Draft Pavement Design - Mercer Corridor Improvements Projects

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This memorandum transmits the pavement designs for the Mercer Corridor Improvements Projects.

The pavement design provided includes:

- Portland Cement Concrete Pavement (PCCP) to be used on Mercer Street, 9th Avenue, and Fairview Avenue with 40 years of design life.

- Hot Mix Asphalt (HMA) Pavement to be used on Valley Street, Westlake Avenue, Roy Street, Broad Street with 20 years of design life, and I-5 Ramps with 40 years of design life.

The memorandum is broken down into 5 sections on the following pages:

1. PCCP Pavement Design Results and Requirements
2. HMA Pavement Design Results and Requirements
3. Subsurface Soil Geotechnical Analysis
4. Traffic Analysis (ESAL Projection) and Design Worksheets
5. Mercer Street Life Cycle Cost Analysis

1. PCC PAVEMENT DESIGN RESULTS AND REQUIREMENTS

Design Results – PCC Pavement		
Roadway Section	**Traffic Load**	**Depth**
Mercer Street	EB ESALs: 89,123,775 WB ESALs: 66,460,436	14″
Fairview Avenue and 9^{th} Ave	NB ESALs: 30,152,839 SB ESALs: 27,210,805	12″

Notes:

1. HMA pavement distresses such as rutting, shoving, and corrugations caused by slow moving traffic, braking and acceleration forces are typically occurred in the urban intersection areas under heavy traffic loading. Therefore, PCC pavement was proposed on the above mentioned streets to ensure better long term pavement performance. A Life cycle cost analysis was also conducted in Section 5 to help the pavement type selection for Mercer Street.

2. Over excavation material is considered as a part of the pavement structure as base course to develop the proposed concrete pavement depths. CBR value of 1 for the original subgrade soil is used as the pavement design parameter for the conversion of Subgrade Resilient Modulus.

3. The Portland Cement Concrete mix shall be Class 6.5 (1-1/2) according to the City of Seattle Standard Specification Section 5-05.2, 5-05.3.

4. Cross street pavements will be constructed to match the existing section or to be built according to the proposed design depth, whichever has the greater structural depth.

Design Requirements – PCC Pavement	
Reliability (SDOT design criteria for new pavement)	90%
Standard Deviation (SDOT design criteria for PCCP)	0.35
Initial Serviceability (SDOT design criteria for new pavement)	4.5
Terminal Serviceability (SDOT design criteria for new pavement)	2.0
Design Life (SDOT design criteria for PCCP)	40 years
Drainage Coefficient (Cd) (SDOT design criteria for new pavement)	1.0
Modulus of Concrete Elasticity (SDOT design criteria for new pavement)	4,000,000psi
Modulus of Concrete Rupture (SDOT design criteria for new pavement)	650psi
Joint Load Transfer Coefficient (J) (SDOT design criteria for new pavement)	3.2
Granular Base Thickness (SDOT design criteria for new pavement)	6 inches
Granular Base Mr. Value (Typical for unbound granular material)	30,000psi
Subgrade Resilient Modulus (Converted from CBR=1 using NCHRP 1-37A Equation: MR = $2555\ CBR^{0.64}$)	2,555psi
Loss of Support (assigned to account for potential differential vertical soil movements from the poor subgrade soil)	2
Composite Modulus of Subgrade Reaction (K) (AASHTO Guide for Design of Pavement Structures Figure 3.3)	330pci
Effective Modulus of Subgrade Reaction (Keff) (AASHTO Guide for Design of Pavement Structures Figure 3.6)	35pci

Note: 1. Design criteria are in accordance with Seattle Right-of Way Improvements Manual Chapter 4.7.2.

2. HMA PAVEMENT DESIGN RESULTS AND REQUIREMENTS

Design Results – HMA Pavement		
Roadway Section	**Traffic Load**	**Layer Depth**
Valley Street	EB ESALs: 2,542,455 WB ESALs: 2,585,548	HMA CL. ½″ (PG 64-22): D=6″ CSBC: D=6″
Roy Street	EB ESALs: 897,416 WB ESALs: 1,054,122	HMA CL. ½″ (PG 64-22): D=5″ CSBC: D=6″
Broad Street	NB ESALs: 17,264,735	HMA CL. ½″ (PG 64-22): D=11″ CSBC: D=6″
Broad Street	SB ESALs: 2,014,657	HMA CL. ½″ (PG 64-22): D=8″ CSBC: D=6″
Westlake Avenue (North of 9th Ave.)	NB ESALs: 13,483,662 SB ESALs: 11,406,968	HMA CL. ½″ (PG 64-22): D=9″ CSBC: D=6″
Westlake Avenue (South of 9th Ave.)	NB ESALs: 4,733,253 SB ESALs: 2,033,546	HMA CL. ½″ (PG 64-22): D=7″ CSBC: D=6″
I-5 Ramp	EB ESALs: 56,914,545 WB ESALs: 59,555,138	HMA CL. ½″ (PG 70-22): D=13″ CSBC: D=6″

Notes:

1. An extra inch of HMA thickness was proposed to Roy St. pavement design to provide adequate resistance to the potential excessive tensile stress/strain (fatigue cracking) that might develop at the bottom of a thin HMA layer.

2. Over excavation material is considered as a part of the pavement structure as base course to develop the proposed concrete pavement depths. CBR value of 1 for the original subgrade soil is used as the pavement design parameter for the conversion of Subgrade Resilient Modulus.

3. The HMA mix shall be according to the City of Seattle the City of Seattle Standard Plan No. 402 and Standard Specification Section 5-02, 5-04.

4. Cross street pavements will be constructed to match the existing section or to be built according to the proposed design depth, whichever has the greater structural depth.

Design Requirements – HMA Pavement	
Reliability (SDOT design criteria for new pavement)	90%
Reliability (WSDOT design criteria for new pavement)	95%
Standard Deviation (SDOT design criteria for HMA pavement)	0.45
Standard Deviation (WSDOT design criteria for HMA pavement)	0.5
Initial Serviceability (SDOT design criteria for new pavement)	4.5
Initial Serviceability (WSDOT design criteria for new pavement)	4.5
Terminal Serviceability (SDOT design criteria for new pavement)	2.0
Terminal Serviceability (WSDOT design criteria for new pavement)	3.0
Design Life (SDOT design criteria for HMA)	20 years
Design Life (WSDOT design criteria for HMA)	40 years
Drainage Coefficient (Cd) (WSDOT/SDOT design criteria for new pavement)	1.0
Structural Coefficient HMA Class ½" and Class 1" (SDOT design criteria for new pavement)	0.39
Structural Coefficient HMA Class ½" and Class 1" (WSDOT design criteria for new pavement)	0.44
Structural Coefficient of Base Mineral Aggregate Type 2 (WSDOT/SDOT design criteria for new pavement)	0.13
Structural Coefficient of Subbase Mineral Aggregate Type 14 (recommended by CH2M HILL Geotechnical Engineer)	0.13
Subgrade Resilient Modulus (Valley, Westlake, Roy) (Converted from CBR=1 using NCHRP 1-37A Equation: MR = $2555\ CBR^{0.64}$)	2,555psi
Subgrade Resilient Modulus (Broad) (Converted from CBR=5 using NCHRP 1-37A Equation: MR = $2555\ CBR^{0.64}$)	7,157psi
Subgrade Resilient Modulus (I-5 Ramps) (Converted from CBR=10 using NCHRP 1-37A Equation: MR = $2555\ CBR^{0.64}$)	11,153psi

Notes:

1. Design criteria are in accordance with Seattle Right-of Way Improvements Manual Chapter 4.7.2.

2. WSDOT HMA pavement design requirements are applied for I-5 ramps with 40-year design life.

3. In general, the project site soils are not adequate to support the roadway. The site soils typically consist of very loose fill material which will be unable to support the roadway under design traffic loading. The geotechnical report for this project recommends excavating the subgrade to a depth of at least 3 feet below finished grade and backfilling with a high quality granular material up to the roadway section. It is further recommended that this material is wrapped in a high strength nonwoven geotextile to prevent mixing of the existing site soils and the proposed backfill material over time. Detailed geotechnical analysis for subgrade improvements of this project is provided in the following section.

4. Over excavation areas include: Valley St., Westlake Ave., and Roy St. The pavement design was conducted with CBR of 1 assigned for the untreated subgrade soil in these areas. The over-ex backfilling material was treated as a part of the pavement structure (subbase layer) in the proposed pavement design.

5. CBR of 10 was assigned for subgrade soils that consist of native glacial soil in the I-5 ramp areas.

6. CBR of 5 was assigned for Broad Street as the majority of the subgrade soils consist of up to 12 feet of imported fill material.

7. The NCHRP 1-37A equation was developed for AASHTO 2002 Guide for Design of New and Rehabilitated Pavement Structures. The equation (correlation) was developed for "Input Level 2" when the knowledge of inputs variables was fair.

3. SUBSURFACE SOIL GEOTECHNICAL ANALYSIS

The following sections are summaries of subsurface soil conditions based on selected existing explorations located within the Project area.

Mercer Street On/Off Ramp Area

In the area of the on/off ramps to I-5 and east of Fairview, existing boring logs indicate the subsurface consists of very dense silty sand and hard silt and clay. At the north side of the off ramp, there are some zones of fill consisting of medium dense silty sand and soft to stiff silt fill. Available geologic information suggests that Esperance sands over Lawton Clay will be the basic geologic section. The Lawton Clay is a highly overconsolidated deposit of silt and clay that is quite strong in its undisturbed state, but can become very weak when allowed to deform. In many locations, deformation due to stress relief during deglaciation or undercutting of the toe of slope during highway construction has caused fissures, slickensides, and movement which reduced the material to its residual strength. Several landslides occurred to the east of the Project area during the original construction of I-5. These landslides were stabilized by a series of large diameter cylinder pile walls.

Mercer Street Area

Borings and geologic mapping indicate the Broad Street ramp area consists of ice-contact deposits. Boring logs indicate that between 8^{th} and 9^{th} Avenue on Mercer Street the subsurface transitions to include up to approximately 30 feet of soft/loose fill underlain by dense to very dense sandy glacial deposits. Between 9^{th} Avenue and the east side of Fairview, borings indicate 10 to 20 feet of fill over silty sand and fine-grained lake deposits underlain by very dense sandy glacial deposits. The fill along Mercer Street predominately consists of very loose to loose silty sand and soft to firm silt with debris, wood, and organic inclusions. The fill thickness lessens toward the western and eastern edges of the Project. Fill thicknesses taper to relatively shallow depths at 8^{th} Avenue and at the eastern side of Fairview Avenue. The lake deposits consist of firm to stiff silt, clay, organic soil, and peat.

Valley Street Area

Valley Street is mapped as very soft to medium stiff, lake deposits. Boring logs indicate up to 40 feet of soft/loose fill containing wood, lumber, and bricks may be encountered along Valley Street. Historically, the area was filled in the early 1900's with uncompacted fill containing garbage and other debris as shown in Figure 5. The fill is predominately classified in the existing borings as very loose to loose silty sand with wood and other debris.

Logs of borings located just north of the planned substation on Valley Street indicate that subsurface soils consist of up to 10 feet of loose/soft fill that contains wood debris and organics, underlain by medium dense to dense sand or hard clay.

Pavement Subgrade Improvement

As discussed previously, the site subsurface typically consists of uncompacted fill with debris and organics between 8th Avenue and Fairview Avenue. Outside of these limits, however, the subsurface is anticipated to consist of compact glacial soil.

Where subgrade soils consist of native glacial soil or imported compacted granular fill, subgrade conditions are anticipated to be sufficient to support the proposed traffic loading. These conditions are anticipated east of Fairview Avenue on the I-5 ramps, west of 8th Avenue and in locations of 4 or more feet of fill to reach the subgrade elevation, a CBR of 10 can be assumed. In addition, it is recommended that stabilization geotextile meeting the requirements of City of Seattle Standard Specification Table 3 be placed on top of the prepared subgrade prior to placement of the pavement section. The geotextile is included to protect the subgrade from damage due to construction traffic loading as well as to mitigate migration of the gravel into the underlying soils and/or fines migration into the overlying gravel due to repeated live loading after construction is completed.

Between 8th Avenue and Fairview Avenue (including Fairview Avenue), the subgrade is anticipated to be inadequate to withstand the proposed traffic loading without improvements. Based on SPT blow counts and soil type, a subgrade CBR of approximately 1.0 is anticipated at the site between 8th Avenue and the east side of Fairview Avenue. The extent of the weak/soft existing soils in this portion of the site is generally more than 20 feet deep. Ideally all soft soils would be excavated to a sound foundation and replaced with compacted granular backfill. Due to the depth of the material to be removed and presence of groundwater it is believed this option is cost prohibitive. However, leaving this material in-place will result in the potential for long-term settlement and degradation of the subgrade and underlying soils.

To reduce loading of the soft subgrade and mitigate potential future settlement, it is recommended that a high-strength at low strain geotextile be used in conjunction with 18-inches of overexcavation and backfilling with a compacted, high quality crushed rock backfill. The overexcavation will reduce traffic pressures on the subgrade as well as remove existing, subgrade soils damaged under existing traffic loading. The depth of overexcavation was limited to 18-inches in order to minimize the impact of the excavation on existing shallow utilities. The high strength geotextile will provide support over soft areas during construction as well as in areas where future settlement and degradation may occur due to the underlying soft, organic soil. The recommended minimum properties for the high strength geotextile are presented in Table 5. The recommended product for this application is Mirafi HP570.

Regardless of the relative compaction achieved, the pavement subgrade must be firm and non-yielding. Where practical, proof-rolling of the subgrade with heavy equipment should be completed to verify that the subgrade is firm and relatively non-yielding, regardless of relative density achieved. Except for proof rolling, it is recommended that construction equipment, truck traffic and other loading be prevented from operating directly on the subgrade until after the gravel backfill has been placed and compacted. The excavation should be finished with a smooth bucket (i.e. no teeth) to provide an undisturbed subgrade.

Location of the top elevation of existing utilities at a frequent interval is recommended to ensure they are protected during construction. A qualified professional should monitor the soil conditions exposed along all excavations to confirm suitable bearing soils are exposed. This individual should be qualified to provide design modifications if necessary.

Improvement of the subgrade by admixtures (e.g. cement) could also improve subgrade performance under traffic loading. However, this stabilization method is believed to be less effective than a high strength geotextile in supporting the pavement section in areas of settlement and degradation of the weak, underlying soils.

These recommendations for subgrade improvements are intended to improve the performance of the pavement by reducing traffic loading to the subgrade and limiting the impacts of settlement and degradation of the underlying poor quality soil. However, these recommendations cannot completely protect the pavement from the degradation and settlement of underlying soil nor will it protect against liquefaction related effects. Subgrade improvement through overexcavation and use of a high strength geotextile should result in improved pavement performance compared to no improvements; however, it still has the potential to require maintenance because of the poor quality of the underlying soil.

4. TRAFFIC ANALYSIS AND DESIGN WORKSHEETS

Pavement design traffic estimates were based on traffic volumes developed for analysis in the Mercer Street Corridor Improvement Project, Transportation Discipline Report. Exhibit TR-B7 of the report shows 2010 Build PM Peak Hour traffic volumes for intersections on the design roadways of Roy Street, Broad Street, Valley Street, the Broad Street Ramps at 8th Avenue/9th Avenue, Mercer Street, and the I-5 On and Off-Ramps at Fairview Avenue. The 2010 Build PM Peak Hour traffic volumes were adjusted to 24-Hour volumes using factors obtained from current 24-Hour traffic data. The 2010 Build 24-Hour traffic volumes were then used to determine design year traffic. A two percent compound growth rate was used to grow 2010 traffic volumes to design year traffic levels. A design year of 2030 was used for hot-mix asphalt (HMA) pavement and a design year of 2050 was used for Portland Cement concrete pavement (PCCP). The two percent growth rate was suggested by Seattle Department of Transportation engineers to account for spikes in heavy vehicle traffic not normally accounted for in long-term traffic growth projections. Calculated growth rates from forecasts developed in the project's Transportation Discipline Report were less than one percent per year.

The design year (2030-HMA, 2050-PCCP) traffic volumes were then distributed to thirteen FHWA vehicle classifications, from two-axle passenger cars to seven-or-more axle multi-trailer trucks. The distribution was based on 16-Hour (5 AM to 9 PM) vehicle classification counts conducted in May 2005 at six key intersections. They were 9th Avenue at Broad Street, 9th Avenue at Mercer Street, Westlake Avenue at Valley Street, Westlake Avenue at Mercer Street, Fairview Avenue at Valley Street, and Fairview Avenue at Mercer Street. Because the project will be converting Mercer Street to two-way traffic and moving the Broad Street access points, assumptions about shifts in traffic patterns were assumed and applied to the vehicle distributions. One assumption made was that heavy vehicles currently traveling northbound on Fairview Avenue from the Interstate 5 off-ramps and turning westbound on Valley Street would shift to traveling westbound on Mercer Street directly from Interstate 5. Traffic remaining on westbound Valley Street after the shift would not include large tractor-trailer combinations, but mostly passenger cars and single-unit trucks. Also, vehicles currently entering/exiting Broad Street at 9th Avenue would all shift to the Broad Street Ramps at 8th Avenue and 9th Avenue. Traffic remaining on Broad Street adjacent to Valley Street would not include large tractor-trailer combinations, but mostly passenger cars and single-unit trucks. Finally, vehicles currently traveling eastbound on Mercer Street and on the I-5 On and Off-Ramps would continue to do so in a similar vehicle distribution pattern to today.

After applying the traffic shift assumptions to the vehicle distribution data, design year traffic estimates were converted to annual design year traffic volumes. The final calculation of annual design year ESALs was made using load limit factors for each vehicle classification. The total design ESALs were summed from the individual vehicle classification values.

Mercer Street Traffic Projections

Mercer Street - Eastbound						
FHWA Vehicle Class	**Vehicle Distribution**	**2010 24-Hour Traffic Volumes**	Year 2050			
			Design Year Traffic	**Annual Design Traffic**	**ESAL Factor**	**Design ESAL**
			(per day)	(per year)	(for load limit)	
All	N/A	42,300	2,554,920	932,545,800	N/A	N/A
1-3	96.6%	N/A	2,468,053	900,839,243	0.004	3,603,357
4	0.8%	N/A	20,439	7,460,366	2.5	18,650,916
5	1.3%	N/A	33,214	12,123,095	1.611	19,530,307
6	0.2%	N/A	5,110	1,865,092	2.568	4,789,555
7	0.1%	N/A	2,555	932,546	3.733	3,481,193
8	0.1%	N/A	2,555	932,546	4.826	4,500,466
9	0.2%	N/A	5,110	1,865,092	5.323	9,927,883
10	0.1%	N/A	2,555	932,546	6.083	5,672,676
11	0.1%	N/A	2,555	932,546	6.487	6,049,425
12	0.1%	N/A	2,555	932,546	5.533	5,159,776
13	0.4%	N/A	10,220	3,730,183	8.053	30,039,165
Total			2,554,920	932,545,800		**111,404,719**
					DL Factor=0.8	**89,123,775**
Mercer Street - Westbound						
FHWA Vehicle Class	**Vehicle Distribution**	**2010 24-Hour Traffic Volumes**	Year 2050			
			Design Year Traffic	**Annual Design Traffic**	**ESAL Factor**	**Design ESAL**
			(per day)	(per year)	(for load limit)	
All	N/A	31,500	1,902,600	694,449,000	N/A	N/A
1-3	96.5%	N/A	1,836,009	670,143,285	0.004	2,680,573
4	0.9%	N/A	17,123	6,250,041	2.68	16,750,110
5	1.4%	N/A	26,636	9,722,286	1.611	15,662,603
6	0.1%	N/A	1,903	694,449	2.568	1,783,345
7	0.1%	N/A	1,903	694,449	3.733	2,592,378
8	0.1%	N/A	1,903	694,449	4.826	3,351,411
9	0.4%	N/A	7,610	2,777,796	5.323	14,786,208
10	0.1%	N/A	1,903	694,449	6.083	4,224,333
11	0.0%	N/A	0	0	6.487	0
12	0.0%	N/A	0	0	5.533	0
13	0.4%	N/A	7,610	2,777,796	8.053	22,369,591
Total			1,902,600	694,449,000		**83,075,545**
					DL Factor=0.8	**66,460,436**

Mercer Street – Eastbound (3 lanes)

PCCP THICKNESS DESIGN --

2050 design lane ESALs **89,123,775**

DETERMINING SLAB DEPTH D Note: Z=.841 for R=80
Z=1.282 for R=90 Z=1.645 for R=95 Esb=30,000psi

D	S'c	Z	So	P0	Pt	Cd	Ec	J	Keff	ESAL
14.00	650	1.282	0.35	4.5	2	1	4,000,000	3.2	35	**94,737,424**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	OUTPUT

Mercer Street – Westbound (3 lanes)

PCCP THICKNESS DESIGN --

2050 design lane ESALs = **66,460,436**

DETERMINING SLAB DEPTH D Note: Z=.841 for R=80
Z=1.282 for R=90 Z=1.645 for R=95 Esb=30,000psi

D	S'c	Z	So	P0	Pt	Cd	Ec	J	Keff	ESAL
13.50	650	1.282	0.35	4.5	2	1	4,000,000	3.2	35	**73,664,258**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	OUTPUT

Fairview Ave. Traffic Projections

Fairview Ave. - Northbound						
			Year 2050			
FHWA Vehicle Class	**Vehicle Distribution**	**2010 24-Hour Traffic Volumes**	**Design Year Traffic**	**Annual Design Traffic**	**ESAL Factor**	**Design ESAL**
			(per day)	(per year)	(for load limit)	
All	N/A	16,600	1,002,640	365,963,600	N/A	N/A
1-3	96.7%	N/A	969,553	353,886,801	0.004	1,415,547
4	1.1%	N/A	11,029	4,025,600	2.5	10,063,999
5	1.8%	N/A	18,**048**	6,587,345	1.611	10,612,212
6	0.1%	N/A	1,003	365,964	2.568	939,795
7	0.0%	N/A	0	0	3.733	0
8	0.0%	N/A	0	0	4.826	0
9	0.1%	N/A	1,003	365,964	5.323	1,948,024
10	0.1%	N/A	1,003	365,964	6.083	2,226,157
11	0.0%	N/A	0	0	6.487	0
12	0.0%	N/A	0	0	5.533	0
13	0.1%	N/A	1,003	365,964	8.053	2,947,105
Total			**1,002,640**	**365,963,600**		**30,152,839**

Fairview Ave. - Southbound						
			Year 2050			
FHWA Vehicle Class	**Vehicle Distribution**	**2010 24-Hour Traffic Volumes**	**Design Year Traffic**	**Annual Design Traffic**	**ESAL Factor**	**Design ESAL**
			(per day)	(per year)	(for load limit)	
All	N/A	12,200	736,880	268,961,200	N/A	N/A
1-3	96.0%	N/A	707,405	258,202,752	0.004	1,032,811
4	1.2%	N/A	8,843	3,227,534	2.5	8,068,836
5	2.2%	N/A	16,211	5,917,146	1.611	9,532,523
6	0.2%	N/A	1,474	537,922	2.568	1,381,385
7	0.0%	N/A	0	0	3.733	0
8	0.0%	N/A	0	0	4.826	0
9	0.2%	N/A	1,474	537,922	5.323	2,863,361
10	0.0%	N/A	0	0	6.083	0
11	0.0%	N/A	0	0	6.487	0
12	0.0%	N/A	0	0	5.533	0
13	0.2%	N/A	1,474	537,922	8.053	4,331,889
Total			**736,880**	**268,961,200**		**27,210,805**

Fairview Ave - Northbound

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PCCP THICKNESS DESIGN --

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2050 design lane ESALs **30,152,839**

DETERMINING SLAB DEPTH D Note: Z=.841 for R=80

Z=1.282 for R=90 Z=1.645 for R=95 Esb=30,000psi

D	S'c	Z	So	P0	Pt	Cd	Ec	J	Keff	ESAL
12.00	650	1.282	0.35	4.5	2	1	4,000,000	3.2	35	32,738,535
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	OUTPUT

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Fairview Ave - Southbound

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PCCP THICKNESS DESIGN --

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2050 design lane ESALs = **27,210,805**

DETERMINING SLAB DEPTH D Note: Z=.841 for R=80

Z=1.282 for R=90 Z=1.645 for R=95 Esb=30,000psi

D	S'c	Z	So	P0	Pt	Cd	Ec	J	Keff	ESAL
12.00	650	1.282	0.35	4.5	2	1	4,000,000	3.2	35	32,738,535
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	OUTPUT

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Valley Street Traffic Projections

Valley Street - Eastbound						
			Year 2030			
FHWA Vehicle Class	Vehicle Distribution	2010 24-Hour Traffic Volumes	Design Year Traffic	Annual Design Traffic	ESAL Factor	Design ESAL
			(per day)	(per year)	(for load limit)	
All	N/A	5,900	143,370	52,330,050	N/A	N/A
1-3	98.0%	N/A	140,503	51,283,449	0.004	205,134
4	0.3%	N/A	430	156,990	2.632	413,198
5	1.2%	N/A	1,720	627,961	1.59	998,457
6	0.1%	N/A	143	52,330	1.683	88,071
7	0.1%	N/A	143	52,330	2.824	147,780
8	0.0%	N/A	0	0	4.765	0
9	0.3%	N/A	430	156,990	4.394	689,815
10	0.0%	N/A	0	0	3.414	0
11	0.0%	N/A	0	0	6.407	0
12	0.0%	N/A	0	0	2.554	0
13	0.0%	N/A	0	0	4.494	0
Total			**143,370**	**52,330,050**		**2,542,455**

Valley Street - Westbound						
			Year 2030			
FHWA Vehicle Class	Vehicle Distribution	2010 24-Hour Traffic Volumes	Design Year Traffic	Annual Design Traffic	ESAL Factor	Design ESAL
			(per day)	(per year)	(for load limit)	
All	N/A	6,000	145,800	53,217,000	N/A	N/A
1-3	98.0%	N/A	142,884	52,152,660	0.004	208,611
4	0.3%	N/A	437	159,651	2.632	420,201
5	1.2%	N/A	1,750	638,604	1.59	1,015,380
6	0.1%	N/A	146	53,217	1.683	89,564
7	0.1%	N/A	146	53,217	2.824	150,285
8	0.0%	N/A	0	0	4.765	0
9	0.3%	N/A	437	159,651	4.394	701,506
10	0.0%	N/A	0	0	3.414	0
11	0.0%	N/A	0	0	6.407	0
12	0.0%	N/A	0	0	2.554	0
13	0.0%	N/A	0	0	4.494	0
Total			**145,800**	**53,217,000**		**2,585,548**

Valley Street – Eastbound

AC THICKNESS DESIGN --

2030 design lane ESALs = 2,542,455

DETERMINING SNf

Note: Z=.841 for R=80; Z=1.282 for R=90; Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	**ESAL**
5.200	2555	1.282	0.45	4.5	2	**2,547,049**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.39	1.00	**6**	2.34
AC BASE	0.39	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00	**18**	2.34
SUBBASE	0.00	1.00		0.00
SNprop.				**5.46**
Design ok?				☑

Valley Street – Westbound

AC THICKNESS DESIGN --

2030 design lane ESALs = 2,585,548

DETERMINING SNf

Note: Z=.841 for R=80; Z=1.282 for R=90; Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	**ESAL**
5.220	2555	1.282	0.45	4.5	2	**2,623,790**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.39	1.00	**6**	2.34
AC BASE	0.39	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00	**18**	2.34
SUBBASE	0.00	1.00		0.00
SNprop.				**5.46**
Design ok?				☑

Roy Street Traffic Projections

Roy Street - Eastbound						
			Year 2030			
FHWA Vehicle Class	**Vehicle Distribution**	**2010 24-Hour Traffic Volumes**	**Design Year Traffic**	**Annual Design Traffic**	**ESAL Factor**	**Design ESAL**
			(per day)	(per year)	(for load limit)	
All	N/A	400	9,720	3,547,800	N/A	N/A
1-3	87.5%	N/A	8,505	3,104,325	0.004	12,417
4	3.0%	N/A	292	106,434	2.632	280,134
5	7.0%	N/A	680	248,346	1.59	394,870
6	1.0%	N/A	97	35,478	1.683	59,709
7	1.5%	N/A	146	53,217	2.824	150,285
8	0.0%	N/A	0	0	4.765	0
9	0.0%	N/A	0	0	4.394	0
10	0.0%	N/A	0	0	3.414	0
11	0.0%	N/A	0	0	6.407	0
12	0.0%	N/A	0	0	2.554	0
13	0.0%	N/A	0	0	4.494	0
Total			**9,720**	**3,547,800**		**897,416**

Roy Street - Westbound						
			Year 2030			
FHWA Vehicle Class	**Vehicle Distribution**	**2010 24-Hour Traffic Volumes**	**Design Year Traffic**	**Annual Design Traffic**	**ESAL Factor**	**Design ESAL**
			(per day)	(per year)	(for load limit)	
All	N/A	1,200	29,160	10,643,400	N/A	N/A
1-3	95.8%	N/A	27,935	10,196,377	0.004	40,786
4	1.0%	N/A	292	106,434	2.632	280,134
5	2.0%	N/A	583	212,868	1.59	338,460
6	0.4%	N/A	117	42,574	1.683	71,651
7	0.4%	N/A	117	42,574	2.824	120,228
8	0.4%	N/A	117	42,574	4.765	202,863
9	0.0%	N/A	0	0	4.394	0
10	0.0%	N/A	0	0	3.414	0
11	0.0%	N/A	0	0	6.407	0
12	0.0%	N/A	0	0	2.554	0
13	0.0%	N/A	0	0	4.494	0
Total			**29,160**	**10,643,400**		**1,054,122**

Roy Street – Eastbound

AC THICKNESS DESIGN --

2030 design lane ESALs = 897,416

DETERMINING SNf

Note: Z=.841 for R=80; Z=1.282 for R=90; Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	**ESAL**
4.540	2555	1.282	0.45	4.5	2	**905,493**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.39	1.00	**4**	1.56
AC BASE	0.39	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00	**18**	2.34
SUBBASE	0.00	1.00		

SNprop. **4.68**

Design ok? ☑

Roy Street – Westbound

AC THICKNESS DESIGN --

2030 design lane ESALs = 1,054,122

DETERMINING SNf

Note: Z=.841 for R=80; Z=1.282 for R=90; Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	**ESAL**
4.650	2555	1.282	0.45	4.5	2	**1,084,297**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.39	1.00	**4**	1.56
AC BASE	0.39	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00	**18**	2.34
SUBBASE	0.00	1.00		

SNprop. **4.68**

Design ok? ☑

Broad Street Traffic Projections

Broad Street EB Off-Ramp Southbound						
			Year 2030			
FHWA Vehicle Class	Vehicle Distribution	2010 24-Hour Traffic Volumes	Design Year Traffic	Annual Design Traffic	ESAL Factor	Design ESAL
			(per day)	(per year)	(for load limit)	
All	N/A	9,800	238,140	86,921,100	N/A	N/A
1-3	99.0%	N/A	235,759	86,051,889	0.004	344,208
4	0.2%	N/A	476	173,842	2.632	457,553
5	0.7%	N/A	1,667	608,448	1.59	967,432
6	0.0%	N/A	0	0	1.683	0
7	0.1%	N/A	238	86,921	2.824	245,465
8	0.0%	N/A	0	0	4.765	0
9	0.0%	N/A	0	0	4.394	0
10	0.0%	N/A	0	0	3.414	0
11	0.0%	N/A	0	0	6.407	0
12	0.0%	N/A	0	0	2.554	0
13	0.0%	N/A	0	0	4.494	0
Total			**238,140**	**86,921,100**		**2,014,657**

Broad Street WB On-Ramp Northbound						
			Year 2030			
FHWA Vehicle Class	Vehicle Distribution	2010 24-Hour Traffic Volumes	Design Year Traffic	Annual Design Traffic	ESAL Factor	Design ESAL
			(per day)	(per year)	(for load limit)	
All	N/A	23,300	566,190	206,659,350	N/A	N/A
1-3	96.6%	N/A	546,940	199,632,932	0.004	798,532
4	1.2%	N/A	6,794	2,479,912	2.632	6,527,129
5	1.6%	N/A	9,059	3,306,550	1.59	5,257,414
6	0.1%	N/A	566	206,659	1.683	347,808
7	0.1%	N/A	566	206,659	2.824	583,606
8	0.1%	N/A	566	206,659	4.765	984,732
9	0.1%	N/A	566	206,659	4.394	908,061
10	0.0%	N/A	0	0	3.414	0
11	0.0%	N/A	0	0	6.407	0
12	0.0%	N/A	0	0	2.554	0
13	0.2%	N/A	1,132	413,319	4.494	1,857,454
Total			**566,190**	**206,659,350**		**17,264,735**

Broad Street EB Off-Ramp – Southbound

AC THICKNESS DESIGN --

2030 design lane ESALs = 2,014,657

DETERMINING SNf   Note: Z=.841 for R=80
Z=1.282 for R=90   Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	**ESAL**
3.655	7157	1.282	0.45	4.5	2	**2,016,526**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.39	1.00	**8**	3.12
AC BASE	0.39	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00		0.00
SUBBASE	0.00	1.00		0.00
			T & E	
SNprop.				**3.90**
Design ok?				☑

Broad Street WB On-Ramp – Northbound

AC THICKNESS DESIGN --

2030 design lane ESALs = 17,264,735

DETERMINING SNf   Note: Z=.841 for R=80
Z=1.282 for R=90   Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	**ESAL**
4.890	7157	1.282	0.45	4.5	2	**17,331,733**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.39	1.00	**11**	4.29
AC BASE	0.39	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00		0.00
SUBBASE	0.00	1.00		0.00
SNprop.				**5.07**
Design ok?				☑

Westlake Ave. Traffic Projections

Westlake Ave. - North of 9th Ave.						
FHWA Vehicle Class	Vehicle Distribution	2010 24-Hour Traffic Volumes	Year 2030			
			Design Year Traffic	Annual Design Traffic	ESAL Factor	Design ESAL
			(per day)	(per year)	(for load limit)	
All	N/A	19,000	461,700	168,520,500	N/A	N/A
1-3	96.8%	N/A	446,926	163,127,844	0.004	652,511
4	0.6%	N/A	2,770	1,011,123	2.632	2,661,276
5	1.6%	N/A	7,387	2,696,328	1.59	4,287,162
6	0.3%	N/A	1,385	505,562	1.683	850,860
7	0.1%	N/A	462	168,521	2.824	475,902
8	0.1%	N/A	462	168,521	4.765	803,000
9	0.2%	N/A	923	337,041	4.394	1,480,958
10	0.0%	N/A	0	0	3.414	0
11	0.0%	N/A	0	0	6.407	0
12	0.0%	N/A	0	0	2.554	0
13	0.3%	N/A	1,385	505,562	4.494	2,271,993
Total			**461,700**	**168,520,500**		**13,483,662**

Westlake Ave. - South of 9th Ave.						
FHWA Vehicle Class	Vehicle Distribution	2010 24-Hour Traffic Volumes	Year 2030			
			Design Year Traffic	Annual Design Traffic	ESAL Factor	Design ESAL
			(per day)	(per year)	(for load limit)	
All	N/A	13,500	328,050	119,738,250	N/A	N/A
1-3	98.1%	N/A	321,817	117,463,223	0.004	469,853
4	0.5%	N/A	1,640	598,691	2.632	1,575,755
5	1.2%	N/A	3,937	1,436,859	1.59	2,284,606
6	0.2%	N/A	656	239,477	1.683	403,039
7	0.0%	N/A	0	0	2.824	0
8	0.0%	N/A	0	0	4.765	0
9	0.0%	N/A	0	0	4.394	0
10	0.0%	N/A	0	0	3.414	0
11	0.0%	N/A	0	0	6.407	0
12	0.0%	N/A	0	0	2.554	0
13	0.0%	N/A	0	0	4.494	0
Total			**328,050**	**119,738,250**		**4,733,253**

Westlake Ave. - North of 9th Ave.

AC THICKNESS DESIGN --

2030 design lane ESALs = 13,483,662

DETERMINING SNf — Note: Z=.841 for R=80; Z=1.282 for R=90; Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	ESAL
6.424	2555	1.282	0.45	4.5	2	**13,497,483**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.39	1.00	**9**	3.51
AC BASE	0.39	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00	**18**	2.34
SUBBASE	0.00	1.00		
SNprop.				**6.63**
Design ok?				☑

Westlake Ave. - South of 9th Ave.

AC THICKNESS DESIGN --

2030 design lane ESALs = 4,733,253

DETERMINING SNf — Note: Z=.841 for R=80; Z=1.282 for R=90; Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	ESAL
5.631	2555	1.282	0.45	4.5	2	**4,736,943**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.39	1.00	**7**	2.73
AC BASE	0.39	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00	**18**	2.34
SUBBASE	0.00	1.00		
SNprop.				**5.85**
Design ok?				☑

I-5 Ramps Traffic Projections

I-5 On-Ramps - Eastbound						
			Year 2050			
FHWA Vehicle Class	Vehicle Distribution	2010 24-Hour Traffic Volumes	Design Year Traffic	Annual Design Traffic	ESAL Factor	Design ESAL
			(per day)	(per year)	(for load limit)	
All	N/A	39,300	2,373,720	866,407,800	N/A	N/A
1-3	96.7%	N/A	2,295,387	837,816,343	0.004	3,351,265
4	0.7%	N/A	16,616	6,064,855	2.632	15,962,697
5	1.4%	N/A	33,232	12,129,709	1.59	19,286,238
6	0.3%	N/A	7,121	2,599,223	1.683	4,374,493
7	0.0%	N/A	0	0	2.824	0
8	0.0%	N/A	0	0	4.765	0
9	0.3%	N/A	7,121	2,599,223	4.394	11,420,988
10	0.2%	N/A	4,747	1,732,816	3.414	5,915,832
11	0.0%	N/A	0	0	6.407	0
12	0.0%	N/A	0	0	2.554	0
13	0.4%	N/A	9,495	3,465,631	4.494	15,574,547
Total			**2,373,720**	**866,407,800**		**75,886,060**
					DL Factor=0.75	**56,914,545**
I-5 Off-Ramps - Westbound						
			Year 2050			
FHWA Vehicle Class	Vehicle Distribution	2010 24-Hour Traffic Volumes	Design Year Traffic	Annual Design Traffic	ESAL Factor	Design ESAL
			(per day)	(per year)	(for load limit)	
All	N/A	39,100	2,361,640	861,998,600	N/A	N/A
1-3	96.7%	N/A	2,283,706	833,552,646	0.004	3,334,211
4	0.9%	N/A	21,255	7,757,987	2.632	20,419,023
5	1.5%	N/A	35,425	12,929,979	1.59	20,558,667
6	0.1%	N/A	2,362	861,999	1.683	1,450,744
7	0.1%	N/A	2,362	861,999	2.824	2,434,284
8	0.1%	N/A	2,362	861,999	4.765	4,107,423
9	0.2%	N/A	4,723	1,723,997	4.394	7,575,244
10	0.1%	N/A	2,362	861,999	3.414	2,942,863
11	0.0%	N/A	0	0	6.407	0
12	0.0%	N/A	0	0	2.554	0
13	0.3%	N/A	7,085	2,585,996	4.494	11,621,465
Total			**2,361,640**	**861,998,600**		**74,443,923**
					DL Factor=0.8	**59,555,138**

I-5 On-Ramps – Eastbound (4 lanes)

AC THICKNESS DESIGN --

2050 design lane ESALs = 56,914,545

DETERMINING SNf

Note: Z=.841 for R=80; Z=1.282 for R=90; Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	ESAL
6.230	11153	1.645	0.5	4.5	3	**57,043,335**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.44	1.00	**12.5**	5.50
AC BASE	0.44	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00	**0**	0.00
SUBBASE	0.00	1.00		0.00
			T & E	
SNprop.				**6.28**
Design ok?				☑

I-5 Off-Ramps – Westbound (3 lanes)

AC THICKNESS DESIGN --

2050 design lane ESALs = 59,555,138

DETERMINING SNf

Note: Z=.841 for R=80; Z=1.282 for R=90; Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	ESAL
6.290	11153	1.645	0.5	4.5	3	**61,329,318**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.44	1.00	**13**	5.72
AC BASE	0.44	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00	**0**	0.00
SUBBASE	0.00	1.00		0.00
			T & E	
SNprop.				**6.50**
Design ok?				☑

5. MERCER STREET LIFE CYCLE COST ANALYSIS

Introduction

A life cycle cost analysis (LCCA) for Mercer Street was performed to evaluate the over-all-long-term economic efficiency for HMA and Portland Cement Concrete Pavement (PCCP) alternatives with 40 years of design life. In addition, pavement design and engineering analysis were also performed to identify the best value (the lowest long-term cost that satisfies the performance objective being sought) for the competing alternatives. The analysis is based on the section between 9th Ave. North and Fairview Ave. North. Agency costs including the initial construction cost, anticipated maintenance/rehabilitation cost of each alternative were calculated and converted to the total present worth (PW) to support the decision making of pavement type selection for Mercer Street.

LCCA Assumptions and Analysis Results

Life cycle costs were determined using a present worth analysis. Four percent interest and discount rate over a 40-year period was used in the analysis. All the costs were converted and analyzed per square yard for equivalent comparison purposes and then converted back to the total cost for the analyzed construction areas. User costs resulting from travel time delay, fuel consumption, and vehicle damage and operating cost due to the construction are not included in this analysis. Salvage values were assigned as zero value assuming alternatives have reached full life cycle at the end of analysis. Mobilization (5%), sales tax (8.9%), engineering and contingencies (15%), and preliminary engineering (10%) were included in the maintenance cost calculation based on WSDOT guideline for pavement life cycle cost analysis (2). Cost for the traffic control (10%) was also included in the analysis.

Initial construction costs for both alternatives are based on the SDOT unit cost estimate for 12" depth of HMA and 14" depth of PCCP. Pavement depths for each alternative were developed based on the eastbound Mercer Street traffic prediction for 40-year design life. Adopted pavement design parameters were described in sections 1 and 2. Costs of CSBC materials were considered the same for both alternatives. Where applicable, maintenance costs were determined using the same construction costs to calculate the initial construction costs for each alternative. Other costs for maintenance items were based on the latest historical bid item costs with similar quantities provided by WSDOT.

The following section describes the maintenance and rehabilitation strategies used for both alternatives in this analysis:

Maintenance scenarios for HMA pavement include:

- 2-inch mill and overlay

Maintenance scenarios for concrete pavement include:

- Joint resealing and diamond grinding
- Slab jacking

Milling and overlaying of HMA pavement is performed every 8 years due to the potential rutting and shoving/washboarding caused by the heavy traffic and frequent stopping and accelerating at the intersections. For Portland cement concrete pavement, joint resealing and diamond grinding is required every 20 years. While faulting and settlement usually are occurred in the undoweled PCC pavement, minor slab settlement due to the weak subgrade in the project site is also taken into consideration in the analysis after discussion with the concrete pavement specialist, Jim Tobin, from the Northwest Chapter of American Concrete Pavement Association and the project Geotechnical Engineer. Slab jacking to lift potential minor slab settlements is therefore applied once for 10% of the pavement areas at year 24. Costs described above are shown in Table 1.

Table 1. LCCA Costs

	Alternative 1: HMA	**Alternative 2: PCCP**
Initial Construction Cost incl. Roadway Excavation	$91.67/SY for 12" Depth	$131.38/SY for 14" Depth
Maintenance Costs	• Milling - $2.68/SY • 2" HMA Overlay - $13.67/SY • Tack Coat - $0.13/SY	• Joint/Crack Sealing - $2.00 per LF • PCCP Grinding - $18.00/SY • Slab Jacking - $117.00 /SY

The analysis results are shown in Table 2. It combines the initial construction cost and maintenance cost together for 40 years service life and shows the total life cycle cost percent difference between both alternatives. The result shows the HMA alternative will cost $246,577 or 7% more of the present worth than the PCCP alternative with 40 years of service life. According to the WSDOT Pavement Type Selection Protocol (2), an engineering analysis needs to be performed as the results are within the ± 15% threshold between 2 alternatives. The analysis is shown in the following section.

Table 2. Life Cycle Cost Analysis Results Summary

	Alternative 1: HMA (12.0")	**Alternative 2: PCCP (14.0")**
Initial Construction Cost	$1,601,325 ($91.67/SY)	$2,293,292 ($131.38/SY)
Total Maintenance Cost (Present Value)	$ 1,832,283	$ 893,739.20
Total Life Cycle Cost for 40-year Service Life	**$ 3,433,608**	**$ 3,187,031**
Percent Difference	**+7%** *	-

* Positive value indicates that the HMA option has a higher cost than the PCCP option

Engineering Analysis

The engineering analysis recommends PCCP alternative due to the following:

- **HMA pavement long term performance issues under heavy traffic loading:** Severe HMA rutting and shoving are prone to occur due to frequent stopping/accelerating and slow moving heavy traffic at intersections within the Mercer Street corridor.
- **HMA pavement long term performance issues under heavy traffic loading**: Severe HMA rutting and shoving are prone to occur due to frequent stopping/accelerating and slow moving heavy traffic at intersections.

- **Cost and impact due to more frequent HMA maintenance activities**: HMA alternative applies rehabilitation/maintenance of the same section of roadway at eight-year or possibly more frequent cycles will not reflect well in the public's point of view. Costs stemmed from increases in travel time caused by the reduction in roadway capacity and subsequent route diversion, as well as from potential impacts on businesses can be significant for the HMA alternative.

- **Lower Environmental Mitigating Impacts**:
  1) Less future rehabilitations of PCCP alternative will not require additional aggregate sources.
  2) Less noise and number if hauls due to fewer construction activities will lower the impact to the neighborhood.
  3) Fewer rehabilitation will conserve energy and natural resources.

- **Reduced Exposure and Increases Safety**
  1) Road user safety will be increased due to less work zone hazards.

Conclusion and Recommendation

While user costs were not quantified and included in the analysis, a study conducted in 2003 by WSDOT (3) for 7 Washington State Routes shows that all the user cost of the 7 state routes for PCCP are lower that of HMA reconstruction project if the maintenance/rehabilitation cycles are performed in every 8 years for 40 years design life. The user cost for HMA pavement will be much higher than that of PCCP once the maintenance cycles increases to every 6 and 4 years. Table 3 shows the user cost comparison for SR2 Divisions Street and Francis Avenue, which has similar Average Daily Vehicle volume with the Mercer Street (37,000 vs. 42,000). This intersection also has experienced severe rutting issues due to the heavy traffic volume. The results shows that the user cost for the HMA option can be higher than the PCCP option from 8% to 13% with maintenance cycles range from 8 years to 4 years.

Table 3. User Cost Comparison for SR2 Divisions Street and Francis Avenue

	User Cost (40 yr design life)		
Maintenance Cycles (year)	HMA	PCCP	Percent Difference
8	$815,188	$751,880	+8%
6	$849,288	$751,880	+13%
4	$895,344	$751,880	+19%

* Positive value indicates that the HMA option has a higher cost than the PCCP option

In summary, the 40 years life cycle cost analysis shows that the PCCP alternative will cost $246,577 or 7% less than the HMA alternative with possibly higher cost difference if user cost was included. The engineering analysis also indicates that the PCCP option will have less impact to the public, environment, and road user safety. The PCC pavement also will have better long term pavement performance against the potential severe HMA distresses at the project site. Therefore, the PCCP is the recommended alternative for Mercer Street.

<u>Reference</u>

1. Khader Abu Al-eis, Irene K. LaBarca, "Evaluation of the Uretak Method of Pavement Lifting" Final Report, Report # WI-02-07, Wisconsin Department of Transportation, Madison, Wisconsin, April 2007.
2. "Pavement Type Selection Protocol", Washington Department of Transportation, Environmental and Engineering Programs Division, Materials Laboratory, Olympia, Washington, January 2005.
3. Jeff S. Uhlmeyer, "PCCP Intersections Design and Construction in Washington State" Final Report, Report # WA-RD 503.2 Washington State Transportation Center (TRAC), University of Washington, June 2003.

Sealing cost for 15 foot joint spacing

Assume Pavement 34' wide and 1430 feet long				
Assume 8 longitudinal Joints each 1430' long		11,440	LF	
Assume transverse joints each 110 feet long		10,597	LF	
Total LF of sealing / SY		22,037	LF	
Total SY of Pavement		17,469	SY	
Total LF of sealing / SY		1.26	LF/SY	
Total cost of sealing (LF)	$	2.00		
Traffic control (10%)	$	0.20		
Total Cost of sealing (LF/SY)	**$**	**2.70**		
Mobilization (5%)	$	0.14		
Sales Tax (8.9%)	$	0.25		
Engineering and Contingencies (15%)	$	0.46		
Preliminary Engineering (10%)	$	0.36		
Total	**$**	**3.91**	SY	

Cement Concrete Grinding

Cement Concrete Grinding	$	18.00	SY	
Traffic control (10%)	$	1.80		
Mobilization (5%)	$	0.99		
Sales Tax (8.9%)	$	1.85		
Engineering and Contingencies (15%)	$	3.40		
Preliminary Engineering (10%)	$	2.60		
Total	**$**	**28.64**	SY	

Slab Jacking

Slab Jacking	**$**	**23.40**	SY	Assume 20% areas settle, $117/SY
Traffic control (10%)	$	2.34		
Mobilization (5%)	$	1.29		
Sales Tax (8.9%)	$	2.41		
Engineering and Contingencies (15%)	$	4.41		
Preliminary Engineering (10%)	$	3.38		
Total	**$**	**37.23**	SY	

HMA Pavement Overlay

2" Milling (entire width)	$	2.68	SY	
HMA Overlay 2" (entire width)	$	13.67	SY	Assume $120/ton cost
Tack Coat (Asphalt Emulsion CSS-1)	$	0.13	SY	Assume 0.08gal/SY rate, 0.000334 ton/SY, $400/ton
Traffic control (10%)	$	1.65		
Mobilization (5%)	$	0.91		
Sales Tax (8.9%)	$	1.69		
Engineering and Contingencies (15%)	$	3.11		
Preliminary Engineering (10%)	$	2.38		
Total	**$**	**26.22**	SY	

MERCER STREET
LIFE CYCLE COST ANALYSIS

d Discount Rate 4.0%
analyzed per SY
n without Salvage Value assuming alternatives have reached full life cycle at the end of analysis

Initial Cost	Analysis Period	Maintenance Costs (Future Value)										Salvage Value	PW of Maintenance Costs		Total PW	Total Cost
		Year														
		4	8	10	16	20	24	28	32	35	40					
$ 91.67	40		$ 35.89		$ 49.11		$ 67.21		$ 91.99			0%	$ 104.89	$ 1,832,283.46	$ 196.55	$ 3,433,608.46
$ 131.28	40					$ 71.31	$ 47.72					0%	$ 51.16	$ 893,739.20	$ 182.44	$ 3,187,030.70

<u>Note</u>:

1. Year 20 maintenance activities: joint sealing and concrete pavement grinding.
2. Year 24 maintenance activities: slab jacking.

Mercer Street - Eastbound

AC THICKNESS DESIGN --

2050 design lane ESALs = **71,383,770**

DETERMINING SNf

Note: Z=.841 for R=80
Z=1.282 for R=90 Z=1.645 for R=95

SNf	MR	Z	So	P1	P2	ESAL
7.61	2555	1.282	0.35	4.5	2	**72,045,483**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	

LAYER	STR COEF	DRAIN m	DEPTH (in)	SNi
AC SURF	0.39	1	**12**	4.68
AC BASE	0.39	1.00	**0**	0.00
SUBBASE	0.13	1.00	**6**	0.78
SUBBASE	0.13	1.00	**18**	2.34
SUBBASE	0.00	1.00		0.00
SNprop.				**7.8**

Mercer Street - Eastbound

PCCP THICKNESS DESIGN --

2050 design lane ESALs **89,123,775**

DETERMINING SLAB DEPTH D

Note: Z=.841 for R=80
Z=1.282 for R=90 Z=1.645 for R=95 Esb=30,000psi

D	S'c	Z	So	P0	Pt	Cd	Ec	J	Keff	ESAL
14.00	650	1.282	0.35	4.5	2	1	4,000,000	3.2	35	**94,737,424**
T & E	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	OUTPUT