2011 CAPTG WORKSHOP

THE EVOLUTION OF SUSTAINABILITY IN AIRFIELD PAVING SPECIFICATIONS

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Montreal, Quebec
September 15, 2011

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PRESENTATION OUTLINE

- Introduction to Sustainability
- Sustainability in Pavement Applications
- Example of Highway Pavement Sustainability Evaluation
- Airfield Pavement Specifications in Canada
- Amended P-401 Specification
- AAPTP Program
- Airfield Pavement Life Cycle Cost Analysis
- Non-Load Related Pavement Damage
- Additional Aspects
- Conclusions

WHAT IS SUSTAINABILITY?

Sustainable development is defined in the Brundtland Report in 1987 as:

"….. development that meets the needs of the present without compromising the ability of future generation to meet their needs"

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WORLD TRENDS

- Global Warming
- Green House Gas (GHG) emissions
  - Transportation responsible for 28% of GHG emissions – 85% of this due to road transportation
- Rapid population growth in urban areas
- Everyone seeking greater affluence
- World ecosystem increasingly impacted by population growth, increasing affluence and **technology** growth
- Transport is a significant component of human consumption

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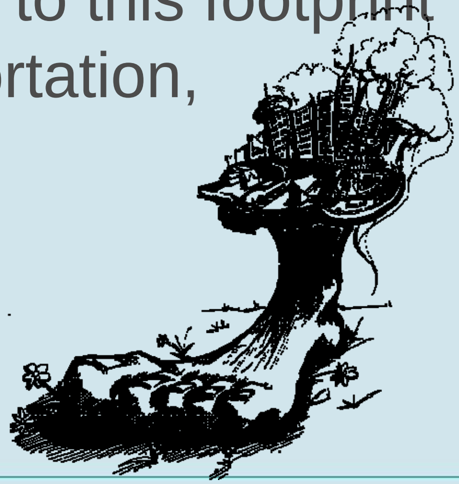
ECOLOGICAL FOOTPRINT

- Every person consumes resources to maintain their lifestyle
- Combined impact of this consumption has an impact on the earth
- Ecological footprint measures what we consume in terms of productive land and water needed to produce these resources and also too absorb all the waste we make
- Components of consumption that contribute to this footprint are food, housing, services, energy, transportation, consumer goods, and services



WHAT IS THE CONCERN?

- In 1900
  - There were 5.6 ha of biologically productive land available per world citizen
  - Average Canadian needed 1 ha to support their lifestyle
- In 2000
  - Estimated that only 2 ha available per person
  - Current consumption levels
    - United States – 12 ha/person
    - Canada – 8 ha/person
    - Italy – 6 ha/person

CURRENT TREND IS NOT SUSTAINABLE!

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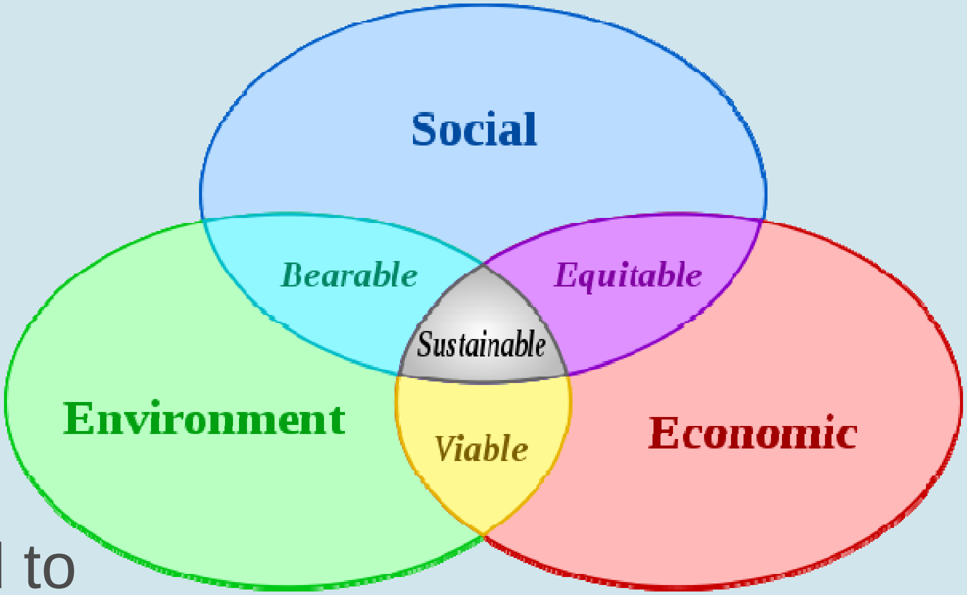
TRIPLE BOTTOM LINE

- To achieve sustainability three aspects need to be considered
  - Economic – associated costs
  - Environment – impact to our surroundings
  - Social – impact on the general public
- Technical aspects also need to be considered in addition to the triple bottom line to achieve sustainability



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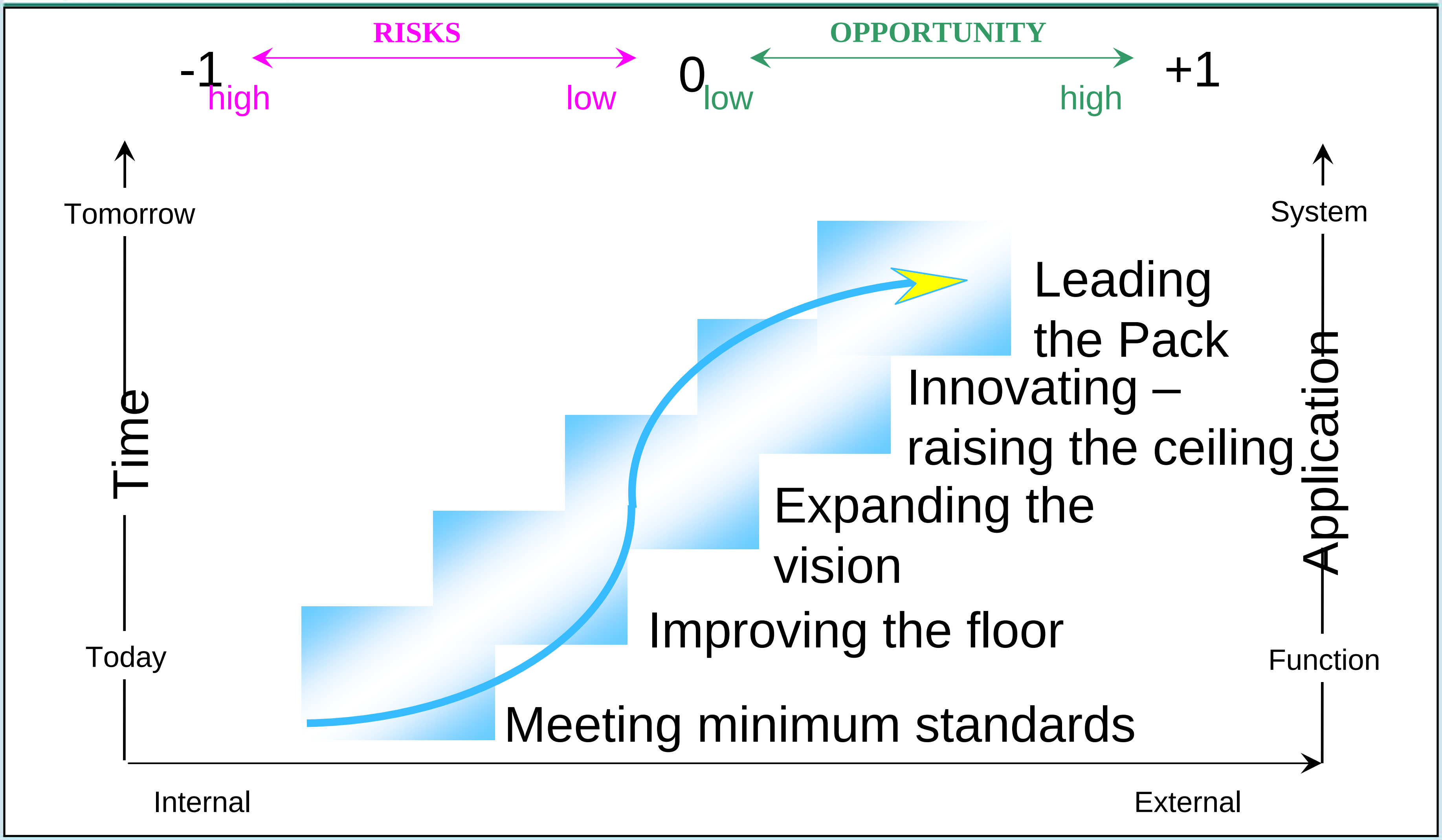
THE ROAD TO LEADERSHIP



Adapted from *Transforming Sustainability Strategy into Action*, Beloff et al, 2005

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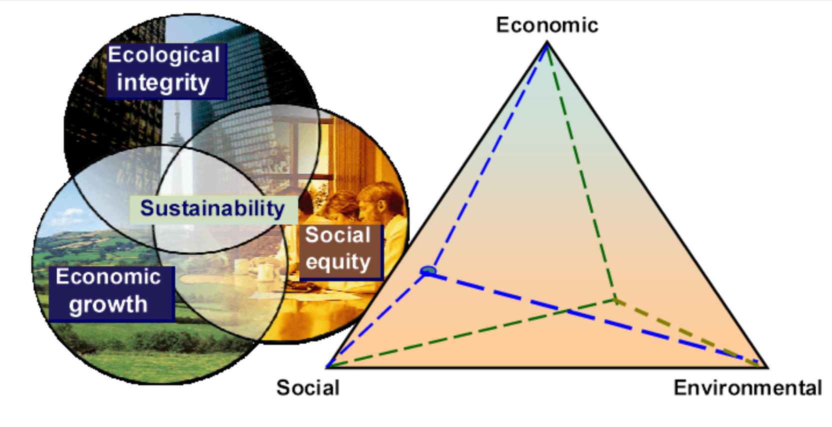
Transportation and Sustainability

- Sustainability principles applied to every stage
  - Airport planning
  - Development
  - Construction
  - Operations
  - Maintenance



- Cooperation between owners and their engineers
- Achieve balance between technical, economic, social and environmental factors

Sustainable Pavements

- Sustainable Pavements – safe, efficient, durable, minimum impact on environment

- Criteria
  - Minimize use of natural resources
  - Reduced energy consumption
  - Reduced GHG emissions
  - Limiting Pollution
  - Improving safety and risk prevention
  - Reduced user delay and increased comfort
  - Longer lasting
  - Innovative
- Cannot compromise pavement performance

SUSTAINABLE PAVEMENTS

- Social
  - Skills training and accreditation
  - Improved safety
  - Decreased user delay costs
- Economic
  - Use of recycled materials – reduced costs
  - Reduced waste disposal costs
  - Reduced haulage costs
  - Reduced quantity of new materials

SUSTAINABLE PAVEMENTS

- Environment
  - Increased recycling and re-use of waste material
  - Reduced energy consumption from reduced haulage
  - Preventive maintenance to prolong serviceable life
  - Conservation of finite resources
  - Reduced use of bituminous products through recycling
  - Reduced GHG emissions through reduced haulage requirements

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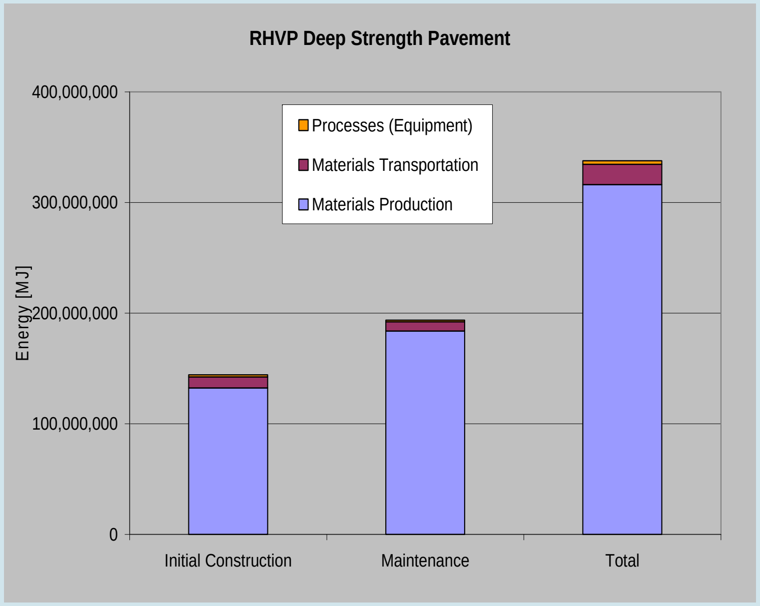
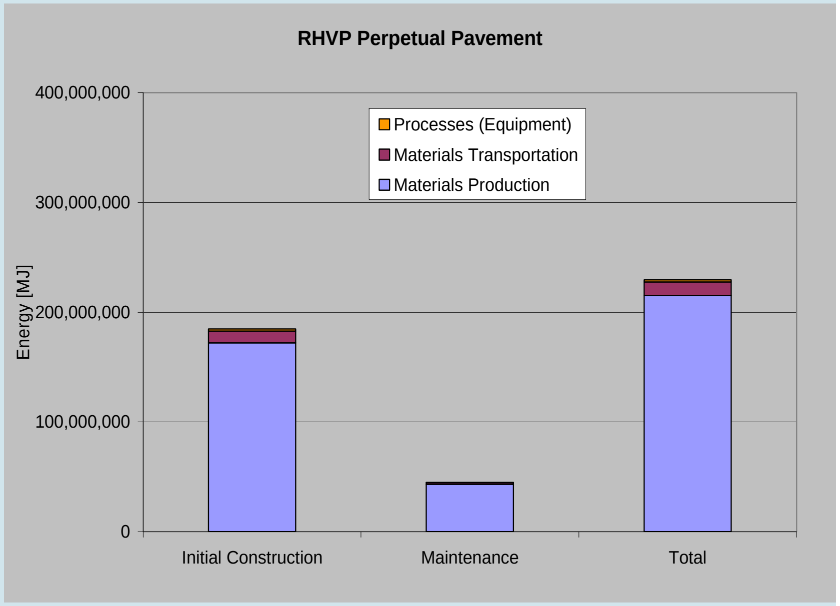
ROAD PAVEMENT SUSTAINABILITY EVALUATION

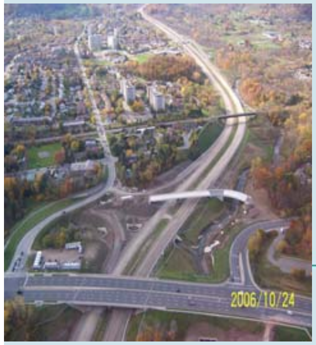
- Examples of available programs
  - Green Road – FHWA (University of Washington)
  - GreenPave – Ontario Ministry of Transportation (MTO)
  - PaLATE
  - GoldSET

Reduced Environmental Impacts

Life Cycle Energy Consumption







Conventional

Perpetual

Pavement Life-cycle Assessment Tool for Environmental and Economic Effects (PaLATE): A. Horvath

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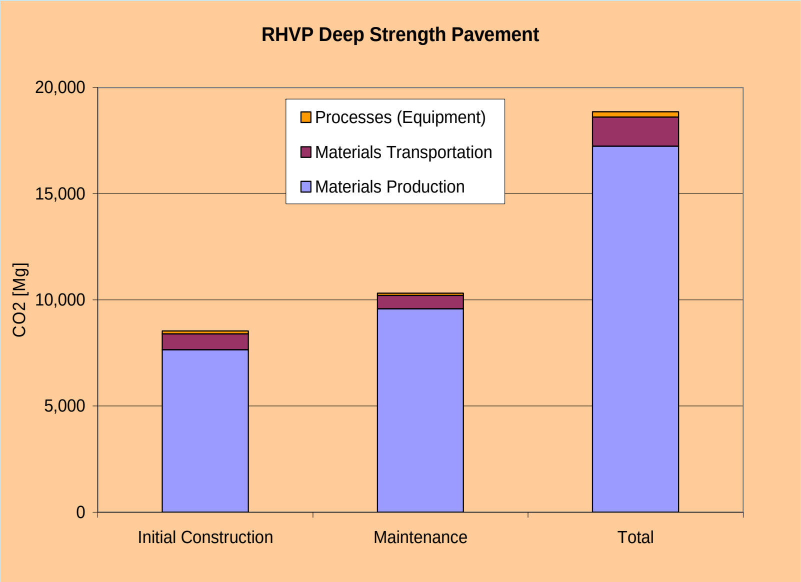
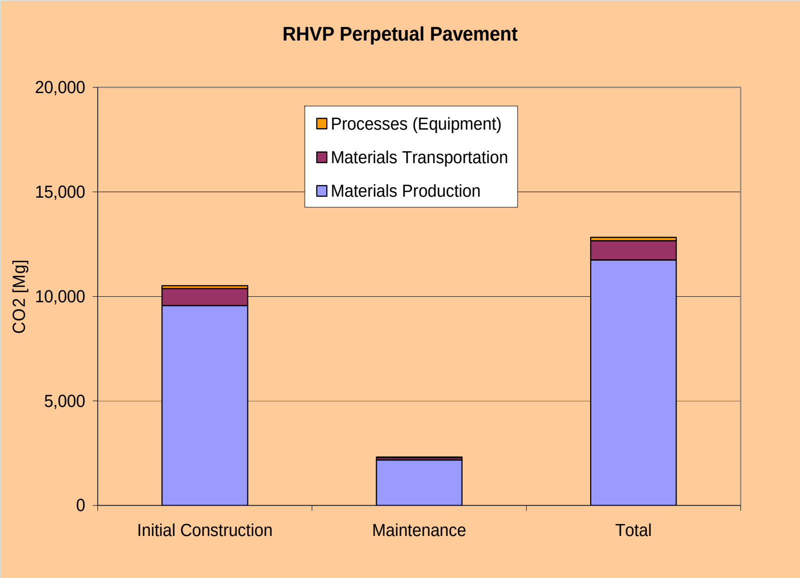
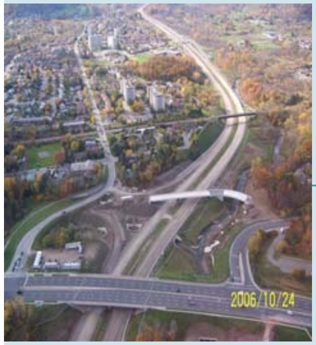
Reduced Environmental Impacts

Life Cycle CO_2 Emissions







Conventional

Perpetual

Pavement Life-cycle Assessment Tool for Environmental and Economic Effects (PaLATE): A. Horvath

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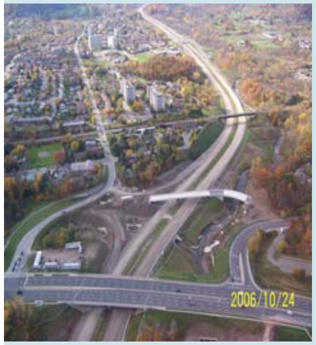
Sustainability Comparison-Environmental



ENVIRONMENTAL ASPECTS	Option 1					Option 2				
	-2	-1	0	1	2	-2	-1	0	1	2
Use of Natural Resources										
New Aggregates				X						X
Bituminous Materials				X				X		
Atmospheric Emissions										
Air Emissions		X							X	
Dust and Noise		X				X				
Waste Generation										
Excess Material Off-site		X						X		
Value-Added Re-Use			X					X		
Consumed Energy										
Consumed energy		X						X		
Transportation Impact										
Transportation impact	X								X	

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Sustainability Comparison-Social

SOCIAL ASPECT	Option 1					Option 2				
Health and safety										
Local resident safety			X						X	
Worker safety		X								X
Impact on community										
Work pollution (noise, dust, visual aspects, etc)			X						X	
Duration of works		X							X	
Quality of Life (Frustration, ride quality, etc.)	X									X
Adding value to the road corridor				X						X
Equity										
Training of employees			X					X		
Preferably local job			X					X		
Corporate image										
Corporate image			X							X
Future Maintenance Needs										
On-going local employment					X		X			

Sustainability Comparison-Economic

ECONOMIC ASPECT	Option 1					Option 2				
Economic performance										
Total construction cost				X			X			
Life Cycle Cost		X								X
Local suppliers										
Local suppliers			X				X			
Sustainability										
Durability			X							X
Level of maintenance and repair										
Level of Maintenance and repair			X							X
Technological aspect										
Research and development			X						X	
Technological uncertainties				X			X			

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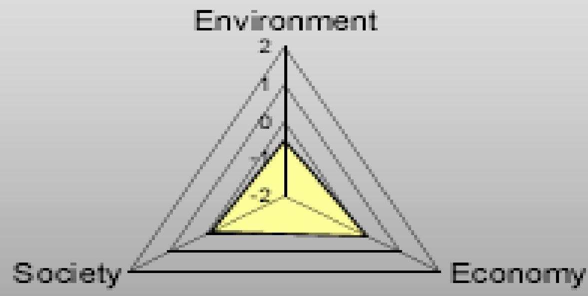
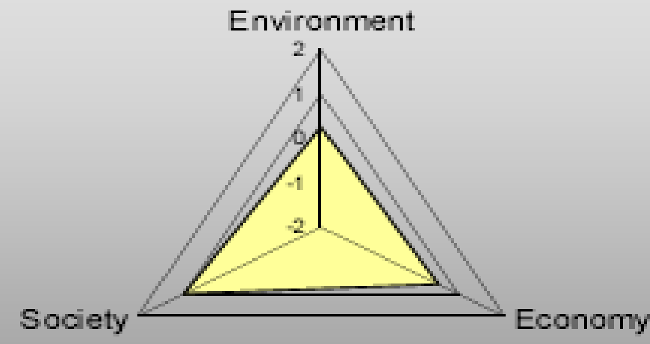
Sustainability Comparison-Combined

RESULTS - OPTION 1	
ENVIRONMENT	-0.50
SOCIETY	-0.10
ECONOMY	0.14



Conventional

RESULTS - OPTION 2	
ENVIRONMENT	0.25
SOCIETY	1.00
ECONOMY	0.57



Perpetual

AIRFIELD PAVEMENT – SUSTAINABILITY ASPECTS

Technical

- Follow technical standards
- Optimizing other aspects without compromising quality and pavement performance
- Pavement design life
- Life cycle cost analysis
- Better materials
  - New/better asphalt mixes
  - Performance graded asphalt cement (PGAC)

Technical

- Recycling
  - Reclaimed Asphalt Pavement (RAP)
  - Hot In-Place Recycling (HIR)
  - Cold In-Place Recycling (CIR)
  - Full Depth Reclamation (FDR)
  - Foamed asphalt stabilization
  - Pavement reclamation
  - Recycled concrete and granular materials

AIRFIELD PAVEMENT – SUSTAINABILITY ASPECTS

Technical

- Innovative mix verification testing
  - Mechanistic properties
    - Rutting resistance
    - Cracking endurance
    - Modulus
    - Low temperature cracking

Technical

- Advanced testing to evaluate pavement condition
  - Falling Weight Deflectometer (FWD) – structural condition
  - Ground Penetrating Radar (GPR) – layer thickness and profiles
  - Inertial profiler - smoothness
- Preventive maintenance
  - Extend pavement life
  - Address non-load related distresses

HOT-MIX ASPHALT PAVING

Review of Airport Paving Specifications SWIFT 2008

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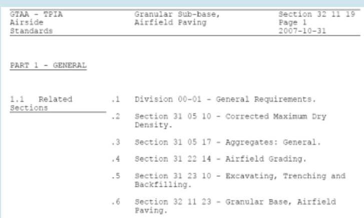
VARIOUS PAVING SPECIFICATIONS



GTAA - TPIA Airside Standards | Granular Sub-base, Airfield Paving | Section 32 11 19 Page 1 2007-10-31

PART 1 - GENERAL

1.1 Related Sections

.1 Division 00-01 - General Requirements.

.2 Section 31 05 10 - Corrected Maximum Dry Density.

.3 Section 31 05 17 - Aggregates: General.

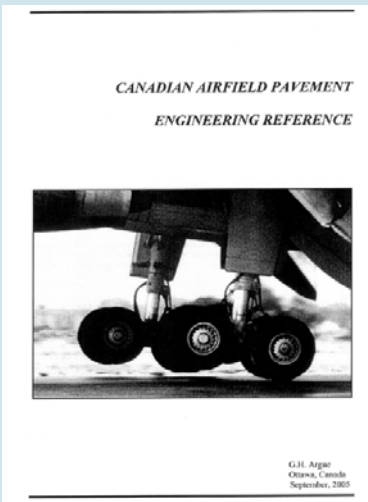
.4 Section 31 22 14 - Airfield Grading.

.5 Section 31 23 10 - Excavating, Trenching and Backfilling.

.6 Section 32 11 23 - Granular Base, Airfield Paving.

- Greater Toronto Airport Authority (GTAA)
- Department of National Defence (DND)
- Calgary Airport Authority (CAA)
- Winnipeg Airports Authority (WAA)
- Saskatoon International Airport (SIA)

VARIOUS PAVING SPECIFICATIONS



- Vancouver International Airport Authority (YVR)
- Canadian Airfield Pavement Engineering Reference (CAP)
- Public Works and Government Services Canada (PWGSC)

- Reference to Federal Aviation Administration (FAA)

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HOT-MIX ASPHALT BINDER COURSE

- Gradation
- Asphalt cement content and grade

Gradation												
Sieve Size (mm)	Percent Passing											
	GTAA		DND		CAP, PWGSC		CAA		WAA		FAA (25 mm Mix)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
25.0	100	100	100	100	100	100	100	100	100	100	100	100
19.0	90	100	90	100	-	-	-	-	90	100	76	98
16.0	75	95	80	92	-	-	-	-	-	-		
12.5	-	-	70	85	70	85	70	85	70	85	66	86
9.5	50	75	58	78	-	-	-	-	60	76	57	77
4.75	30	50	40	65	40	65	40	65	40	60	40	60
2.36	20	40	30	53	-	-	-	-	-	-	26	46
2.00	-	-	-	-	30	50	30	50	30	50		
1.18	10	35	23	43	-	-	-	-	-	-	17	37
0.600	5	26	16	34	-	-	-	-	-	-	11	27
0.425	-	-	-	-	15	30	15	30	15	30		
0.300	3	15	10	25	-	-	-	-	-	-	7	19
0.180	-	-	-	-	5	20	5	20	5	20		
0.150	1	7	5	15	-	-	-	-	-	-	6	16
0.075	1	5	2	7	3	8	3	8	3	8	3	6
Asphalt cement content (%)	5.0	5.4	5.0	-	-	-	-	-	4.5	6.0	4.5	7.0
Asphalt cement grade	PG 64-28		Pen 80-100		Site specific (pen or PG)		P120-150A		Pen 150-200		PG site specific	

HOT-MIX ASPHALT SURFACE COURSE

- Gradation
- Asphalt cement content and grade

Gradation														
Sieve Size (mm)	Percent Passing													
	GTAA		DND		CAP, PWGSC		CAA, SIA		WAA		YVR		FAA (19 mm Mix)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
19.0	100	100	-	-	-	-	-	-	-	-	100	100	100	100
16.0	95	100	100	100	-	-	-	-	100	100	-	-	-	-
13.2	90	98	-	-	-	-	-	-	-	-	-	-	-	-
12.5	80	95	87	95	100	100	100	100	87	95	79	95	79	99
9.5	75	85	76	90	-	-	-	-	76	90	68	75	68	88
4.75	45	65	55	75	55	75	55	75	55	75	48	55	48	68
2.36	35	50	40	60	-	-	-	-	-	-	33	45	33	53
2.00	-	-	-	-	35	55	35	55	35	55	-	-	-	-
1.18	25	40	27	47	-	-	-	-	-	-	20	35	20	40
0.600	15	30	18	35	-	-	-	-	-	-	14	25	14	30
0.425	-	-	-	-	15	30	15	30	15	30	-	-	-	-
0.300	7	20	10	25	-	-	-	-	-	-	9	20	9	21
0.180	-	-	-	-	5	20	5	20	5	20	-	-	-	-
0.150	1	8	5	15	-	-	-	-	-	-	6	15	6	16
0.075	1	5	2	7	3	8	3	8	3	8	3	6	3	6
Asphalt cement content (%)	4.8	5.2	4.8	-	-	-	-	-	5.0	6.0	> 5.0*	-	5.0	7.5
Asphalt cement grade	PG 70-28 PMA surface PG 64-28 binder		Pen 80-100		Site specific (pen)		CAA - Pen 120-150A SIA - Pen 150-200A		Pen 150-200		PG 64-22		PG site specific	

* By dry weight of aggregate.

HOT-MIX ASPHALT

- Materials

Material Type	Specification Limits	Specifications Compared			Remarks
		Item included		Total	
		Yes	No		
Asphalt cement:					
PG grade		2	6	8	
Pen grade		6	2	8	
Aggregate:					
Dolomitic rock or trap rock		1	7	8	GTAA
Crushed stone		8	-	8	
Crushed gravel		7	1	8	
Natural sand, max	10%	2	6	8	

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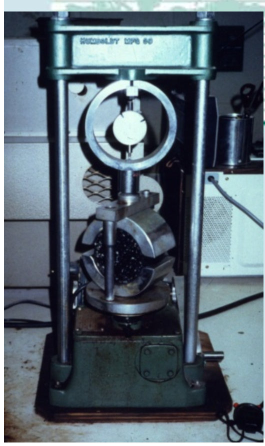
HOT-MIX ASPHALT

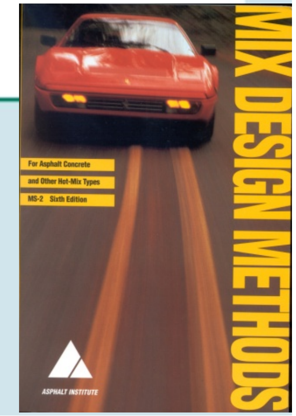
- Material properties

Prpoerties/Construction Requirements	Specification Limits	Specifications Compared			Remarks
		Item included		Total	
		Yes	No		
Los Angeles degradation, max	25% - 35%	7	1	8	
Micro Deval, max	15% - 25%	1	7	8	DND
Absorption, coarse aggregate, max	1.75% - 2.2%	8	-	8	
Fractured paritcles, min	100%	1	7	8	GTAA
	60% - 90%	7	1	8	
Sand equivalent, min	40% - 50%	8	-	8	
Soundness loss, max	12% - 16%	8	-	8	
Loss by washing, max	1.0% - 2.0%	8	-	8	
Lighweight particles, max	1.5% - 3.0%	8	-	8	
Flat and elengated particles, ratio 5, max	8.0% - 15.0%	8	-	8	SIA - ratio 3
Liquid limit, max	25	2	6	8	
Plasticity Index, max	6	2	6	8	
Petrographic Number, max	135 - 160%	1	7	8	DND
Polished Stone Value, min	60	1	7	8	GTAA
Polishing characterisitcs		5	3	8	

HOT-MIX ASPHALT



- Mix design



Prpoerties/Construction Requirements	Layer	Specification Limits	Specifications Compared			Remarks
			Item included		Total	
			Yes	No		
Compactive effort, blows per face		75	4	4	8	
		50	4	4	8	
Marshall stability, kN, min						
75 blows	binder	10 - 14	4	4	8	
	surface	12 - 14	4	4	8	
50 blows	binder	9.0	4	4	8	
	surface	9.0 - 10.0	4	4	8	
Flow, mm	binder	2 - 4	8	-	8	
	surface	2 - 4	8	-	8	
Air voids, %	binder	3 - 5	8	-	8	
	surface	2.5 - 5	8	-	8	
VMA, %, min	binder	13 - 14.5	8	-	8	
	surface	13 - 15	8	-	8	
Marshall retained stability, %,min	binder	75	5	3	8	
	surface	75	5	3	8	
	surface	85	1	7	8	SIA
Minimum film thicnkness			2	6	8	
TSR, %, min	surface	75 - 80	2	6	8	YVR
RAP	binder	15%	1	7	8	YVR
	surface		-	8	8	

HOT-MIX ASPHALT

- Construction

Construction Requirements	Location	Specification Limits	Specifications Compared		
			Item included		Total
			Yes	No	
Echelon paving			7	1	8
MTV or Shuttle Buggy			3	5	8
Test strip			8	-	8
Compaction, Marhsall density	mat	100%	1	7	8
		98%	6	2	8
		96%	1	7	8
	joint	97%	1	7	8
Maximum lift thickness, mm	surface	50	2	6	8
	binder	65 - 100	2	6	8
Minimum air temperature		5ºC - 7ºc	8	-	8
Minimum compaction temerature		100º	7	1	8
Joint offset	transverse	600 mm	8	-	8
	longitudinal	150 mm	8	-	8

HOT-MIX ASPHALT

- Surface requirements

Construction Requirements	Location	Specification Limits	Specifications Compared		
			Item included		Total
			Yes	No	
Smoothness:					8
California Profilograph, mm/km, max	runway	80 mm/km	1	7	8
	taxiway, apron	110 - 120	2	6	8
Finish tolerances, mm	surface	3.0 - 5.0	8	-	8
	binder	6.0	1	7	8
Coefficient of friction, min		0.75	1	7	8
Segregation			1	7	8

HOT-MIX ASPHALT

- Acceptance

Construction Requirements	Specifications Compared			Remarks
	Item included		Total	
	Yes	No		
Acceptance:			8	
asphalt cement content	8	-	8	
gradation	8	-	8	
air voids	8	-	8	
stability	8	-	8	
field compaction	8	-	8	
joint compaction	1	7	8	
smoothness	8	-	8	
grade	1	7	8	
End product specification	1	7	8	CAA
Payment adjustment	1		8	DND

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ISSUES WITH AIRFIELD PAVING

- Inconsistent airfield paving specifications
- Large differences between road and airfield paving
- High costs of asphalt and Portland cement concrete paving

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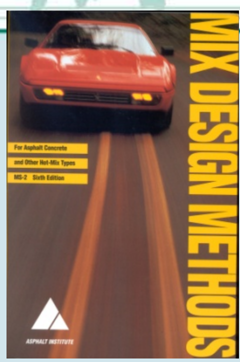
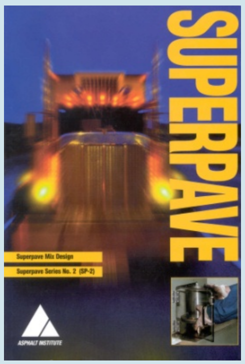
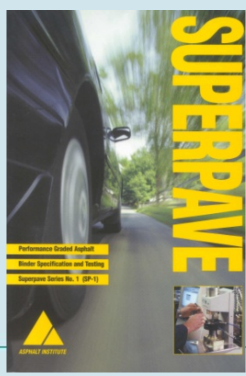
ISSUES WITH AIRFIELD PAVING







- Hot-mix asphalt paving technology
  - Significant improvement in the last 10 years
    - Materials
    - Procedures
    - Long lasting (perpetual) pavement
- Marshall vs. Superpave mixes
- Performance graded vs. penetration graded asphalt cements
- Mix materials and gradations
  - Pavement texture
  - Pavement frictional characteristics
- Asphalt paving specifications improvements
  - End product specification (EPS)
  - QC/QA procedures

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INITIAL SUGGESTIONS

- Discussion should involve
  - Agencies/owners
  - Consultants
  - Contractors
  - Materials suppliers
  - Universities
- Action plan required
- Positive examples
  - Canadian Airfield Pavement Engineering Reference
- CAPTG?

INITIAL SUGGESTIONS

- Work close with road agencies
- Define the properties that should be tested
- Address testing procedures
  - Sieve sizes
  - Other
- Address mix design procedures and requirements
- Address QC/QA procedures
- Address acceptance procedures
- **Consider sustainability!!!**

AMENDED FAA P-401 SPECIFICATION

- Flexible Surface Courses P-401

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Standards for Specifying Construction of Airports

Date: 9/30/2009
Initiated by: AAS-100

AC No.: 150/5370-10E
Change:

AMENDED FAA P-401 SPECIFICATION

- RAP
  - Up to 30% allowed
  - If more than 15% of RAP PG grade softening should be considered

AMENDED FAA P-401 SPECIFICATION

TABLE 5. MARSHALL ACCEPTANCE LIMITS FOR STABILITY, FLOW, AIR VOIDS, DENSITY

TEST PROPERTY	Pavements Designed for Aircraft Gross Weights of 60,000 Lbs. or More or Tire Pressures of 100 Psi or More		Pavements Designed for Aircraft Gross Weights Less Than 60,000 Lbs. or Tire Pressures Less Than 100 Psi	
Number of Blows	75		50	
	Specification Tolerance Limits		Specification Tolerance Limits	
	L	U	L	U
Stability, minimum, pounds	1800	--	1000	--
Flow, 0.01-inch	8	16	8	20
Air Voids Total Mix, percent	2	5	2	5
Surface Course Mat Density, percent	96.3	[101.3]	96.3	[101.3]
Base Course Mat Density, percent	95.5	101.3]--	95.5	[101.3]
Joint density, percent	93.3	--	93.3	--

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AMENDED FAA P-401 SPECIFICATION

Table A. Binder Grade Selection and Grade Bumping Based on Gross Aircraft Weight.

Aircraft Gross Weight (pounds)	High Temperature Adjustment to Base Binder Grade	
	Pavement Type	
	Runway	Taxiway/Apron
Less than 12,500	--	--
Less than 60,000	--	1
Less than 100,000	--	1
Greater than 100,000	1	2

NOTES:

1. PG grades above a –22 on the low end (e.g. 64–16) are not recommended. Limited experience has shown this to be a poor performer.
2. PG grades below a 64 on the high end (e.g. 58-22) are not recommended. These binders often provide tender tendencies.
3. PG grades above a 76 on the high end (e.g. 82-22) are very stiff and may be difficult to work and compact.

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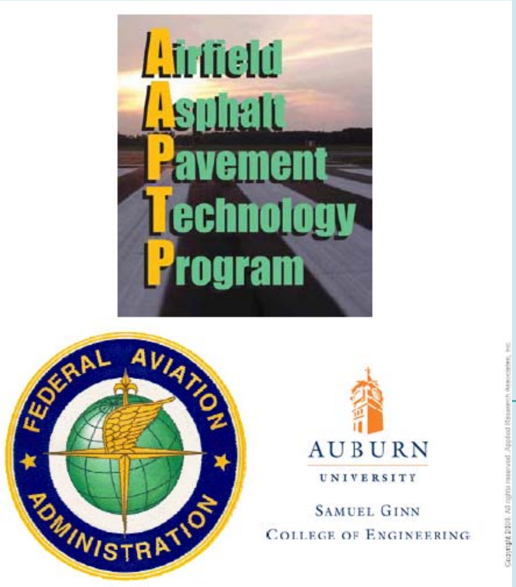
AMENDED FAA P-401 SPECIFICATION

(1) Stability
(2) Flow
(3) Air voids
(4) Mat density
(5) Joint density
(6) Thickness
(7) Smoothness
(8) Grade

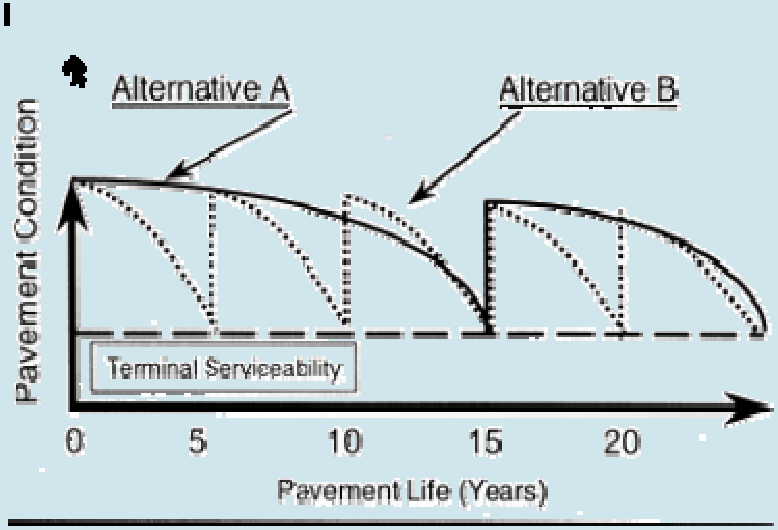
AAPTP Projects

- “Use of RAP in Airfield HMA Pavements”, AAPTP No 05-06
- “Life Cycle Cost Analysis for Airport Pavements”, AAPTP No 06-06
- “Techniques for Prevention and Remediation of Non-Load Related Distresses on HMA Airport Pavements”, AAPTP No 05-07



LIFE CYCLE COST ANALYSIS

- Economic analysis tool
- Enables comparison of different alternatives with different maintenance requirements during life cycle
- Alternatives with higher capital costs may have lower
  - Maintenance costs
  - Longer design life
  - Greater salvage value
- LCCA identifies alternative that provides best economic value for investment



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AAPTP REPORT 06-06

- Describes life cycle cost analysis for airfield pavement
- Spreadsheet Implementation
- Flexible and rigid pavements
- Describes and provides guidance on all aspects of LCCA
- Report includes
  - Pavement construction, maintenance and rehabilitation activities for airfield pavements
  - Typical costs and sources of data for costs
  - Use of airport PMS for LCCA
  - Review of other LCCA methods
  - Guidelines for conducting LCCA

LCCA Framework

- Analysis Period
  - Include at least 1 rehabilitation for all alternatives
  - Should not extend beyond period of reliable forecast
- Analysis technique
  - Net Present Value or Equivalent Uniform Annual Cost
- Discount rate
  - Function of interest rate and inflation rate
- Cost factors
  - Direct/owner costs and indirect/user costs
- Statistical Computation Approach
  - Deterministic or Probabilistic

PAVEMENT PERFORMANCE AND M&R

- Service life
  - Initial design life
  - Life after rehabilitation treatments
  - Estimated in various ways
- M&R Treatments
  - PMS and historical records
  - Timing of extents of treatment
  - Includes routine activities, preventive activities and major repairs

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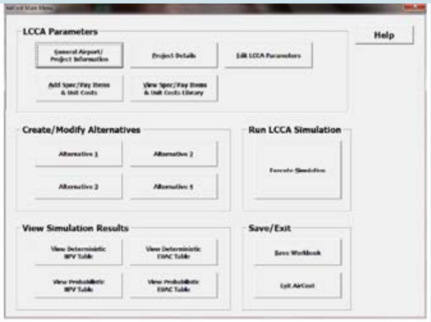
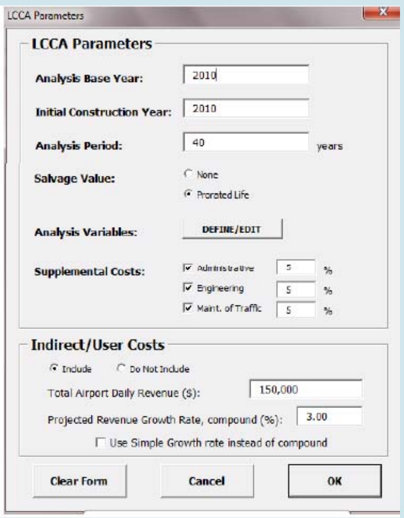
OWNER COSTS AND USER COSTS





- Owner costs
  - Cost of building, maintaining and rehabilitating pavements
  - Quantify salvage value at the end of service life
- User costs
  - Costs incurred by airport users - includes passengers and airlines
  - Type and duration of pavement facility restriction – unique to each airport
  - Reduction in airport operations, passengers and cargo
  - Loss of daily operating revenue

NON-LOAD RELATED DISTRESS

- Distresses caused by changes in HMA temperature, moisture, and climatic exposure
- 20% of HMA-surfaced airfield pavement exhibit some form of non-load related distress
- Type of distresses
  - Block cracking
  - Longitudinal and transverse cracking
  - Ravelling and weathering

CONTRIBUTING FACTORS

- Climate conditions
  - Thermal shrinkage stresses
  - Warping stresses
  - Age hardening of binder
  - Moisture
  - Solar radiation

- Crude sources and binder properties
- HMA mix design
  - Aggregate absorptivity
  - Binder PG Grade
  - Binder Additives

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REMEDIES FOR NON-LOAD RELATED DISTRESSES

- Pavement preservation program is critical
- Preventive Maintenance
  - Crack sealing
  - Surface treatments – fog seals and slurry seals
  - Thin overlays
  - Microsurfacing
  - Ultrathin bonded wearing course
- Apply treatments before damage becomes visible
  - Take advantage of PMS data
- Hot in-place recycling (HIR) or cold in-place recycling
  - Extensive surface cracking
  - Pavement is structurally sound

GEOTHERMAL SYSTEMS AT AIRPORTS

- Using geothermal systems for runways
  - Heating in winter
    - Removal of ice and snow build up
    - Sensors
  - Cooling is summer
    - Heat recharge
- Europe
  - UK
    - Heathrow
    - Gatwick
  - Sweden
  - Norway

CONCLUSIONS

- The days of focusing on meeting minimum technical requirements and basic LCCA analysis is coming to an end
- Consider four aspects of pavement sustainability
- Take advantage of existing advanced paving technology
- Take advantage of PMS
- Implement pavement preservation program
- Consider longer pavement life
- Highway pavements are much more advanced in sustainability than airport pavements
- Use available sustainability evaluation systems

THANK YOU!

QUESTIONS?

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