KEYS TO MEETING THE CHALLENGES OF RUNWAY PAVEMENT CONSTRUCTION AT WATERLOO AIRPORT

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PRESENTATION OUTLINE

- Acknowledgements
- Introduction
- Pavement Investigation and Design
- Specification Development
- Construction
- Lessons Learned and Conclusions

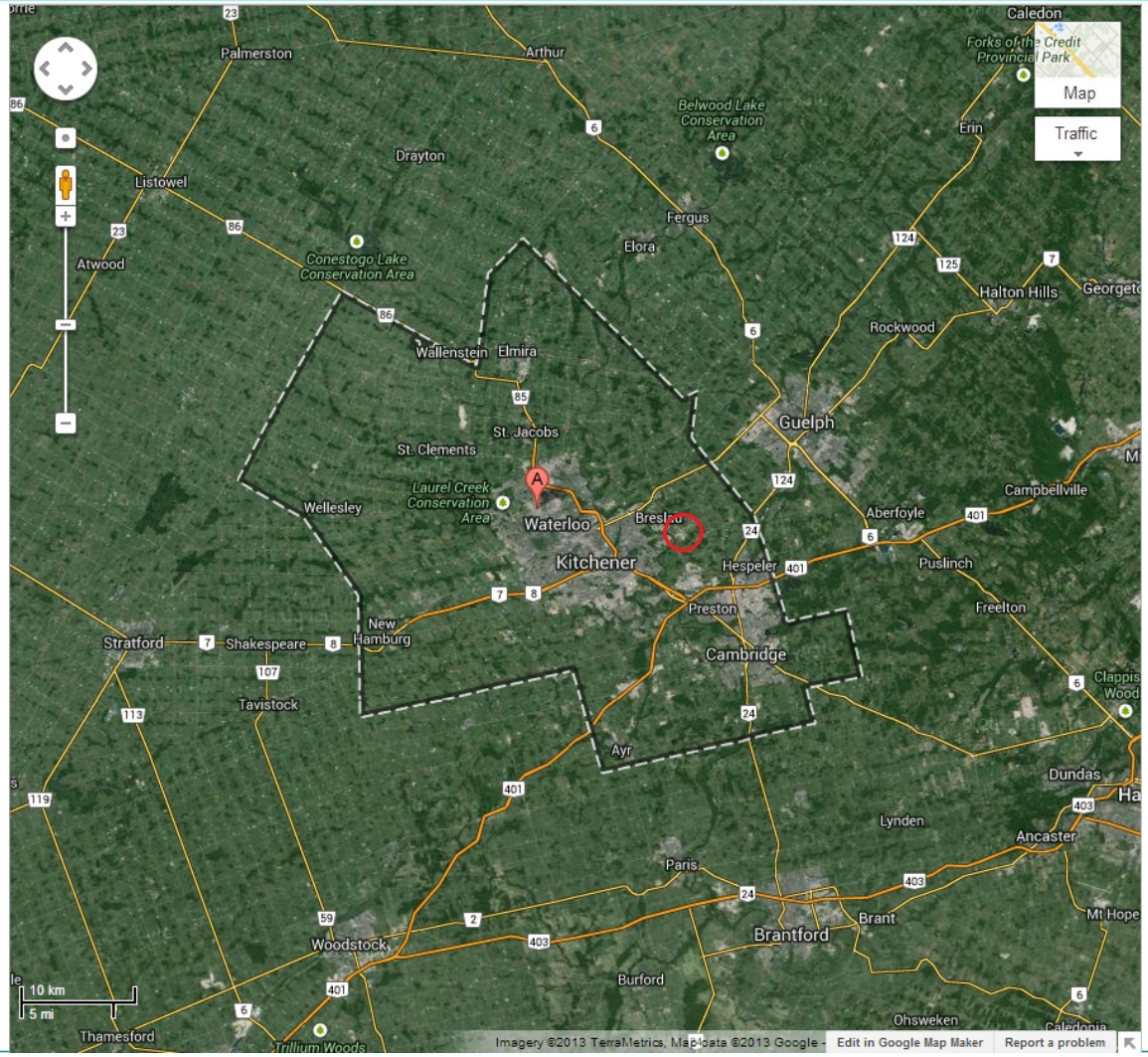
ACKNOWLEDGEMENTS

- Laboratory and field staff from Golder
- Mr. Andrew Turner, MMM Group Limited
- Mr. John Hammer, Region of Waterloo
- Mr. Frank Kosa, Region of Waterloo
- Mr. Chris Wood, Region of Waterloo International Airport

INTRODUCTION

- Located in Breslau in the Region of Waterloo, Ontario
- Serves an area with a population of about 750,000
- Flights to Canada, United States and the Caribbean
- Airside pavements include:
  - Runway 08-26 - 45 m wide and 2,134 m long
  - Runway 14-32 – 45 m wide and 1,250 m long
  - Five Taxiways
  - Three Aprons
- Project included rehabilitation design and construction for a Section of Runway 08-26

REGION OF WATERLOO



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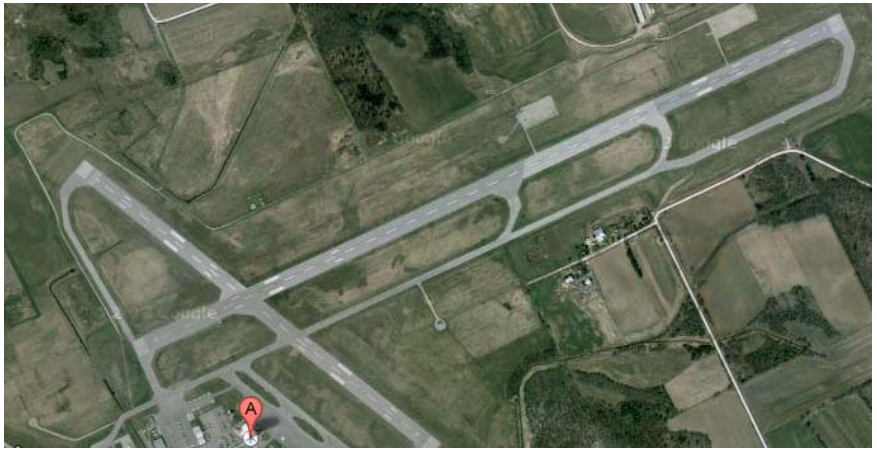
WATERLOO INTERNATIONAL AIRPORT

RUNWAY 08-26

- Section 1
  - 1159 m constructed in 1940's
  - Overlay in 1973 and 1993
- Section 2
  - 346 m extension in 1984
  - No rehabilitation since
- Section 3
  - 579 m extension in 2002
  - No rehabilitation since



RUNWAY 08-26

Existing Pavement

Section	Asphalt	Granular Base	Granular Subbase
1993	100	300	340
1984	90	225	150
2002	100	300	340

PAVEMENT INVESTIGATION

- Review information from previous investigations
- Limited new geotechnical investigation
  - Six boreholes
  - Laboratory testing
- Falling Weight Deflectometer (FWD) testing
  - Pavement overall structural capacity
  - Subgrade bearing capacity
  - 3 m and 7 m offset from centreline

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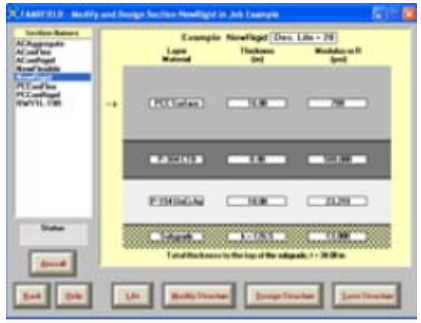
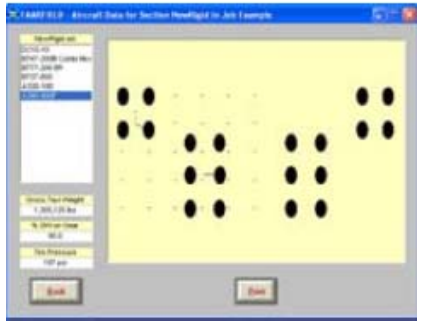
INVESTIGATION FINDINGS

- 1993 and 1984 section has lower structural capacity that 2002 section
- 1993 section and higher structural capacity that 1984 section
- Backcalculated moduli for granular material and subgrade for 1984 section was relatively low
- Granular material in 1984 section was of variable and poor quality
- Granular material in 1993 section was of relatively good quality

REHABILITATION DESIGN

- Required PLR of 9.8
- Structural design using Transport Canada procedures and verified using FAA procedures
- 2002 section not to be rehabilitated





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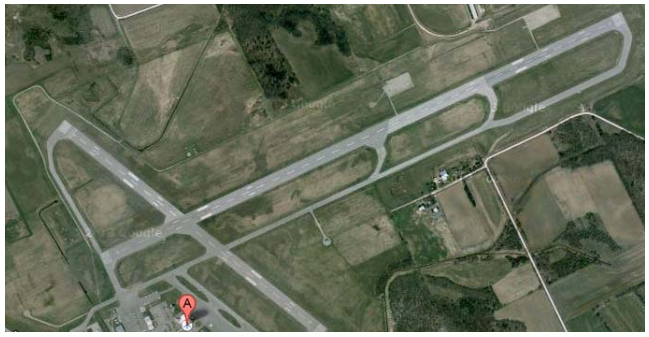
REHABILITATION DESIGN

1993 Section		1984 Section	
Keel	Outside Keel	Keel	Outside Keel
▪ Remove 200 mm of existing pavement ▪ Place 150 mm of binder course HMA ▪ Place 50 mm of surface course HMA	▪ Mill 100 mm of existing pavement ▪ Place 50 mm of binder course HMA ▪ Place 50 mm of surface course HMA	▪ Remove 750 mm below existing grade ▪ Place 550 mm of granular base ▪ Place 150 mm of binder course HMA and ▪ Place 50 mm of surface course HMA	▪ Remove 750 mm below existing grade ▪ Place 650 mm of granular base ▪ Place 50 mm of binder course HMA ▪ Place 50 mm of surface course HMA



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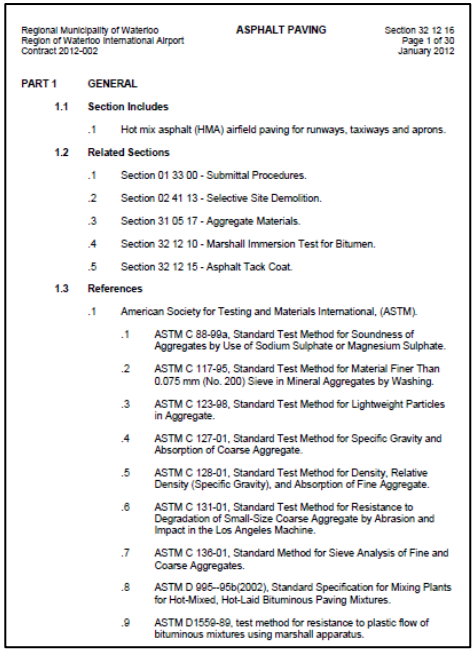
SPECIFICATION DEVELOPMENT

- Custom specification to meet budget, material, environmental and loading requirements at the airport
- Specifications altered to consider the very strict timelines
- Specifications for
  - Subgrade preparation
  - Granular base materials and placement
  - Asphalt tack coat
  - Asphalt materials and paving



Regional Municipality of Waterloo
Region of Waterloo International Airport
Contract 2012-002

ASPHALT PAVING

Section 32 12 16
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January 2012

PART 1 GENERAL

1.1 Section Includes

.1 Hot mix asphalt (HMA) airfield paving for runways, taxiways and aprons.

1.2 Related Sections

.1 Section 01 33 00 - Submittal Procedures.

.2 Section 02 41 13 - Selective Site Demolition.

.3 Section 31 05 17 - Aggregate Materials.

.4 Section 32 12 10 - Marshall Immersion Test for Bitumen.

.5 Section 32 12 15 - Asphalt Tack Coat.

1.3 References

.1 American Society for Testing and Materials International, (ASTM).

.1 ASTM C 88-99a, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate.

.2 ASTM C 117-95, Standard Test Method for Material Finer Than 0.075 mm (No. 200) Sieve in Mineral Aggregates by Washing.

.3 ASTM C 123-98, Standard Test Method for Lightweight Particles in Aggregate.

.4 ASTM C 127-01, Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.

.5 ASTM C 128-01, Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate.

.6 ASTM C 131-01, Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

.7 ASTM C 136-01, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

.8 ASTM D 995--95b(2002), Standard Specification for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures.

.9 ASTM D1559-89, test method for resistance to plastic flow of bituminous mixtures using marshall apparatus.

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ASPHALT CEMENT AND AGGREGATE

- Asphalt Cement
  - Surface Course – PG 70-28 PMA
  - Binder Course – PG 64-28
- Surface Course Aggregates
  - 100 percent crushed
  - Dolomitic rock or traprock
  - Natural aggregates not permitted
- Binder Course Aggregates
  - 100 percent crushed
  - Limestone
  - Max 10% natural aggregates

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AGGREGATE PROPERTIES

Physical Property	Test Method	Surface Course Limits		Binder Course Limits	
		Coarse Aggregate	Fine Aggregate	Coarse Aggregate	Fine Aggregate
Sand Equivalent - Minimum	ASTM D2419	50			
Magnesium Sulphate Soundness - Maximum[1]	ASTM C88	12%	16%	12%	16%
Unconfined Freezing and Thawing – Maximum	CAN A23.2-24A	6%			
Los Angeles Abrasion - Maximum	ASTM C131	25%	-	30%	-
Absorption - Maximum	ASTM C127	1.75%	-	2.00%	-
Loss by Washing – Maximum[2]	ASTM C117	1.50%	-	2.00%	-
Lightweight Particles – Maximum[3]	ASTM C123	1.50%		3.00%	
Flat and Elongated Particles – Maximum[4]	ASTM D4791	8%	-	10%	-
Polished Stone Value – Minimum	BS 812 Part 114	65		-	

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ASPHALT MIX REQUIREMENTS

Physical Property	Test Method	Requirement	
		Surface Course	Binder Course
Marshall Stability at 60°C - Minimum	ASTM T245	14.0 kN	12.0 kN
Flow Value	ASTM T245	2-4 mm	2-4 mm
Air Voids in Mixture	ASTM D3203	3%-5%	3%-5%
Target Air Voids in Mixture	ASTM D3203	4%	4%
Marshall Retained Stability - Minimum	MTO LS-283	75%	75%
Asphalt Cement Content on Total Mass of Mix - Minimum	-	5.3	5.0

Percent Passing 4.75 mm by Mass	Minimum Voids in Mineral Aggregate (VMA)	
	Nominal Maximum Particle Size of 13.2 mm	Nominal Maximum Particle Size of 19.0 mm
40	13.0	12.0
45	13.5	12.5
50	14.0	13.0
55	14.5	13.5
60	15.0	14.0
Over 60	15.5	14.5

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PAVING REQUIREMENTS

- Echelon paving to minimize number of cold longitudinal joints
- Joint heaters to improve quality of cold longitudinal joints
- Shuttle Buggy® to minimize thermal and gradation segregation, eliminate bumps during mix downloading

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PAVING REQUIREMENTS

- Spare equipment (paver, rollers) required on site to minimize delays due to equipment failure

- Trial batch and test strip required prior to start of paving on the runway

QUALITY ASSURANCE

- Acceptance based on quality assurance testing
- Testing included
  - Laboratory
    - Granular materials testing
    - Asphalt testing
  - Field
    - Granular layers compaction testing using nuclear gauges
    - Asphalt mat thickness
    - Asphalt mat compaction using nuclear gauge
    - Longitudinal joint compaction using nuclear gauge
    - Smoothness measurement using straight edge

QUALITY ASSURANCE

- Construction inspection
  - Compliance with approved paving plan
  - Asphalt temperature checks
    - Placement
    - Compaction
  - Surface appearance
    - Granular layers
      - Segregation
      - Any deformation
    - Asphalt
      - Segregation
      - Fat spots
      - Other defects

PAYMENT ADJUSTMENT

- Requested to be included in specification by the airport
- Payment adjustment to allow the airport flexibility in dealing with defective pavement
- Payment adjustment equations developed for
  - Asphalt mix properties measured in the laboratory
  - Asphalt compaction
  - Asphalt pavement smoothness

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PAYMENT ADJUSTMENT

- Asphalt mix properties included in the adjustment
  - Asphalt cement content
  - Aggregate gradation
  - Air void content
- Payment adjustment applied only to lot results

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PAYMENT FACTORS

Deviation	Payment Factor - PF_{AC}
-0.31% to –0.4% or +0.36% to + 0.45%	0.8
-0.41% to -0.5% or +0.46% to +0.5%	0.6
> ± 0.5%	0

Air Voids	Payment Factor - PF_{VOIDS}
2.2% to 2.4% or 5.6% to 5.8%	0.9
2.0% to 2.1% or 5.9% to 6.0%	0.8
<2.0% or >6.0%	0.5

PAYMENT FACTORS

Asphalt Mat Compaction	Payment Factor - PF_C
97.0% to 97.9%	0.9
96.0% to 96.9%	0.8
<96.0%	0.5

Deviation	Payment Factor - PF_S
5.1 to 5.5	0.9
5.6 to 6.0	0.8
> 6.0	0.5

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CONSTRUCTION

- Staging to allow sections of the runway to remain open for limited operations during construction
- Paving operations
  - Started on April 23, 2012
  - Completed on May 13, 2012
- Construction included
  - Milling all HMA and placement of new 200 mm of HMA for 1,120 m
  - Pavement full reconstruction for 400 m

CONSTRUCTION

- Construction operations to continue 24 hours a day
- Two shifts for field and laboratory technicians
- 24 hour turnaround time for laboratory testing results
- Immediate acceptance evaluation

ASPHALT MIX DESIGN

- Mixes developed using the 75 blow Marshall method
- Mix design submitted for review and acceptance
- Surface course mix
  - 100% crushed traprock
  - 5.3% polymer modified asphalt cement (PG 70-28)
  - 3.7% air voids
  - 15.2 kN stability

ASPHALT MIX DESIGN

- Binder course mix
  - 100% crushed pit run material
  - 5.0% asphalt cement (PG 64-28)
  - 3.1% air voids
  - 14.8 kN stability
- Moisture susceptibility was tested for both mixes

TRIAL BATCH AND TEST STRIP

- Trial batch and test strip required
- Trial batch samples were tested and accepted
- Test strip for the surface and binder course placed on the runway in non major areas
- Asphalt samples obtained from the test strip placement
- Compaction pattern established during test strip

TRIAL BATCH AND TEST STRIP

- Asphalt cores obtained from test strip to calibrate nuclear gauge
- Joint construction methods were evaluated during test strip placement
- Test strip pavement surface inspected for
  - Segregation
  - Texture to ensure adequate friction
  - Bleeding due to excess asphalt cement

STAGE 2 AND 2A CONSTRUCTION

- Included milling and placement of 200 mm of new asphalt on 440 m of the runway pavement
- Issues encountered
  - Segregation at isolated longitudinal joints – joint reheated using infra-red heater and compaction effort applied with pneumatic tire roller
  - Localized bump at a longitudinal joint – Bump ground down and then reheated and compacted with PTR

STAGE 2 AND 2A CONSTRUCTION

- Issues encountered
  - Slight segregation due to paver extension – Contractor advised to preheat extension of pavers to prevent thermal segregation
- All binder and surface course asphalt samples were generally acceptable
- Asphalt mat and joint compaction met specification requirements

STAGE 3 CONSTRUCTION

- Milling and overlaying 200 mm of new HMA for 680 m of runway
- Reconstruction for 400 m of runway
- Issues encountered
  - Localized soft subgrade identified through proofrolling – soft soils were removed and replaced with approved backfill
  - Asphalt thickness placed lower than design thickness – defective asphalt immediately removed and granular material was regraded

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STAGE 3 CONSTRUCTION

- Issues encountered
  - Paving temperatures below the specified minimum – routinely checked asphalt mat temperature and extra rollers added to achieve compaction
- Binder and surface course mixes were generally acceptable
- Contractor was immediately informed of borderline measurements and appropriate adjustments were made at the asphalt plant

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BINDER COURSE PAYMENT ADJUSTMENT

Lot	Acceptable (A)/Borderline (B)/Rejectable (R)						PF_{DLS}	$PF_{4.75}$	$PF_{0.600}$	$PF_{0.075}$	PF_{AC}	PF_{VOIDS}	PF_{G}	PF_{M}
	12.5 mm	4.75 mm	0.600 mm	0.075 mm	AC Content	Air Voids								
1	A	A	A	A	A	A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	B	A	A	B	A	A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	A	A	A	R	A	A	1.00	1.00	1.00	0.80	1.00	1.00	0.95	0.9875
4	B	A	A	B	A	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	A	A	A	B	A	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	A	A	A	A	A	A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	A	A	A	A	A	A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	A	A	A	A	A	A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	A	A	A	A	A	A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	A	A	A	A	A	A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note: PF is the payment factor

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SURFACE COURSE PAYMENT ADJUSTMENT

Lot	Acceptable (A)/Borderline (B)/Rejectable (R)						PF_{DLS}	$PF_{4.75}$	$PF_{0.600}$	$PF_{0.075}$	PF_{AC}	PF_{VOIDS}	PF_{Q}	PF_{M}
	12.5 mm	4.75 mm	0.600 mm	0.075 mm	AC Content	Air Voids								
1	A	A	A	A	A	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	A	A	A	A	A	A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	A	A	A	A	A	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	A	A	A	A	A	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	A	A	A	A	A	A	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note: PF is the payment factor

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COMPACTION PAYMENT ADJUSTMENT

Lot	Mat Compaction	Joint Compaction	Acceptable (A)/Borderline (B)/Rejectable (R)		PF_C
			Mat Compaction	Joint Compaction	
1	96	95	A	A	1.0
2	97	95	A	A	1.0
3	96	96	A	A	1.0
4	96	-	A	A	1.0
5	97	97	A	A	1.0
6	96	96	A	A	1.0
7	97	96	A	A	1.0
8	97	96	A	A	1.0
9	96	96	A	A	1.0
10	97	97	A	A	1.0

Lot	Mat Compaction	Joint Compaction	Acceptable (A)/Borderline (B)/Rejectable (R)		PF_C
			Mat Compaction	Joint Compaction	
1	96	96	A	A	1.0
2	96	96	A	A	1.0
3	96	96	A	A	1.0
4	96	95	A	A	1.0
5	96	95	A	A	1.0

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SMOOTHNESS MEASUREMENTS

- 428 sublot measurements using a straightedge
  - 414 acceptable, 6 borderline, and 8 rejectable
- Rejectable areas were brought to the attention of the owner
  - Areas found to be ponding water were repaired
- Lot smoothness – average of sublot smoothness measurements
- Payment adjustment was calculated to be zero for the smoothness measurements

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LESSONS LEARNED

- Consultations with all parties during all stages of construction
- Detailed customized, clear specifications to ensure the desired product is achieved and can be enforced
- Properly organized, approved and followed paving plan
- Spare equipment required to be on site to minimize delays
- Very well organized QC and QA to allow for timely decision making

- **Excellent teamwork between contractor, consultant and owner to solve encountered issues immediately and effectively!!!**

THANK YOU!
QUESTIONS?

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