

# Life-Cycle Pavement Cost Analysis (LCPCA) Examples

## Joint Adhesive - UBCO

Abbreviations: M = Route Mainline IS = Route Inside Shoulder  
OS = Route Outside Shoulder R = Ramps

### Roadway Data:

#### Mainline Route:

Length = 5,817 ft

Width = (4) 12-ft Lanes + (2) 4-ft Inside Shoulders + (2) 10-ft Outside Shoulders = 48 ft + 8 ft + 20ft = 76 ft

Area ((2) 26-ft Mainline) = (5,817 ft) x (52 ft) x (1/9 yd<sup>2</sup>/ft<sup>2</sup>) = 33,610 yd<sup>2</sup>

Area ((2) 4-ft Inside Shoulders) = (5,817 ft) x (2) x (4 ft) x (1/9 yd<sup>2</sup>/ft<sup>2</sup>) = 5,170 yd<sup>2</sup>

Area ((2) 8-ft Outside Shoulders) = (5,817 ft) x (2) x (8 ft) x (1/9 yd<sup>2</sup>/ft<sup>2</sup>) = 10,341 yd<sup>2</sup>

#### Ramps (All combined):

Length = 7,762 ft

Width = 16-ft Lane + 4-ft Inside Shoulder + 8-ft Outside Shoulder = 16 ft + 4 ft + 8 ft = 28 ft

Area (Mainline, Inside Shoulder, and Outside Shoulder) = (7,762 ft) x (28 ft) x (1/9 yd<sup>2</sup>/ft<sup>2</sup>) = 24,148 yd<sup>2</sup>

### HMA Pavement Treatment Cost

Route Mainline and Shoulders: 13 inches of HMA Pavement

Ramps: 10 inches of HMA Pavement

### Pay Items:

#### Route Mainline & Inside Shoulder

165 lb/sys QC/QA - HMA, 4, 76, Surface, 9.5 mm

275 lb/sys QC/QA - HMA, 4, 76, Intermediate, 19.0 mm

990 lb/sys QC/QA - HMA, 4, 64, Base, 25.0 mm

300 lb/sys QC/QA - HMA, 4, 76, Intermediate, OG, 19.0 mm (Drainage Layer)

6 inches of Compacted Aggregate, No. 53 (Separation Layer)

Geotextile for Pavement, Type 2A

Subgrade Treatment Type IBC (14" Chemical Modification using Cement)

#### Route Outside Shoulder

165 lb/sys QC/QA - HMA, 2, 64, Surface, 9.5 mm

275 lb/sys QC/QA - HMA, 2, 64, Intermediate, 19.0 mm

990 lb/sys QC/QA - HMA, 2, 64, Base, 25.0 mm

300 lb/sys QC/QA - HMA, 4, 76, Intermediate, OG, 19.0 mm (Drainage Layer)

6 inches of Compacted Aggregate, No. 53 (Separation Layer)

Geotextile for Pavement, Type 2A

Subgrade Treatment Type IBC (14" Chemical Soil Modification using Cement)

#### Ramps (Mainline, Inside and Outside Shoulders)

165 lb/sys QC/QA - HMA, 3, 70, Surface, 9.5 mm

275 lb/sys QC/QA - HMA, 3, 70, Intermediate, 19.0 mm

660 lb/sys QC/QA - HMA, 3, 64, Base, 25.0 mm

250 lb/sys QC/QA - HMA, 4, 76, Intermediate, OG, 19.0 mm (Drainage Layer)

4 inches of Compacted Aggregate, No. 53 (Separation Layer)

Geotextile for Pavement, Type 2A

Subgrade Treatment Type IBC (14" Chemical Soil Modification using Cement)

**Initial Construction Cost:**

Surface (Route...M & IS)	$(38,780 \text{ yd}^2) \times (165 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$82.72/\text{t})$	=	\$264,650.23
Surface (Route...OS)	$(10,341 \text{ yd}^2) \times (165 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$70.01/\text{t})$	=	\$59,727.81
Surface (Ramps)	$(24,148 \text{ yd}^2) \times (165 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$84.86/\text{t})$	=	\$169,058.94
Joint Adhesive, Surface*	$(38,792 \text{ lft}) \times (\$0.33/\text{lft})$	=	\$12,801.36
Liquid Asphalt Sealant	$(38,792 \text{ lft}) \times (\$0.14/\text{lft})$	=	\$5,430.88
Intermediate (Route...M & IS)	$(38,780 \text{ yd}^2) \times (275 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$78.51/\text{t})$	=	\$418,634.95
Intermediate (Route...OS)	$(10,341 \text{ yd}^2) \times (275 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$67.79/\text{t})$	=	\$96,389.75
Intermediate (Ramps)	$(24,148 \text{ yd}^2) \times (275 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$74.58/\text{t})$	=	\$247,631.70
Joint Adhesive, Intermediate*	$(38,792 \text{ lft}) \times (\$0.50/\text{lft})$	=	\$19,396.00
Base (Route...M & IS)	$(38,780 \text{ yd}^2) \times (990 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$68.50/\text{t})$	=	\$1,314,932.85
Base (Route...OS)	$(10,341 \text{ yd}^2) \times (990 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$66.15/\text{t})$	=	\$338,608.29
Base (Ramps)	$(24,148 \text{ yd}^2) \times (990 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$72.03/\text{t})$	=	\$573,995.55
Intermediate OG (Route)	$(49,121 \text{ yd}^2) \times (300 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$64.01/\text{t})$	=	\$471,635.28
Intermediate OG (Ramps)	$(24,148 \text{ yd}^2) \times (250 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$64.01/\text{t})$	=	\$193,214.19
Compacted Aggregate, No.53 (Route)	$(6/12 \text{ ft/in}) \times (76 \text{ lft}) \times (5,817 \text{ ft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (\$50.44/\text{yd}^3)$	=	\$412,946.68
Compacted Aggregate, No.53 (Ramps)	$(4/12 \text{ ft/in}) \times (28 \text{ lft}) \times (7,762 \text{ ft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (\$50.44/\text{ft}^3)$	=	\$135,338.62
Tack (Route...M, IS & OS)	$(49,121 \text{ yd}^2) \times (4) \times (\$0.31/\text{yd}^2)$	=	\$60,910.04
Tack (Ramps)	$(24,148 \text{ yd}^2) \times (4) \times (\$0.31/\text{yd}^2)$	=	\$29,943.52
Geotextile for Pavement, Type 2A (Route)	$(49,121 \text{ yd}^2) \times (\$1.11/\text{yd}^2)$	=	\$54,524.31
Geotextile for Pavement, Type 2A (Ramps)	$(24,148 \text{ yd}^2) \times (\$1.11/\text{yd}^2)$	=	\$26,804.28
Subgrade Treatment, Type IBC (Route)	$(49,121 \text{ yd}^2) \times (\$8.97/\text{yd}^2)$	=	\$440,615.37
Subgrade Treatment, Type IBC (Ramps)	$(24,148 \text{ yd}^2) \times (\$8.97/\text{yd}^2)$	=	\$216,607.56
Common Excavation (Route)	$(49,121 \text{ yd}^2) \times (12 \text{ in}) \times (1/36 \text{ yd/in}) \times (\$14.72/\text{yd}^3)$	=	\$241,020.37
Common Excavation (Ramps)	$(24,148 \text{ yd}^2) \times (12 \text{ in}) \times (1/36 \text{ yd/in}) \times (\$14.72/\text{yd}^3)$	=	\$118,486.19
Aggregate for Underdrain (Route)	$(5,817 \text{ lft}) \times (2) \times (2) \times (14 \text{ in}) \times (18 \text{ in}) \times (1/144 \text{ ft}^2/\text{in}^2) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (\$52.59/\text{yd}^3)$	=	\$79,311.56
Aggregate for Underdrain (Ramps)	$(7,762 \text{ lft}) \times (2) \times (2) \times (14 \text{ in}) \times (18 \text{ in}) \times (1/144 \text{ ft}^2/\text{in}^2) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (\$52.59/\text{yd}^3)$	=	\$52,915.28
Geotextile for Underdrain (Route)	$(5,817 \text{ lft}) \times (2) \times (2) \times (74 \text{ in} \times 1/12 \text{ ft/in}) \times (1/9 \text{ yd}^2/\text{ft}^2) \times (\$3.77/\text{yd}^2)$	=	\$60,104.69
Geotextile for Underdrain (Ramps)	$(7,762 \text{ lft}) \times (2) \times (2) \times (74 \text{ in} \times 1/12 \text{ ft/in}) \times (1/9 \text{ yd}^2/\text{ft}^2) \times (\$3.77/\text{yd}^2)$	=	\$40,100.79
Outlet protector (Route)	$(60 \text{ each}) \times (\$879.07/\text{each})$	=	\$52,744.20
Outlet protector (Ramps)	$(40 \text{ each}) \times (\$879.07/\text{each})$	=	\$35,162.80

Pipe, Circular, Type 4, 6 in. (Route)	$(5,817 \text{ lft}) \times (2) \times (2) \times (\$5.98/\text{lft})$	=	\$139,142.64
Pipe, Circular, Type 4, 6 in. (Ramps)	$(7,762 \text{ lft}) \times (2) \times (\$5.98/\text{lft})$	=	\$92,833.52
CA, Wedge, No.53 (Route)	$(2) \times (2) \times (5.65 \text{ ft}^2) \times (5,817 \text{ lft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (1.69 \text{ t}/\text{yd}^3) \times (\$27.76/\text{t})$	=	\$228,428.30
CA, Wedge, No.53 (Ramps)	$(2) \times (5.65 \text{ ft}^2) \times (7,762 \text{ lft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (1.69 \text{ t}/\text{yd}^3) \times (\$27.76/\text{t})$	=	\$152,403.34
30% Contingency of Pavement Items		=	\$2,056,935.55
<b>Total Cost</b>			<b>\$8,913,387.38</b>

\*Assume 4 mainline joints and 2 ramp joints.

### **Maintenance Costs:**

#### **Joint Seal Cost:**

##### Age 3

Mainline Route & Ramps	$(38,792 \text{ lft}) \times (25\%) \times (\$1.0/\text{lft})$	=	\$9,698.00
Traffic Maintenance	5% of Contract Cost	=	\$484.90
<b>Total Cost</b>			<b>\$10,182.90</b>

##### Age 6

Mainline Route & Ramps	$(38,792 \text{ lft}) \times (50\%) \times (\$1.0/\text{lft})$	=	\$19,396.00
Traffic Maintenance =	5% of Contract Cost	=	\$969.80
<b>Total Cost</b>			<b>\$20,365.80</b>

##### Age 9

Mainline Route & Ramps	$(38,792 \text{ lft}) \times (75\%) \times (\$1.0/\text{lft})$	=	\$29,094.00
Traffic Maintenance	5% of Contract Cost	=	\$1,454.70
<b>Total Cost</b>			<b>\$30,548.70</b>

##### Age 12 & Beyond

Mainline Route & Ramps	$(38,792 \text{ lft}) \times (100\%) \times (\$1.0/\text{lft})$	=	\$38,792.00
Traffic Maintenance	5% of Contract Cost	=	\$1,939.60
<b>Total Cost</b>			<b>\$40,731.60</b>

## Rehabilitation Costs:

### **1.5" Mill and 1.5" HMA Overlay Cost (PM at Age 15):**

Milling Cost (Route)	(49,121 yd <sup>2</sup> ) x (\$1.31/yd <sup>2</sup> )	=	\$64,348.51
Milling Cost (Ramps)	(24,148 yd <sup>2</sup> ) x (\$1.31/yd <sup>2</sup> )	=	\$31,633.88
Tack (Route)	(49,121 yd <sup>2</sup> ) x (\$0.31/yd <sup>2</sup> )	=	\$15,277.51
Tack (Ramps)	(24,148 yd <sup>2</sup> ) x (\$0.31/yd <sup>2</sup> )	=	\$7,485.88
Partial Depth Patch on TL (Route)	(33,610 yd <sup>2</sup> ) x (440 lb/yd <sup>2</sup> ) x (1/200 t/lb) x (1%) x (\$125.77/t)	=	\$9,299.69
Partial Depth Patch on TL (Ramps)	(13,800 yd <sup>2</sup> ) x (440 lb/yd <sup>2</sup> ) x (1/200 t/lb) x (1%) x (\$131.47/t)	=	\$3,991.43
Surface (Route...M & IS)	(38,780 yd <sup>2</sup> ) x (165 lb/yd <sup>2</sup> ) x (1/2000 t/lb) x (\$82.72/t)	=	\$264,650.23
Surface (Route...OS)	(10,341 yd <sup>2</sup> ) x (165 lb/yd <sup>2</sup> ) x (1/2000 t/lb) x (\$70.01/t)	=	\$59,727.81
Surface (Ramps)	(24,148 yd <sup>2</sup> ) x (165 lb/yd <sup>2</sup> ) x (1/2000 t/lb) x (\$84.86/t)	=	\$169,058.94
Joint Adhesive, Surface*	(38,792 lft) x (\$0.33/lft)	=	\$12,801.36
Liquid Asphalt Sealant	(38,792 lft) x (\$0.14/lft)	=	\$5,430.88
Traffic Maintenance	5% of Contract Cost	=	\$32,182.81
Total Cost			\$675,838.92

\*Assume 4 mainline joints and 2 ramp joints.

### **1.5" Mill and 1.5" HMA Overlay Cost (PM at Age 26):**

Milling Cost (Route)	(49,121 yd <sup>2</sup> ) x (\$1.31/yd <sup>2</sup> )	=	\$64,348.51
Milling Cost (Ramps)	(24,148 yd <sup>2</sup> ) x (\$1.31/yd <sup>2</sup> )	=	\$31,633.88
Tack (Route)	(49,121 yd <sup>2</sup> ) x (\$0.31/yd <sup>2</sup> )	=	\$15,277.51
Tack (Ramps)	(24,148 yd <sup>2</sup> ) x (\$0.31/yd <sup>2</sup> )	=	\$7,485.88
Partial Depth Patch on TL (Route)	(33,610 yd <sup>2</sup> ) x (440 lb/yd <sup>2</sup> ) x (1/200 t/lb) x (2%) x (\$125.77/t)	=	\$18,599.37
Partial Depth Patch on TL (Ramps)	(13,800 yd <sup>2</sup> ) x (440 lb/yd <sup>2</sup> ) x (1/200 t/lb) x (2%) x (\$131.47/t)	=	\$7,982.86
Surface (Route...M & IS)	(38,780 yd <sup>2</sup> ) x (165 lb/yd <sup>2</sup> ) x (1/2000 t/lb) x (\$82.72/t)	=	\$264,650.23
Surface (Route...OS)	(10,341 yd <sup>2</sup> ) x (165 lb/yd <sup>2</sup> ) x (1/2000 t/lb) x (\$70.01/t)	=	\$59,727.81
Surface (Ramps)	(24,148 yd <sup>2</sup> ) x (165 lb/yd <sup>2</sup> ) x (1/2000 t/lb) x (\$84.86/t)	=	\$169,058.94
Joint Adhesive, Surface*	(38,792 lft) x (\$0.33/lft)	=	\$12,801.36
Liquid Asphalt Sealant	(38,792 lft) x (\$0.14/lft)	=	\$5,430.88
Traffic Maintenance	5% of Contract Cost	=	\$32,847.36
Total Cost			\$689,794.59

\*Assume 4 mainline joints and 2 ramp joints.

**1.5” Mill and 4” HMA Overlay Cost (MSO at Age 36):**

Milling Cost (Route)	$(49,121 \text{ yd}^2) \times (\$1.31/\text{yd}^2)$	=	\$64,348.51
Milling Cost (Ramps)	$(24,148 \text{ yd}^2) \times (\$1.31/\text{yd}^2)$	=	\$31,633.88
Tack (Route)	$(49,121 \text{ yd}^2) \times (2) \times (\$0.31/\text{yd}^2)$	=	\$30,455.02
Tack (Ramps)	$(24,148 \text{ yd}^2) \times (2) \times (\$0.31/\text{yd}^2)$	=	\$14,971.76
Partial Depth Patch on TL (Route)	$(33,610 \text{ yd}^2) \times (440 \text{ lb}/\text{yd}^2) \times (1/200 \text{ t}/\text{lb}) \times (3\%) \times (\$125.77/\text{t})$	=	\$27,899.06
Partial Depth Patch on TL (Ramps)	$(13,800 \text{ yd}^2) \times (440 \text{ lb}/\text{yd}^2) \times (1/200 \text{ t}/\text{lb}) \times (3\%) \times (\$131.47/\text{t})$	=	\$11,974.29
Full Depth Patch on TL (Route)	$(33,610 \text{ yd}^2) \times (1,760 \text{ lb}/\text{yd}^2) \times (1/200 \text{ t}/\text{lb}) \times (1\%) \times (\$137.09/\text{t})$	=	\$40,546.84
Full Depth Patch on TL (Ramps)	$(13,800 \text{ yd}^2) \times (1,375 \text{ lb}/\text{yd}^2) \times (1/200 \text{ t}/\text{lb}) \times (1\%) \times (\$142.77/\text{t})$	=	\$13,545.30
Patch SGT, Type ID (Both)	$(33,610 + 13,800 \text{ yd}^2) \times (1\%) \times (\$29.38/\text{yd}^2)$	=	\$13,929.06
Surface (Route...M & IS)	$(38,780 \text{ yd}^2) \times (165 \text{ lb}/\text{yd}^2) \times (1/2000 \text{ t}/\text{lb}) \times (\$82.72/\text{t})$	=	\$264,650.23
Surface (Route...OS)	$(10,341 \text{ yd}^2) \times (165 \text{ lb}/\text{yd}^2) \times (1/2000 \text{ t}/\text{lb}) \times (\$70.01/\text{t})$	=	\$59,727.81
Surface (Ramps)	$(24,148 \text{ yd}^2) \times (165 \text{ lb}/\text{yd}^2) \times (1/2000 \text{ t}/\text{lb}) \times (\$84.86/\text{t})$	=	\$169,058.94
Joint Adhesive, Surface*	$(38,792 \text{ lft}) \times (\$0.33/\text{lft})$	=	\$12,801.36
Liquid Asphalt Sealant	$(38,792 \text{ lft}) \times (\$0.14/\text{lft})$	=	\$5,430.88
Intermediate (Route...M & IS)	$(38,780 \text{ yd}^2) \times (275 \text{ lb}/\text{yd}^2) \times (1/2000 \text{ t}/\text{lb}) \times (\$78.51/\text{t})$	=	\$418,634.95
Intermediate (Route...OS)	$(10,341 \text{ yd}^2) \times (275 \text{ lb}/\text{yd}^2) \times (1/2000 \text{ t}/\text{lb}) \times (\$67.79/\text{t})$	=	\$96,389.75
Intermediate (Ramps)	$(24,148 \text{ yd}^2) \times (275 \text{ lb}/\text{yd}^2) \times (1/2000 \text{ t}/\text{lb}) \times (\$74.58/\text{t})$	=	\$247,631.70
Joint Adhesive, Intermediate*	$(38,792 \text{ lft}) \times (\$0.50/\text{lft})$	=	\$19,396.00
Var Depth O Wedge (Route)	$(2) \times (2) \times (0.25 \text{ ft}^2) \times (5,817 \text{ lft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (1.69 \text{ t}/\text{yd}^3) \times (\$27.76/\text{t})$	=	\$10,107.45
Var Depth O Wedge (Ramps)	$(2) \times (0.25 \text{ ft}^2) \times (7,762 \text{ lft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (1.69 \text{ t}/\text{yd}^3) \times (\$27.76/\text{t})$	=	\$6,743.51
Traffic Maintenance	5% of Contract Cost	=	\$77,993.81
Total Cost			\$1,637,870.11

\*Assume 4 mainline joints and 2 ramp joints

## **PCCP Treatment Cost**

Mainline and Shoulders: 10.5 inches of PCCP  
 Ramps: 9 inches of PCCP

### **Pay Items:**

#### Mainline and Shoulders:

10.5 in. QC/QA PCCP with 14-ft wide slab for outside lane with D-1 Contraction Joints @ 15 ft spacing on 3" HMA OG on 6 inches of Compacted Aggregate, No. 53, on Geotextile for Pavement, Type 2A, on Subgrade Treatment Type IBC (14" Chemical Modification using Cement)

#### Ramps (Mainline, Inside Shoulder, and Outside Shoulder):

9 in. QC/QA PCCP with D-1 Contraction Joints @ 16 ft spacing on Subbase for PCCP, on Subgrade Treatment Type IBC (14" Chemical Modification using Cement)

### **Initial Construction Cost:**

Route...M, IS, & OS (10.5" PCCP)	$(49,121 \text{ yd}^2) \times (\$45/\text{yd}^2)$	=	\$2,210,445.00
Ramps (9" PCCP)	$(24,148 \text{ yd}^2) \times (\$40/\text{yd}^2)$	=	\$965,920.00
Intermediate OG (Route)	$(49,121 \text{ yd}^2) \times (300 \text{ lb}/\text{yd}^2) \times (1/2000 \text{ t}/\text{lb}) \times (\$64.01/\text{t})$	=	\$471,635.28
9" Subbase for PCCP (Ramps)	$(24,148 \text{ yd}^2) \times (9/12 \text{ in}/\text{ft}) \times (1/3 \text{ yd}/\text{ft}) \times (\$56.72/\text{yd}^3)$	=	\$342,418.64
Geotextile for Pavement, Type 2A (Route)	$(49,121 \text{ yd}^2) \times (\$1.11/\text{yd}^2)$	=	\$54,524.31
Compacted Aggregate, No.53 (Route)	$(6/12 \text{ ft}/\text{in}) \times (76 \text{ lft}) \times (5,817 \text{ ft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (\$50.44/\text{yd}^3)$	=	\$412,946.68
D-1 Joints (Route)	$(5,817 \text{ lft}) \times (1/15 \text{ J}/\text{lft}) \times (76 \text{ lft}) \times (\$8.86/\text{lft})$	=	\$261,129.01
D-1 Joints (Ramps)	$(7,762 \text{ lft}) \times (1/16 \text{ J}/\text{lft}) \times (28 \text{ lft}) \times (\$8.86/\text{lft})$	=	\$120,349.81
Subgrade Treatment, Type IBC (Route)	$(49,121 \text{ yd}^2) \times (\$8.97/\text{yd}^2)$	=	\$440,615.37
Subgrade Treatment, Type IBC (Ramp)	$(24,148 \text{ yd}^2) \times (\$7.85/\text{yd}^2)$	=	\$216,607.56
Common Excavation (Route)	$(49,121 \text{ yd}^2) \times (12 \text{ in}) \times (1/36 \text{ yd}/\text{in}) \times (\$14.72/\text{yd}^3)$	=	\$241,020.37
Common Excavation (Ramps)	$(24,148 \text{ yd}^2) \times (12 \text{ in}) \times (1/36 \text{ yd}/\text{in}) \times (\$14.72/\text{yd}^3)$	=	\$118,486.19
Aggregate for Underdrain (Route)	$(5,817 \text{ lft}) \times (2) \times (2) \times (14 \text{ in}) \times (18 \text{ in}) \times (1/144 \text{ ft}^2/\text{in}^2) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (\$52.59/\text{yd}^3)$	=	\$79,311.56
Aggregate for Underdrain (Ramps)	$(7,762 \text{ lft}) \times (2) \times (2) \times (14 \text{ in}) \times (18 \text{ in}) \times (1/144 \text{ ft}^2/\text{in}^2) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (\$52.59/\text{yd}^3)$	=	\$52,915.28
Geotextile for Underdrain (Route)	$(5,817 \text{ lft}) \times (2) \times (2) \times (74 \text{ in} \times 1/12 \text{ ft}/\text{in}) \times (1/9 \text{ yd}^2/\text{ft}^2) \times (\$3.77/\text{yd}^2)$	=	\$60,104.69
Geotextile for Underdrain (Ramps)	$(7,762 \text{ lft}) \times (2) \times (2) \times (74 \text{ in} \times 1/12 \text{ ft}/\text{in}) \times (1/9 \text{ yd}^2/\text{ft}^2) \times (\$3.77/\text{yd}^2)$	=	\$40,100.79
Outlet protector (Route)	$(60 \text{ each}) \times (\$879.07/\text{each})$	=	\$52,744.20
Outlet protector (Ramps)	$(40 \text{ each}) \times (\$879.07/\text{each})$	=	\$35,162.80

Pipe, Circular, Type 4, 6 in. (Route)	$(5,817 \text{ ft}) \times (2) \times (2) \times (\$5.98/\text{ft})$	=	\$139,142.64
Pipe, Circular, Type 4, 6 in. (Ramps)	$(7,762 \text{ ft}) \times (2) \times (\$5.98/\text{ft})$	=	\$92,833.52
CA, Wedge, No.53 (Route)	$(2) \times (2) \times (5.65 \text{ ft}^2) \times (5,817 \text{ ft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (1.69 \text{ t}/\text{yd}^3) \times (\$27.76/\text{t})$	=	\$228,428.30
CA, Wedge, No.53 (Ramps)	$(2) \times (5.65 \text{ ft}^2) \times (7,762 \text{ ft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (1.69 \text{ t}/\text{yd}^3) \times (\$27.76/\text{t})$	=	\$152,403.34
30% Contingency of Pavement Items		=	\$2,036,773.60
<b>Total Cost</b>			<b>\$8,826,018.94</b>

### **Preventive Maintenance – Concrete Pavement (Age 10):**

#### **Joint Seal Cost:**

D-1 Joints (Route)	$(5,817 \text{ ft}) \times (1/15 \text{ joints}/\text{ft}) \times (76 \text{ ft}) \times (10\%) \times (\$1/\text{ft})$	=	\$2,947.28
D-1 Joints (Ramps)	$(7,762 \text{ ft}) \times (1/16 \text{ joints}/\text{ft}) \times (28 \text{ ft}) \times (10\%) \times (\$1/\text{ft})$	=	\$1,358.35
Longitudinal Joint (Route)	$(5,817 \text{ ft}) \times (4) \times (10\%) \times (\$1/\text{ft})$	=	\$2,326.80
Longitudinal Joint (Ramps)	$(7,762 \text{ ft}) \times (10\%) \times (\$1/\text{ft})$	=	\$1,552.40
Traffic Maintenance	5% of Contract Cost	=	\$409.24
<b>Total Cost</b>			<b>\$8,594.07</b>

### **Concrete Pavement Restoration (Age 18):**

D-1 Joints (Route)	$(5,817 \text{ ft}) \times (1/15 \text{ joints}/\text{ft}) \times (76 \text{ ft}) \times (20\%) \times (\$1/\text{ft})$	=	\$5,894.56
D-1 Joints (Ramps)	$(7,762 \text{ ft}) \times (1/16 \text{ joints}/\text{ft}) \times (28 \text{ ft}) \times (20\%) \times (\$1/\text{ft})$	=	\$2,716.70
Longitudinal Joint (Route)	$(5,817 \text{ ft}) \times (4) \times (20\%) \times (\$1/\text{ft})$	=	\$4,653.60
Longitudinal Joint (Ramps)	$(7,762 \text{ ft}) \times (20\%) \times (\$1/\text{ft})$	=	\$3,104.80
Partial Depth D-1 Joint Repair (TL Route)	$(5,817 \text{ ft}) \times (1/15 \text{ J}/\text{ft}) \times (52 \text{ ft}) \times (1 \text{ ft}) \times (3\%) \times (\$51.30/\text{sft})$	=	\$31,034.86
Partial Depth D-1 Joint Repair (TL Ramps)	$(7,762 \text{ ft}) \times (1/16 \text{ J}/\text{ft}) \times (16 \text{ ft}) \times (1 \text{ ft}) \times (3\%) \times (\$51.30/\text{sft})$	=	\$11,945.72
Partial Depth Long. Joint Repair (Route)	$(5,817 \text{ ft}) \times (4 \text{ Joints}) \times (1 \text{ ft}) \times (3\%) \times (\$51.30/\text{sft})$	=	\$35,809.45
Partial Depth Long. Joint Repair (Ramps)	$(7,762 \text{ ft}) \times (1 \text{ Joints}) \times (1 \text{ ft}) \times (3\%) \times (\$51.30/\text{sft})$	=	\$11,945.72
Full depth PCCP Patch (TL Route)	$(33,610 \text{ yd}^2) \times (1.5\%) \times (\$247.90/\text{sys})$	=	\$124,978.79
Full Depth PCCP Patch (TL Ramps)	$(13,800 \text{ yd}^2) \times (1.5\%) \times (\$247.90/\text{sys})$	=	\$51,315.30
Full Depth Patch Subbase (Route)	$(33,610 \text{ yd}^2) \times (9/36 \text{ in}/\text{yd}) \times (1.5\%) \times (\$56.72/\text{yd}^3)$	=	\$7,148.85
Full Depth Patch Subbase (Ramps)	$(13,800 \text{ yd}^2) \times (9/26 \text{ in}/\text{yd}) \times (1.5\%) \times (\$56.72/\text{yd}^3)$	=	\$2,935.26
Patch SGT, Type ID (Both)	$(33,610 + 13,800 \text{ yd}^2) \times (1.5\%) \times (\$29.38/\text{yd}^2)$	=	\$20,893.59
Traffic Maintenance	5% of Contract Cost	=	\$15,718.86
<b>Total Cost</b>			<b>\$330,096.04</b>

**Concrete Pavement Restoration (Age 30):**

D-1 Joints (Route)	$(5,817 \text{ lft}) \times (1/15 \text{ joints/ft}) \times (76 \text{ lft}) \times (30\%) \times (\$1/\text{lft})$	=	\$8,841.84
D-1 Joints (Ramps)	$(7,762 \text{ lft}) \times (1/16 \text{ joints/ft}) \times (28 \text{ lft}) \times (30\%) \times (\$1/\text{lft})$	=	\$4,075.05
Longitudinal Joint (Route)	$(5,817 \text{ lft}) \times (4) \times (30\%) \times (\$1/\text{lft})$	=	\$6,980.40
Longitudinal Joint (Ramps)	$(7,762 \text{ lft}) \times (30\%) \times (\$1/\text{lft})$	=	\$4,657.20
Partial Depth D-1 Joint Repair (TL Route)	$(5,817 \text{ lft}) \times (1/15 \text{ J/lft}) \times (52 \text{ lft}) \times (1 \text{ lft}) \times (5\%) \times (\$51.30/\text{sft})$	=	\$51,724.76
Partial Depth D-1 Joint Repair (TL Ramps)	$(7,762 \text{ lft}) \times (1/16 \text{ J/lft}) \times (16 \text{ lft}) \times (1 \text{ lft}) \times (5\%) \times (\$51.30/\text{sft})$	=	\$19,909.53
Partial Depth Long. Joint Repair (Route)	$(5,817 \text{ lft}) \times (4 \text{ Joints}) \times (1 \text{ lft}) \times (5\%) \times (\$51.30/\text{sft})$	=	\$59,682.42
Partial Depth Long. Joint Repair (Ramps)	$(7,762 \text{ lft}) \times (1 \text{ Joints}) \times (1 \text{ lft}) \times (5\%) \times (\$51.30/\text{sft})$	=	\$19,909.53
Full depth PCCP Patch (TL Route)	$(33,610 \text{ yd}^2) \times (3\%) \times (\$247.90/\text{sys})$	=	\$249,957.57
Full Depth PCCP Patch (TL Ramps)	$(13,800 \text{ yd}^2) \times (3\%) \times (\$247.90/\text{sys})$	=	\$102,630.60
Full Depth Patch Subbase (Route)	$(33,610 \text{ yd}^2) \times (9/36 \text{ in/lyd}) \times (3\%) \times (\$56.72/\text{yd}^3)$	=	\$14,297.69
Full Depth Patch Subbase (Ramps)	$(13,800 \text{ yd}^2) \times (9/26 \text{ in/lyd}) \times (3\%) \times (\$56.72/\text{yd}^3)$	=	\$5,870.52
Patch SGT, Type ID (Both)	$(33,610 + 13,800 \text{ yd}^2) \times (3\%) \times (\$29.38/\text{yd}^2)$	=	\$41,787.17
PCCP Profiling or Diamond Grind (Both)	$(33,610 + 13,800 \text{ yd}^2) \times (100\%) \times (\$5.00/\text{yd}^2)$	=	\$237,050.00
Traffic Maintenance	5% of Contract Cost	=	\$41,368.71
Total Cost			\$868,743.01

**Unbounded Concrete Overlay (Age 40):****Mainline and Shoulders:**

9 in. QC/QA PCCP with 14-ft wide slab for outside lane with D-1 Contraction Joints @ 15 ft spacing, on 110 lb/sys QC/QA - HMA, 2, 64, Intermediate, 9.5 mm, on Existing Concrete

**Ramps (Mainline, Inside Shoulder, and Outside Shoulder):**

8 in. QC/QA PCCP with D-1 Contraction Joints @ 16 ft spacing on Subbase for PCCP, on 110 lb/sys QC/QA - HMA, 2, 64, Intermediate, 9.5 mm, on Existing Concrete

**Cost:**

Route...M, IS, & OS (9" PCCP)	$(49,121 \text{ yd}^2) \times (\$40/\text{yd}^2)$	=	\$1,964,840.00
HMA Intermediate (Route...M & IS)	$(49,121 \text{ yd}^2) \times (110 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$65.0/\text{t})$	=	\$175,607.58
Ramps...M, IS, & OS (8" PCCP)	$(24,148 \text{ yd}^2) \times (\$38/\text{yd}^2)$	=	\$917,624.00
HMA Intermediate (Route...M & IS)	$(24,148 \text{ yd}^2) \times (110 \text{ lb/yd}^2) \times (1/2000 \text{ t/lb}) \times (\$65.0/\text{t})$	=	\$86,329.10
D-1 Joints (Route)	$(5,817 \text{ lft}) \times (1/15 \text{ J/lft}) \times (76 \text{ lft}) \times (\$8.86/\text{lft})$	=	\$261,129.01
D-1 Joints (Ramps)	$(7,762 \text{ lft}) \times (1/16 \text{ J/lft}) \times (28 \text{ lft}) \times (\$8.86/\text{lft})$	=	\$120,349.81



Full depth PCCP Patch (TL Route)	$(33,610 \text{ yd}^2) \times (3\%) \times (\$247.90/\text{sys})$	=	\$249,957.57
Full Depth PCCP Patch (TL Ramps)	$(13,800 \text{ yd}^2) \times (3\%) \times (\$247.90/\text{sys})$	=	\$102,630.60
Full Depth Patch Subbase (Route)	$(33,610 \text{ yd}^2) \times (9/36 \text{ in/yd}) \times (3\%) \times (\$56.72/\text{yd}^3)$	=	\$14,297.69
Full Depth Patch Subbase (Ramps)	$(13,800 \text{ yd}^2) \times (9/26 \text{ in/yd}) \times (3\%) \times (\$56.72/\text{yd}^3)$	=	\$5,870.52
Patch SGT, Type ID (Both)	$(33,610 + 13,800 \text{ yd}^2) \times (3\%) \times (\$29.38/\text{yd}^2)$	=	\$41,787.17
CA, Wedge, No.53 (Route)	$(2) \times (2) \times (2.53 \text{ ft}^2) \times (5,817 \text{ lft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (1.69 \text{ t/yd}^3) \times (\$27.76/\text{t})$	=	\$102,287.36
CA, Wedge, No.53 (Ramps)	$(2) \times (2.1 \text{ ft}^2) \times (7,762 \text{ lft}) \times (1/27 \text{ yd}^3/\text{ft}^3) \times (1.69 \text{ t/yd}^3) \times (\$27.76/\text{t})$	=	\$56,712.92
Traffic Maintenance	5% of Contract Cost	=	\$204,971.17
Total Cost			\$4,304,394.50

<b>HMA PW Cost for Initial, Future Maintenance, and Future Rehabilitation</b>			
Age in Years	Rehab.	Cost \$	Present Worth Cost \$
0	Initial Construction Cost	8,913,387.38	8,913,387.38
3	Joint Seal	10,182.90	9,184.39
6	Joint Seal	20,365.80	16,567.59
9	Joint Seal	30,548.70	22,414.53
12	Joint Seal	40,731.60	26,955.49
15	Mill and Resurface	675,838.92	403,401.91
18	Joint Seal	10,182.90	5,482.08
21	Joint Seal	20,365.80	9,889.04
24	Joint Seal	30,548.70	13,379.02
26	Mill and Resurface	689,794.59	282,014.01
29	Joint Seal	10,182.90	3,754.93
32	Joint Seal	20,365.80	6,773.46
35	Joint Seal	30,548.70	9,163.90
36	Mill and 2 lifts HMA Overlay	1,637,870.11	474,708.34
39	Joint Seal	10,182.90	2,661.94
42	Joint Seal	20,365.80	4,801.83
45	Joint Seal	30,548.70	6,496.46
48	Joint Seal	40,731.60	7,812.58
50	Salvage Value	0.00	0.00
<b>Total HMA PW Cost</b>			<b>\$10,218,848.88</b>

<b>PCCP PW Cost for Initial, Future Maintenance, and Future Rehabilitation</b>			
Age in Years	Rehab.	Cost \$	Present Worth Cost \$
0	Initial Construction Cost	8,826,018.94	8,826,018.94
10	PM Concrete Pavement	8,594.07	6,092.50
18	Concrete Pavement Restoration	330,096.04	177,710.88
30	Concrete Pavement Restoration	868,743.01	309,514.38
40	Unbounded Concrete Overlay	4,304,394.50	1,087,171.54
50	Salvage Value	2,582,636.70	-462,429.82
<b>Total PCCP PW Cost</b>			<b>\$9,944,078.43</b>

$$PW = F [1/(1+i)^n]$$

Where: F = Future Construction Cost

i = Discount rate (3.5%)

n = Number of years from year zero

**Initial Construction Cost and**  
**PW of Future Rehilitation & Maintenance Cost**

X1 = HMA Section = \$10,218,848.88

X2 = PCCP Section = \$9,944,078.43

% Difference =  $\frac{(X1 - X2)}{(X1 + X2)/2}$  **2.73%**