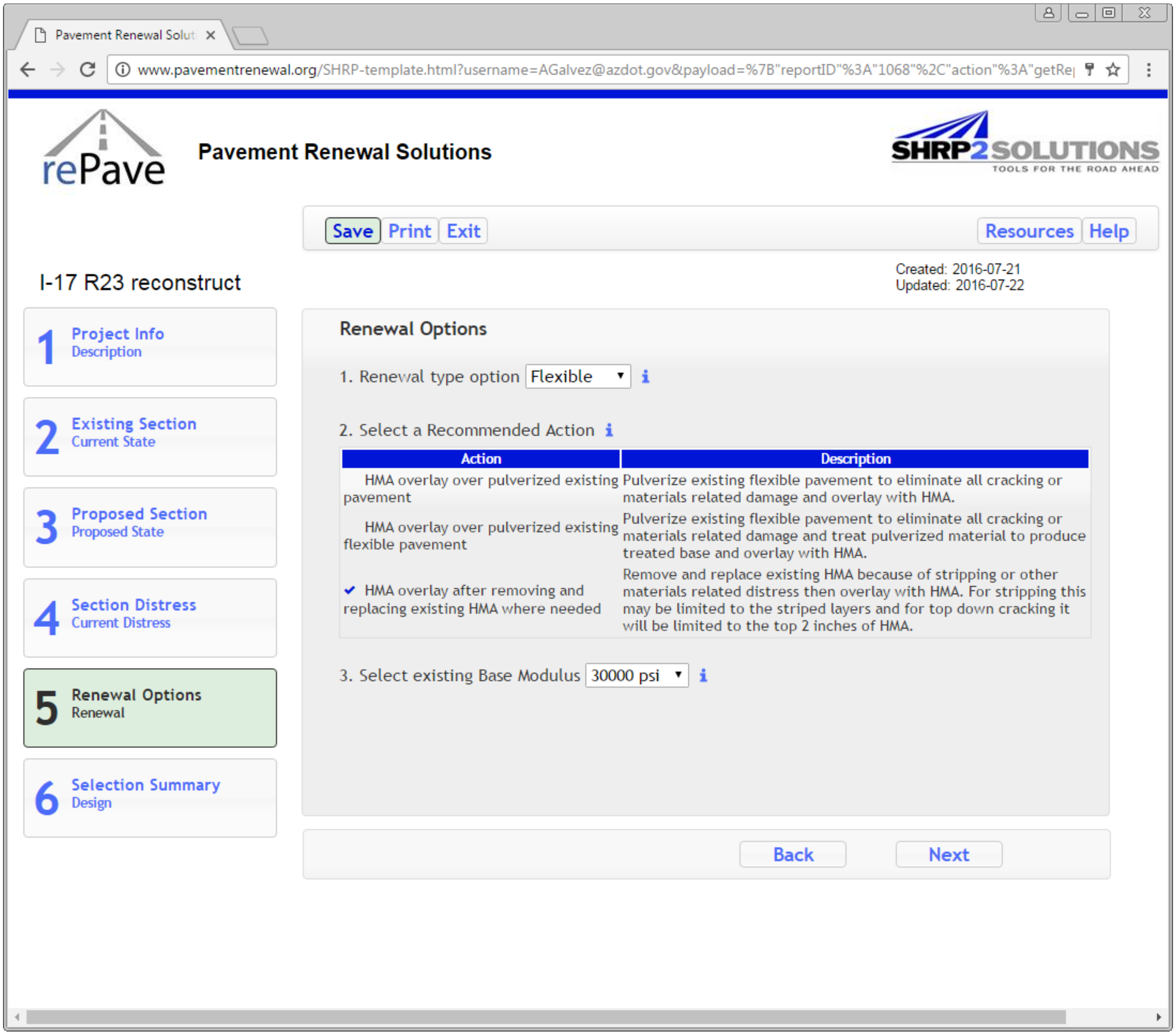


**Figure 4.2: Selection of Recommended Action**

Table 4.1 shows the new AC thickness recommended by the *rePave Scoping Tool,* under the *Reconstruction* scenario, along with the 30 Year accumulated ESALs for each roadway section.

**Table 4.1: New AC Requirement (Reconstruction Scenario) from the *rePave Scoping Tool***

| Interstate | 30 Year ESALs (in millions) | New AC (in inches) |
|---|---|---|
| ***I-8*** | 31 | 11.0 |
| ***I-10*** | 56 | 11.5 |
| ***I-17*** | 44 | 12.0 |
| ***I-19*** | 18 | 10.0 |

### *4.2 Rehabilitation*

Under this scenario, the goal was to mill the existing AC partially and replace with a new AC overlay. Designers chose to design the pavement with both *Shallow* mill (2 ½" to 3") and *Deep* mill (4" to 5 ½") alternatives. However, it was observed that, for pavements with top-down fatigue cracks more than 10 percent, this tool limits the milling of existing AC layer only to two (2) inches. Also, the presence of a single transverse crack in a 100 feet section prompts the scoping tool to propose complete removal of the existing AC layer. Therefore, a different approach was taken to make the software mill to the desired depth and recommend overlay thickness. To go around, certain facts such as presence of any transverse crack (although in reality, it might be present), Full depth fatigue cracks (if the extent is more than 10 percent) were overlooked. In addition, AC layer thickness which needs to be milled was regarded as "Stripped Layer". Figure 4.3 below shows how the distress information (stripped top 2.5" AC layer) was incorporated into the software to facilitate 2.5" milling of existing pavement**.**

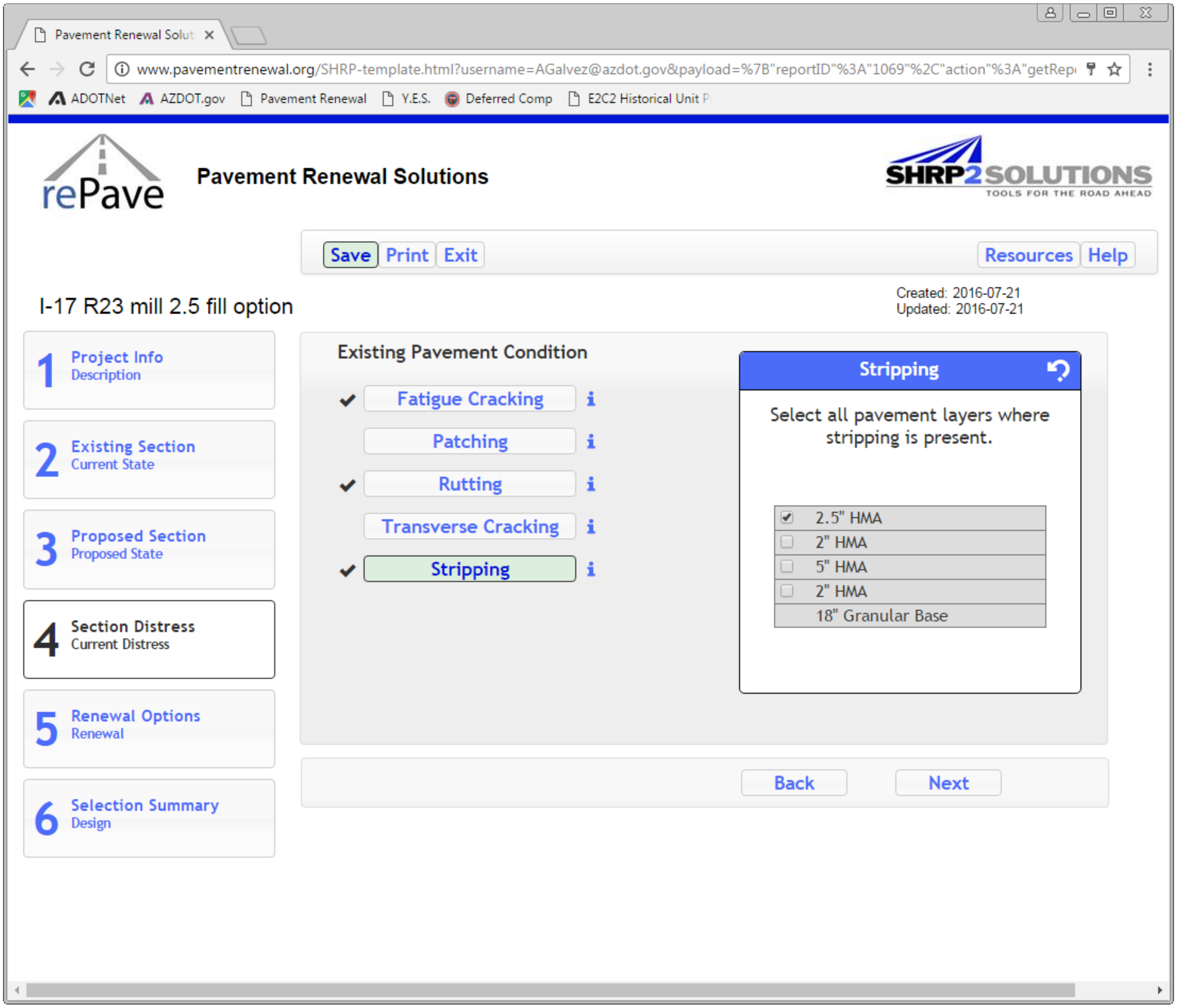


**Figure 4.3: "Stripping" shown in the Top AC Layer (Rehabilitation Scenario)**

Results from the analysis of each section using both the *Shallow* and *Deep* mill options are compiled and presented in Table 4.2.

**Table 4.2: New AC Overlay Requirement calculated from the *rePave Scoping Tool***

| | | Shallow Mill (in inches) | | Deep Mill (in inches) | |
|---|---|---|---|---|---|
| **Interstate** | **30 Year ESALs (in millions)** | **Mill Depth** | **AC Overlay** | **Mill Depth** | **AC Overlay** |
| ***I-8*** | 31 | 2.5 | 5.0 | 4.0 | 6.5 |
| ***I-10*** | 56 | 3.0 | 4.5 | 4.5 | 6.0 |
| ***I-17*** | 44 | 2.5 | 3.0 | 4.5 | 5.0 |
| ***I-19*** | 18 | 2.5 | 3.5 | 5.5 | 6.5 |

# Chapter 5

## Data Analysis with ADOT Pavement Design Tools

ADOT Pavement Design Section's standard pavement design methods include the following:

1) AASHTO (1993) Pavement Design Method
2) AASHTOWare Pavement Mechanistic Empirical (ME) Design Method
3) Structural Overlay Design Method for Arizona (SODA)

ADOT uses the AASHTO (1993) and Pavement ME design methods for both new construction & rehabilitation. In order to give a complete and fair assessment and comparison between the rePave scoping tool and the ADOT pavement design tools, equivalent inputs were used to the extent possible for each method. To ensure the design tool inputs were the same as scoping tool inputs, in some cases, designers had to tweak some of the inputs in order to justify a good comparison.

It is important to mention that ADOT regularly uses the SODA method in the design of any flexible pavement rehabilitation project. This design method primarily uses deflection information from Falling Weight Deflectometer (FWD) tests, International Roughness Index (IRI) and a Seasonal Variation Factor to recommend an AC thickness for a specified design ESAL (i.e. Design Life). Although the SODA method uses different input parameters than the above-mentioned AASHTO methods, results from the SODA method are included in this report for comparison purposes.

Again, the two (2) scenarios, indicated in the previous chapter, were considered for comparison purpose:

1) Reconstruction: Reconstruction of the pavement by removing the existing asphaltic concrete completely and replacing it with a new asphaltic concrete layer to carry the design traffic

2) Rehabilitation: Rehabilitation of the pavement by milling the existing asphaltic concrete layer partially and replacing with a new asphaltic concrete layer to carry design traffic

### *5.1 Reconstruction*

With the AASHTO (1993) design method, a component analysis was used in order to design the pavements. In order to keep the design as consistent as possible with the rePave analysis, the same input values were used for ESALs, resilient modulus, and existing base material type and thickness. For other input parameters, ADOT Pavement Design Guidelines (for Interstate Highway) were consulted. The layer coefficient value for existing aggregate base was assumed to be 0.11. Finally, the required Structural Number (SN) was calculated, and thereby, the required thickness of new AC was determined.

Again, for the Pavement ME design method, equivalent input values were used in order to keep the designs consistent with each other. These included the resilient modulus and the existing base material thickness. Virtual climate stations, based on the location of the project within the state, were used. Traffic information mentioned in Table 2.2 was used in the design.

The results from these two design methods are shown in Table 5.1.

**Table 5.1: New AC Requirement (Reconstruction Scenario) from ADOT Design Tools**

| *Interstate* | *30 Year ESALs (in millions)* | *New AC (Inches) AASHTO (1993)* | *New AC (Inches) Pavement ME* |
|---|---|---|---|
| ***I-8*** | 31 | 9.0 | 12.5 |
| ***I-10*** | 56 | 10.5 | 13.5 |
| ***I-17*** | 44 | 11.0 | 12.0 |
| ***I-19*** | 18 | 8.5 | 10.5 |

***5.2 Rehabilitation***

Design with both *Shallow* mill (2 ½” to 3”) and *Deep* mill (4” to 5 ½”) options were performed to calculate the required thickness of the new AC overlay. AASHTO (1993) and Pavement ME design methods were used for the analysis. For the AASHTO (1993) design method, the layer coefficient value for existing AC was assumed to be 0.30.

Finally, the SODA design method was used for analysis as FWD and IRI data was available for all these pavement sections. As indicated earlier, the ADOT Pavement Design Section regularly uses the SODA design method to perform pavement overlay design.

The results from all three (3) methods are shown in Table 5.2:

**Table 5.2: New AC Overlay Requirement (Rehabilitation Scenario) from ADOT Design Tools**

| Shallow Mill (in inches) | | | | | |
|---|---|---|---|---|---|
| **Interstate** | ***30 Year ESALs (in millions)*** | ***Mill Depth*** | ***AC Overlay (AASHTO 1993)*** | ***AC Overlay (Pavement ME)*** | ***AC Overlay (SODA)*** |
| ***I-8*** | 31 | 2.5 | 5.0 | 5.5 | 3.9 |
| ***I-10*** | 56 | 3.0 | 5.5 | 5.5 | 8.0 |
| ***I-17*** | 44 | 2.5 | 5.0 | 3.5 | 5.8 |
| ***I-19*** | 18 | 2.5 | 5.0 | 4.5 | 4.2 |
| **Deeper Mill (in inches)** | | | | | |
| **Interstate** | ***30 Year ESALs (in millions)*** | ***Mill Depth*** | ***AC Overlay (AASHTO 1993)*** | ***AC Overlay (Pavement ME)*** | ***AC Overlay (SODA)*** |
| ***I-8*** | 31 | 4.0 | 6.0 | 6.5 | 4.5 |
| ***I-10*** | 56 | 4.5 | 6.5 | 7.0 | 8.0 |
| ***I-17*** | 44 | 4.5 | 6.5 | 5.5 | 5.5 |
| ***I-19*** | 18 | 5.5 | 6.0 | 7.5 | 5.5 |

# Chapter 6

## Comparison of Results (rePave Scoping Tool vs ADOT Design Tools)

The main objective of this project was to compare the output from the rePave tool with those from regular ADOT design tools (AASHTO 1993, Pavement ME and SODA). If the outputs are found to be reasonably close, then the rePave tool can possibly be used for a pavement rehabilitation project, during the scoping phase, when detailed design data is not usually available.

This chapter compares the results from the rePave Scoping Tool with those from ADOT Design Tools for all four interstate (I-8, I-10, I-17 & I-19) pavement sections. Comparisons were made for *Reconstruction* scenario as well as *Rehabilitation* scenario. Under *Rehabilitation* scenario, separate analyses were performed for both *Shallow* mill (2.5" to 3") and *Deep* mill (4" to 5.5") options. Table 6.1 shows the new AC thickness requirement, calculated using the rePave scoping tool and the ADOT design tools, for a 30-year design life.

**Table 6.1: Comparison of Required New AC (in Inches) calculated from Scoping & Design Tools**

| | | Route | | | |
|---|---|---|---|---|---|
| | | ***I-8*** | ***I-10*** | ***I-17*** | ***I-19*** |
| **Criteria** | *ESAL'S (in millions)* | 31 | 56 | 44 | 18 |
| | *Base Thickness (inches)* | 10 | 14 | 18 | 9 |
| **Reconstruction** | | | | | |
| **Design Thickness (inches)** | ***rePave*** | 11.0 | 11.5 | 12.0 | 10.0 |
| | ***AASHTO (1993)*** | 9.0 | 10.5 | 11.0 | 8.5 |
| | ***Pavement ME*** | 12.5 | 13.5 | 12.0 | 10.5 |
| **New AC Overlay (OL) w/ Shallow Mill Option** | | | | | |
| **Criteria** | *Milled Depth (inches)* | 2.5 | 3.0 | 2.5 | 2.5 |
| | *Remaining AC Layer Thickness (inches)* | 6.0 | 7.0 | 9.0 | 6.5 |
| **Design OL Thickness (inches)** | ***rePave*** | 5.0 | 4.5 | 3.0 | 3.5 |
| | ***AASHTO (1993)*** | 5.0 | 5.5 | 5.0 | 5.0 |
| | ***Pavement ME*** | 5.5 | 5.5 | 3.5 | 4.5 |
| | ***SODA*** | 2.5 | 8.0 | 3.0 | 3.0 |
| **New AC Overlay (OL) w/ Deep Mill Option** | | | | | |
| **Criteria** | *Milled Depth (inches)* | 4.0 | 4.5 | 4.5 | 5.5 |
| | *Remaining AC Layer Thickness (inches)* | 4.5 | 5.5 | 7.0 | 3.5 |
| **Design OL Thickness (inches)** | ***rePave*** | 6.5 | 6.0 | 5.0 | 6.5 |
| | ***AASHTO (1993)*** | 6.0 | 6.5 | 6.5 | 6.0 |
| | ***Pavement ME*** | 6.5 | 7.0 | 5.5 | 7.5 |
| | ***SODA*** | 4.5 | 8.0 | 5.5 | 5.5 |

Under the *Reconstruction* scenario, the rePave tool predicted thickness results which fell between the AASHTO (1993) and Pavement ME design tools. The rePave results were found to be consistently higher than the AASHTO (1993) results, and generally, lower than the Pavement ME results.

Under the *Rehabilitation* (Shallow Mill) scenario, thickness results from the rePave scoping tool were consistently found to be lower than the Pavement ME results. However, the results were well within an acceptable range (0" to 1"). When compared with the AASHTO (1993) design method, rePave results were either the same or lower.

Under the Rehabilitation (Deep Mill) scenario, thickness results from the rePave scoping tool were lower than or equal to the Pavement ME results. The results were well within the acceptable range (0" to 1"). When compared with AASHTO (1993) method, the results were mixed.

Finally, the results from the rePave tool and the SODA method were not comparable, most likely because of the fact that these are two very different pavement analysis tools. In addition, these tools require very different input parameters for the analysis. Figure 6.1 thru Figure 6.4 show the graphic representations of the results from Table 6.1.

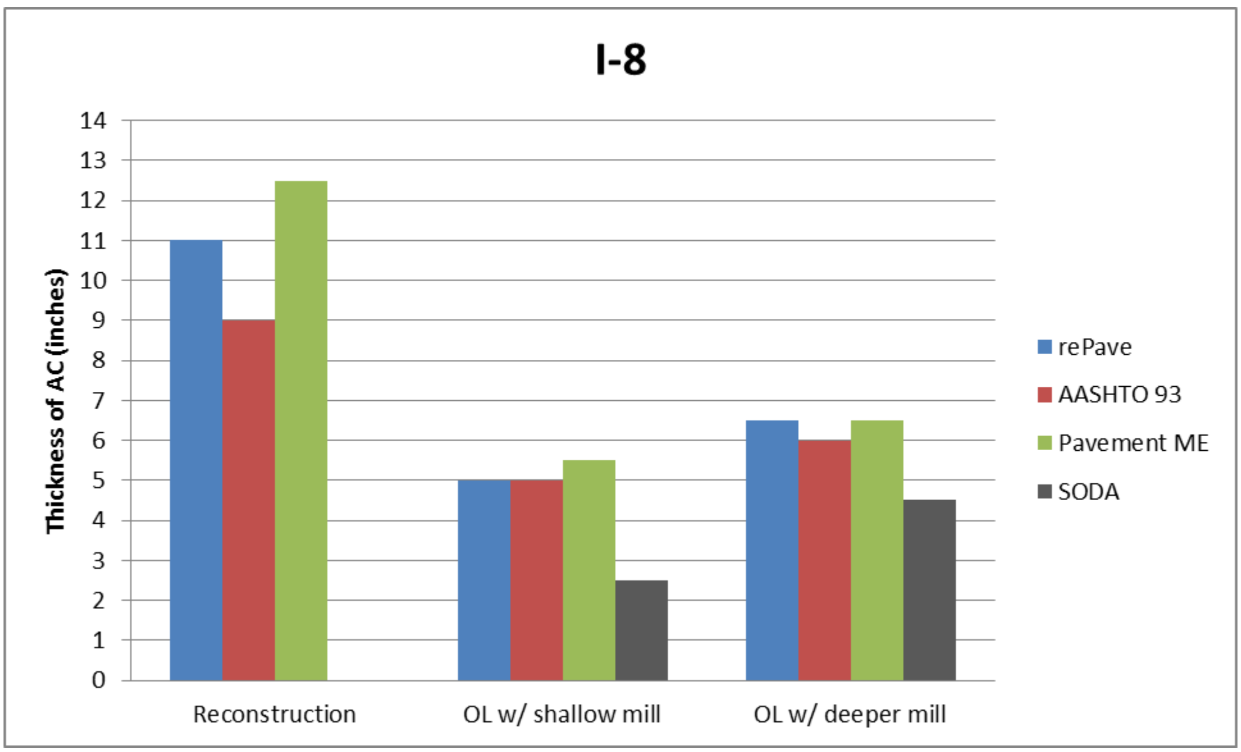


**Figure 6.1: Graphic Representation of Required New AC Thickness on I-8**

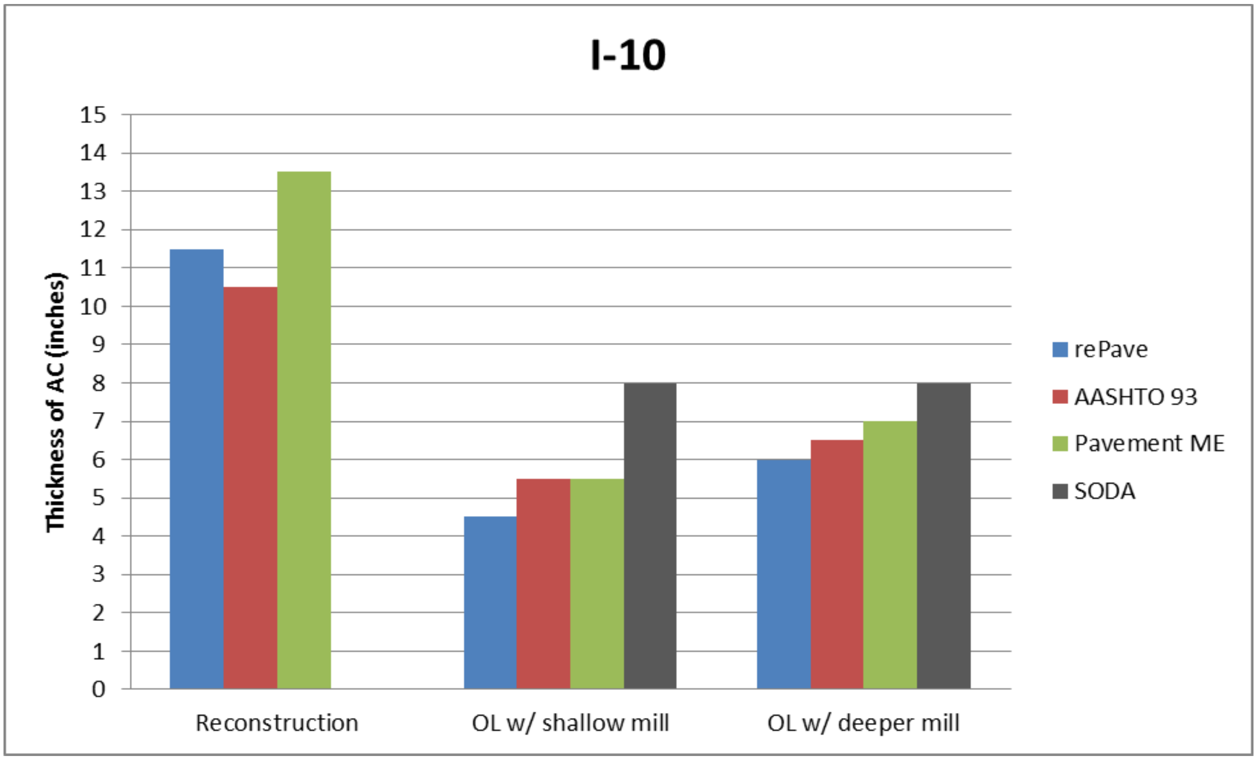


**Figure 6.2: Graphic Representation of Required New AC Thickness on I-10**

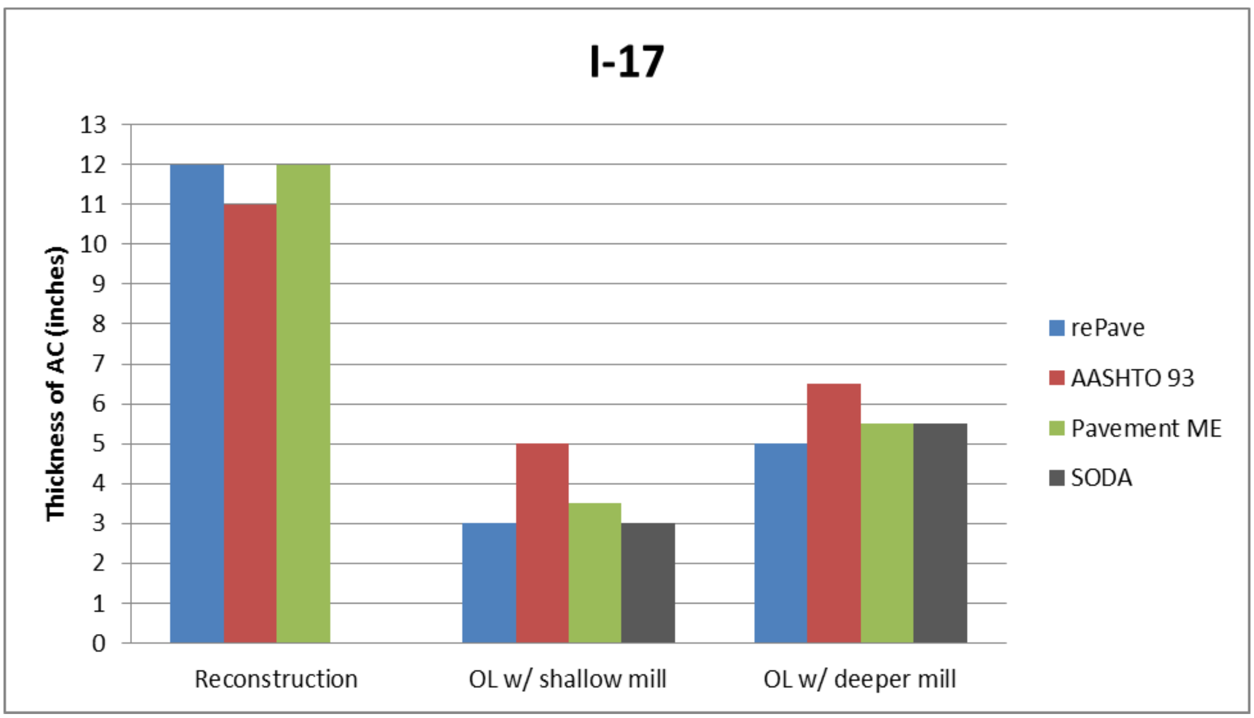


**Figure 6.3: Graphic Representation of Required New AC Thickness on I-17**

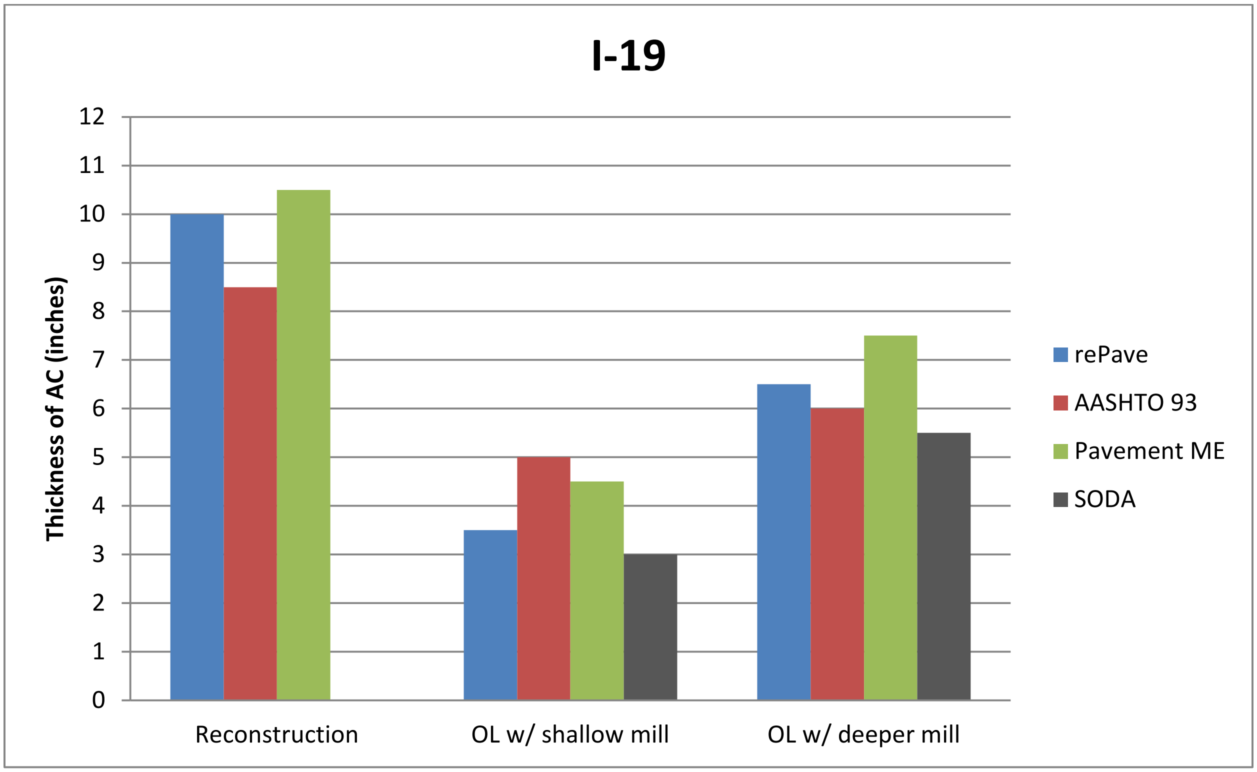


**Figure 6.4: Graphic Representation of Required New AC Thickness on I-19**

# Chapter 7

# Discussion of Findings

This chapter briefly states the lessons learned from this project as well as ADOT's evaluation of the rePave software as a Scoping Tool.

## *7.1 Lessons learned*

Historically, ADOT engineers usually have not put enough emphasis on performing pavement coring operation directly over the cracks. Typically, for any pavement rehabilitation project, ADOT pavement designers would submit a request to take pavement cores at every half a mile over the length of the project. In almost all cases, cores were extracted at non-crack locations. Cores at non-crack locations usually come out to be intact with minimal signs of distresses below the pavement surface. As part of this R23 project, pavement cores at the crack (such as alligator crack along the wheel path and transverse crack) locations were extracted which revealed important sub-surface information. All of the cores at transverse crack locations showed that the crack extended full-depth. Cores taken at the alligator cracks showed whether the cracks were full depth or top-down, and also, showed the extent of stripping within AC layer. In summary, it can be concluded that it is very important to take pavement cores at crack locations, as well as non-crack locations, to better understand the overall sub-surface condition of the existing pavement to be rehabilitated.

## *7.2 Implementation of the rePave Tool within ADOT*

As the Highways and Interstates of Arizona are relatively new, ADOT anticipates little need for full reconstruction in the near future. However, ADOT does expect more rehabilitation of existing highway pavements in the near future. The *rePave Scoping Tool* is essentially a reconstruction tool and has very limited use when it comes to rehabilitation. For example, the presence of even a single transverse crack (in a mile) for a rehabilitation project results in the software recommending complete removal of the existing AC layer and replace it with a new one. If the fatigue cracking is found to be top-down for a rehabilitation project, the tool would normally require removal of only the top two (2) inches irrespective of the actual depth of the crack. The severity level (low, medium or high) of alligator cracks does not appear to have any impact on the outcome. There are other limitations; however, these are some of the more significant ones, to name a few.

Despite the limitations of this scoping tool, ADOT wanted to see if, during scoping phase when the design data is very limited, this tool could reliably predict the AC overlay thickness requirement both for *Shallow* & *Deep* Mill options for a pavement requiring *Rehabilitation*. The following conclusions were made:

a) Using the same data required for the rePave tool, ADOT Pavement Designers would prefer to use the Pavement ME software to determine a pavement solution

b) For Non-Pavement Engineers (such as those involved in the planning and scoping of pavement projects), the rePave software could be used as a quick tool to perform a preliminary cost estimate for an ADOT Rehabilitation project