October 14, 2020

Richard Martinez
Director
Department of Public Works
City of Corpus Christi
2525 Hygia Street
Corpus Christi, TX 78469-9277

Dear Mr. Martinez:

Roadway Asset Services, LLC (RAS) is pleased to submit this letter addressing the City of Corpus Christi pavement selection criteria when bidding street projects using both hot mix asphalt concrete (HMAC) and Portland Cement Concrete (PCC) pavement. The purpose of this letter was to provide additional criteria for consideration in design of street projects to streamline the decision process and to provide consideration of not only traffic loading conditions and Life Cycle Cost Analysis (LCCA), but also subgrade support characteristics and surrounding surface pavement types.

In preparation of this project, we received the following documents for review:

- A memorandum from Freese and Nichols titled, "Pavement Selection Criteria", dated April 22, 2019
- A City of Corpus Christi Memorandum titled, "City Council Action Request (CCAR) – January 31, 2017 Bidding Street Bond Projects with Both Portland Cement Concrete (PCC) and Hot-Mix-Asphalt-Concrete (HMAC), dated February 2, 2017
- A City of Corpus Christi Memorandum titled, "City Council Action Request (CCAR) – April 25, 2017 Bidding Street Bond Projects with Both Portland Cement Concrete (PCC) and Hot-Mix-Asphalt-Concrete (HMAC), dated June 2, 2017
- A City of Corpus Christi Memorandum titled, "City Council Action Request (CCAR) – Hot-Mix-Asphalt-Concrete (HMAC) & Portland Cement Concrete (PCC) Pavements, dated April 22, 2019

Background

Based upon review of the provided documents, we understand the City started designing and bidding street projects using both HMAC and PCC as part of the 2008 Bond program. Prior to 2008, the City would typically design arterial road reconstruction projects with HMAC pavement. In 2013 the City Council modified the pavement design standards with a 30-year design for both HMAC and PCC using the American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures. The market at the time allowed for more projects to be constructed with PCC. Then in 2016, the City began designing and bidding all arterial Bond projects with both HMAC and PCC alternatives and choosing the lower life cycle cost alternative. In 2017, Engineering Services provided a response to a City Council Action Request providing information on LCCA guidelines for evaluating both HMAC and PCC pavement designs for street project bids. The response provided information on the cost savings of selecting PCC with lower maintenance cost of approximately $100,000 per lane-mile, or $14,20 per square yard. This difference was used by staff to determine which pavement surface material to use based on project bids. If the PCC bid cost was within $100,000 of the HMAC bid, then PCC was chosen as the surface material.

In 2019 Freese and Nichols (FNI) provided a report with further analysis and guidelines into the decision process of using LCCA to determine which pavement surface to use for each project. The Freese and Nichols memo provided guidelines for using the Federal Highway Administration's (FHWA) "Real Cost" program to perform the LCCA analysis. This memo also provided cost data and maintenance cycle guidelines for both HMAC and PCC alternatives. The Freese and Nichols memo also introduced a weighted decision matrix as a tool to determine which pavement surface to use when the difference between total project bid pricing for HMAC and PCC pavement alternatives falls between a specified range of cost. The matrix included such factors as Average Daily Traffic (ADT), Percentage of Trucks and Buses, Adjacent Development/# of Driveways, and Other Engineering Factors. Each factor was provided a weight factor to determine a total score for each alternative. Recommendations from the memo provided a new set of guidelines based on the LCCA performed as part of the design, with current data, and the following criteria:

1. When the cost difference of PCC is **below $96,000 ($13,57/SY)**, the City should recommend PCC

2. When the cost difference of PCC is **within the range of $96,000 ($13.57/SY) to $156,000 ($22.55/SY)**, the City should review the decision matrix to assist with the pavement recommendation (subject to availability of funds)

3. When the dost difference of PCC is **above $156,000 ($22.55/SY)**, the City should recommend HMAC

An April 2019 City Council Action Request Memo states that "Although Engineering Services agrees with using the FNI decision matrix to decide which projects are appropriate to bid with both PCC and HMAC, staff also believe adopting a bid award recommendation policy that is known in advance by bidders is a more fair and transparent process. FNI's decision criteria are good to use in the Design Phase (not Bid Phase) when deciding whether it is appropriate to design and bid a project with both HMAC and PCC pavements." The memo recommends Engineering Services raise the amount to $125,000 per lane mile ($17.75/square yard), which is approximately the midpoint of the range of $96,000 and $156,000 where FNI recommends applying the decision matrix.

The City Council Action Request Memo, dated April 22, 2019, also states that "Engineering Services believe that most arterials are good candidates to design and bid with both PCC and HMAC pavement. Residential collectors and residential streets are not as good candidates for PCC due to factors listed in the FNI decision matrix as well as other factors."

Decision Criteria Updates

In review of the 2019 Freese and Nichols report we believed the LCCA models could be revised to include guidelines for treatment applications based on our experience with pavement evaluations and deterioration curves. We wanted to incorporate some of the decision matrix issues into the LCCA to simplify this process and remove the need for the matrix system. We believe the average daily traffic and percentage truck issues are important issues to consider, but these factors are largely accounted for in the design of the pavement structure, which is the initial capital expense. The option that we thought would be most helpful in keeping this process simple would be to break the LCCA guidelines into two main categories based on arterial level streets and residential streets. With this division, the LCCA can consider

the different performance expectations and maintenance needs for each main distinction in traffic volumes.

Based on our experience evaluating pavement networks and general performance, we believe residential pavements may have a longer service life due partially to the lower truck volume and most distresses being related to environmental factors and the tolerance of a slightly lower level of service than arterial streets. Residential streets require maintenance to enhance the performance with low traffic and exposure to the environmental elements, but often less structural repair. In contrast, arterial streets require more frequent maintenance and often more structural improvements, due to the heavier loading from traffic. The types of maintenance for arterial streets are different than those needed for residential streets. We developed two different approaches for maintenance for arterial and residential streets.

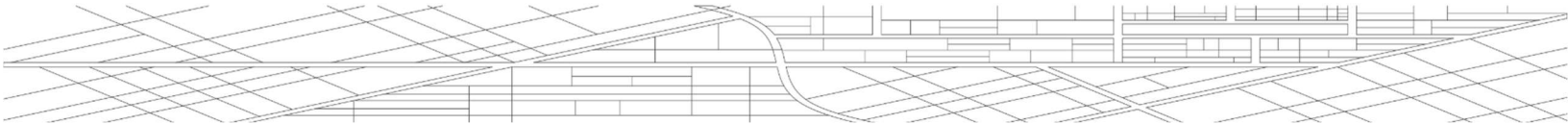
In addition to the traffic impact, we believe the soil types, support characteristics, and expansive potential of clay soils also have a major impact on the performance of pavement structures. In our experience, pavements on clays soils must be designed with an additional stabilized layer, which should be accounted for in the initial design and capital expenses. However, due to deep wetting of the subgrade, expansive soils will also require more frequent maintenance due to the higher percentage of cracking and differential movement anticipated and, in some cases, different maintenance. HMAC pavements will likely require addition mill and overlay activities to correct differential movement and PCC pavements will likely require grinding and additional panel replacements due to the differential movements. A separate set of guidelines were developed for both the arterial and residential classifications of roadway for expansive soils. We characterize expansive soils as those exhibiting plasticity indices (PI) greater than 30. Laboratory tests and swell testing can be conducted to find specific characteristics of soil samples within each roadway, but a PI of 30 is largely considered as the threshold from low to moderate expansion potential among geotechnical engineers.

We used typical maintenance treatments that the City of Corpus Christi would use for the various classifications of streets. We visited with the City Engineering Services staff to identify treatments, estimated costs per square yard, and when and how often they would typically apply these treatments for each level of roadway. We did not consider minor activities such as periodic pothole patching in the LCCA models and analysis as these costs are sporadic and negligible to the overall life cycle cost.

The following tables present our recommended maintenance activities, year of application, and estimated cost for each treatment. Illustrations of the deterioration models used to develop the maintenance criteria and strategies are included in Appendix A of this report.

Table 1 -PCC Arterials

PCC Life Cycle Cost Activities	Year	Cost ($/SY)	Cost ($/laneMile)
Full Reconstruction - PCC	0	*	
Reseal Joints and Cracks #1	7	$3	$21,120
Panel Replacement #1 (25%)	14	$80	$563,200
Reseal Joints and Cracks #2	18	$3	$21,120
Panel Replacement #2 (25%)	26	$80	$563,200
Reseal Joints and Cracks #3	29	$3	$21,120
Panel Replacement #3 (25%)	33	$80	$563,200



*Use Total Project Bid for PCC including all Utilities

Table 2 - HMAC Arterials

HMAC Life Cycle Cost Activities	Year	Cost ($/SY)	Cost ($/laneMile)
Full Reconstruction - HMAC	0	*	
Surface Seal #1	5	$4	$28,160
Crack Seal #1	10	$1	$7,040
Mill and Overlay #1	15	$45	$316,800
Surface Seal #2	20	$4	$28,160
Crack Seal #2	23	$1	$7,040
Mill and Overlay #2	29	$45	$316,800
Surface Seal #3	35	$4	$28,160

*Use Total Project Bid for HMAC including all utilities

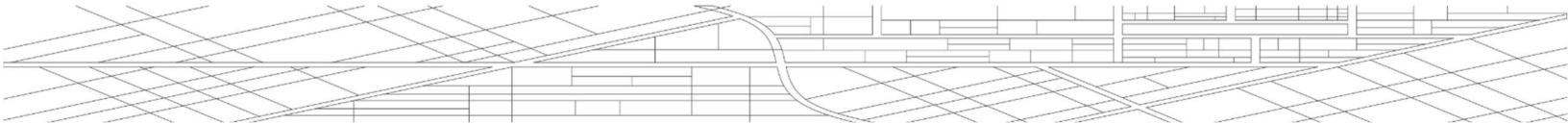
Table 3 - PCC Arterials on Expansive Soils

PCC Life Cycle Cost Activities	Year	Cost ($/SY)	Cost ($/laneMile)
Full Reconstruction - PCC	0	*	
Reseal Joints and Cracks #1	5	$3	$21,120
Panel Replacement #1 (25%)	11	$80	$563,200
Reseal Joints and Cracks #2	14	$3	$21,120
Panel Replacement #2 (25%)	20	$80	$563,200
Diamond Grinding with Joint Replacement	25	$20	$140,800
Panel Replacement #3 (25%)	29	$80	$563,200
Reseal Joints and Cracks #3	32	$3	$21,120

*Use Total Project Bid for PCC including all Utilities

Table 4 - HMAC Arterials with Expansive Soils

HMAC Life Cycle Cost Activities	Year	Cost ($/SY)	Cost ($/laneMile)
Full Reconstruction - HMAC	0	*	
Surface Seal #1	4	$4	$28,160
Crack Seal #1	8	$1	$7,040
Mill and Overlay #1	13	$45	$316,800
Surface Seal #2	17	$4	$28,160
Crack Seal #2	20	$1	$7,040
Mill and Overlay #2	25	$45	$316,800
Surface Seal #3	29	$4	$28,160
Mill and Overlay #3	33	$45	$316,800



*Use Total Project Bid for HMAC including all utilities

Table 5 - PCC Residentials

PCC Life Cycle Cost Activities	Year	Cost ($/SY)	Cost ($/laneMile)
Full Reconstruction - PCC	0	*	
Reseal Joints and Cracks #1	9	$3	$21,120
Reseal Joints and Cracks #2	15	$3	$21,120
Reseal Joints and Cracks #3	20	$3	$21,120
Panel Replacement #1 (25%)	26	$80	$563,200
Reseal Joints and Cracks #4	35	$3	$21,120

*Use Total Project Bid for PCC including all Utilities

Table 6 - HMAC Residentials

HMAC Life Cycle Cost Activities	Year	Cost ($/SY)	Cost ($/laneMile)
Full Reconstruction - HMAC	0	*	
HA5 seal #1	5	$5	$35,200
Crack Seal #1	15	$1	$7,040
Mill and Overlay #1	20	$45	$316,800
HA5 seal #2	24	$5	$35,200
Crack Seal #2	33	$1	$7,040

*Use Total Project Bid for HMAC including all utilities

Table 7 - PCC Residentials on Expansive Soils

PCC Life Cycle Cost Activities	Year	Cost ($/SY)	Cost ($/laneMile)
Full Reconstruction - PCC	0	*	
Reseal Joints and Cracks #1	6	$3	$21,120
Reseal Joints and Cracks #2	15	$3	$21,120
Panel Replacement #1 (25%)	20	$80	$563,200
Diamond Grinding with Joint Replacement	27	$20	$140,800
Panel Replacement #2 (25%)	33	$80	$563,200

*Use Total Project Bid for PCC including all Utilities

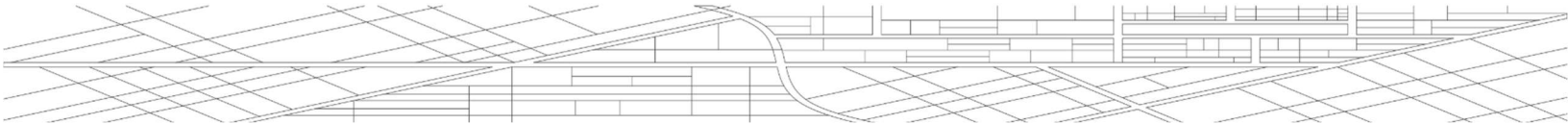


Table 8 - HMAC Residentials with Expansive Soils

HMAC Life Cycle Cost Activities	Year	Cost ($/SY)	Cost ($/laneMile)
Full Reconstruction - HMAC	0	*	
HA5 Seal #1	4	$5	$35,200
Crack Seal #1	11	$1	$7,040
Mill and Overlay #1	20	$45	$316,800
HA5 seal #2	24	$5	$35,200
Crack Seal #2	33	$1	$7,040

*Use Total Project Bid for HMAC including all utilities

Life Cycle Cost Analysis (LCCA) Models

We used a simple spreadsheet (modeled similar to the Federal Highway Administration's *"Real Cost"* program, but more transparent and simple to follow) to evaluate the LCCA for the four categories (eight scenarios) developed using the split between arterials and residential streets, and non-expansive soils versus expansive soils for both HMAC and PCC pavements. The spreadsheet was used to model the assigned maintenance activities developed from the deterioration curves and assigned costs determined in the previous section for each activity based on the year of application. A 4.0% discount rate and 3.0% inflation rate were used to determine future costs and equate them to present worth value for a 40-year analysis per lane mile. A simple user fee was also accounted for based upon an assumed delay due to the activity and a simple cost per hour of the delay. The total present worth value was used for each scenario to determine the total 40-year maintenance cost anticipated per lane mile for each scenario. The difference between this maintenance cost per lane mile were used to develop new recommendations for when to choose PCC over HMAC based on the maintenance differential costs.

Table 9 - LCCA Comparison of Alternatives

	PWV ($/lane mile)	Difference
PCC Arterial	$472,190	
HMAC Arterial	$600,698	$128,509
PCC Arterial (Expansive)	$605,053	
HMAC Arterial (Expansive)	$623,099	$18,046
PCC Residential	$274,970	
HMAC Residential	$333,909	$58,938
PCC Residential (Expansive)	$367,446	
HMAC Residential (Expansive)	$334,475	-$32,971

The results indicate that for arterial streets on soils with a PI less than 30, if the initial construction bid is within $128,000 ($18.18/SY) between HMAC and PCC, then PCC should be chosen. If the difference in initial construction bid is greater than $128,00, then HMAC should be chosen. A much lower level was found for arterials on expansive soils and in residential streets. For streets with expansive soils, where the PI of the majority of the soil is greater than 30 and defined as a moderate to high swell potential by the design Geotechnical Engineer, the LCCA models indicate a HMAC surface should be used for both arterial streets and residential streets. Further evaluation of the arterial streets shows the comparison of the alternatives based on agency costs and user costs.

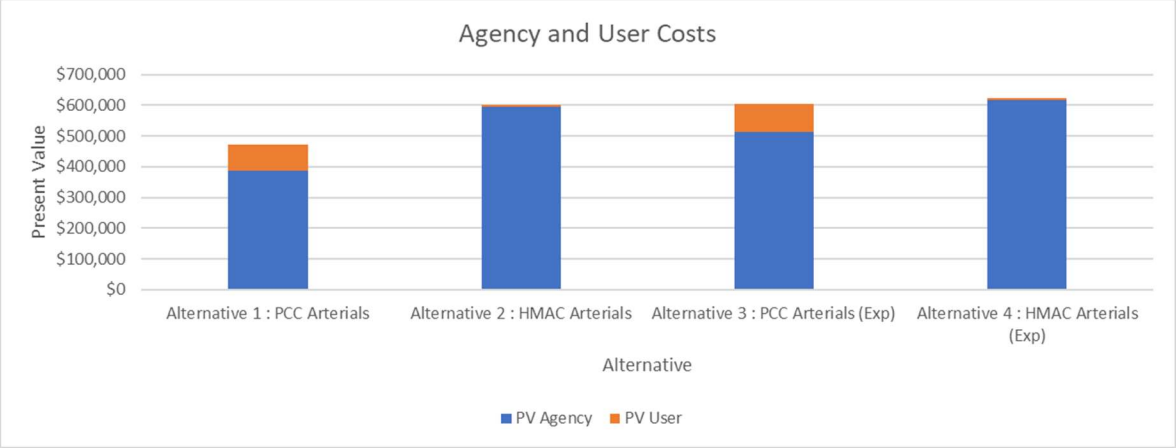


Figure 1 - Comparison of Agency and User Costs for Arterial Streets

Complete results of all the LCCA evaluations for all eight scenarios are presented in Appendix B of this letter.

Recommendations

Based upon the results of our evaluations, we recommend the City adopt a simple process for making the decision between HMAC and PCC pavements when bidding street projects. We believe the initial division should separate projects between arterial/collector business streets and residential streets. The secondary division should then consider the supporting subgrade within the project, between expansive clay soils and non-expansive soils, based on the geotechnical design report, which will summarize the basic soil types in the project. We recommend defining the project as on expansive soils when most of the subgrade within the alignment contains a PI greater than 30, or as classified by the project Geotechnical Engineer as expansive soil. These two divisions divide potential projects into four categories.

The first category is an arterial street on non-expansive soils. We recommend choosing PCC pavement when the bid price is within $128,000 per lane mile ($18.18/SY). This will allow a good portion of PCC pavements for the high traffic volume streets and provide a durable, lowest cost maintenance option for the street.

The second category is an arterial street on expansive soils. We recommend choosing HMAC pavement when the subgrade soils contain mostly moderate to highly expansive soils. Design can account for some of the expansion potential of the soils and stabilized layers beneath the pavement structure can certainly reduce the risk and improve structural strength and performance. However, based upon the nature of expansive soils and the depth of potential wetting of the subgrade, expansion and vertical movement can

occur as deep as eight (8) feet below the pavement surface, or even deeper in extreme situations. This movement causes differential movement at PCC joints and uplift of all pavement surfaces in isolated heaves oriented perpendicular to traffic travel. The deterioration models were designed to account for this potential movement to model the maintenance that would be required for each pavement type. The LCCA results indicate the bid for a PCC pavement would need to be within $18,000 per lane mile to make sense to pave with PCC. Due to this low differential is maintenance cost, we recommend choosing HMAC for this category regardless of the bid price.

The third and forth categories are for residential streets on non-expansive soils and expansive soils. The LCCA model for residential streets on non-expansive soils indicated if the PCC bid is within $59,000/lane mile, PCC should be chosen. The LCCA model for residential streets on expansive soils indicates there is no bid price that would make PCC a cheaper selection based upon the maintenance anticipated. Based upon the financial investments in the initial pavement structure and utilities, likelihood of cuts in the pavement for the numerous residential utility extensions, and the difficulty in reconstruction and maintenance of PCC in residential areas, we do not recommend selecting PCC in either these categories for residential streets.

Based upon the results of the LCCA criteria and models established in this evaluation, we recommend the pavement surface material selection should be based on the following:

1. When the cost difference of PCC is below **$128,000/lane mile ($18.18/SY)**, the City should recommend PCC.
2. When the project contains a majority subgrade with a PI greater than 30 or deemed as a moderate to highly expansive soil by the design Geotechnical Engineer, the City should recommend HMAC.
3. When the project is a residential street classification, for non-expansive and expansive subgrade soils, the City should recommend HMAC.
4. Other criteria to consider is if the adjacent pavement section is PCC, consideration should be given to providing a uniform surface type, at the discretion of the City Engineering Services staff.

Thank you for the opportunity to provide professional services for the evaluation and development of recommendations for pavement selection criteria when bidding street projects using both hot mix asphalt concrete (HMAC) and Portland Cement Concrete (PCC) pavement. Please call if you have any questions regarding the recommendations provided in this letter.

Respectfully submitted,

G. Scot Gordon, PE, IAM
President
Roadway Asset Services, LLC (TxBPE firm # 22104)

Appendix A – Deterioration Models

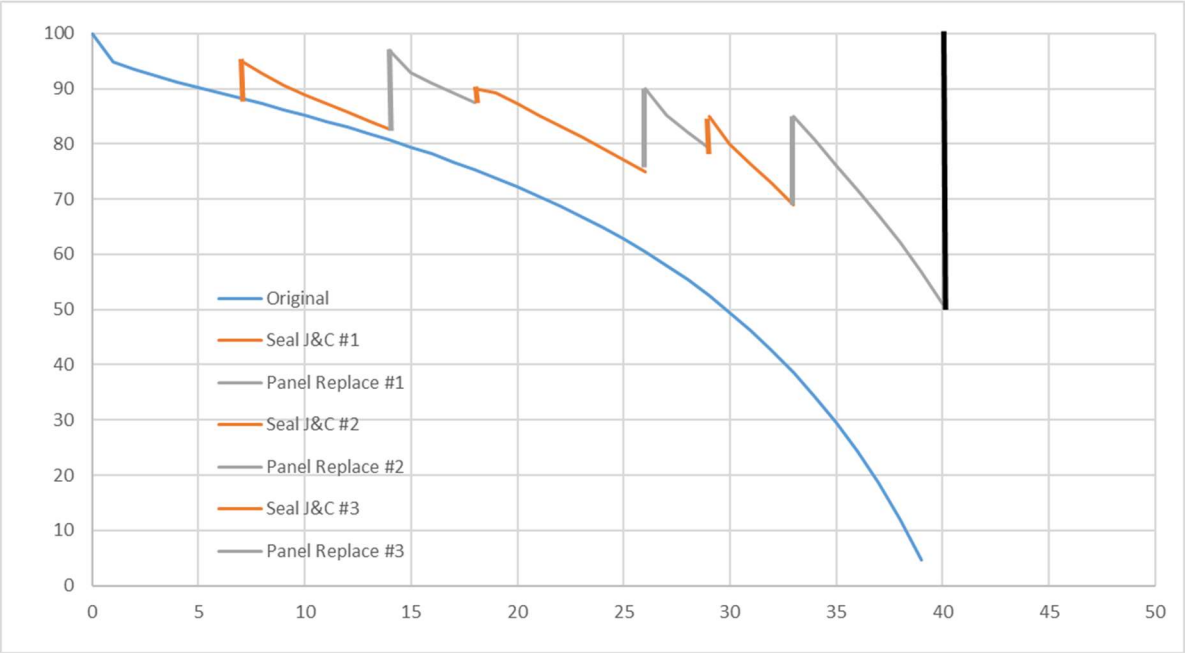


Figure A-1 - PCC Arterials

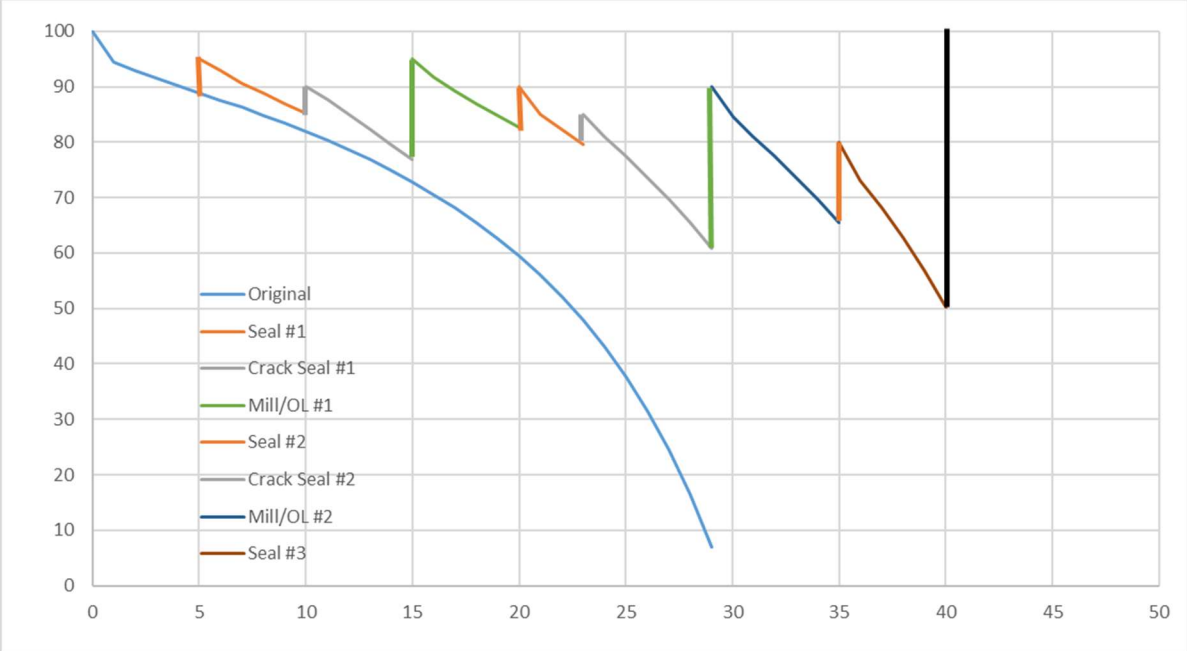


Figure A-2 - HMAC Arterials

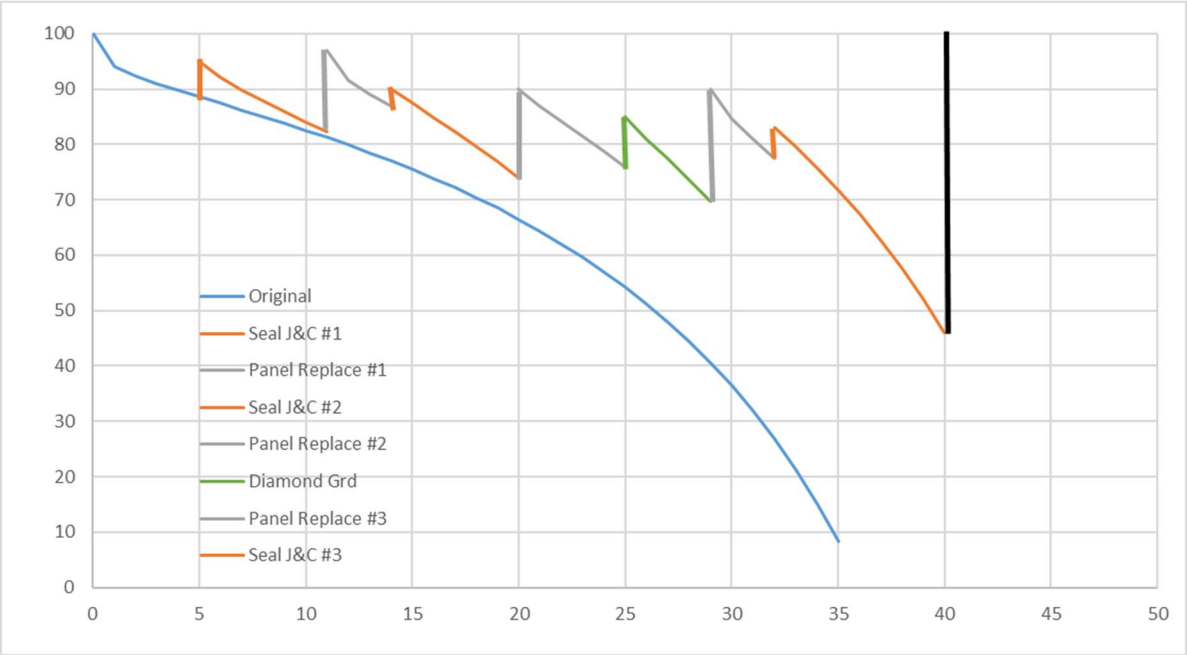


Figure A-3 - PCC Arterials with Expansive Soils

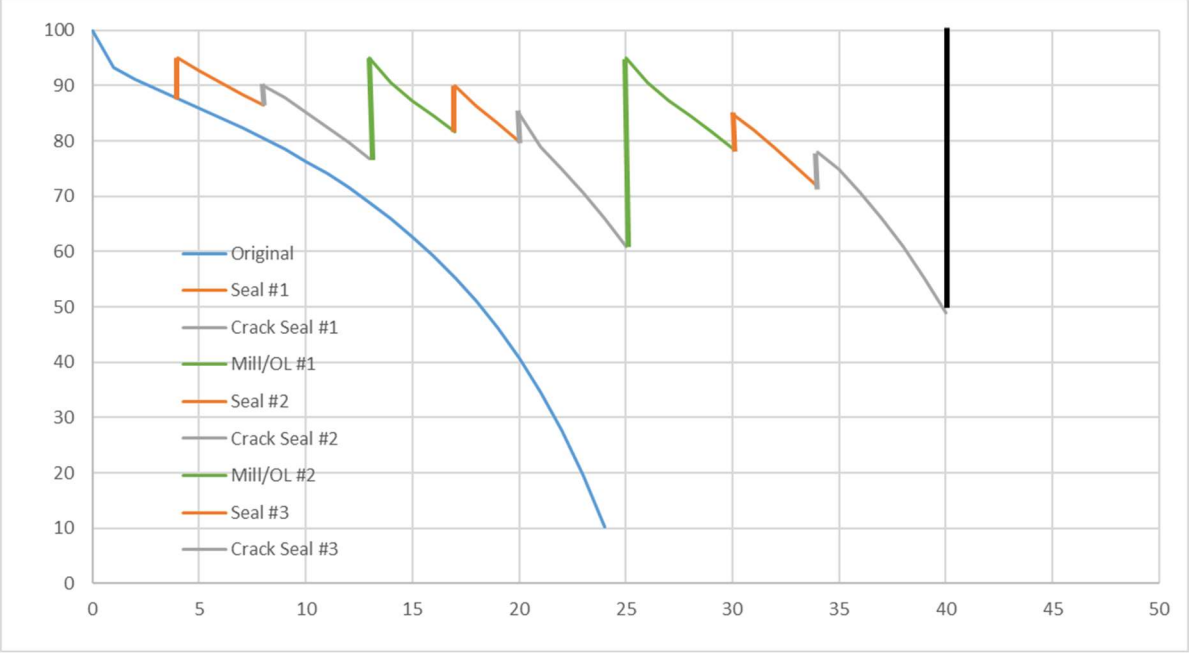


Figure A-4 - HMAC Arterials with Expansive Soils

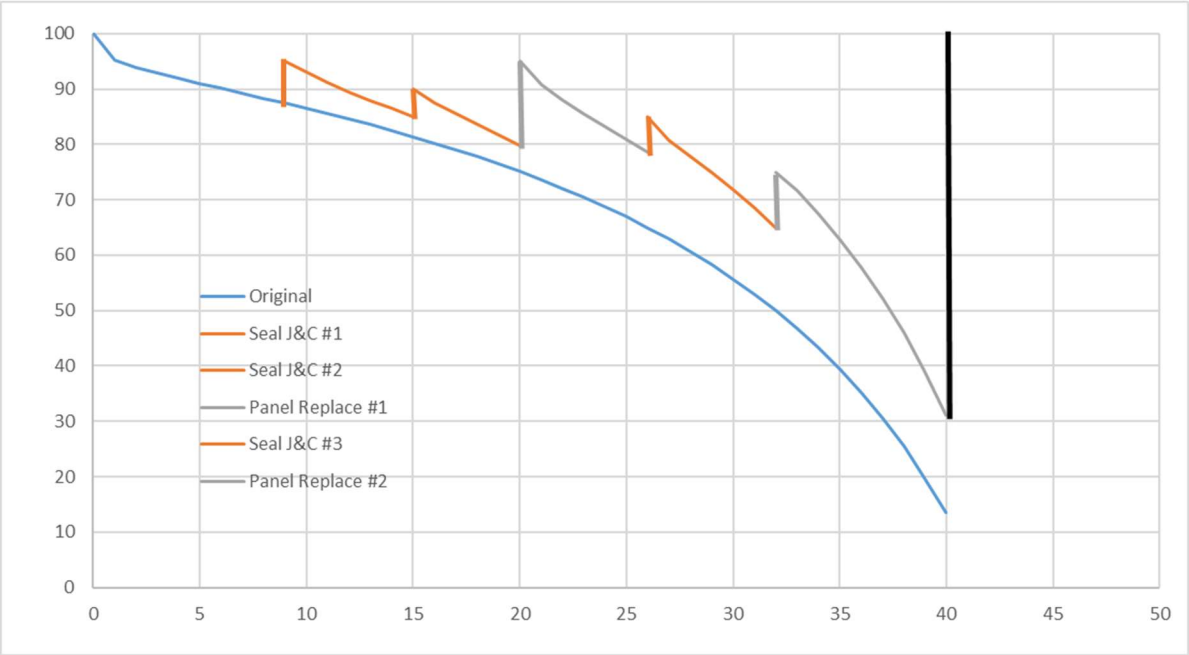


Figure A-5 - PCC Residentials

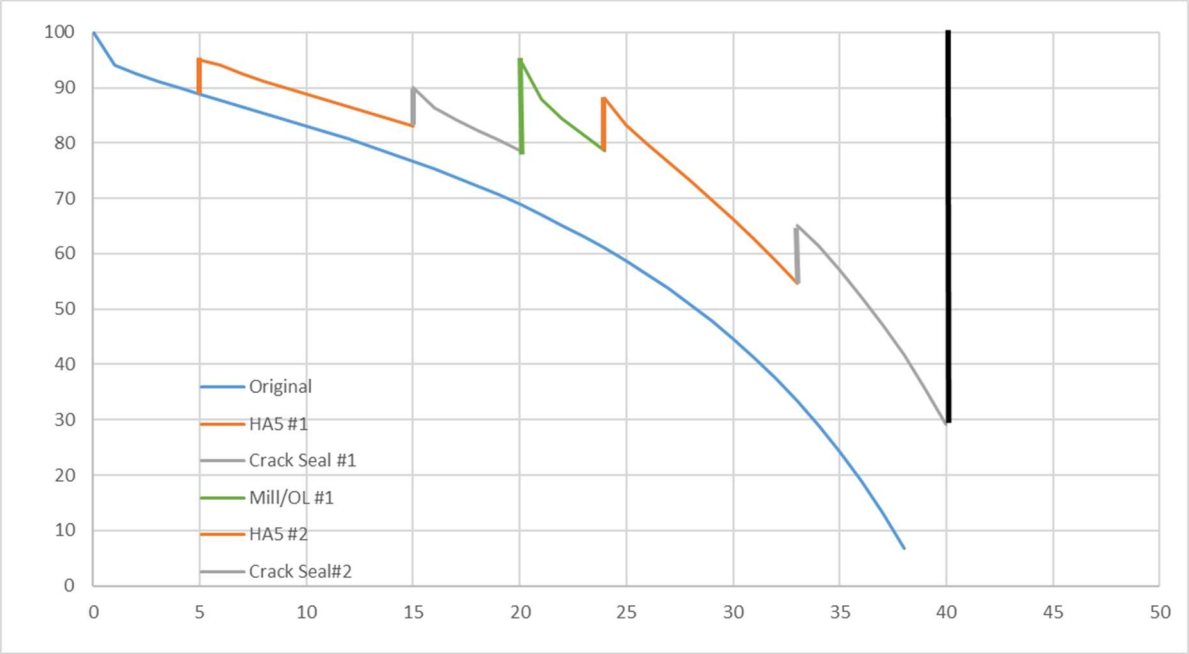


Figure A-6 - HMAC Residentials

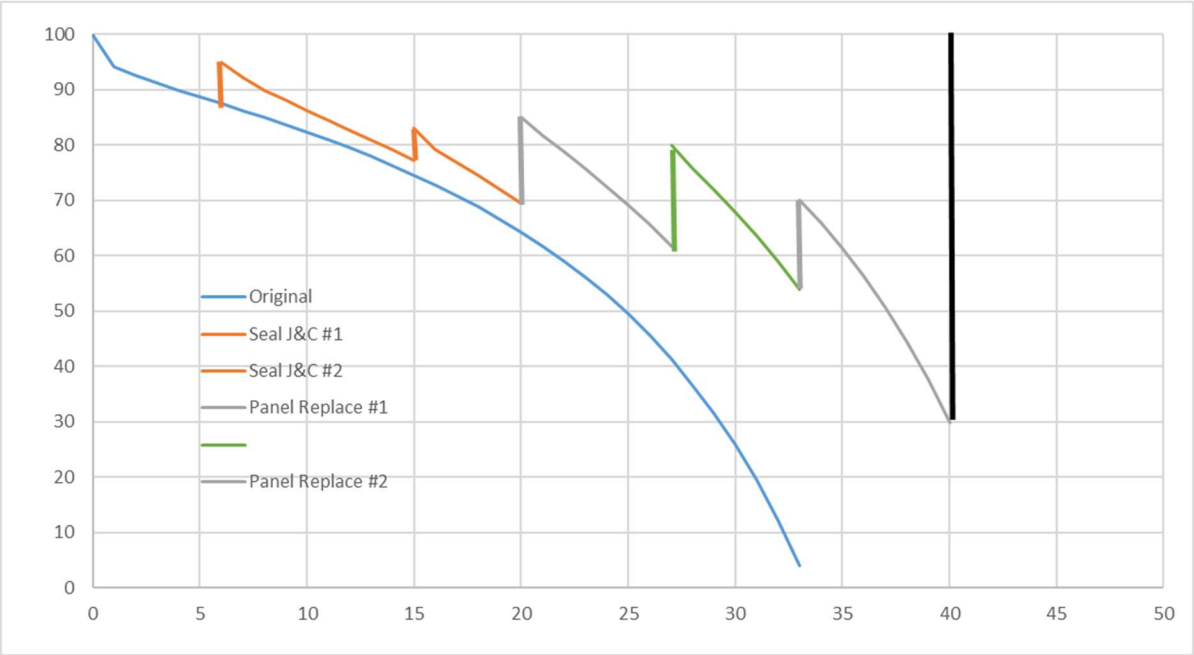


Figure A-7 - PCC Residentials with Expansive Soils

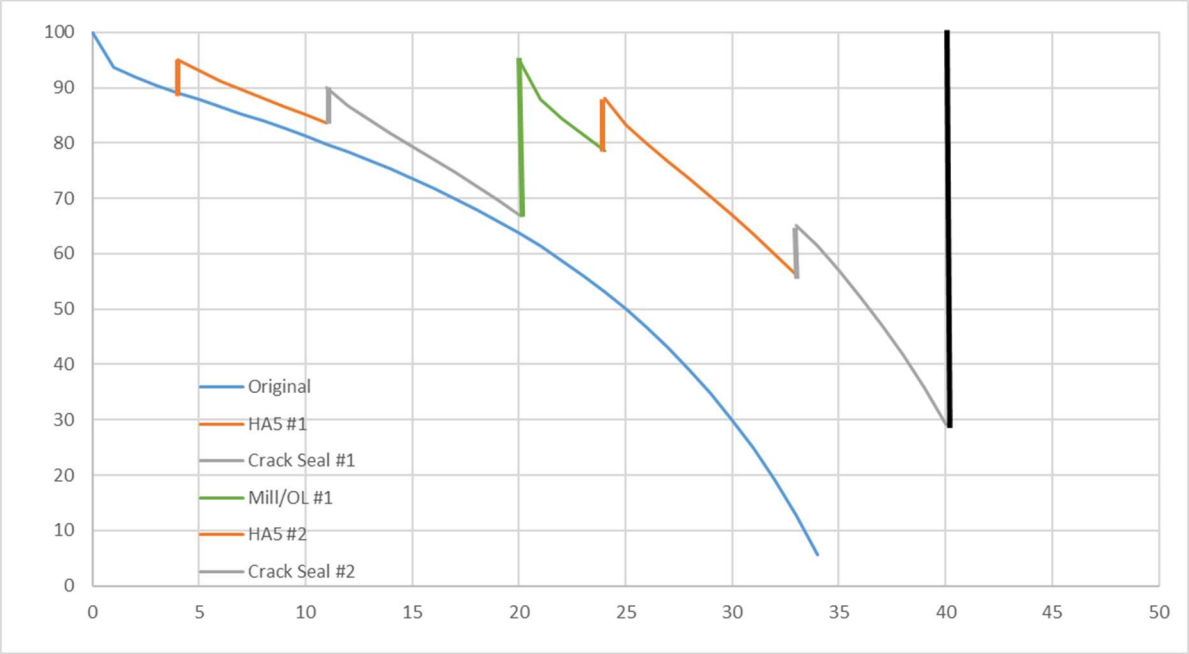


Figure A-8 - HMAC Residentials with Expansive Soils

Appendix B – LCCA Results

DATE: 10/9/2020
TITLE: Corpus Christi
PCC Arterial

Assumed ADT: **30,000**

INFLATION RATE: 3.00%
DISCOUNT RATE: 4.00%
ANALYSIS PERIOD: 40 years
PROJECT SIZE: 7,040 square yards

YEAR	OPTION	UNIT COST	QUANTITY	UNITS	AGENCY Cost	USER COST	COSTS BY YEAR	PRESENT VALUE
0								
0								$0.00
7	Reseal Joints and Cracks #1	$3.69	7,040	sq yds	$25,974.94			
7	User Delay Costs	$1.23	250	hours		$307.47		
7							$26,282.40	$19,972.47
14	Panel Replacement #1 (25%)	$121.01	1,760	sq yds	$212,972.63			
14	User Delay Costs	$1.51	35,000	hours		$52,940.64		
14							$265,913.27	$153,558.29
18	Reseal Joints and Cracks #2	$5.11	7,040	sq yds	$35,955.39			
18	User Delay Costs	$1.70	250	hours		$425.61		
18							$36,380.99	$17,958.68
26	Panel Replacement #2 (25%)	$172.53	1,760	sq yds	$303,648.05			
26	User Delay Costs	$2.16	35,000	hours		$75,480.69		
26							$379,128.74	$136,747.66
29	Reseal Joints and Cracks #3	$7.07	7,040	sq yds	$49,770.66			
29	User Delay Costs	$2.36	250	hours		$589.14		
29							$50,359.80	$16,147.94
33	Panel Replacement #3 (25%)	$212.19	1,760	sq yds	$373,448.80			
33	User Delay Costs	$2.65	35,000	hours		$92,831.73		
33							$466,280.53	$127,804.78
					$1,001,770.47	$222,575.29	$1,224,345.76	

PRESENT WORTH = ***$472,189.82***

UNIT COSTS	Cost	Units	Delay (mins)	Duration (days)
Reseal Joints and Cracks	$3.00	sq yd	0.5	1
Panel Replacement (25%)	$80.00	sq yd	5	14
Diamond Grinding with joint replacment	$20.00	sq yd	5	2
User Delay Costs	$1.00	hour		

Life Cycle Cost Analysis

Fig. B-1

DATE:	10/9/2020			**INFLATION RATE:**		3.00%		
TITLE:	Corpus Christi			**DISCOUNT RATE:**		4.00%		
	HMAC Arterial			**ANALYSIS PERIOD:**		40	years	
				PROJECT SIZE:		7,040	square yards	
Assumed ADT:	**30,000**							

YEAR	OPTION	UNIT COST	QUANTITY	UNITS	AGENCY Cost	USER COST	COSTS BY YEAR	PRESENT VALUE
0								
0								$0.00
5	Surface Seal #1	$4.64	7,040	sq yds	$32,645.16			
5	User Delay Costs	$1.16	250	hours		$289.82		
5							$32,934.98	$27,070.15
10	Crack Seal #1	$1.34	7,040	sq yds	$9,461.17			
10	User Delay Costs	$1.34	250	hours		$335.98		
10							$9,797.15	$6,618.60
15	Mill and Overlay #1	$70.11	7,040	sq yds	$493,564.08			
15	User Delay Costs	$1.56	2,500	hours		$3,894.92		
15							$497,459.00	$276,221.32
20	Surface Seal #2	$7.22	7,040	sq yds	$50,860.09			
20	User Delay Costs	$1.81	250	hours		$451.53		
20							$51,311.62	$23,417.95
23	Crack Seal #2	$1.97	7,040	sq yds	$13,894.05			
23	User Delay Costs	$1.97	250	hours		$493.40		
23							$14,387.45	$5,837.37
29	Mill and Overlay #2	$106.05	7,040	sq yds	$746,559.95			
29	User Delay Costs	$2.36	2,500	hours		$5,891.41		
29							$752,451.37	$241,274.60
35	Surface Seal #3	$11.26	7,040	sq yds	$79,238.37			
35	User Delay Costs	$2.81	250	hours		$703.47		
35							$79,941.83	$20,258.50
					$1,426,222.87	$12,060.52	$1,438,283.39	

PRESENT WORTH = ***$600,698.49***

UNIT COSTS	Cost	Units	Delay (mins)	Duration (days)
Surface Seal	$4.00	sq yd	0.5	1
Crack Seal	$1.00	sq yd	0.5	1
Mill and Overlay	$45.00	sq yd	5	1
HA5	$5.00	sq yd	0.5	1
User Delay Costs	$1.00	hour		

Life Cycle Cost Analysis

Fig. B-2

DATE: 10/9/2020
TITLE: Corpus Christi
PCC Arterial (Expansive)

INFLATION RATE: 3.00%
DISCOUNT RATE: 4.00%
ANALYSIS PERIOD: 40 years
PROJECT SIZE: 7,040 square yards

Assumed ADT: **30,000**

YEAR	OPTION	UNIT COST	QUANTITY	UNITS	AGENCY Cost	USER COST	COSTS BY YEAR	PRESENT VALUE
0								
0								$0.00
5	Reseal Joints and Cracks #1	$3.48	7,040	sq yds	$24,483.87			
5	User Delay Costs	$1.16	250	hours		$289.82		
5							$24,773.69	$20,362.16
11	Panel Replacement #1 (25%)	$110.74	1,760	sq yds	$194,900.13			
11	User Delay Costs	$1.38	35,000	hours		$48,448.19		
11							$243,348.31	$158,074.42
14	Reseal Joints and Cracks #2	$4.54	7,040	sq yds	$31,945.89			
14	User Delay Costs	$1.51	250	hours		$378.15		
14							$32,324.04	$18,666.33
20	Panel Replacement #2 (25%)	$144.49	1,760	sq yds	$254,300.46			
20	User Delay Costs	$1.81	35,000	hours		$63,213.89		
20							$317,514.36	$144,909.41
25	Diamond Grinding with Joint Re	$41.88	7,040	sq yds	$294,803.93			
25	User Delay Costs	$2.09	5,000	hours		$10,468.89		
25							$305,272.82	$114,512.96
29	Panel Replacement #3 (25%)	$188.53	1,760	sq yds	$331,804.42			
29	User Delay Costs	$2.36	35,000	hours		$82,479.79		
29							$414,284.22	$132,840.82
32	Reseal Joints and Cracks #3	$7.73	7,040	sq yds	$54,385.75			
32	User Delay Costs	$2.58	250	hours		$643.77		
32							$55,029.52	$15,686.60
					$1,186,624.46	$205,922.50	$1,392,546.96	

PRESENT WORTH = ***$605,052.71***

UNIT COSTS	Cost	Units	Delay (mins)	Duration (days)
Reseal Joints and Cracks	$3.00	sq yd	0.5	1
Panel Replacement (25%)	$80.00	sq yd	5	14
Diamond Grinding with joint replacment	$20.00	sq yd	5	2
User Delay Costs	$1.00	hour		

Life Cycle Cost Analysis

Fig. B-3

DATE: 10/9/2020
TITLE: Corpus Christi
HMAC Arterial (Expansive)

INFLATION RATE: 3.00%
DISCOUNT RATE: 4.00%
ANALYSIS PERIOD: 40 years
PROJECT SIZE: 7,040 square yards

Assumed ADT: **30,000**

YEAR	OPTION	UNIT COST	QUANTITY	UNITS	AGENCY Cost	USER COST	COSTS BY YEAR	PRESENT VALUE
0								
0								$0.00
4	Surface Seal #1	$4.50	7,040	sq yds	$31,694.33			
4	User Delay Costs	$1.13	250	hours		$281.38		
4							$31,975.71	$27,332.97
8	Crack Seal #1	$1.27	7,040	sq yds	$8,918.06			
8	User Delay Costs	$1.27	250	hours		$316.69		
8							$9,234.75	$6,747.74
13	Mill and Overlay #1	$66.08	7,040	sq yds	$465,231.48			
13	User Delay Costs	$1.47	2,500	hours		$3,671.33		
13							$468,902.81	$281,610.88
17	Surface Seal #2	$6.61	7,040	sq yds	$46,544.19			
17	User Delay Costs	$1.65	250	hours		$413.21		
17							$46,957.40	$24,106.67
20	Crack Seal #2	$1.81	7,040	sq yds	$12,715.02			
20	User Delay Costs	$1.81	250	hours		$451.53		
20							$13,166.55	$6,009.04
25	Mill and Overlay #2	$94.22	7,040	sq yds	$663,308.85			
25	User Delay Costs	$2.09	2,500	hours		$5,234.44		
25							$668,543.29	$250,781.82
30	Surface Seal #3	$9.71	7,040	sq yds	$68,351.71			
30	User Delay Costs	$2.43	250	hours		$606.82		
30							$68,958.53	$21,261.20
34	Crack Seal #3	$2.73	7,040	sq yds	$19,232.61			
34	User Delay Costs	$2.73	250	hours		$682.98		
34							$19,915.59	$5,248.80
					$1,315,996.25	$11,658.38	$1,327,654.64	

PRESENT WORTH = ***$623,099.12***

UNIT COSTS	Cost	Units	Delay (mins)	Duration (days)
Surface Seal	$4.00	sq yd	0.5	1
Crack Seal	$1.00	sq yd	0.5	1
Mill and Overlay	$45.00	sq yd	5	1
HA5	$5.00	sq yd	0.5	1
User Delay Costs	$1.00	hour		

Life Cycle Cost Analysis

Fig. B-4

DATE:	10/9/2020	**INFLATION RATE:**	3.00%
TITLE:	Corpus Christi	**DISCOUNT RATE:**	4.00%
	PCC Residential	**ANALYSIS PERIOD:**	40 years
		PROJECT SIZE:	7,040 square yards

Assumed ADT: **2,000**

YEAR	OPTION	UNIT COST	QUANTITY	UNITS	COST	COSTS BY YEAR	PRESENT VALUE
0							
0							$0.00
9	Reseal Joints and Cracks #1	$3.91	7,040	sq yds	$27,556.81		
9	User Delay Costs	$1.30	17	hours	$21.75		
9						$27,578.56	$19,376.33
15	Reseal Joints and Cracks #2	$4.67	7,040	sq yds	$32,904.27		
15	User Delay Costs	$1.56	17	hours	$25.97		
15						$32,930.24	$18,284.99
20	Panel Replacement #1 (25%)	$144.49	1,760	sq yds	$254,300.46		
20	User Delay Costs	$1.81	933	hours	$1,685.70		
20						$255,986.17	$116,828.74
26	Reseal Joints and Cracks #3	$6.47	7,040	sq yds	$45,547.21		
26	User Delay Costs	$2.16	17	hours	$35.94		
26						$45,583.15	$16,441.35
32	Panel Replacement #2 (25%)	$206.01	1,760	sq yds	$362,571.65		
32	User Delay Costs	$2.58	933	hours	$2,403.41		
32						$364,975.06	$104,039.04

PRESENT WORTH = ***$274,970.46***

UNIT COSTS	Cost	Units	Delay (mins)	Duration (days)
Reseal Joints and Cracks	$3.00	sq yd	0.5	1
Panel Replacement (25%)	$80.00	sq yd	2	14
Diamond Grinding with joint replacment	$20.00	sq yd	2	2
User Delay Costs	$1.00	hour		

Life Cycle Cost Analysis

Fig. B-5

DATE:	10/9/2020	**INFLATION RATE:**	3.00%
TITLE:	Corpus Christi	**DISCOUNT RATE:**	4.00%
	HMAC Residential	**ANALYSIS PERIOD:**	40 years
		PROJECT SIZE:	7,040 square yards

Assumed ADT: **2,000**

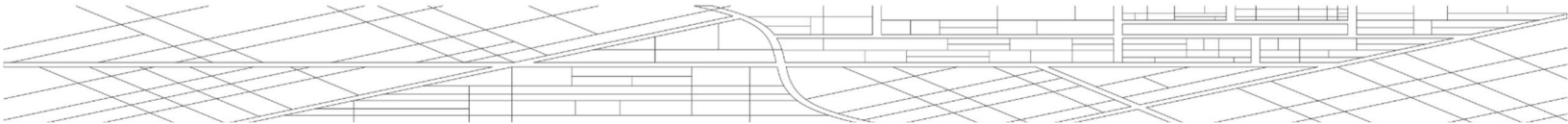
YEAR	OPTION	UNIT COST	QUANTITY	UNITS	COST	COSTS BY YEAR	PRESENT VALUE
0							
0							$0.00
5	HA5 Seal #1	$5.80	7,040	sq yds	$40,806.45		
5	User Delay Costs	$1.16	33	hours	$38.64		
5						$40,845.09	$33,571.69
15	Crack Seal #1	$1.56	7,040	sq yds	$10,968.09		
15	User Delay Costs	$1.56	17	hours	$25.97		
15						$10,994.06	$6,104.61
20	Mill and Overlay #1	$81.28	7,040	sq yds	$572,176.04		
20	User Delay Costs	$1.81	33	hours	$60.20		
20						$572,236.24	$261,161.15
24	HA5 Seal #2	$10.16	7,040	sq yds	$71,554.35		
24	User Delay Costs	$2.03	33	hours	$67.76		
24						$71,622.11	$27,941.32
33	Crack Seal #2	$2.65	7,040	sq yds	$18,672.44		
33	User Delay Costs	$2.65	17	hours	$44.21		
33						$18,716.65	$5,130.12

PRESENT WORTH = ***$333,908.89***

UNIT COSTS	Cost	Units	Delay (mins)	Duration (days)
Surface Seal	$4.00	sq yd	0.5	1
Crack Seal	$1.00	sq yd	0.5	1
Mill and Overlay	$45.00	sq yd	1	1
HA5	$5.00	sq yd	1	1
User Delay Costs	$1.00	hour		

Life Cycle Cost Analysis

Fig. B-6



DATE:	10/9/2020	**INFLATION RATE:**	3.00%
TITLE:	Corpus Christi	**DISCOUNT RATE:**	4.00%
	PCC Residential (Expansive)	**ANALYSIS PERIOD:**	40 years
		PROJECT SIZE:	7,040 square yards

Assumed ADT: **2,000**

YEAR	OPTION	UNIT COST	QUANTITY	UNITS	COST	COSTS BY YEAR	PRESENT VALUE
0							
0							$0.00
6	Reseal Joints and Cracks #1	$3.58	7,040	sq yds	$25,218.38		
6	User Delay Costs	$1.19	17	hours	$19.90		
6						$25,238.29	$19,946.18
15	Reseal Joints and Cracks #2	$4.67	7,040	sq yds	$32,904.27		
15	User Delay Costs	$1.56	17	hours	$25.97		
15						$32,930.24	$18,284.99
20	Panel Replacement #1 (25%)	$144.49	1,760	sq yds	$254,300.46		
20	User Delay Costs	$1.81	1,400	hours	$2,528.56		
20						$256,829.02	$117,213.41
27	Diamond Grinding with Joint Re	$44.43	7,040	sq yds	$312,757.49		
27	User Delay Costs	$2.22	200	hours	$444.26		
27						$313,201.75	$108,623.56
33	Panel Replacement #2 (25%)	$212.19	1,760	sq yds	$373,448.80		
33	User Delay Costs	$2.65	1,400	hours	$3,713.27		
33						$377,162.07	$103,377.93

PRESENT WORTH = ***$367,446.07***

UNIT COSTS	Cost	Units	Delay (mins)	Duration (days)
Reseal Joints and Cracks	$3.00	sq yd	0.5	1
Panel Replacement (25%)	$80.00	sq yd	3	14
Diamond Grinding with joint replacment	$20.00	sq yd	3	2
User Delay Costs	$1.00	hour		

Life Cycle Cost Analysis

Fig. B-7

DATE: 10/9/2020
TITLE: Corpus Christi
HMAC Residential (Expansive)

INFLATION RATE: 3.00%
DISCOUNT RATE: 4.00%
ANALYSIS PERIOD: 40 years
PROJECT SIZE: 7,040 square yards

Assumed ADT: **2,000**

YEAR	OPTION	UNIT COST	QUANTITY	UNITS	COST	COSTS BY YEAR	PRESENT VALUE
0							
0							$0.00
4	HA5 Seal #1	$5.63	7,040	sq yds	$39,617.91		
4	User Delay Costs	$1.13	33	hours	$37.52		
4						$39,655.43	$33,897.63
11	Crack Seal #1	$1.38	7,040	sq yds	$9,745.01		
11	User Delay Costs	$1.38	17	hours	$23.07		
11						$9,768.08	$6,345.16
20	Mill and Overlay #1	$81.28	7,040	sq yds	$572,176.04		
20	User Delay Costs	$1.81	33	hours	$60.20		
20						$572,236.24	$261,161.15
24	HA5 Seal #2	$10.16	7,040	sq yds	$71,554.35		
24	User Delay Costs	$2.03	33	hours	$67.76		
24						$71,622.11	$27,941.32
33	Crack Seal #2	$2.65	7,040	sq yds	$18,672.44		
33	User Delay Costs	$2.65	17	hours	$44.21		
33						$18,716.65	$5,130.12

PRESENT WORTH = ***$334,475.38***

UNIT COSTS	Cost	Units	Delay (mins)	Duration (days)
Surface Seal	$4.00	sq yd	0.5	1
Crack Seal	$1.00	sq yd	0.5	1
Mill and Overlay	$45.00	sq yd	1	1
HA5	$5.00	sq yd	1	1
User Delay Costs	$1.00	hour		

Life Cycle Cost Analysis

Fig. B-8