FINAL PAVEMENT DESIGN REPORT FOR:

MADERA CANYON ROAD - FLORIDA CANYON BRIDGE
Federal Project No. PPM-0(273)D
ADOT TRACS No. T0540 01C
Pima County Project ID 24041PJ
&

MADERA CANYON ROAD - MEDIUM WASH BRIDGE
Federal Project No. PPM-0(274)D
ADOT TRACS No. T0541 01C
Pima County Project ID 24043PJ

May 7, 2026

ABSTRACT

Solis Engineering Co. prepared this pavement design report for the Medium Wash and Florida Canyon Wash bridge replacement projects located in Pima County, AZ

Prepared For:

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&

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1. INTRODUCTION

This project is located on S Madera Canyon Road located approximately seven miles southeast of Green Valley, Pima County, Arizona.

- The bridge replacement at Medium Wash will occur within Township 19S, Range 14E, Section 11, at approximate latitude 31 Deg, 47 Min, 16.46 Sec / longitude -110 Deg, 53 Min, 3.95 Sec, and
- The bridge replacement at Florida Canyon Wash will occur within Township 19S, Range 14E, Section 14 at approximate latitude 31 Deg, 46 Min, 55.53 Sec / longitude -110 Deg, 53 Min, 12.95 Sec.

1.1. Project Description

The Pima County Department of Transportation (PCDOT) has recommended that the both single-lane structures at Medium Wash (Structure #8301) and Florida Canyon Wash (Structure #8302) be replaced with new two-lane bridge structures. The bridge replacements will improve operational efficiency, public safety, and hydraulic adequacy at the bridge crossings.

1.2. Purpose & Objectives

The purpose of this Pavement Design Report is to provide a design pavement section in support of the two bridge replacement projects. The recommended pavement section will also consider long-term maintenance considerations.

1.3. Pavement Design Report Procedures

This pavement design report was prepared using the methodologies listed below:

- The number of equivalent 18-kip single axle loads (ESALs) were developed using procedures set forth in ADOTs latest Pavement Design Manual, Dated September 29, 2017, herein referred to as the “PDM”. Solis Engineering Co. verified the use of this methodology with the Pima County Department of Transportation rather than the older ESAL methodology listed in Section 3.13 of the Pima County Roadway Design Manual, Fourth Edition, 2013 (Updated Oct 12, 2016). The Pima County Roadway Design Manual is herein referred to as the “RDM”.
- ADOTs latest Pavement Design Manual was generally used for pavement structure design with required parameters appropriate for Pima County, per the RDM.

2. GEOTECHNICAL DATA

2.1. Soils Information

Preliminary geotechnical investigation data of the existing soils at the bridge replacement locations was provided on October 22, 2025 and was performed by Terracon. A summary of the geotechnical results are shown in **Table 1** below, along with Correlated and Tested R-values.

The boring locations are shown in the picture at right and was copied in from Terracon's Geotechnical Field Investigation Plan dated November 18, 2025.

The Unified Soil Classification System (USCS) soil classifications for each boring are displayed in **Table 1**, below. They exhibit a mix of Clayey Sands, Sand-Gravel-Clay Mixtures and Silty Sand with Sand-Gravel-Silt Mixtures.

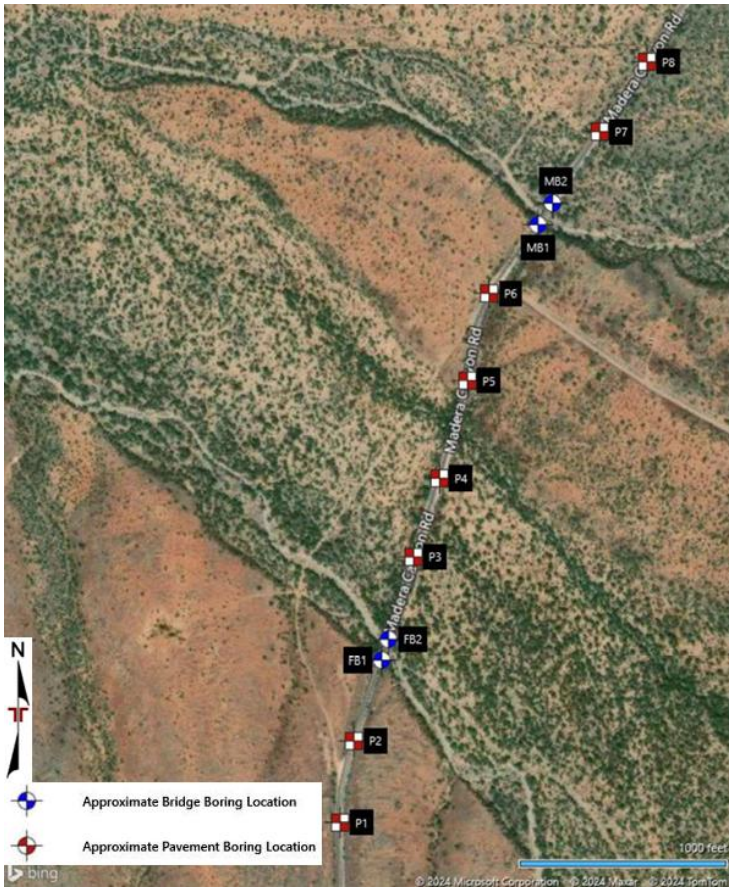


Table 1 – Summary of Geotechnical Data & Correlated and Tested R-values

Boring	Depth	% Passing No. 200 Sieve	Plasticity Index	Base Correlated R_{CB} -Value	Pima County Correlated R_{PC} -Value	Tested R-Value	USCS	Description
P1	1'-4'	34	12	39	24		SC	CLAYEY SAND with GRAVEL
P2	1'-4'	39	16	31	19		SC	CLAYEY SAND with GRAVEL
P3	1'-4'	15	NP	81	59	72	SM	SILTY SAND with GRAVEL
P4	1'-4'	37	4	51	34		SC-SM	SILTY, CLAYEY SAND with GRAVEL
P5	1'-4'	35	14	36	22		SC	CLAYEY SAND with GRAVEL
P6	1'-4'	21	4	64	44		SC-SM	SILTY, CLAYEY SAND with GRAVEL
P7	1'-4'	26	10	47	31	45	SC	CLAYEY SAND with GRAVEL
P8	1'-4'	20	5	62	43		SC-SM	SILTY, CLAYEY SAND with GRAVEL
				Averages	**34**	**59**		
				Standard Deviation of Correlated Rpc-Value (σpc)	**13.5**	**-**		
				Standard Deviation of Tested R-Values (σt)	**-**	**19.1**		
				No. of tested values (Nt)	**-**	**2**		
				No. of correlated values (Nc)	**8**	**-**		
				Adjusted Rt	**-**	**49**		
				Adjusted Rpc	**31**	**-**		
				R_{Mean}	**33**			
				R_{Design}	**30**			

3. TRAFFIC DATA

3.1. Existing Traffic Classification Counts

Vehicle classifications were collected with the 24-hour traffic volume data collection on January 28, 2025 (See **Appendix B**). The Federal Highway Administration (FHWA) defines heavy vehicles that fall within the categories of "2 Axle 6 Tire" through ">6 Axle Multi". The existing vehicle classifications are summarized in **Table 2**.

Table 2 - Heavy Vehicle Classification Data

Bikes	Cars & Trailers	2 Axle Long	Bus	2 Axle 6-Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	5 Axle Multi	6 Axle Multi	>6 Axle Multi
Madera Canyon Road, south of White House Canyon Road												
2	441	61	0	30	0	0	3	0	0	0	0	0
0.4%	82.1%	11.4%	0.0%	5.6%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%

3.2. Existing ADT & Build Year ADT

The measured Average Daily Traffic (ADT)(two-way) for Madera Canyon Road was 537 veh/day (vpd), on January 28, 2025 (See **Appendix B).** The off-system bridge (OSB) replacement applications prepared by Pima County in year 2023 included an ADT of 740 vpd, but there is no record of this ADT in County files, indicating it may have been derived from an informal or undocumented estimate. It should be noted that the measured ADT of 537 vpd closely compares to the traffic volumes included on the 2003 plans for the original bridge replacement design project that was never built. Those plans included a year 2000 ADT of 335 vpd and a design year 2020 ADT of 500 vpd, resulting in a 2% growth rate.

Design ADT's used in analysis are shown in **Table 3**. Both listed ADT's were used in ESAL calculations to identify the sensitivity of each ADT on pavement design requirements. Truck volumes for the OSB application ADT were estimated by applying the truck percentages of single and combo trucks from the 2025 traffic classification tube counts.

Table 3 - Existing Traffic ADTs

Year	ADT (veh/day)	Build Year (2026) ADT (veh/day)	Estimated Growth Rate	Source
2023	**740***	774	1.5%	*OSB Application
2025	**537****	548	2%	**24-hour traffic classification volume data tube count (**See Appendix B**)

3.3. Functional Classification

Madera Canyon Road is functionally classified as a **Rural Minor Collector**.

3.4. Pavement Design Calculation (ESALs)

To determine pavement design ESAL inputs, the ADOT Pavement Design Manual was referenced, and the Equivalent Single Axle Loads (ESALs) methodology was followed. See **Table 4** for results. See **Appendix C** for ESAL spreadsheets.

An estimated annual growth rate of 1.5% per year was applied to the ADT of 740 vpd included in the OSB application and was used to derive the build year ADT. This lower growth was used for the 740 vpd since the measured ADT of 537 is almost 30% less. An estimated annual growth rate of 2.0% was used for the ADT of 537 vpd. This rate assumes minimal growth in this area.

The directional distribution of 50% was used for the "two-lane roadway" per the Pima County Roadway Design Manual. This value closely reflects the measured traffic data.

Table 4 - ESALs Calculation Summary

ADT	Build Year (2026) ADT	Desing Life (Years)	Estimated Annual Growth Rate	Single Truck Volume	Combos Truck Volume	ESALs
740	774	20	1.5%	41	4	126,754
537	548	20	2%	30	3	92,205

4. PAVEMENT STRUCTURE DESIGN & SUBGRADE ACCEPTANCE

4.1. Pavement Design Parameters & Minimums

Per Section 3.13 of the Pima County Roadway Design Manual, the following parameters were used to determine the pavement design:

4.1.1. Seasonal Variation Factor (SVF): 2.0 (Estimated per Figure 2-1, ADOT PDM)
4.1.2. Level of Reliability (Collector): 90%
4.1.3. Standard Normal Deviate (ZR): -1.282 (this value is a measure of how likely the pavement is to fail within the design period. This value corresponds to the 90% reliability required for collectors)
4.1.4. Combined Standard Error (So): 0.35
4.1.5. Initial Serviceability Index (Po): 4.1
4.1.6. Terminal Serviceability Index (Pt): 2.6
4.1.7. Present Serviceability Index (DPSI): 1.5
4.1.8. Structural Coefficients for Asphaltic Concrete (AC): 0.44
4.1.9. Structural Coefficients for Aggregate Base (AB): 0.12 => 0.11 (Drainage coefficient of 0.92 for projects in the Tucson area)
4.1.10. Structural Coefficients for Cement or Bituminous Subgrade: 0.23
- If used, the minimum thickness of the course shall be 6 inches

4.1.11. The minimum thickness of a paving course for a Collector Roadway Classification is as follows:
- Collector (1,000 to 2,500 ADT)
  - Single Lift Asphalt 3.0 inches
  - Aggregate Base 4.0 inches
  - Minimum SN 1.75

4.1.12. The ratio of AB to AC generally shall be between 1:1 and 1.75:1
- Note: If minimum thickness of the AC and AB courses together does not provide the necessary SN, increasing the thickness of AC is preferable to specifying deeper sections of AB.

4.1.13. Average Project Elevation = 3,670-ft+/-

Per ADOTs latest Pavement Design Manual ("PDM"), dated September 29, 2017, the following parameters were used in the determination of the pavement design:

4.1.14. Per the PDM, the design Mr value for subgrade materials should not exceed 26,000 psi.
4.1.15. Per page 16 of the PDM, when analyzing geogrid, the Mean R-value (Design R-Value) should be increased by 10 when a geogrid is used.

4.2. Pavement Design

The **Required SN's** for the two ESAL values considered were determined through iteration using the following ADOT PDM equation. Pavement design output sheets are included in **Appendix D**.

$$log_{10}(W_{18}) = Z_R S_O + 9.36 log_{10}(SN+1) - 0.20 + \left\{ \frac{log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} \right\} + 2.32 log_{10}(M_R) - 8.07$$

Table 5 below displays a summary of the pavement design trials and options for implementation. It should be noted that the required Structural Numbers (SN) vary based on the design ADT (and corresponding ESALs) and the subgrade preparation strategy used. For example, Trial 8 includes a Design R-Value of 32 [Mean R-Value of 22 + 10 (see parameter 4.1.15 above)], Resilient Modulus value of 12,615 psi, a required SN of 1.93, and a Calculated SN of 1.98, therefore exceeding the required SN and "passing".

Table 5 - Summary of Pavement Design Trials

Evaluated Pavement Sections	Existing ADT	Asphaltic Concrete (in)	Aggregate Base Course (in)	Stabilization Type / Reinforcement	Design R-Value	Resilient Modulus, *Mr*	Calculated SN	Required SN	Pass / Fail
Trial 1	537	3	4	None	30	11,793 psi	1.76	1.87	Fail
Trial 2	**537**	**3**	**6**	**None**	**30**	**11,793 psi**	**1.98**	**1.87**	**Pass**
Trial 3	740	3	4	None	30	11,793 psi	1.76	1.98	Fail
Trial 4	**740**	**3**	**6**	**None**	**30**	**11,793 psi**	**1.98**	**1.98**	**Pass**
Trial 5	**740**	**3**	**4**	**6" CTS**	**22**	**8,716 psi**	**3.14**	**2.23**	**Pass**
Trial 6	**740**	**3**	**6**	**6" CTS**	**22**	**8,716 psi**	**3.36**	**2.23**	**Pass**
Trial 7	740	3	4	Geogrid	32	12,615 psi	1.76	1.93	Fail
Trial 8	**740**	**3**	**6**	**Geogrid**	**32**	**12,615 psi**	**1.98**	**1.93**	**Pass**

4.3. Subgrade Acceptance Chart

The provided subgrade acceptance chart is from the Pima County RDM - Appendix 3-W.

- All material placed within 3-feet of the pavement section shall meet the requirements of the subgrade acceptance chart (**Appendix A**), use R=30.
- Construction near Borings P1, P2, and P5, which resulted in low Correlated R-Values (See **Appendix A, 2nd Page**), should be monitored and tested during construction. The estimated project extents that could exhibit low Correlated R-Values are below:
  - **Boring P1 – Sta. 206+32 to Sta. 208+31**
  - **Boring P2 – Sta. 208+31 to Sta. 214+97**
  - **Boring P5 – Sta. 226+12 to Sta. 230+73**

  For design and construction, it is recommended that the design Engineer include provisions for subgrade stabilization, geogrid reinforcement, or subgrade excavation and replacement with suitable material if constructing within these extents.

4.4. Recommendations

4.4.1. Pavement Section Design

Based on the existing soil data and anticipated traffic loading, it is recommended that 3-inches of Pima Association of Governments (PAG) PAG Mix No. 2 PG 76-22TR+ be placed over 6-inches of Aggregate Base meeting the requirements of Section 303 of the PAG Standard Specifications or as amended as a stored specification by Pima County. Asphaltic Binder shall meet the requirements of the Special Provision for Section 1005 (See **Appendix E**). This proposed pavement section also

has the added benefit of providing a thick enough section that can maintain at least 1.5-inches of existing asphalt during a 1.5-inch mill and fill operation during pavement maintenance.

4.4.2. Pavement Section Design Options for Deficient Subgrade

The pavement design options provided in the table below provide mitigation options for areas of deficient subgrade. Using current unit pricing from ADOT's E2C2 bid history website, total costs per square yard (Total COST / 1 SY) were developed and they are listed below for comparison purposes.

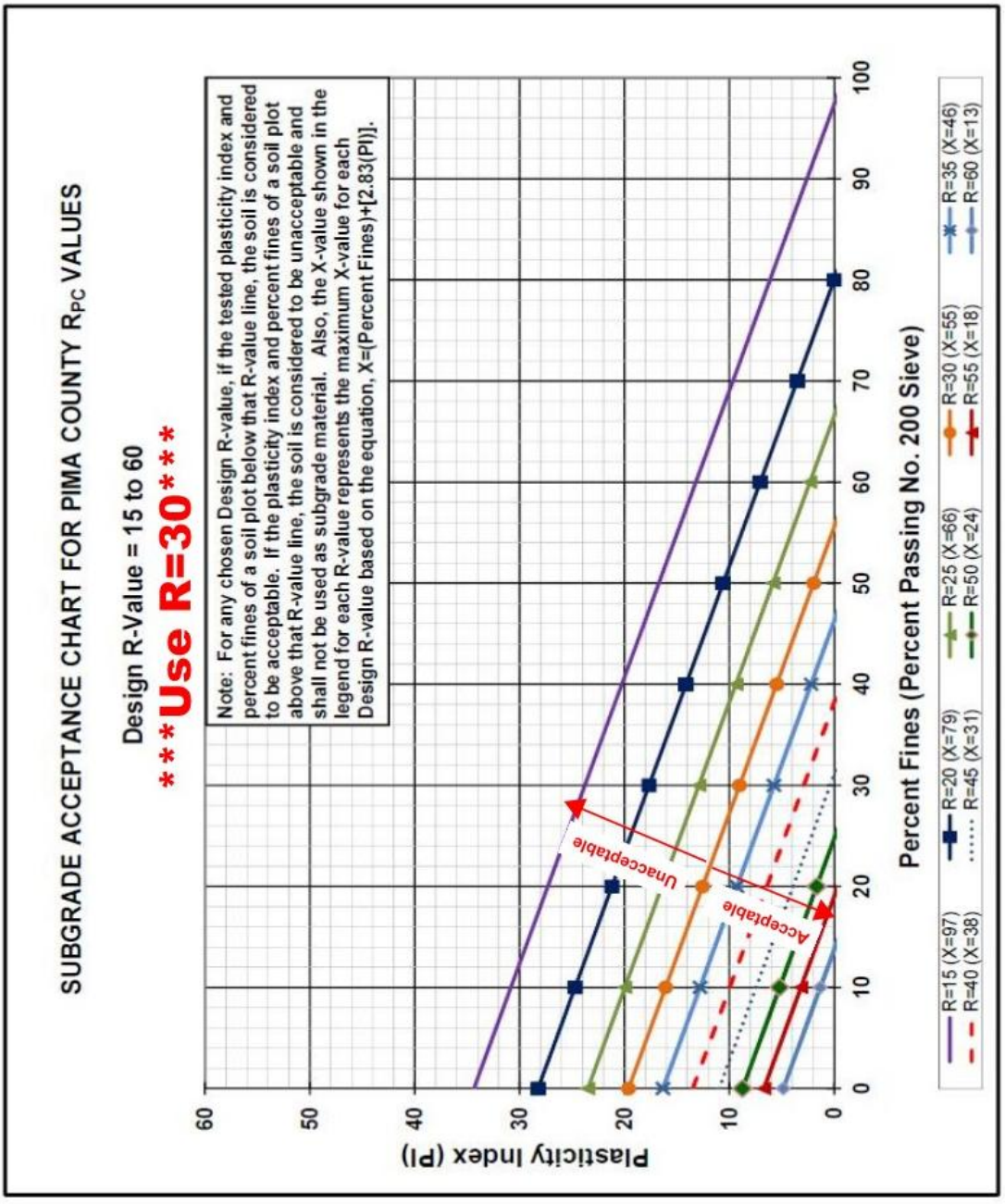
				Option 1	Option 2	Option 3
				3"AC / 6"AB / 3' Deep Exc. & Borrow	3"AC / 6"AB / Geogrid	3"AC / 6"AB / 6"CTS
ITEM No.	ITEM DESCRIPTION	UNIT	PRICE / SY	COST / SY	COST / SY	COST / SY
2030300	Roadway Excavation	C.Y.	$ 35.00	$ 35.00		
3030003	Aggregate Base	C.Y.	$ 25.00	$ 25.00	$ 25.00	$ 25.00
4060002	Asphaltic Concrete (No. 2)	TON	$ 55.00	$ 55.00	$ 55.00	$ 55.00
3060002	Geogrid Base Reinforcement	S.Y.	$ 25.00		$ 25.00	
3020001	Cement Treated Subgrade	S.Y.	$ 20.00			$ 20.00
3020011	Cementitious Material for Cement Treated Subgrade	TON	$ 15.83			$ 15.83
9300118	Miscellaneous Work 8 (Borrow, X=55)	C.Y.	$ 43.00	$ 43.00		
			Total Costs:	$ 158.00	$ 105.00	$ 115.83

- **Cement Treated Subgrade (CTS)** shall conform to Section 302 of the PAG Standard Specifications for Public Improvements which requires a mix design be furnished by the Contractor for approval by the Engineer. Per Section 302-3.10, Curing and Surface Treatment. After the cement treated course has been finished, it shall be protected against drying by the application of water, until covered by a subsequent layer of aggregate base course or, if required by the Special Provisions, until a bituminous curing seal is applied. When the project plans call for 4 inches or more of aggregate base over the cement treated subgrade, the aggregate base shall be used as the curing seal. The aggregate base shall be kept moist for 72 hours after placement.
- **Geogrid Reinforcement** shall conform to Section 306 of the PAG Standard Specifications for Public Improvements, ADOT's Stored Specification 1014GEOSYN, and be on ADOT's current Approved Products Listing (APL). Vendors or manufacturers not on ADOT's current APL, shall furnish written proof of ADOT's approval. The subgrade surface shall be compacted and finished according to Subsections 203-3.03, 203-9.03 or 205-3.04 prior to placement of the geogrid.

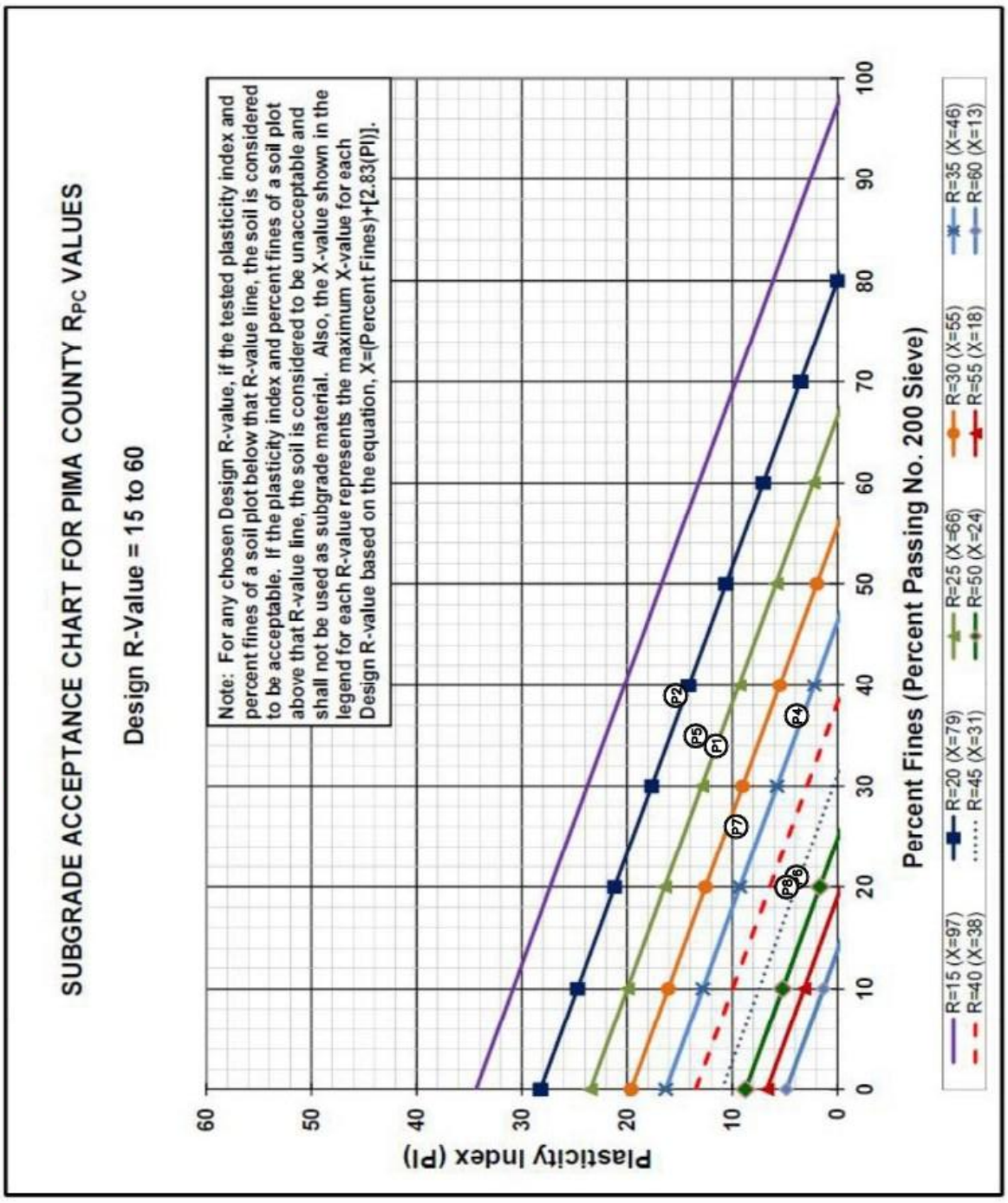
5. REFERENCES

- Arizona Department of Transportation. 2017. Pavement Design Manual. Prepared By Roadway Engineering Group Pavement Design Section
- Pima County Department of Transportation. 2014. Pima County Roadway Design Manual, Fourth Edition. Tucson Arizona.
- Final Geotechnical Data Report. November 18, 2025, By Terracon Project No. 6324506

Appendix A


SUBGRADE ACCEPTANCE CHART FOR PIMA COUNTY R_{PC} VALUES
Design R-Value = 15 to 60
Use R=30
Note: For any chosen Design R-value, if the tested plasticity index and percent fines of a soil plot below that R-value line, the soil is considered to be acceptable. If the plasticity index and percent fines of a soil plot above that R-value line, the soil is considered to be unacceptable and shall not be used as subgrade material. Also, the X-value shown in the legend for each R-value represents the maximum X-value for each Design R-value based on the equation, X=(Percent Fines)+[2.83(PI)].
Plasticity Index (PI)
Percent Fines (Percent Passing No. 200 Sieve)
Unacceptable
Acceptable
R=15 (X=97)
R=20 (X=79)
R=25 (X=66)
R=30 (X=55)
R=35 (X=46)
R=40 (X=38)
R=45 (X=31)
R=50 (X=24)
R=55 (X=18)
R=60 (X=13)
Use R=30

For Reference Only - PI & % Passing 200 Plotted Points



Appendix B

Field Data Services of Arizona
31894 Whitetail Ln.
Temecula, CA 92592
520.316.6745

Site Code: Tues 10/05/21
Station ID: 21-1616-001
El Tiro east of Cocio Rd
32.429390, -111.345380
Latitude: 0' 0.0000 Undefined

Eastbound, Westbound

Start Time	Bikes	Cars & Tlrs	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axle Double	5 Axle Double	>6 Axle Double	<6 Axle Multi	6 Axle Multi	>6 Axle Multi	Total
10/05/21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00	0	2	0	0	0	0	0	0	0	0	0	0	0	2
02:00	0	4	0	0	1	0	0	0	0	0	0	0	0	5
03:00	0	2	0	0	2	0	0	0	0	0	0	0	0	4
04:00	0	5	0	0	2	0	0	0	0	0	0	0	0	7
05:00	0	5	1	1	8	0	0	0	0	0	0	0	0	15
06:00	0	18	11	0	6	0	0	0	**1**	0	0	0	0	36
07:00	0	19	19	**3**	**10**	0	0	0	0	0	0	0	0	51
08:00	0	**24**	10	2	7	0	0	0	0	0	0	0	0	43
09:00	0	23	**21**	0	10	0	0	0	0	0	0	0	0	**54**
10:00	0	20	6	0	9	0	0	0	0	0	0	0	0	35
11:00	0	24	12	0	8	**1**	0	0	0	0	0	0	0	45
12 PM	**1**	27	**21**	0	8	1	0	0	0	0	0	0	0	58
13:00	0	24	15	2	**13**	1	0	0	0	0	0	0	0	55
14:00	0	24	13	2	12	**2**	0	0	0	0	0	0	0	53
15:00	0	8	6	1	4	0	0	**1**	0	0	0	0	0	20
16:00	0	5	0	0	2	0	0	0	0	0	0	0	0	7
17:00	0	**36**	7	2	12	0	0	0	0	0	0	0	0	57
18:00	0	34	17	**4**	10	0	0	0	0	0	0	0	0	**65**
19:00	0	17	6	0	3	0	0	0	0	0	0	0	0	26
20:00	0	12	3	0	3	0	0	0	0	0	0	0	0	18
21:00	0	7	2	0	0	0	0	0	0	0	0	0	0	9
22:00	0	11	4	0	3	0	0	0	0	0	0	0	0	18
23:00	0	8	6	1	6	0	0	0	0	0	0	0	0	21
Day Total	1	359	180	18	139	5	0	1	1	0	0	0	0	704
Percent	0.1%	51.0%	25.6%	2.6%	19.7%	0.7%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	
AM Peak		08:00	09:00	07:00	07:00	11:00			06:00					09:00
Vol.		24	21	3	10	1			1					54
PM Peak	12:00	17:00	12:00	18:00	13:00	14:00		15:00						18:00
Vol.	1	36	21	4	13	2		1						65
Grand Total	1	359	180	18	139	5	0	1	1	0	0	0	0	704
Percent	0.1%	51.0%	25.6%	2.6%	19.7%	0.7%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	

Appendix C

Design ESAL Calculation Worksheet

TRACS:			Project No.			Project Name:	Madera Canyon Road		
Route:	Madera Canyon	BMP:		Design Life (years):	20	Functional Class	Minor Collector		Rural
		EMP:		Growth Rate (%):	2.00%	Pavement Type	FLEXIBLE	Cluster Number:	2

				Truck Volumes		Percent Trucks (% of total AADT)		(% of total AADTT)		
				Singles	Combos	Singles	Combos	Singles	Combos	TTC
AADT	2025	537	Data Year	30	3	5.59%	0.56%	91%	9%	AZ-6
AADT	2026	548	Build Year					Select appropriate TTC From Table A-1 using % Combos above		

Vehicle Class	1-3	4	5	6	7	8	9	10	11	12	13	Total
Distribution	N/A	7.8	65.8	4.4	0.2	11.7	9.1	0.7	0.2	0.0	0.1	100
Class Volume (daily)	514	3	22	1	0	4	3	0	0	0	0	547
Growth Factor (G)	24.30	24.30	24.30	24.30	24.30	24.30	24.30	24.30	24.30	24.30	24.30	
Class Volume (total)	4558923	26609	195129	8870	0	35478	26609	0	0	0	0	
Truck Load Factor (T_{LF})	0.0008	1.06	0.39	0.96	0.61	0.91	1.34	1.53	1.96	1.33	3.50	
Class ESAL's	3647	28206	76100	8515	0	32285	35656	0	0	0	0	184,409

Total Number of Trucks	292,695
Directional Distribution Factor (D_D)	0.5
Lane Distribution Factor (D_L)	1
Design ESAL's	92,205

Design ESAL Calculation Worksheet

TRACS:			Project No.			Project Name:	Madera Canyon Road		
Route:	Madera Canyon	BMP:		Design Life (years):	20	Functional Class	Minor Collector		Rural
		EMP:		Growth Rate (%):	1.50%	Pavement Type	FLEXIBLE	Cluster Number:	2

				Truck Volumes		Percent Trucks (% of total AADT)		(% of total AADTT)		
				Singles	Combos	Singles	Combos	Singles	Combos	TTC
AADT	2023	740	Data Year	41	4	5.59%	0.56%	91%	9%	AZ-6
AADT	2026	774	Build Year			0.0559	0.0056	Select appropriate TTC From Table A-1 using % Combos above		

Vehicle Class	1-3	4	5	6	7	8	9	10	11	12	13	Total
Distribution	N/A	7.8	65.8	4.4	0.2	11.7	9.1	0.7	0.2	0.0	0.1	100
Class Volume (daily)	726	4	32	2	0	6	4	0	0	0	0	774
Growth Factor (G)	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	
Class Volume (total)	6126569	33755	270042	16878	0	50633	33755	0	0	0	0	
Truck Load Factor (T_{LF})	0.0008	1.06	0.39	0.96	0.61	0.91	1.34	1.53	1.96	1.33	3.50	
Class ESAL's	4901	35780	105316	16203	0	46076	45232	0	0	0	0	253,508

Total Number of Trucks	405,063
Directional Distribution Factor (D_D)	0.5
Lane Distribution Factor (D_L)	1
Design ESAL's	126,754

Appendix D

ADT = 537 VPD ANALYSIS

R-VALUE CORRELATIONS

Boring	Depth	% Passing No. 200 Sieve	Plasticity Index	Base Correlated R_{CB} -Value	Pima County Correlated R_{PC} - Value	Tested R-Value
P1	1'-4'	34	12	39	24	
P2	1'-4'	39	16	31	19	
P3	1'-4'	15	NP	81	59	72
P4	1'-4'	37	4	51	34	
P5	1'-4'	35	14	36	22	
P6	1'-4'	21	4	64	44	
P7	1'-4'	26	10	47	31	45
P8	1'-4'	20	5	62	43	
Average				**52**	**34**	**59**
Standard Deviation of Correlated Rpc-Values (σc)				**16.89**		
Standard Deviation of Correlated Rpc-Values (σcpc)					**13.5**	
Standard Deviation of Tested R-Values (σt)						**19.1**
No. of tested values (Nt)						**2**
No. of correlated values (Nc)				**8**		

$$R_{mean} = \frac{N_t \overline{R_t} \sigma_t^2 + N_c \overline{R_c} \sigma_t^2}{N_t \sigma_t^2 + N_c \sigma_t^2}$$

Where:

N_t = number of tested R-values

N_c = number of correlated R-values (from PI & 200)

$\overline{R_t}$ = average of the tested R-values

$\overline{R_c}$ = average of the correlated R-values

σ_t = standard deviation of the tested R-values

σ_c = standard deviation of the correlated R-values

Adjusted Rt **49**
Adjusted Rc **31**

Mean R-Value	**32.9**
Design / Construction Control R-Value	**30.0**

Seasonal Variation Factor **2.00**

Note: Per ADOT, the design Mr value for subgrade materials should not exceed 26,000 psi.

Resilient Modulus Value, Mr

$$M_R = \frac{1815 + 225(R_{mean}) + 2.40(R_{mean})^2}{0.6(SVF)^{0.6}}$$

Mr = **11793** psi

$$log_{10}(W_{18}) = Z_R S_O + 9.36 log_{10}(SN+1) - 0.20 + \left\{ \frac{log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} \right\} + 2.32 log_{10}(M_R) - 8.07$$

W18 =	92,205
Zr =	-1.282
So =	0.35
△PSI =	1.50
Po =	4.10
Pt =	2.60
Mr =	11793
Reliability =	90%
$Log_{10}(W_{18})$ =	4.965
f(SN) =	4.965
SN =	**1.87**

Table 2-1 Reliability and Z_R Values

Roadway Type - Volume	Level of Reliability	Z_R
Divided Highways, Freeways & Interstates	99%	-2.327
Non-Divided, Non-Interstate Highways, 10,000+ ADT	95%	-1.645
2,001 – 10,000 ADT	90%	-1.282
501 – 2,000 ADT	85%	-1.037
≤ 500 ADT	75%	-0.674

Pavement Sections Evaluation

1. Per PCDOT RDM, the **minimum Structural Number (SN) = 1.75** for Collector (1,000 to 2,500 ADT)
2. Per PCDOT RDM, the AB to AC ratio generally shall be between 1:1 and 1.75:1.

		ai	di	mi	
Trial 1	AC	0.44	3.0	0.00	
	AB	0.12	4.0	0.92	
			Calc. SN =	**1.76**	**FAIL < SN = 1.87**

		ai	di	mi	
Trial 2	AC	0.44	3.0	0.00	
	AB	0.12	6.0	0.92	
			Calc. SN =	**1.98**	**OK > SN = 1.87**

ADT = 740 VPD ANALYSIS

R-VALUE CORRELATIONS

Boring	Depth	% Passing No. 200 Sieve	Plasticity Index	Base Correlated R_{CB} -Value	Pima County Correlated R_{PC} - Value	Tested R-Value
P1	1'-4'	34	12	39	24.4	
P2	1'-4'	39	16	31	18.6	
P3	1'-4'	15	NP	81	58.8	72
P4	1'-4'	37	4	51	33.8	
P5	1'-4'	35	14	36	21.9	
P6	1'-4'	21	4	64	44.1	
P7	1'-4'	26	10	47	30.6	45
P8	1'-4'	20	5	62	42.8	
Average				**52**	**34.4**	**59**
Standard Deviation of Correlated Rpc-Values (σc)				**16.89**		
Standard Deviation of Correlated Rpc-Values (σcpc)					**13.51**	
Standard Deviation of Tested R-Values (σt)						**19.09**
No. of tested values (Nt)						**2**
No. of correlated values (Nc)				**8**		

$$R_{mean} = \frac{N_t \overline{R_t} \sigma_c^2 + N_c \overline{R_c} \sigma_t^2}{N_t \sigma_c^2 + N_c \sigma_t^2}$$

Where:

N_t = number of tested R-values

N_c = number of correlated R-values (from PI & 200)

$\overline{R_t}$ = average of the tested R-values

$\overline{R_c}$ = average of the correlated R-values

σ_t = standard deviation of the tested R-values

σ_c = standard deviation of the correlated R-values

Adjusted Rt **49**

Adjusted Rc **31**

Mean R-Value	**32.9**
Design / Construction Control R-Value	**30.0**

Seasonal Variation Factor **2.00**

Note: Per ADOT, the design Mr value for subgrade materials should not exceed 26,000 psi.

Resilient Modulus value, *Mr*

$$M_R = \frac{1815 + 225(R_{mean}) + 2.40(R_{mean})^2}{0.6(SVF)^{0.6}}$$

Mr = **11793** **psi**

$$log_{10}(W_{18}) = Z_R S_O + 9.36 log_{10}(SN+1) - 0.20 + \left\{ \frac{log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} \right\} + 2.32 log_{10}(M_R) - 8.07$$

W18 =	126,754
Zr =	-1.282
So =	0.35
ΔPSI =	1.50
Po =	4.10
Pt =	2.60
Mr =	11793
Reliability =	90%
$Log_{10}(W_{18})$ =	5.103
f(SN) =	5.103
SN =	**1.98**

Table 2-1 Reliability and Z_R Values

Roadway Type - Volume	Level of Reliability	Z_R
Divided Highways, Freeways & Interstates	99%	-2.327
Non-Divided, Non-Interstate Highways, 10,000+ ADT	95%	-1.645
2,001 – 10,000 ADT	90%	-1.282
501 – 2,000 ADT	85%	-1.037
≤ 500 ADT	75%	-0.674

Pavement Sections Evaluation

1. Per PCDOT RDM, the **Minimum Structural Number (SN) = 1.75** for Collector (1,000 to 2,500 ADT)
2. Per PCDOT RDM, the AB to AC ratio generally shall be between 1:1 and 1.75:1.

		ai	di	mi		
Trial 3	AC	0.44	3.0	0.00		
	AB	0.12	4.0	0.92		
			Calc. SN =	**1.76**	**FAIL < SN = 1.98**	

		ai	di	mi		
Trial 4	AC	0.44	3.0	0.00		
	AB	0.12	6.0	0.92		
			Calc. SN =	**1.98**	**PASS = SN = 1.98**	

ADT = 740 VPD ANALYSIS / CTS

R-VALUE CORRELATIONS

Boring	Depth	% Passing No. 200 Sieve	Plasticity Index	Base Correlated R_{CB} -Value	Pima County Correlated R_{PC} - Value	Tested R-Value
P1	1'-4'	34	12	39	24	
P2	1'-4'	39	16	31	19	
P5	1'-4'	35	14	36	22	
Average				**35**	**22**	**0**
Standard Deviation of Correlated Rpc-Values (σc)				**3.96**		
Standard Deviation of Correlated Rpc-Values (σcpc)					**3**	
Standard Deviation of Tested R-Values (σt)						**1.00**
No. of tested values (Nt)						**0**
No. of correlated values (Nc)				**3**		

$$R_{mean} = \frac{N_t \overline{R_t} \sigma_c^2 + N_c \overline{R_c} \sigma_t^2}{N_t \sigma_c^2 + N_c \sigma_t^2}$$

Where:

N_t = number of tested R-values

N_c = number of correlated R-values (from PI & 200)

$\overline{R_t}$ = average of the tested R-values

$\overline{R_c}$ = average of the correlated R-values

σ_t = standard deviation of the tested R-values

σ_c = standard deviation of the correlated R-values

Mean R-Value	**22**
Design / Construction Conlrol R-Value	**22.0**

Seasonal Variation Factor **2.00**

Note: Per ADOT, the design Mr value for subgrade materials should not exceed 26,000 psi.

Resilient Modulus value, Mr

$$M_R = \frac{1815 + 225(R_{mean}) + 2.40(R_{mean})^2}{0.6(SVF)^{0.6}}$$

Mr = **8716** **psi**

$$log_{10}(W_{18}) = Z_R S_O + 9.36 log_{10}(SN+1) - 0.20 + \left\{ \frac{log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} \right\} + 2.32 log_{10}(M_R) - 8.07$$

	PCDOT
W18 =	126,754
Zr =	-1.28
So =	0.35
ΔPSI =	1.50
Po =	4.10
Pt =	2.60
Mr =	8716
Reliability =	90%
$Log_{10}(W_{18})$ =	5.103
f(SN) =	5.103
SN =	**2.23**

Table 2-1 Reliability and Z_R Values

Roadway Type - Volume	Level of Reliability	Z_R
Divided Highways, Freeways & Interstates	99%	-2.327
Non-Divided, Non-Interstate Highways, 10,000+ ADT	95%	-1.645
2,001 – 10,000 ADT	90%	-1.282
501 – 2,000 ADT	85%	-1.037
≤ 500 ADT	75%	-0.674

Pavement Sections Evaluation

1. Per PCDOT RDM, the **minimum Structural Number (SN) = 1.75** for Collector (1,000 to 2,500 ADT)
2. Per PCDOT RDM, the AB to AC ratio generally shall be between 1:1 and 1.75:1.

Trial 5

	ai	di	mi
AC	0.44	3.0	0.00
AB	0.12	4.0	0.92
CTB	0.23	6.0	
		SN =	**3.14**

OK > SN = 2.23

Trial 6

	ai	di	mi
AC	0.44	3.0	0.00
AB	0.12	6.0	0.92
CTB	0.23	6.0	
		Calc. SN =	**3.36**

OK > SN = 2.23

ADT = 740 VPD ANALYSIS / GEOGRID

R-VALUE CORRELATIONS

Boring	Depth	% Passing No. 200 Sieve	Plasticity Index	Base Correlated R_{CB} -Value	Pima County Correlated R_{PC} - Value	Tested R-Value
P1	1'-4'	34	12	39	24	
P2	1'-4'	39	16	31	19	
P5	1'-4'	35	14	36	22	
Average				**35**	**22**	**0**
Standard Deviation of Correlated Rpc-Values (σc)				**3.96**		
Standard Deviation of Correlated Rpc-Values (σcpc)					**3**	
Standard Deviation of Tested R-Values (σt)						**1.00**
No. of tested values (Nt)						**0**
No. of correlated values (Nc)				**3**		

$$R_{mean} = \frac{N_t \overline{R_t} \sigma_c^2 + N_c \overline{R_c} \sigma_t^2}{N_t \sigma_c^2 + N_c \sigma_t^2}$$

Where:

N_t = number of tested R-values

N_c = number of correlated R-values (from PI & 200)

$\overline{R_t}$ = average of the tested R-values

$\overline{R_c}$ = average of the correlated R-values

σ_t = standard deviation of the tested R-values

σ_c = standard deviation of the correlated R-values

Mean R-Value	**22**
Design / Construction Conlrol R-Value	**32.0**

Seasonal Variation Factor **2.00**

Note: Per ADOT, the design Mr value for subgrade materials should not exceed 26,000 psi.

Resilient Modulus value, *Mr*

$$M_R = \frac{1815 + 225(R_{mean}) + 2.40(R_{mean})^2}{0.6(SVF)^{0.6}}$$

Mr = **12615** psi

$$log_{10}(W_{18}) = Z_R S_O + 9.36 log_{10}(SN+1) - 0.20 + \left\{ \frac{log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} \right\} + 2.32 log_{10}(M_R) - 8.07$$

	PCDOT
W18 =	126,754
Zr =	-1.28
So =	0.35
ΔPSI =	1.50
Po =	4.10
Pt =	2.60
Mr =	12615
Reliability =	90%
$Log_{10}(W_{18})$ =	5.103
f(SN) =	5.103
SN =	**1.93**

Table 2-1 Reliability and Z_R Values

Roadway Type - Volume	Level of Reliability	Z_R
Divided Highways, Freeways & Interstates	99%	-2.327
Non-Divided, Non-Interstate Highways, 10,000+ ADT	95%	-1.645
2,001 – 10,000 ADT	90%	-1.282
501 – 2,000 ADT	85%	-1.037
≤ 500 ADT	75%	-0.674

Pavement Sections Evaluation

1. Per PCDOT RDM, the **minimum Structural Number (SN)** = **1.75** for Collector (1,000 to 2,500 ADT)
2. Per PCDOT RDM, the AB to AC ratio generally shall be between 1:1 and 1.75:1.

		ai	di	mi	
Trial 7	AC	0.44	3.0	0.00	
	AB	0.12	4.0	0.92	
	Geogrid				
			SN =	**1.7616**	**FAIL < SN = 1.93**

		ai	di	mi	
Trial 8	AC	0.44	3.0	0.00	
	AB	0.12	6.0	0.92	
	Geogrid				
			Calc. SN =	**1.98**	**OK > SN = 1.93**

Appendix E

** USE WHEN ASPHALTIC CONCRETE IS TO BE USED. **

(1005BITMAT, 12/19/18)

SECTION 1005 - BITUMINOUS MATERIALS FOR SURFACING

1005-3 BITUMINOUS MATERIAL REQUIREMENTS

1005-3.01 Asphalt Cement of the Standard Specifications is modified to add:

Terminal mix shall use performance grade (PG 76-22 TR+) asphalt binder conforming to the requirements of Table 1005-1.

1005-3.01 Asphalt Cement of the Standard Specifications is modified to revise Table 1005-1:

TABLE 1005-1
PG 76-22 TR+ ASPHALT BINDER

Test Property	Test Method	Requirement	Test Result	Percent of Contract Unit Price Allowed
Solubility in Trichloroethylene, %, minimum	ASTM D 2042	97.5	------	------
Softening Point, °C, minimum	AASHTO T 53	60	≥ 60 57 - 59 < 57	100 85 70 (1)
Elastic Recovery, @ 10 °C, %, minimum	AASHTO T 301	55	≥ 55 50 - 54 < 50	100 85 70 (1)
Phase Angle (δ), @ 70 °C @ 10 rad/sec, degrees, maximum	AASHTO T 315	75	≤ 75 76 - 83 > 83	100 85 65 (1)

(1) Reject Status: The pay adjustment applies if allowed to remain in place.

Notes:

- PG 76-22 TR+ asphalt binder shall contain a minimum of 8 percent crumb rubber and a minimum of two percent SBS (styrene-butadiene-styrene) polymer.
- PG 76-22 TR+ asphalt binder shall conform to the requirements of AASHTO M 320 and, in addition, shall meet the requirements specified above.
- Should the bituminous material be deficient on more than one of the properties listed in Tables 1005-1, the pay adjustment will be the greatest reduction to the contract unit price specified considering individual test results.
- The pressure aging temperature for PG 76-22 TR+ asphalt binder shall be 110 °C.
- The crumb rubber shall be derived from processing whole scrap tires or shredded tire materials. The tires from which the crumb rubber is produced shall be taken from automobiles, trucks, or other equipment owned and operated in the United States. The processing shall not produce, as a waste product, casings or other round tire material that can hold water when stored or disposed of above ground.

1005-3.07 Asphalt Cement of the Standard Specifications is revise to read:

Bituminous material for slurry seal shall be a cationic quick setting asphaltic emulsion conforming to the requirements for PMCQS-1h grade meeting the following requirements:

TESTS ON EMULSIONS	Test Method	Min	Max
Viscosity, Saybolt-Furol at 77°F, sec	AASHTO T 59	20	100

TESTS ON RESIDUE FROM DISTILLATION	Test Method	Min	Max
Residue by evaporation, %	ARIZ 504	60	
Penetration, 25°C (77°F), 100 g., 5 sec	AASHTO T 49	55	75
Ductility, 25°C (77°F), 5 cm per min, cm	AASHTO T 51	40	
Ring and Ball Softening Point	AASHTO T 53	130	
Elastic Recovery, %	AASHTO T 30	55	
Solubility in trichloroethylene, Wt. %	AASHTO T 59	97.5	

Storage Stability Test, 1 day, %	-----	1	
Particle charge test	AASHTO T 59	Positive	

1005-3.08 Other Requirements of the Standard Specifications is modified to revise Table 1005-5:

TABLE 1005-5
OTHER REQUIREMENTS

GRADE OF ASPHALT SPECIFICATION DESIGNATION	RANGE OF TEMPERATURES FOR APPLICATION BY SPRAYING, °F (1)	RANGE OF AGGREGATE TEMPERATURES FOR PLANT MIXING, °F	BASIS OF CONVERSION, AVERAGE GALLONS PER TON AT 60 °F
Paving Asphalt: PG 76-22 TR+ PG 76-XX PG 70-XX PG 64-XX PG 58-XX PG-52-XX	275 – 400	----	---- 229 232 233 235 236 238
Liquid Asphalt: MC-70 MC-250 MC-800 MC-3000	---- 105 - 175 140 - 225 175 - 255 215 – 290	---- 90 - 155 125 - 200 160 - 225 200 - 260	---- 253 249 245 241
Emulsified Asphalt: RS-1 CRS-1 **PMCQS-1h** RS-2 CRS-2 CRS-2P SS-1 CSS-1 HFE – 150P HFE – 300P	---- 70 - 140 125 - 185 125 - 185 **125 - 185** 125 - 185 125 – 185 (2) 70 - 160 70 - 160 ---- ----	----	240
Emulsified Asphalt: (Special Type)	70 – 160	----	240
Recycling Agent: (RA-1, RA-5, RA-25, and RA-75)	----	----	240
Emulsified Recycling Agent: (ERA-1, ERA-5, ERA-25 and ERA-75)	70 – 160	----	240

NOTES:
(1) Not applicable to plant mixing.
(2) Or as directed by the Engineer.