CAPTG WORKSHOP PM

UTILIZATION OF RECYCLED MATERIALS IN AIRPORT PAVEMENTS

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SUMMARY

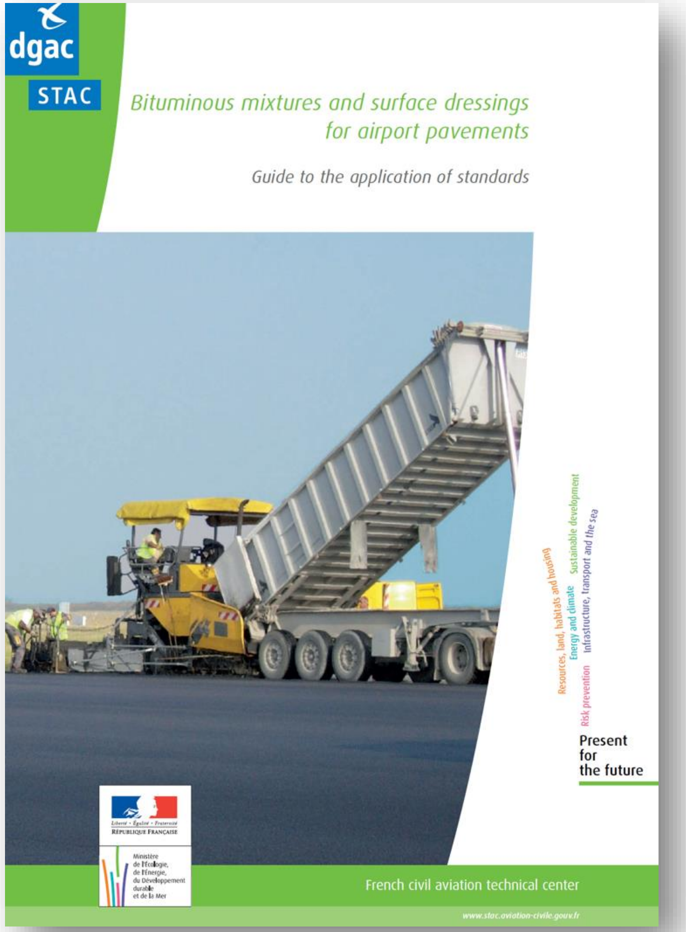
1

Airport vs. road pavements

AIRPORT VS. ROAD PAVEMENT
DIFFERENCES

Table 2 – Characteristics and particular features of airport pavements

Road pavements	Airport pavements
Loads applied	
● loads are applied in a way that presents very low lateral dispersal (which could cause rutting)	● on runways, traffic is dispersed (only the central third of the surface is occupied) and landing gear configurations vary from one aircraft to another. On taxiways, this dispersal is less marked
● a large number of movements (up to 50,000 per day) of relatively light loads (42 t total weight, 4.2 t maximum wheel load), engendering fatigue mainly due to the high frequency of movements each causing small stresses	● a very small number of movements (from very few to more than 100 per day) of differing loads (up to 550 t or more total weight, 45 t for a twin-wheel undercarriage and 115 t for a bogy), causing fatigue mainly due to infrequent movements each causing large stresses
● tyre pressures must not exceed 0.8 MPa (8 bars)	● tyre pressures may attain 1.7 MPa (17 bars) for certain aircraft
● the most aggressive loads are applied at low speeds (less than 90 km/h)	● speeds are highly variable : - very low speeds, which can cause runtting phenomena - very high speeds during takeoff and landing (over 300 km/h)
Particular features	
● particular stresses which require good tyre contact to the pavement in order to provide the best possible roadholding and satisfactory braking performance for vehicles using it	● geometrical and environmental conditions which expose pavement mixtures over long periods to the action of rain, sun etc.
● surface evenness (with no surface defects) is largely related to passenger comfort	● surface evenness is largely related to aircraft safety when taxiing at high speeds
● roughness develops essentially as a result of a polishing phenomenon affecting aggregates over time	● roughness develops progressively as a result of rubber deposits from tyres
● traffic has sometimes to be diverted or stopped in the event of road works	● the operating and safety constraints on traffic make it very difficult for traffic to be stopped or reduced when maintenance or renovation work has to be carried out



2

Airport pavement types

AIRPORT PAVEMENT TYPES
RELATED TO SPEED

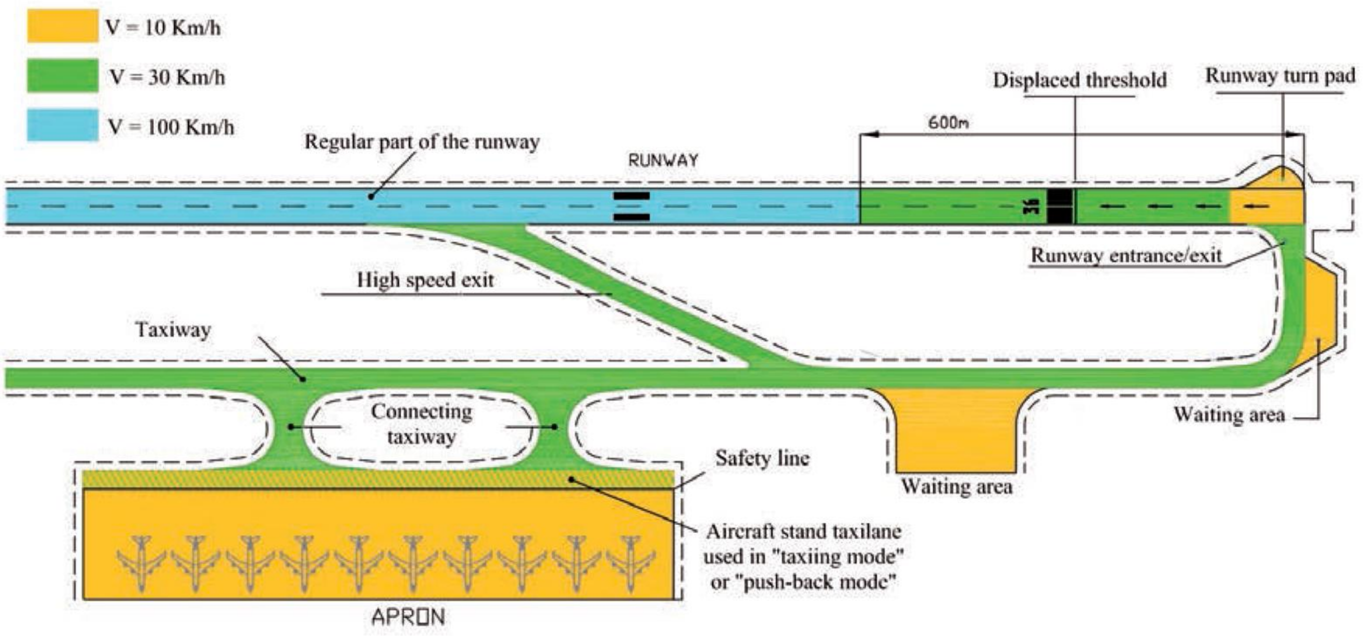
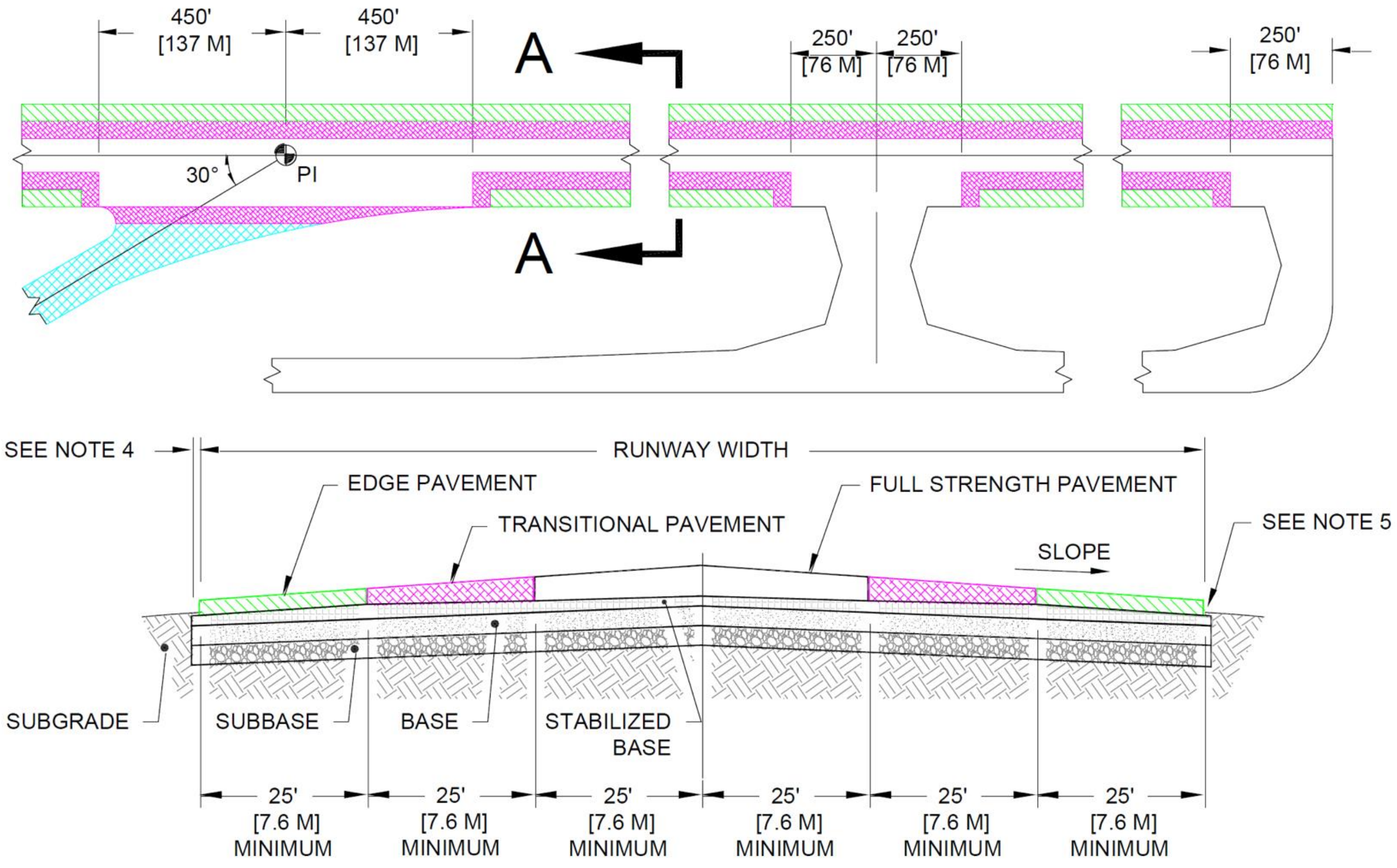
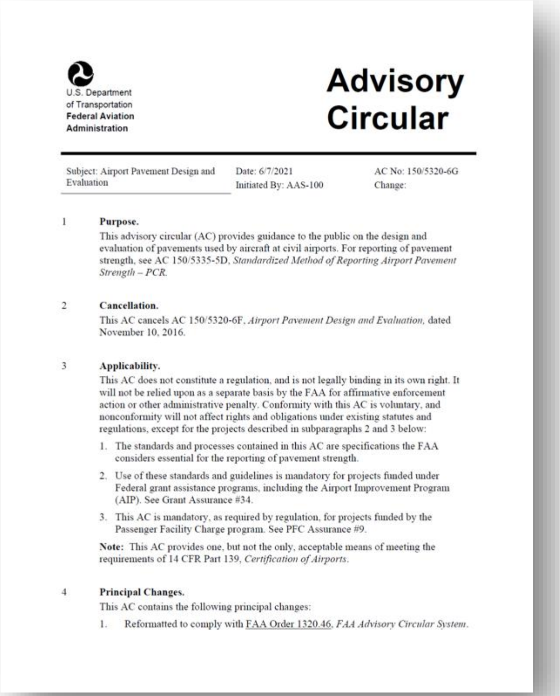


Figure 5 : map between the three families of sections taken into consideration for design purposes and the various usual airfield infrastructures

AIRPORT PAVEMENT TYPES
RELATED TO OCCUPANCY



SECTION A-A (FOR HMA)
NOT TO SCALE



U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Airport Pavement Design and Evaluation
Date: 6/7/2021
Initiated By: AAS-100
AC No: 150/5320-6G
Change:

1 **Purpose.**
This advisory circular (AC) provides guidance to the public on the design and evaluation of pavements used by aircraft at civil airports. For reporting of pavement strength, see AC 150/5335-5D, *Standardized Method of Reporting Airport Pavement Strength – PCR.*

2 **Cancellation.**
This AC cancels AC 150/5320-6F, *Airport Pavement Design and Evaluation,* dated November 10, 2016.

3 **Applicability.**
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Note: This AC provides one, but not the only, acceptable means of meeting the requirements of 14 CFR Part 139, *Certification of Airports*.

4 **Principal Changes.**
This AC contains the following principal changes:

1. Reformatted to comply with FAA Order 1320.46, *FAA Advisory Circular System*.

NOTES

- *The full-strength keel section is the centre 15 m of a 60 m runway.*
- *Outer edge design using departure weights and 1% estimated frequency.*

3

Functional requirements

PAVEMENT FUNCTIONALITIES
FAILURE MODES

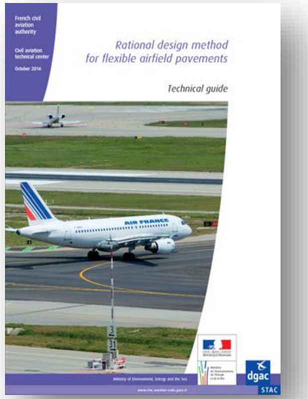


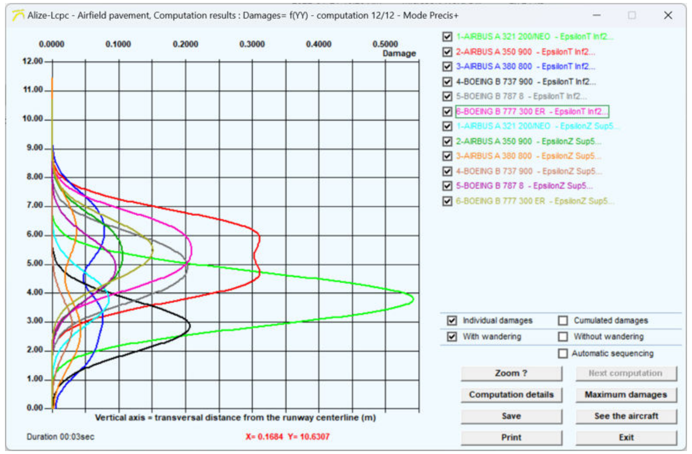
Table 3 –Assessment of aggression levels and surface quality characteristics of a pavement

		Shearing	Rutting	Punching	Durability	Friction
Parking area		++	+++	+++	++	++
Runways	Main part	+	+	+	++	+++
	Turning area	+++	++	+	+++	++
	Exit	+++	+	+	++	+++
	Threshold (*)	+++	+	++	+++	+++
Taxiways	Main part	+	++	+	++	++
	Intersections	++	++	++	+++	++
Apron or holding area		+	+++	+++	++	++

(*) including touch-down area

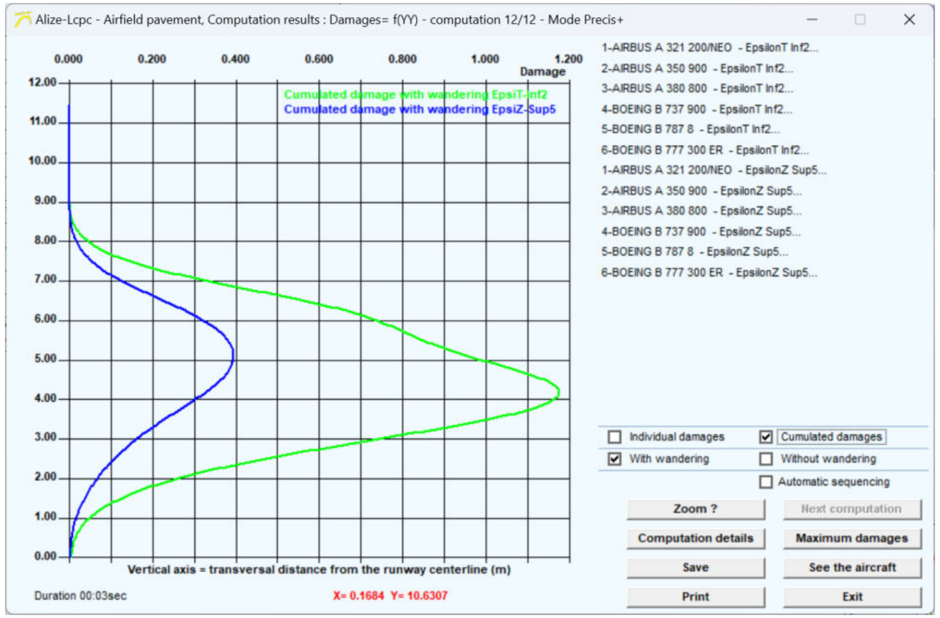
+: *Low level*
++: *Medium level*
+++: *High level*

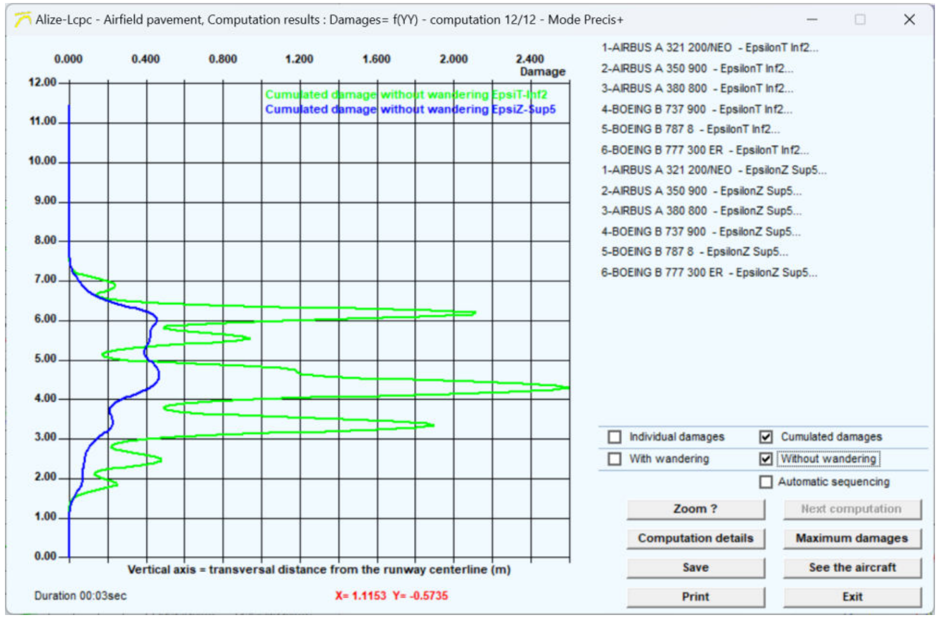
PAVEMENT FUNCTIONALITIES
WANDERING



Pavement section	*Standard deviation S_{bal} (in m)*
High-speed sections	*0.75*
Moderate-speed sections	*0.5*
Aprons and low-speed sections	*0*

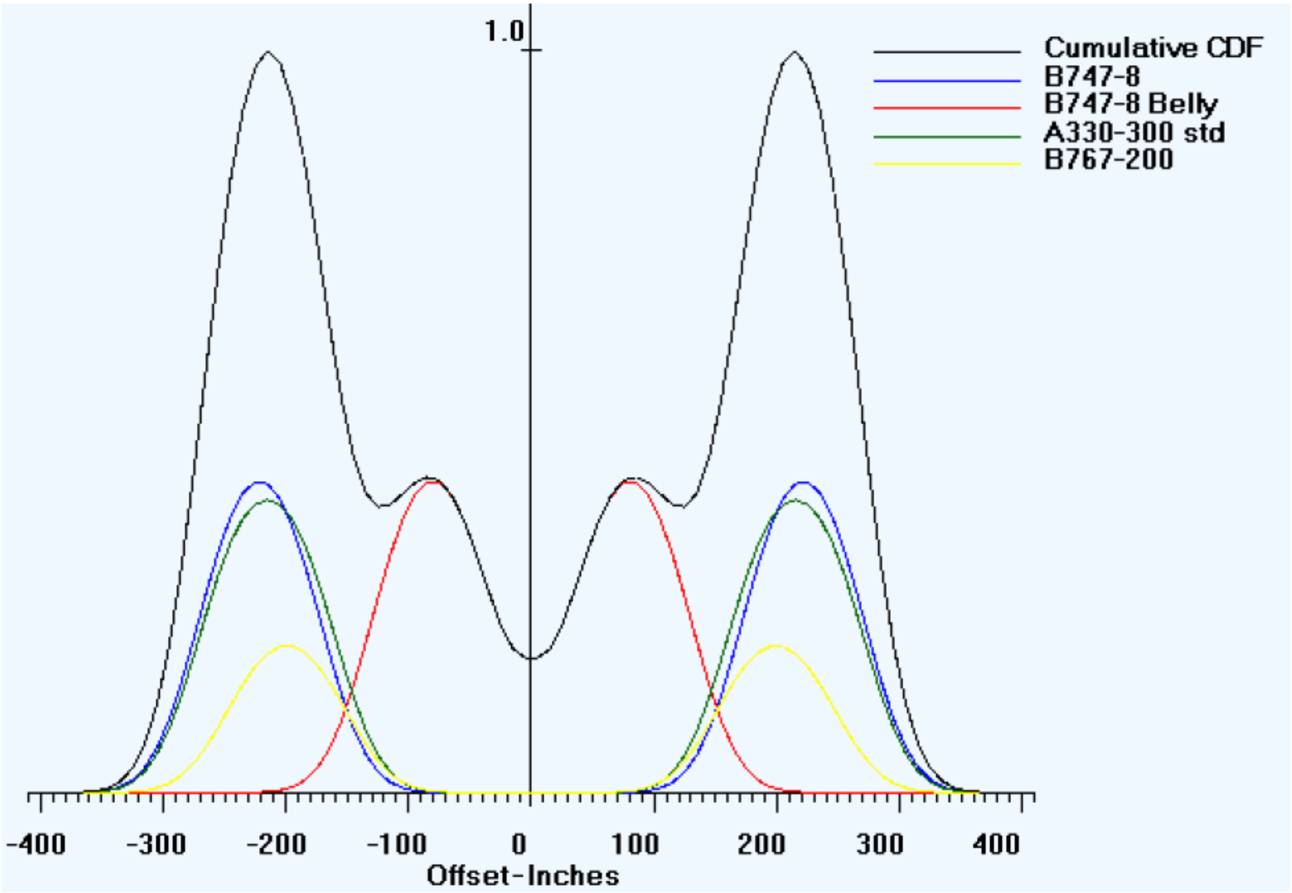
Table 5 : standard deviations according to the type of section

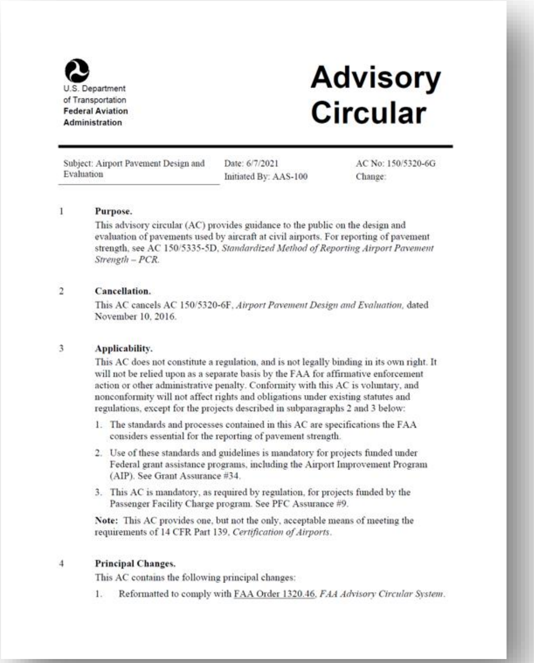




PAVEMENT FUNCTIONALITIES
WANDERING

Figure H-1. CDF Contribution for Aircraft Mix





U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Airport Pavement Design and Evaluation	Date: 6/7/2021 Initiated By: AAS-100	AC No: 150/5320-6G Change:

1 **Purpose.**
This advisory circular (AC) provides guidance to the public on the design and evaluation of pavements used by aircraft at civil airports. For reporting of pavement strength, see AC 150/5335-5D, *Standardized Method of Reporting Airport Pavement Strength – PCR.*

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This AC cancels AC 150/5320-6F, *Airport Pavement Design and Evaluation,* dated November 10, 2016.

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Note: This AC provides one, but not the only, acceptable means of meeting the requirements of 14 CFR Part 139, *Certification of Airports*.

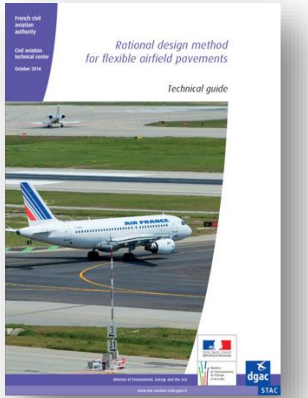
4 **Principal Changes.**
This AC contains the following principal changes:

1. Reformatted to comply with FAA Order 1320.46, *FAA Advisory Circular System*.

NOTE:

» *FAA AC 150/5320-6G specify wander pattern standard deviation of 30.5 inches, (0.775 m).*

PAVEMENT FUNCTIONALITIES
STIFFNESS MODULUS



Pavement section	*Speed of movement in kph to be taken into consideration in the design calculations*
High-speed sections	*100*
Moderate-speed sections	*30*
Aprons and low-speed sections	*10**

** a fictive values used in the calculation. See below « Special case of low-speed sections and aprons »*

Table 4: speed of movement of aircraft according to the type of section

$$f(Hz) = \frac{V(kph)}{10}$$

Alize-Lcpc - Mechanical computation, material library

File Material type Add-Remove

Standard material library : according to NF P98-086 (normative annex F)

Personal library : c:\users\CROTEAJ ...\...\... ents\Alize-Lcpc my files\Libraries\matuser.lib

Bituminous materials

status	name	E (MPA)	Nu	Epsi6 (10°C)	-1/b	SN	Sh (m)	Kc	Variations E(10Hz) = f(temperature) T -10	T 0 °C	T 10 °C	T 20 °C	T 30 °C	T 40 °C
system	eb-bbsg3	9310	0.35	100	5	0.25	stdard	1.1	16000	13500	9310	4690	1800	1000
system	eb-bbme1	11970	0.35	100	5	0.25	stdard	1.1	17300	15400	11970	6030	3000	1900
system	eb-bbme2	14630	0.35	100	5	0.25	stdard	1.1	19500	18200	14630	7370	3800	2300
system	eb-bbme3	14630	0.35	100	5	0.25	stdard	1.1	19500	18200	14630	7370	3800	2300
system	bbm	7315	0.35	/	/	/	stdard	1.1	14800	12000	7315	3685	1300	1000
system	bbtm	4200	0.35	/	/	/	stdard	1.1	8500	7000	4200	1800	1000	800
system	bbdr	4200	0.35	/	/	/	stdard	1.1	8500	7000	4200	1800	1000	800
system	acr	7315	0.35	/	/	/	stdard	1.1	14800	12000	7315	3685	1300	1000
system	eb-gb2	11880	0.35	80	5	0.3	stdard	1.3	22800	18300	11880	6120	2700	1000
system	eb-gb3	11880	0.35	90	5	0.3	stdard	1.3	22800	18300	11880	6120	2700	1000
system	eb-gb4	14300	0.35	100	5	0.3	stdard	1.3	25000	20000	14300	7700	3500	1200
system	eb-eme1	16940	0.35	100	5	0.3	stdard	1	30000	24000	16940	11060	6000	3000
system	eb-eme2	16940	0.35	130	5	0.25	stdard	1	30000	24000	16940	11060	6000	3000
user	SP12.5	5107	0.350	141.0	5.77	0.28	stdard	1.000	16514	10570	5107	1581		
user	SP20	3201	0.350	206.0	6.48	0.23	stdard	1.000	12803	7806	3201	1005		
user	Betoflex0/14E	7256	0.350	204.0	6.23	0.19	stdard	1.000	15396	12158	7256	3283	1111	
user	Betoflex0/14V	7578	0.350	165.0	5.16	0.23	stdard	1.000	18111	12988	7578	3458	1174	
user	Betoflex0/14H	5507	0.350	230.0	6.55	0.20	stdard	1.000	16914	10970	5507	1981	591	
user	Betoflex0/10V	7872	0.350	168.0	4.636	0.34	stdard	1.000		13000	7872	3500		

Teq= 10 °C Fr= 10 Hz Exit

Alize-Lcpc - Mechanical computation, material library

File Material type Add-Remove

Standard material library : according to NF P98-086 (normative annex F)

Personal library : c:\users\CROTEAJ ...\...\... ents\Alize-Lcpc my files\Libraries\matuser.lib

Bituminous materials

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system	eb-bbsg3	7976	0.35	100	5	0.25	stdard	1.1	16000	13500	9310	4690	1800	1000
system	eb-bbme1	10254	0.35	100	5	0.25	stdard	1.1	17300	15400	11970	6030	3000	1900
system	eb-bbme2	12533	0.35	100	5	0.25	stdard	1.1	19500	18200	14630	7370	3800	2300
system	eb-bbme3	12533	0.35	100	5	0.25	stdard	1.1	19500	18200	14630	7370	3800	2300
system	bbm	6266	0.35	/	/	/	stdard	1.1	14800	12000	7315	3685	1300	1000
system	bbtm	3598	0.35	/	/	/	stdard	1.1	8500	7000	4200	1800	1000	800
system	bbdr	3598	0.35	/	/	/	stdard	1.1	8500	7000	4200	1800	1000	800
system	acr	6266	0.35	/	/	/	stdard	1.1	14800	12000	7315	3685	1300	1000
system	eb-gb2	10177	0.35	80	5	0.3	stdard	1.3	22800	18300	11880	6120	2700	1000
system	eb-gb3	10177	0.35	90	5	0.3	stdard	1.3	22800	18300	11880	6120	2700	1000
system	eb-gb4	12250	0.35	100	5	0.3	stdard	1.3	25000	20000	14300	7700	3500	1200
system	eb-eme1	14512	0.35	100	5	0.3	stdard	1	30000	24000	16940	11060	6000	3000
system	eb-eme2	14512	0.35	130	5	0.25	stdard	1	30000	24000	16940	11060	6000	3000
user	SP12.5	4375	0.350	141.0	5.77	0.28	stdard	1.000	16514	10570	5107	1581		
user	SP20	2742	0.350	206.0	6.48	0.23	stdard	1.000	12803	7806	3201	1005		
user	Betoflex0/14E	[illegible]	0.350	204.0	6.23	0.19	stdard	1.000	15396	12158	7256	3283	1111	
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Teq= 10 °C Fr= 3 Hz Exit

PAVEMENT FUNCTIONALITIES

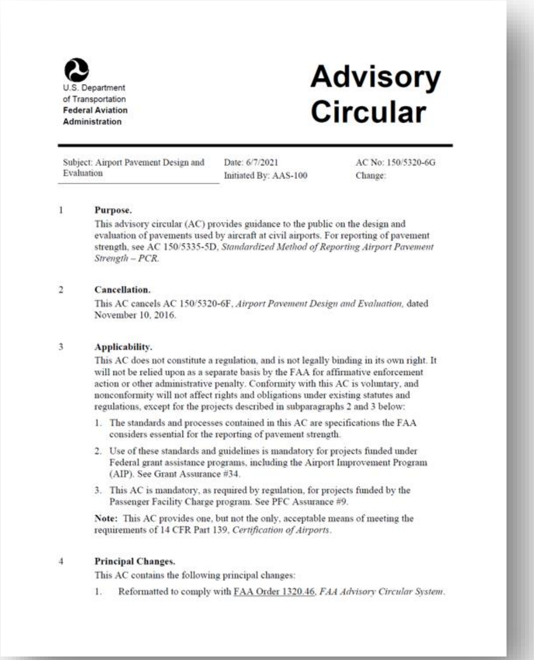
STIFFNESS MODULUS

Table 3-2. Allowable Modulus Values and Poisson's Ratios Used in FAARFIELD

Layer Type	FAA Specified Layer	Rigid Pavement psi (MPa)	Flexible Pavement psi (MPa)	Poisson's Ratio
Surface	P-501 Cement Concrete	4,000,000 (30,000)	NA	0.15
	P-401/P-403[1]/P-404 Asphalt Mixture	NA	200,000 (1,380)[2]	0.35
Stabilized Base and Subbase	P-401/P-403Asphalt Mixture	400,000 (3,000)		0.35
	P-306 Lean Concrete	700,000 (5,000)		0.20
	P-304 cement treated aggregate base	500,000 (3,500)		0.20
	P-220 Cement treated soil base	250,000 (1,700)		0.20
	Variable stabilized rigid	250,000 to 700,000 (1,700 to 5,000)	NA	0.20
	Variable stabilized flexible	NA	150,000 to 400,000 (1,000 to 3,000)	0.35
Granular Base and Subbase	P-209 crushed aggregate	Internal calculation by FAARFIELD[4]		0.35
	P-208, aggregate	Internal calculation by FAARFIELD[4]		0.35
	P-219, Recycled concrete aggregate	Internal calculation by FAARFIELD[4]		0.35
	P-211, Lime rock	Internal calculation by FAARFIELD[4]		0.35
	P-207 Recycled Asphalt aggregate base[3]	25,000-500,000		0.35
	P-154 uncrushed aggregate	Internal calculation by FAARFIELD[4]		0.35
Subgrade[5]	Subgrade	1,000 to 50,000 (7 to 350)		0.35
User-defined	User-defined layer	1,000 to 4,000,000 (7 to 30,000)		0.35

Notes:

1. P-403 as surface when all aircraft less than 60,000 lbs (27,216 kg).
2. A fixed modulus value for hot mix surfacing is set in the program at 200,000 psi (1380 MPa). This modulus value corresponds to a pavement temperature of approximately 90°F (32°C).
3. The modulus of P-207 is dependent upon the quality and if any additional stabilizing material incorporated, e.g. asphalt, cement, fly ash. Perform geotechnical laboratory testing with field materials to determine appropriate value.
4. See FAARFIELD help file for discussion of calculations.
5. CBR values for chemically modified subgrades lessor of 50% of laboratory strength or CBR 20.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Advisory Circular

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4

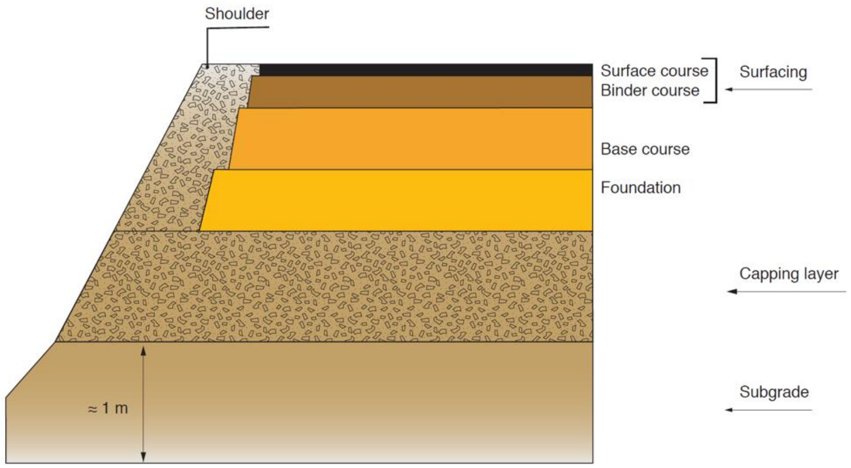
Paving materials for airports

PAVING MATERIALS FOR AIRPORTS
CHALLENGES

SPECIFICITIES
Heavy loads
High pressure tyres
Reduced movements
Very high speed
Work constraints

TYPES
Speed
Occupancy

FUNCTIONALITIES
Failure modes
Stiffness modulus
Wandering
Friction
Smoothness



PAVING MATERIALS FOR AIRPORTS
NATIONAL MASTER SPECIFICATION (NMS), SECTION 32 12 16 ASPHALT PAVING

- » **Template "MASTER" type document**
- » **Material selection left to the consultant**
  - *Design approach highly variable from one airport to another*
- » **Type of mixes,**
  - *Base,*
  - *Surface,*
  - *Sheet asphalt rarely specified*
- » **PG Binder**
  - *Local practice*
- » **Sustainability LEED**
  - *RAP allowed but rarely specified*
- » **Marshall type mixes**
  - *75 blows mainly*

Sieve Designation	% Passing		
	Lower Course	Surface Course	Sheet Asphalt
200 mm	-	-	-
75 mm	-	-	-
50 mm	-	-	-
38.1 mm	-	-	-
25 mm	[100]	-	-
19 mm	-	-	-
12.5 mm	[70-85]	[100]	-
9.5 mm	-	-	[100]
4.75 mm	[40-65]	[55-75]	[85-100]
2.00 mm	[30-50]	[35-55]	[80-95]
0.425 mm	[15-30]	[15-30]	[40-70]
0.180 mm	[5-20]	[5-20]	[10-35]
0.075 mm	[3-8]	[3-8]	[4-14]

Property	Airfield Pavements	Roads	Sheet Asphalt
Marshall Stability at 60 degrees C kN min	[7.0]	[5.5] surface course/[4.5] lower course	[3.0]
Flow Value mm	[2-4]	[2-4]	[2-5]
Air Voids in Mixture, %	[3-5]	[3-5] surface course/[2-6] lower course	[3-5]
Voids in Mineral Aggregate, % min	[15] surface course/[13] lower course	[15] surface course/[13] lower course	[16]
Index of Retained Stability % minimum	[75]	[75]	[75]

PAVING MATERIALS FOR AIRPORTS

FAA AC NO.150/5370-10H

- **Template type document**
- **Type of mixes – dense graded**
  - *P-401 mainly surface course*
  - *P-403 mainly leveling and base course*
  - *P-404 fuel resistant asphalt mixes for surface*
- **PG Binder**
  - *Grade bump for different types of pavement*
- **Sustainability - RAP**
  - *Not allowed in the binder and surface courses*
  - *Up to 30% in the base layers*
- **Marshall and Gyratory type mixes**
  - *75 blows mainly*
  - *Rut test may also be specified*

Table 2. Aggregate - Asphalt Pavements

Sieve Size	Percentage by Weight Passing Sieves		
	Gradation 1	Gradation 2	Gradation 3[1]
1 inch (25.0 mm)	100	--	--
3/4 inch (19.0 mm)	90-100	100	--
1/2 inch (12.5 mm)	68-88	90-100	100
3/8 inch (9.5 mm)	60-82	72-88	90-100
No. 4 (4.75 mm)	45-67	53-73	58-78
No. 8 (2.36 mm)	32-54	38-60	40-60
No. 16 (1.18 mm)	22-44	26-48	28-48
No. 30 (600 µm)	15-35	18-38	18-38
No. 50 (300 µm)	9-25	11-27	11-27
No. 100 (150 µm)	6-18	6-18	6-18
No. 200 (75 µm)	3-6	3-6	3-6
Voids in Mineral Aggregate (VMA)	14	15	16
Asphalt percent by total weight of mixture:			
Stone or gravel	4.5-7.0	5.0-7.5	5.5-8.0
Slag	5.0-7.5	6.5-9.5	7.0-10.5
Recommended Minimum Construction Lift Thickness	3 inch	2 inch	1 1/2 inch

[1]Gradation 3 is intended for leveling courses. FAA approval is required for use in other locations.

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Standard Specifications for Construction of Airports
Date: 12/21/2018
Initiated By: AAS-100
AC No: 150/5370-10H
Change:

1 **Purpose.**
The standard specifications contained in this advisory circular (AC) relate to materials and methods used for construction on airports. Items covered in this AC include general provisions, earthwork, flexible base courses, rigid base courses, flexible surface courses, rigid pavement, fencing, drainage, turf, and lighting installation.

2 **Cancellation.**
This AC cancels AC 150/5370-10G, *Standards for Specifying Construction of Airports*, dated July 21, 2014.

3 **Application.**
The Federal Aviation Administration (FAA) recommends the guidelines and specifications in this AC for materials and methods used in airfield development for construction and rehabilitation projects on airports.

This AC does not constitute a regulation and is not mandatory, however the following applies:

a. The standard specifications contained in this AC are practices that the FAA recommends for the construction of pavements and airport development serving aircraft greater than 30,000 pounds (13,600 kg).

b. This AC contains methods and procedures for compliance with 14 CFR part 139 that are acceptable to the Administrator.

c. The use of this AC is mandatory for all projects funded under Federal grant assistance programs, including the Airport Improvement Program (AIP). See Grant Assurance No. 34., *Policies, Standards, and Specifications*.

d. This AC is mandatory, as required by regulation, for projects funded with the Passenger Facility Charge program. See PFC Assurance #9, *Standards and Specifications*.

e. For building construction, the General Contract Provisions are applicable, in addition applicable laws and local building codes shall serve as construction standards acceptable to the FAA.

Required Grade Bump

Aircraft Gross Weight	High Temperature Adjustment to Asphalt Binder Grade	
	All Pavement Types	Pavement area with slow or stationary aircraft
≤ 12,500 lbs (5670 kg)	--	1 Grade
< 100,000 lbs (45360 kg)	1 Grade	2 Grade
≥ 100,000 lbs (45360 kg)	2 Grade	3 Grade

PAVING MATERIALS FOR AIRPORTS

STAC – GUIDE TO THE APPLICATION OF STANDARDS

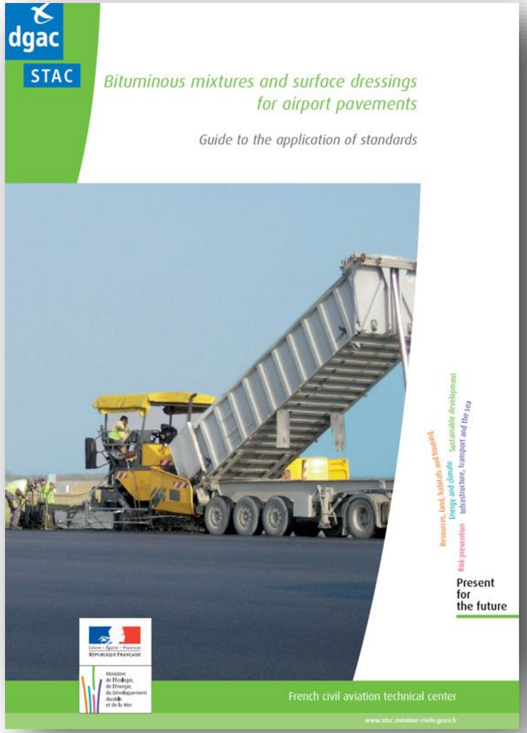
Table 4 – Products which may be used for airport pavements

Name		Classification Class or type	NF EN reference	Grading (1)	Average thickness in use and minimum thickness at any point	Maximum acceptable lack of flatness of existing substrate
EB10-BBA C	surface course and binder course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	6 to 7 cm 4 cm	≤ 2 cm
EB10-BBA D	surface course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	4 to 5 cm 3 cm	≤ 2 cm
EB14-BBA C	surface course and binder course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	7 to 9 cm 5 cm	≤ 2 cm
EB14-BBA D	surface course	Class 0,1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	5 to 7 cm 4 cm	≤ 2 cm
EB10-BBME	surface course and binder course	Class 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	5 to 7 cm 4 cm	≤ 2 cm
EB14-BBME	surface course and binder course	Class 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	6 to 9 cm 5 cm	≤ 2 cm
EB10-BBM	surface course and binder course	Type A, B or C according to grading curve Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	3 to 4 cm 2,5 cm	≤ 1,5 cm
EB14-BBM	surface course and binder course	Type A, B or C according to grading curve Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	3,5 to 5 cm 3 cm	≤ 1,5 cm
BBTM 6	surface course	Class 1 or 2	NF EN 13 108-2	0/6,3	2 to 3 cm 1,5 cm	≤ 1 cm
BBTM 10	surface course	Class 1 or 2	NF EN 13 108-2	0/10	2 to 3 cm 1,5 cm	≤ 1 cm

Table 4 – Products which may be used for airport pavements (continued)

Name		Classification Class or type	NF EN reference	Grading (1)	Average thickness in use and minimum thickness at any point	Maximum acceptable lack of flatness of existing substrate
EB10-BBSG	surface course and binder course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	5 to 7 cm 4 cm	≤ 2 cm
EB14-BBSG	surface course and binder course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	6 to 9 cm 5 cm	≤ 2 cm
ECF	-	-	In progress	0/6 to 0/10	Dosage to 10 or 15 kg/m²	≤ 1 cm
EB14-GB	Base	Class 2, 3 or 4 according to mechanical performance	NF EN 13 108-1	0/14	8 to 14 cm 6 cm	≤ 2 cm
EB20-GB	Base	Class 2, 3 or 4 according to mechanical performance	NF EN 13 108-1	0/20	10 to 16 cm 8 cm	≤ 3 cm
EB10-EME	Base	Class 1 or 2 according to mechanical performance	NF EN 13 108-1	0/10	6 to 8 cm 5 cm	≤ 2 cm
EB14-EME	Base	Class 1 or 2 according to mechanical performance	NF EN 13 108-1	0/14	7 to 13 cm 6 cm	≤ 2 cm
EB20-EME	Base	Class 1 or 2 according to mechanical performance	NF EN 13 108-1	0/20	9 to 15 cm 8 cm	≤ 2 cm
ESU	-	Class A, B or C	NF EN 12 271	2/4	-	≤ 2 cm
EB4 or EB6 sand-mix (2)	-	-	NF EN 13 108-1	0/4 or 0/6	2 cm	≤ 1 cm
Grouted previous bituminous mixtures (EP)	-	-	None	-	4 to 5 cm	≤ 2 cm

(1) A grading corresponding to sieve D of series 1 is admissible.
(2) This is generally prescribed to limit or retard the occurrence of cracks, particularly in the case of foundations treated with cementitious binders (see « Techniques anti-remontée de fissures », a paper on techniques for avoiding cracks, published by STAC in 1999).

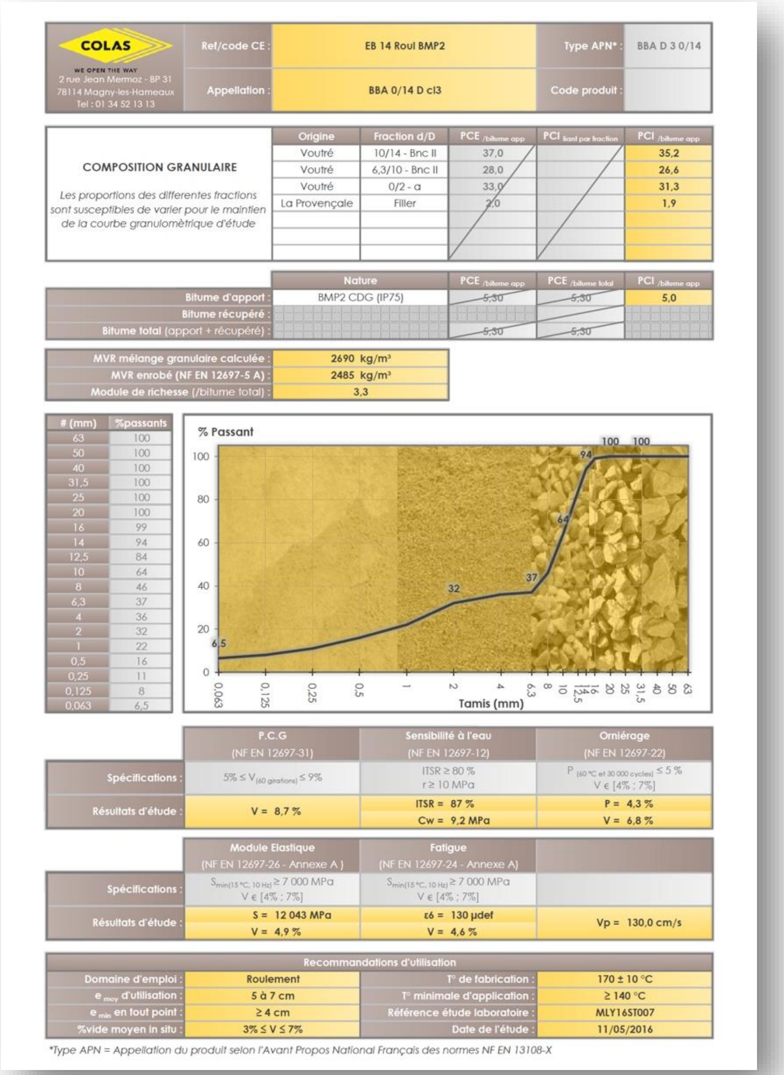


PAVING MATERIALS FOR AIRPORTS

STAC – GUIDE TO THE APPLICATION OF STANDARDS

Table 4 – Products which may be used for airport pavements

Products					Average thickness in use and minimum thickness at any point	Maximum acceptable lack of flatness of existing substrate
Name		Classification Class or type	NF EN reference	Grading (1)		
EB10-BBA C	surface course and binder course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	6 to 7 cm 4 cm	≤ 2 cm
EB10-BBA D	surface course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	4 to 5 cm 3 cm	≤ 2 cm
EB14-BBA C	surface course and binder course	Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	7 to 9 cm 5 cm	≤ 2 cm
EB14-BBA D	surface course	Class 0,1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	5 to 7 cm 4 cm	≤ 2 cm
EB10-BBME	surface course and binder course	Class 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	5 to 7 cm 4 cm	≤ 2 cm
EB14-BBME	surface course and binder course	Class 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	6 to 9 cm 5 cm	≤ 2 cm
EB10-BBM	surface course and binder course	Type A, B or C according to grading curve Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/10	3 to 4 cm 2,5 cm	≤ 1,5 cm
EB14-BBM	surface course and binder course	Type A, B or C according to grading curve Class 0, 1, 2 or 3 according to mechanical performance	NF EN 13 108-1	0/14	3,5 to 5 cm 3 cm	≤ 1,5 cm
BBTM 6	surface course	Class 1 or 2	NF EN 13 108-2	0/6,3	2 to 3 cm 1,5 cm	≤ 1 cm
BBTM 10	surface course	Class 1 or 2	NF EN 13 108-2	0/10	2 to 3 cm 1,5 cm	≤ 1 cm



COLAS WE OPEN THE WAY 2 rue Jean Mermoz - BP 31 78114 Magny-les-Hameaux Tel : 01 34 52 13 13			
Ref/code CE :	EB 14 Roul BMP2	Type APN* :	BBA D 3 0/14
Appellation :	BBA 0/14 D cl3	Code produit :	

COMPOSITION GRANULAIRE	Origine	Fraction d/D	PCE /bitume app	PCI liant par fraction	PCI /bitume app
Les proportions des differentes fractions sont susceptibles de varier pour le maintien de la courbe granulomètrique d'étude	Voutré	10/14 - Bnc II	37,0		35,2
	Voutré	6,3/10 - Bnc II	28,0		26,6
	Voutré	0/2 - a	33,0		31,3
	La Provençale	Filler	2,0		1,9

	Nature	PCE /bitume app	PCE /bitume total	PCI /bitume app
Bitume d'apport :	BMP2 CDG (IP75)	5,30	5,30	5,0
Bitume récupéré :				
Bitume total (apport + récupéré) :		5,30	5,30	

MVR mélange granulaire calculée :	2690 kg/m³
MVR enrobé (NF EN 12697-5 A) :	2485 kg/m³
Module de richesse (/bitume total) :	3,3

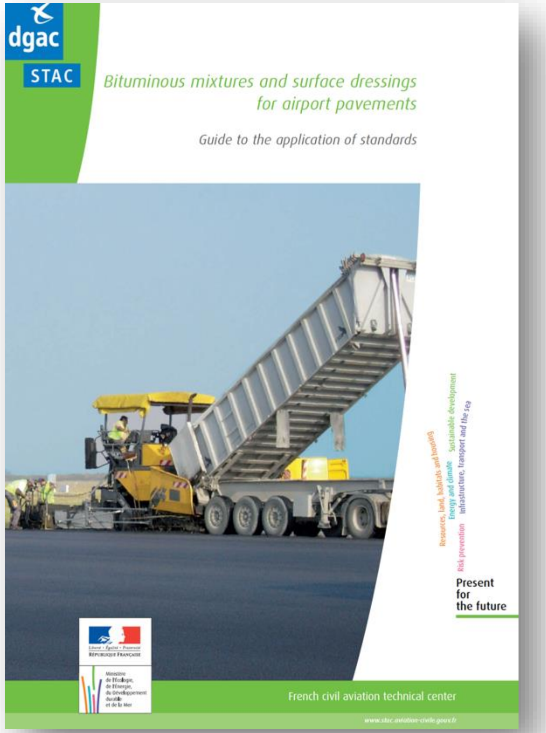
# (mm)	%passants
63	100
50	100
40	100
31,5	100
25	100
20	100
16	99
14	94
12,5	84
10	64
8	46
6,3	37
4	36
2	32
1	22
0,5	16
0,25	11
0,125	8
0,063	6,5

	P.C.G (NF EN 12697-31)	Sensibilité à l'eau (NF EN 12697-12)	Orniérage (NF EN 12697-22)
Spécifications :	5% ≤ $V_{(60\ girations)}$ ≤ 9%	ITSR ≥ 80 % r ≥ 10 MPa	$P_{(60\ °C\ et\ 30\ 000\ cycles)}$ ≤ 5 % V ∈ [4% ; 7%]
Résultats d'étude :	V = 8,7 %	ITSR = 87 % Cw = 9,2 MPa	P = 4,3 % V = 6,8 %

	Module Elastique (NF EN 12697-26 - Annexe A)	Fatigue (NF EN 12697-24 - Annexe A)	
Spécifications :	$S_{min(15\ °C,\ 10\ Hz)}$ ≥ 7 000 MPa V ∈ [4% ; 7%]	$S_{min(15\ °C,\ 10\ Hz)}$ ≥ 7 000 MPa V ∈ [4% ; 7%]	
Résultats d'étude :	S = 12 043 MPa V = 4,9 %	ε6 = 130 µdef V = 4,6 %	Vp = 130,0 cm/s

Recommandations d'utilisation			
Domaine d'emploi :	Roulement	T° de fabrication :	170 ± 10 °C
e_{moy} d'utilisation :	5 à 7 cm	T° minimale d'application :	≥ 140 °C
e_{min} en tout point :	≥ 4 cm	Référence étude laboratoire :	MLY16ST007
%vide moyen in situ :	3% ≤ V ≤ 7%	Date de l'étude :	11/05/2016

*Type APN = Appellation du produit selon l'Avant Propos National Français des normes NF EN 13108-X



PAVING MATERIALS FOR AIRPORTS
STAC – GUIDE TO THE APPLICATION OF STANDARDS

Table 9 – Products that can be used for surface courses

Area of airport		NS 1	NS 2	NS 3	NS 4
Parking areas		EB-BBA 2, ESU, ECF, EP, EB-BBM 1	EB-BBA 3, EB-BBM 2 EB-BBME 1, EP	(***) EP (1)	(***) EP (1)
Runways(*)	Main part	EB-BBA 1, EB-BBM A1, EB-BBM B1, BBTM	EB-BBA 1, EB-BBM A2, BBTM	EB-BBA 2	EB-BBA 2
	Turning area		EB-BBA 2, EB-BBME 1	EB-BBME 2 (2)	EB-BBME 3 (2)
	Exit		EB-BBA 2, EB-BBM A2	EB-BBA 3 EB-BBME 2	EB-BBA 3
	Threshold (**)		EB-BBA 2, EB-BBM A2	EB-BBA 3 (2)	EB-BBA 3 (2)
Taxiways	Main part	EB-BBA 1, ECF, EB-BBM B2, BBTM	EB-BBA 2, EB-BBM B3, BBTM	EB-BBA 2, EB-BBME 1	EB-BBA 3, EB-BBME 2
	Intersections		EB-BBA 2, EB-BBM B3	EB-BBA 3, EB-BBME 2	EB-BBA 3, EB-BBME 2
Apron or holding area		EB-BBA 1, ECF, EB-BBM B2, BBTM	EB-BBA 3, EB-BBM B3	EB-BBME 3	EB-BBME 3

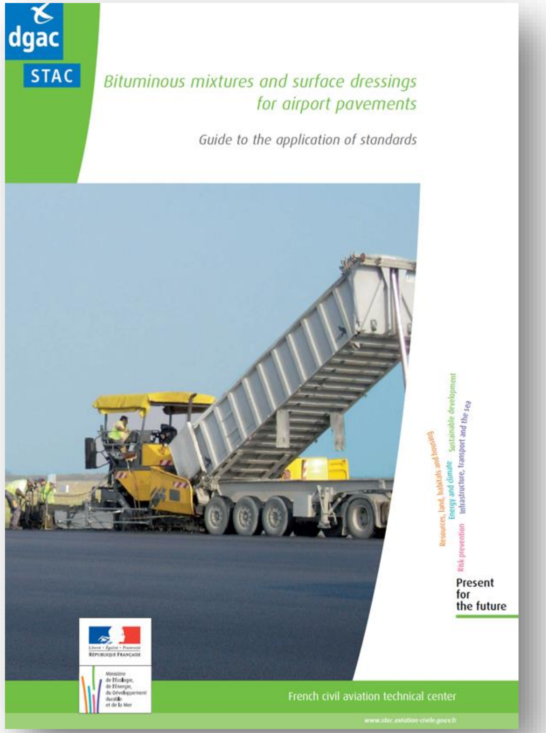


Table 11 – Products which can be used for pavement bases.

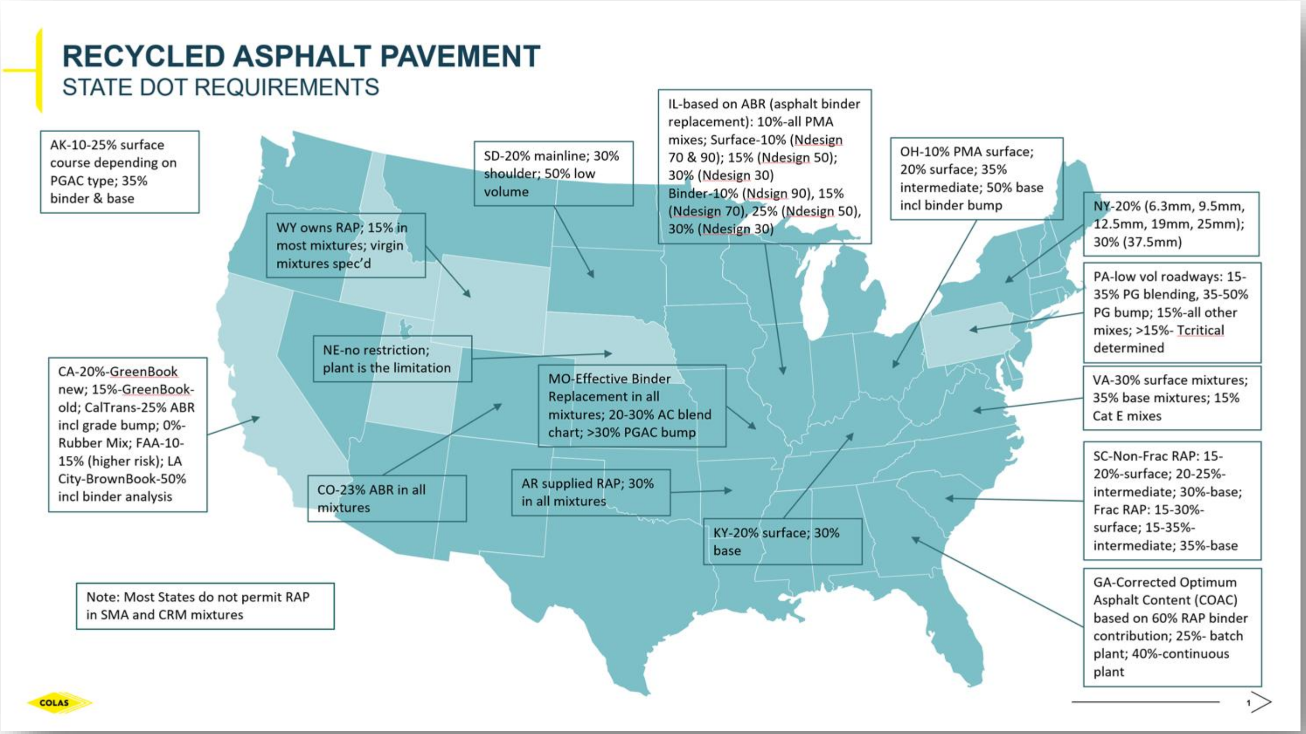
Airport area		NS 1	NS 2	NS 3	NS 4
Parking areas		EB-GB 2	EB-GB 2	(1)	(1)
Runways	Main part	EB-GB 2	EB-GB 2	EB-GB 2 EB-EME 1	EB-GB 3 EB-EME 2
	Turning area			EB-GB 3 EB-EME 1	
	Exit				
	Threshold (**)				
Taxiways	Main part Intersections	EB-GB 2	EB-GB 2	EB-GB 3 EB-EME 1	EB-GB 3 EB-EME 2
Apron or holding areas		EB-GB 2	EB-GB 2	EB-GB 3 EB-EME 1	EB-GB 3 EB-EME 2

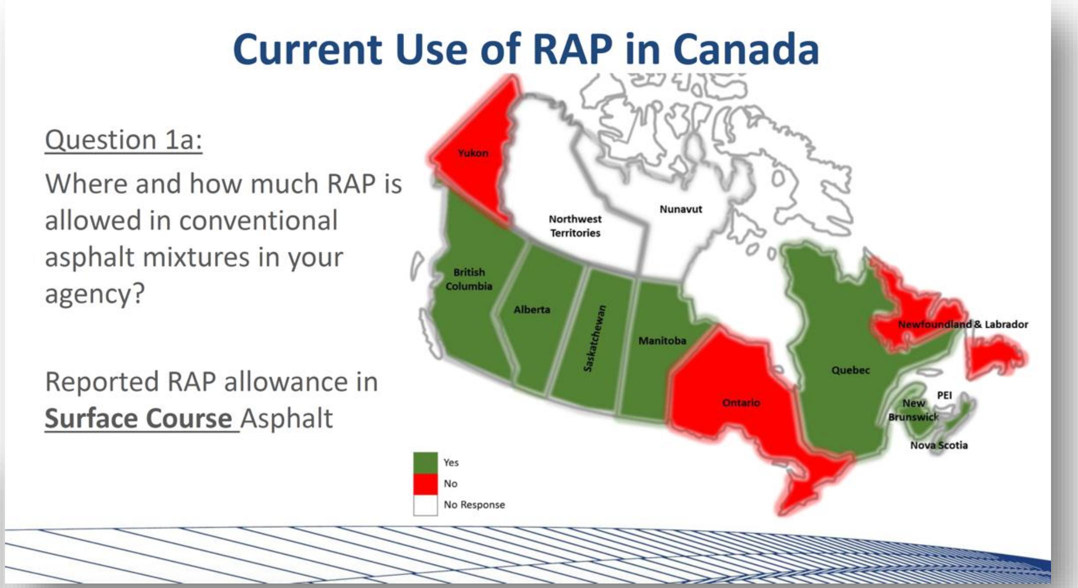
(1) Not relevant. For parking areas where there is a high risk of punching occurring, cement concrete pavements are strongly recommended

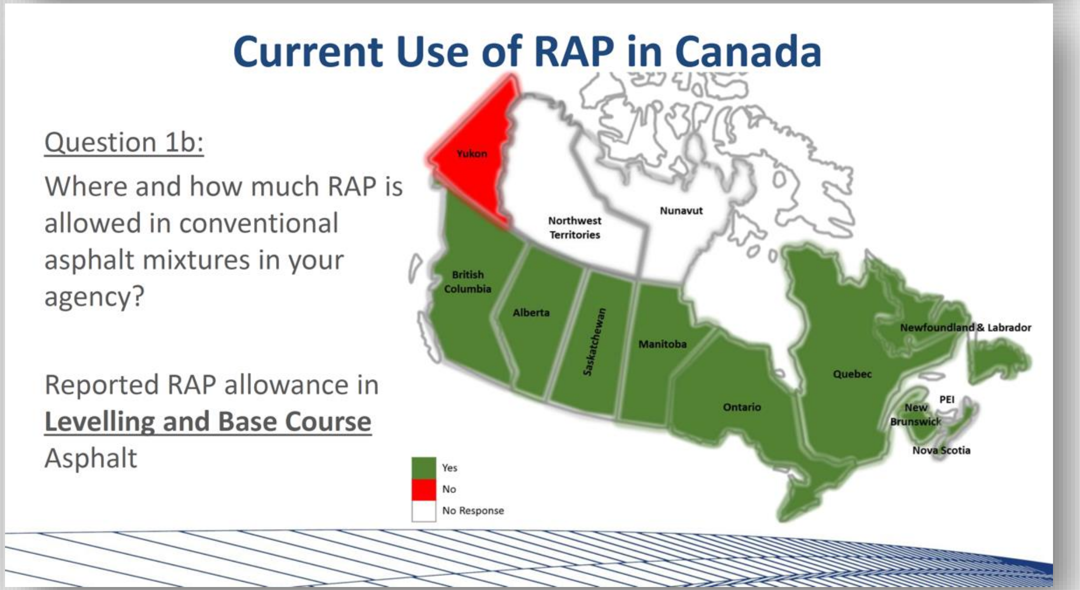
5

Traditional recycling

TRADITIONAL RECYCLING
APPROACHES TO RECYCLING IN NORTH AMERICA

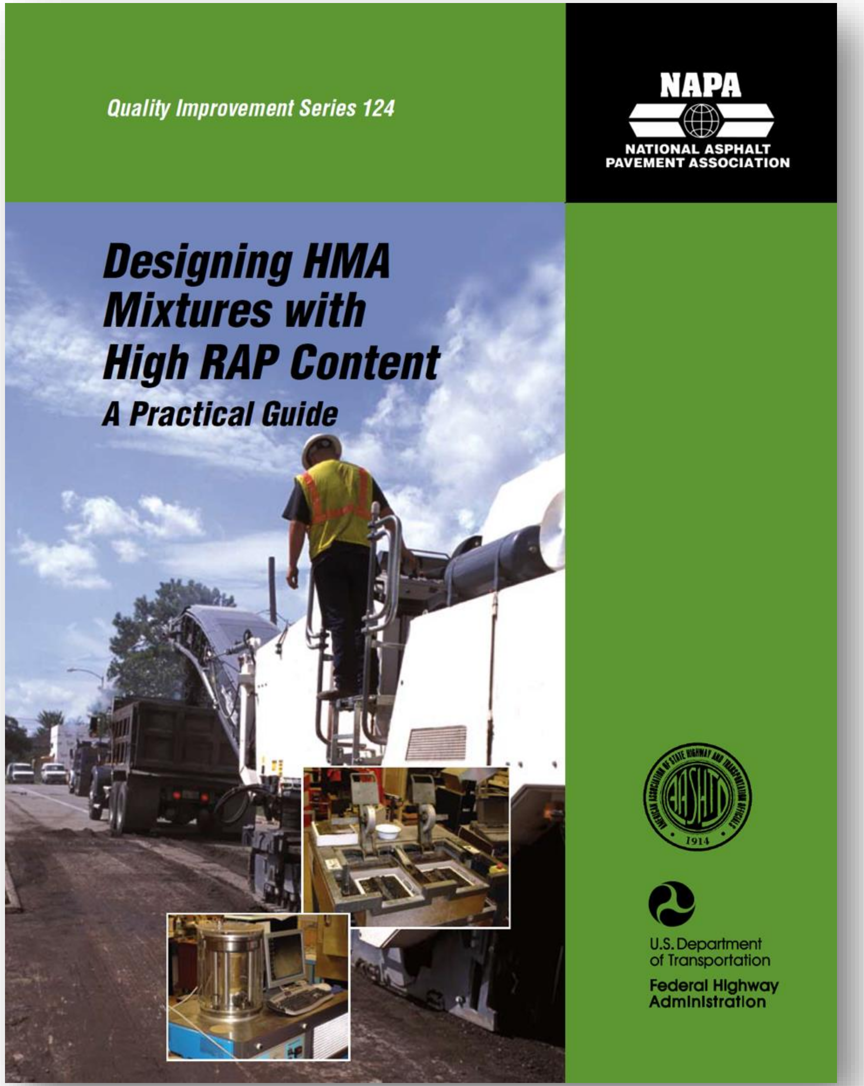




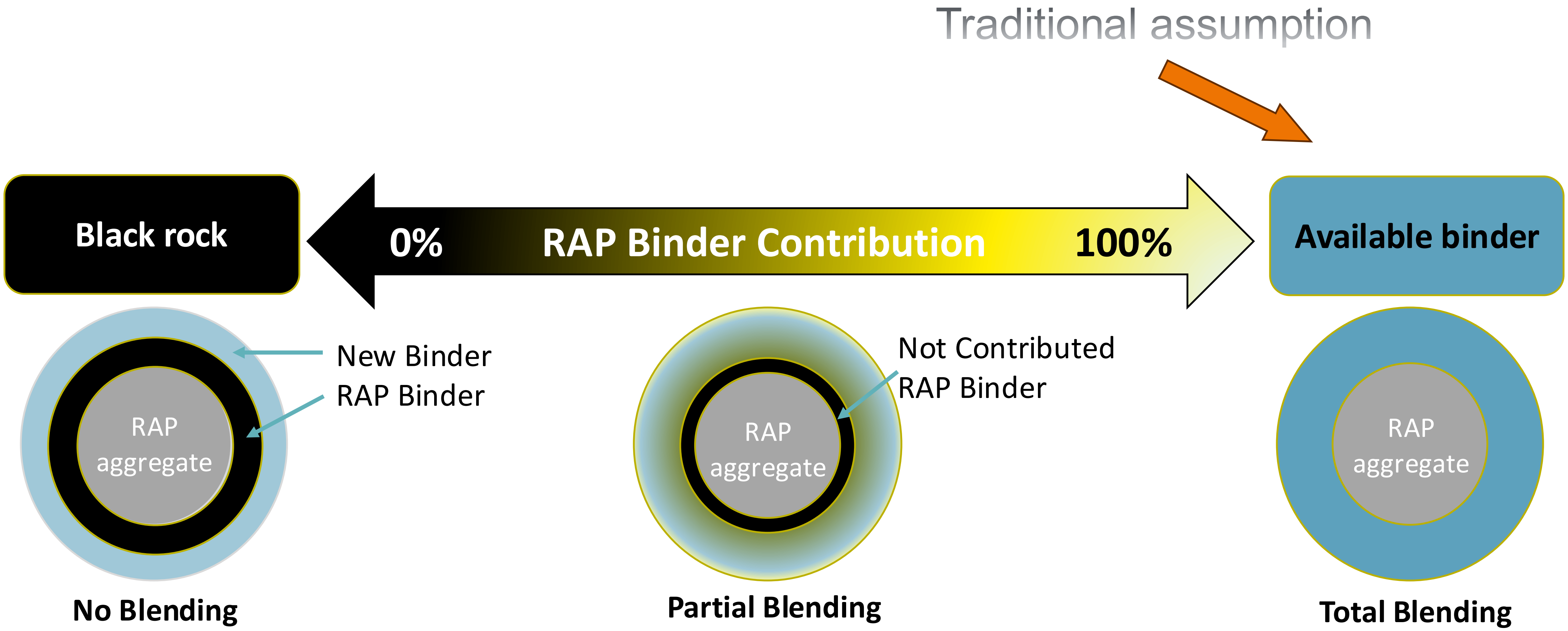


TRADITIONAL RECYCLING
NAPA PRACTICAL GUIDE

A study completed by Kandhal and Foo (1997) indicated that the evaluation of recycled mixture should be based on a three-tier process. Tier 1 included up to 15 percent RAP and would not require that anything be changed in the mix design process. Tier 2 included from 15 to 25 percent RAP and required that the new asphalt grade be dropped by one grade on the high and low ends of the PG grade. Tier 3 included more than 25 percent RAP and required that the asphalt be recovered from the RAP and blended with the virgin asphalt to produce a blended asphalt with the desired properties.



TRADITIONAL RECYCLING
RAP BINDER CONTRIBUTION



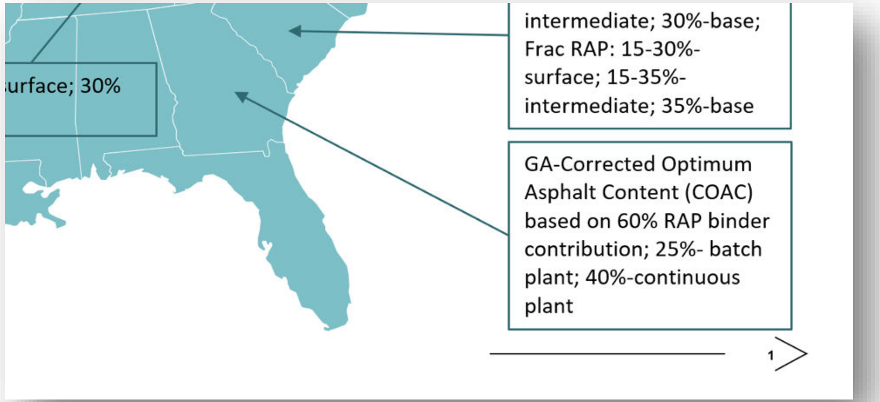
6

Performance-based recycling

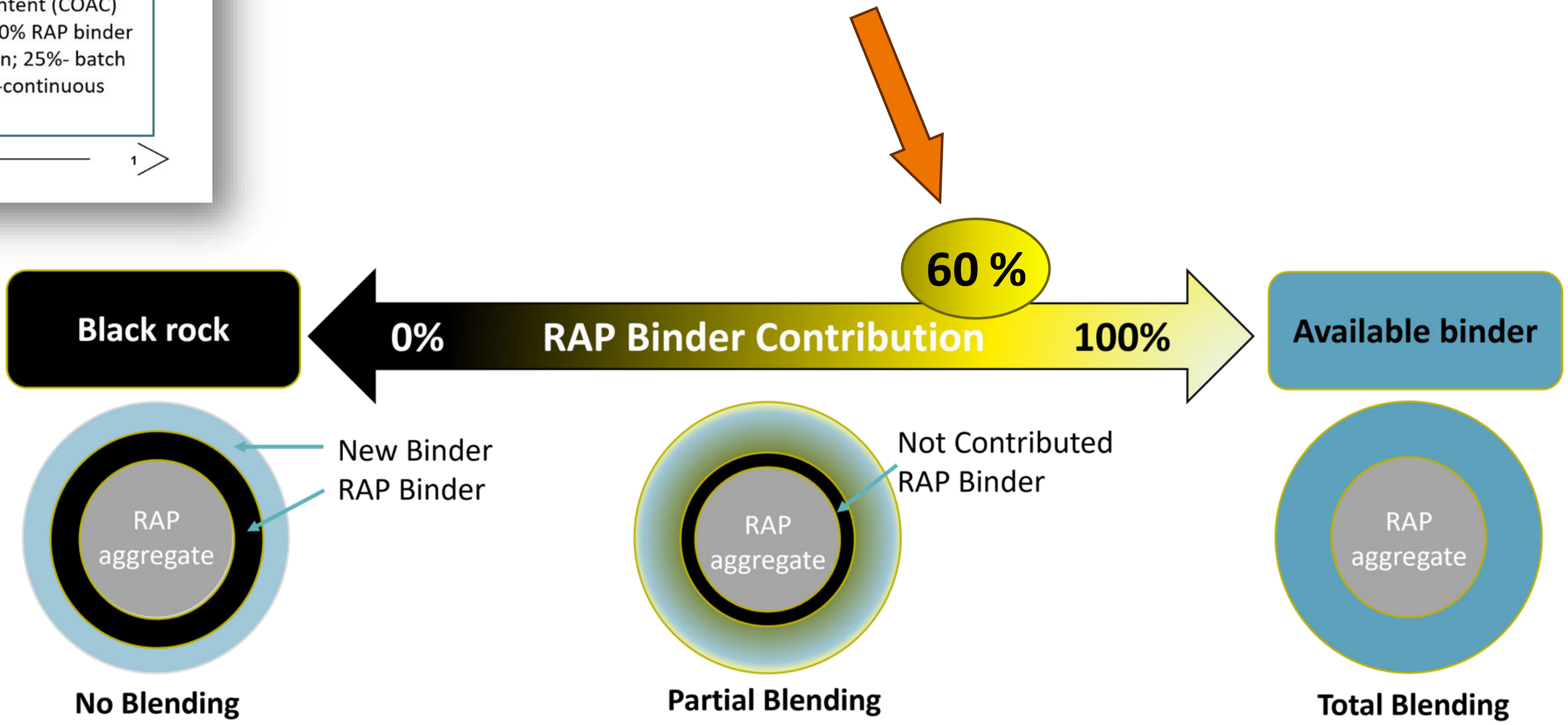
PERFORMANCE-BASED RECYCLING
CHALLENGES AND COMMON WORRIES

- Unsure about overall durability
- Negative effect of aged binder of RAP in new asphalt
- Increases mix stiffness of mix and loss of “ductility”
- Accelerated aging of new asphalt mixture
- Reduces cracking and fatigue resistance of new mixtures
- Blending/diffusion between RAP binder and new virgin binder incomplete
- Questionable permeability associated with lower workability
- Blending of RAP with virgin aggregate and binder
- Potential variability of RAP regarding aggregate and binder
- Asphalt plant capability
- Mixing temperature and heat transfer
- RAP management and control

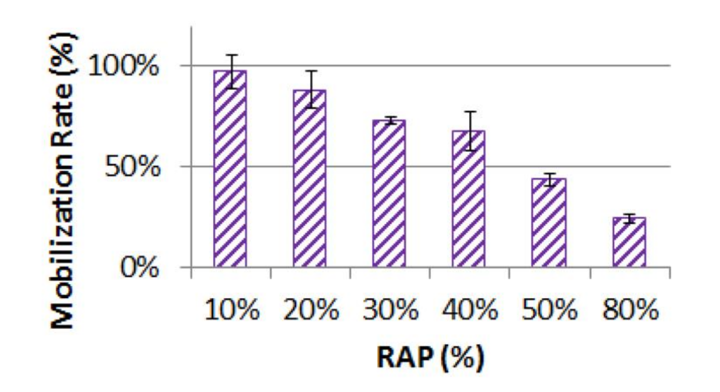
PERFORMANCE-BASED RECYCLING
ALTERNATIVE APPROACH - GEORGIA



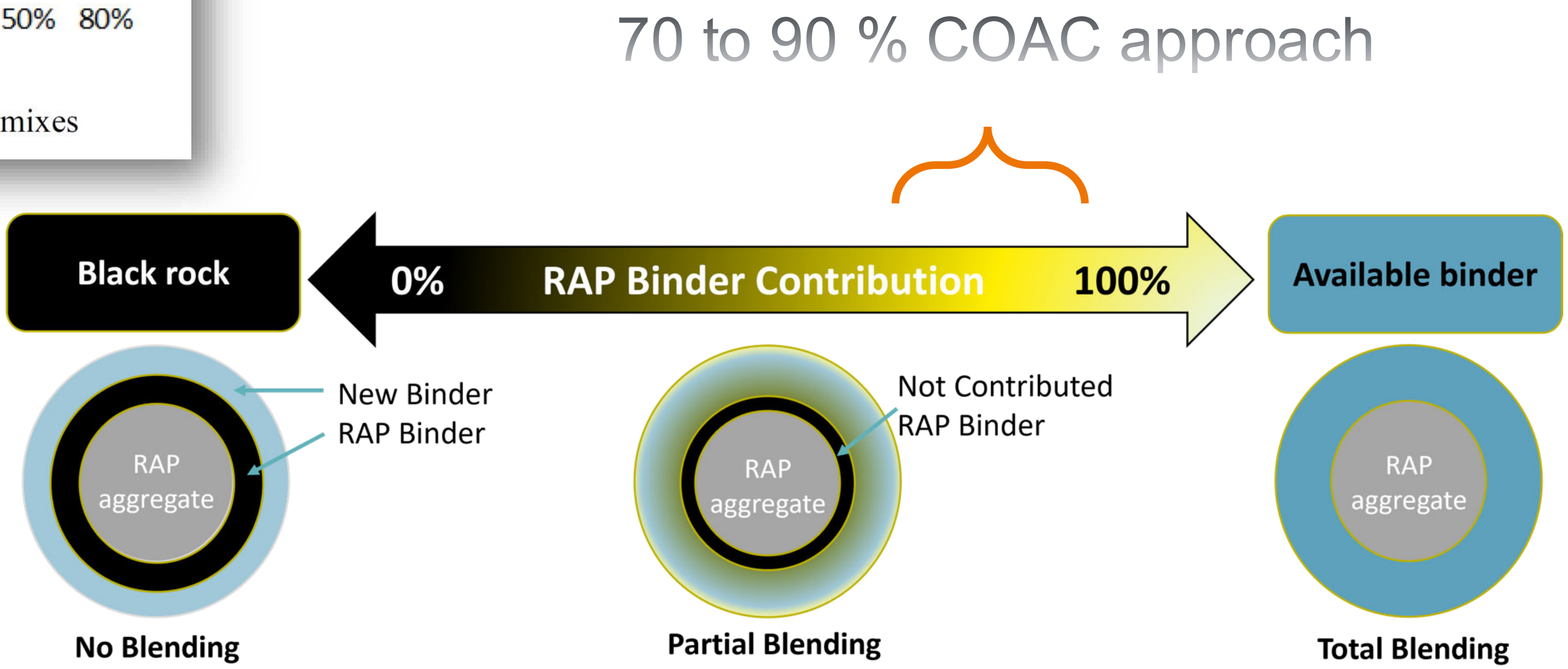
Georgia COAC approach



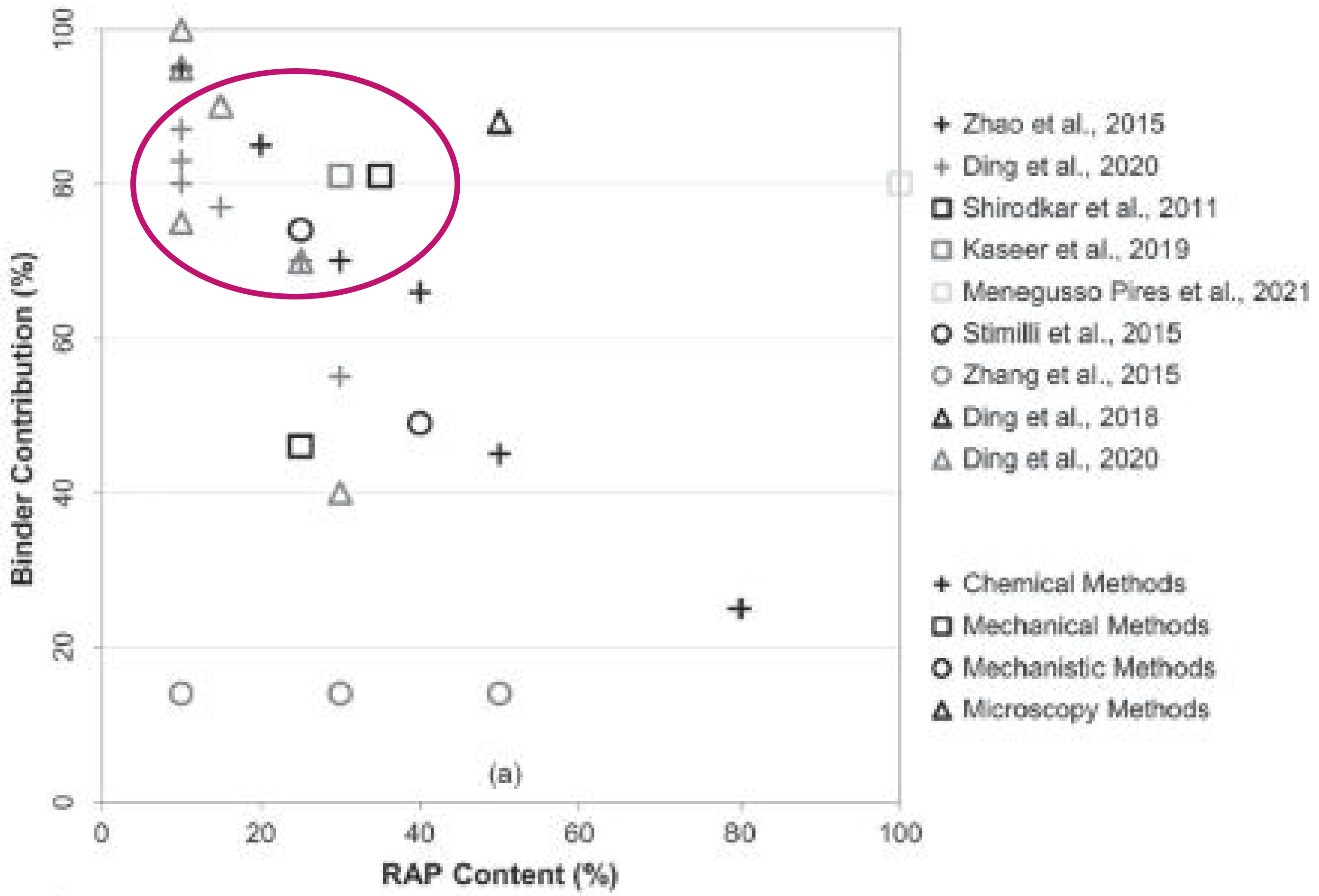
PERFORMANCE-BASED RECYCLING
ALTERNATIVE APPROACH – ZHAO ET AL.



(a) Mobilization rates for RAP mixes

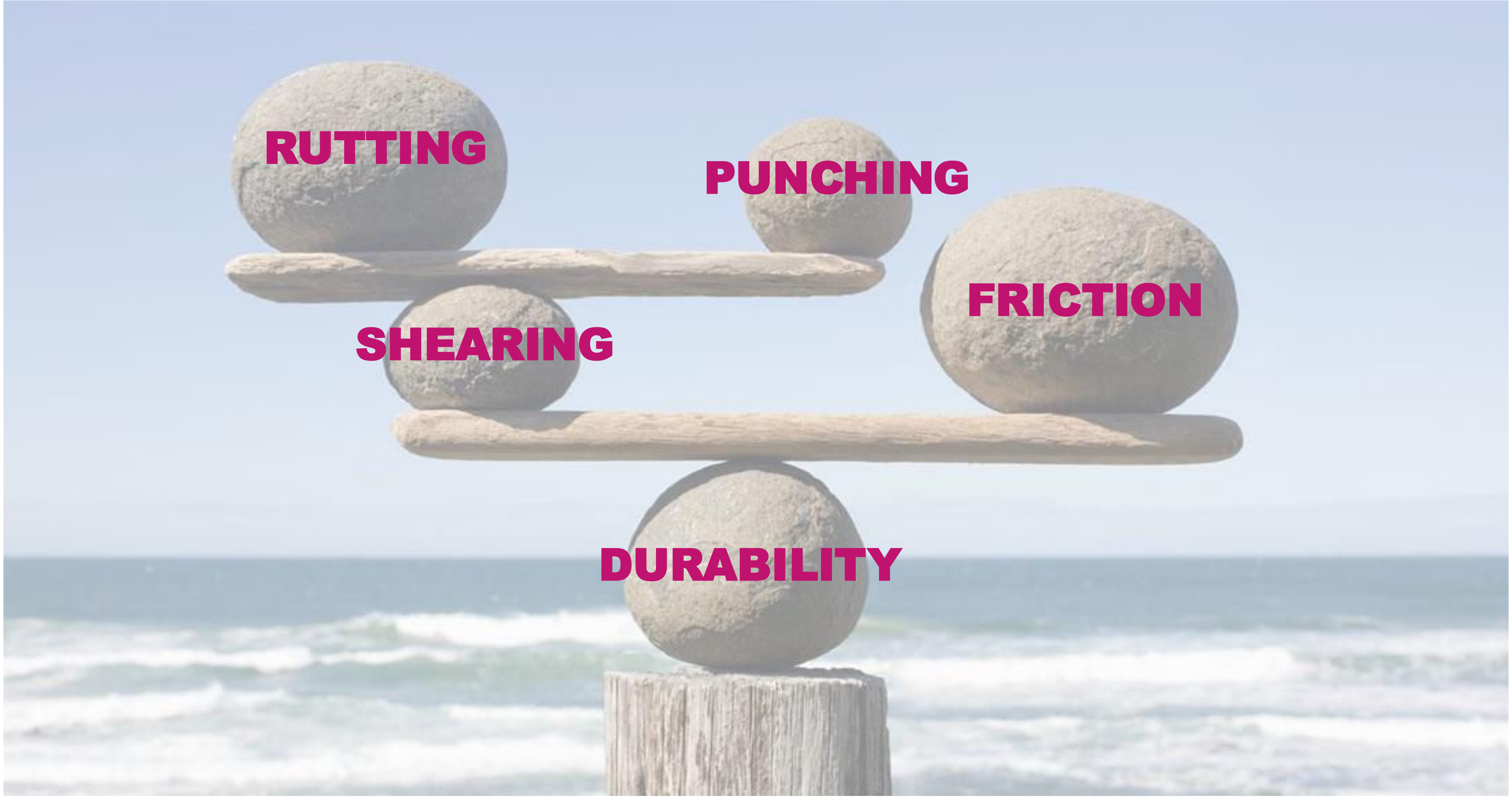


PERFORMANCE-BASED RECYCLING
ALTERNATIVE APPROACH – BAOSHAN H.



PERFORMANCE-BASED RECYCLING

CHALLENGES FOR AIRPORT PAVEMENTS



PERFORMANCE-BASED RECYCLING
CHALLENGES FOR AIRPORT PAVEMENTS

Table 3 –Assessment of aggression levels and surface quality characteristics of a pavement

		Shearing	Rutting	Punching	Durability	Friction
Parking area		++	+++	+++	++	++
Runways	Main part	+	+	+	++	+++
	Turning area	+++	++	+	+++	++
	Exit	+++	+	+	++	+++
	Threshold (*)	+++	+	++	+++	+++
Taxiways	Main part	+	++	+	++	++
	Intersections	++	++	++	+++	++
Apron or holding area		+	+++	+++	++	++

(*) including touch-down area

+: *Low level*
++: *Medium level*
+++: *High level*

PERFORMANCE-BASED RECYCLING
DURABILITY AND LOW IN-PLACE AIR VOIDS

NCAT Report 16-02 (2016) asphalt institute

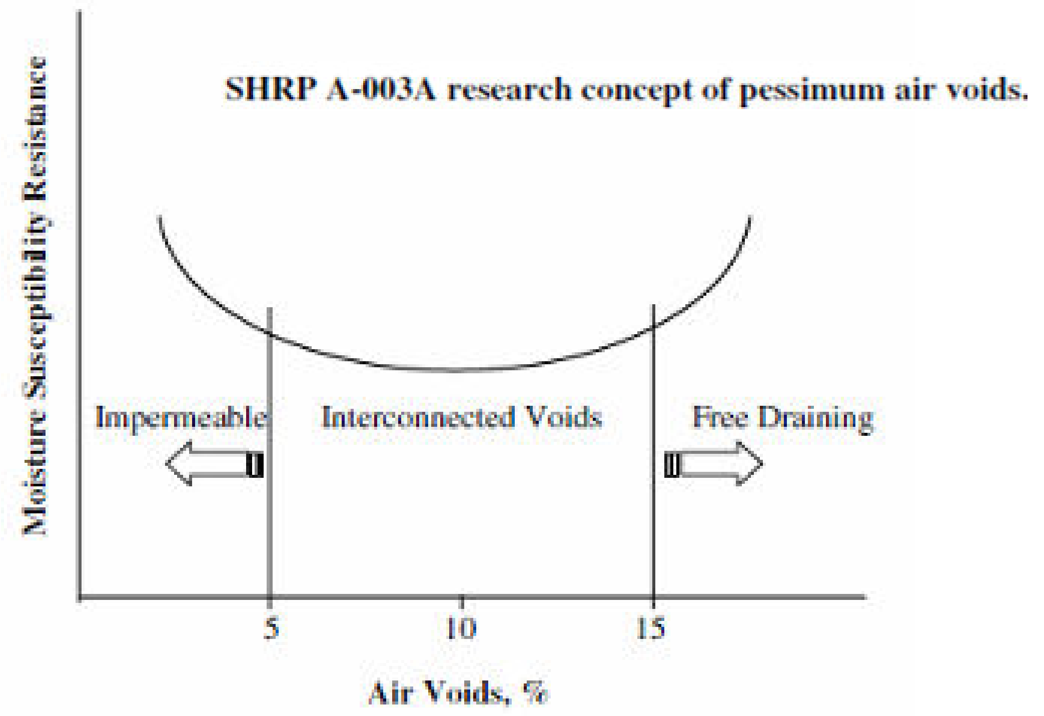
Literature Review on connecting in-place density to performance

- 5 studies cited for fatigue life
- 7 studies cited for rutting
- "A **1% decrease in air voids** was estimated to improve the fatigue performance of asphalt pavements between 8.2 and 43.8%, to improve the rutting resistance by 7.3 to 66.3%, and to **extend the service life by conservatively 10%**."

Goal - Better Densities

"The amount of air voids in an asphalt mixture is probably the single most important factor that affects performance throughout the life of an asphalt pavement."

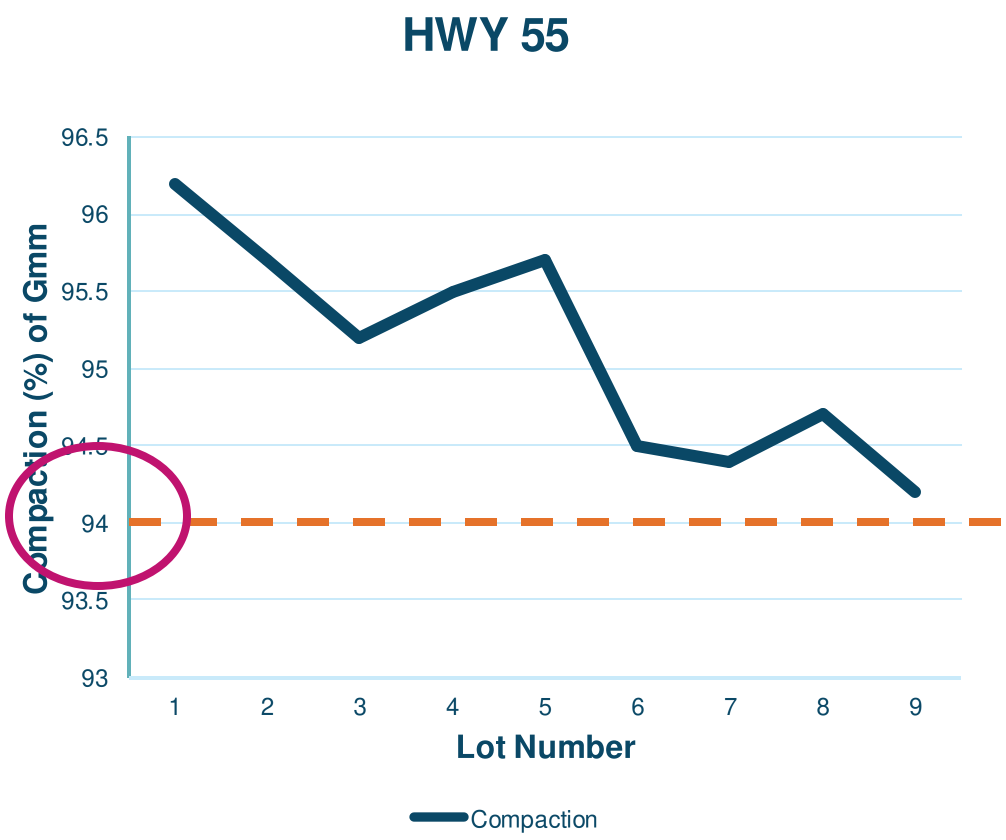
- E. Ray Brown, NCAT Report 90-3

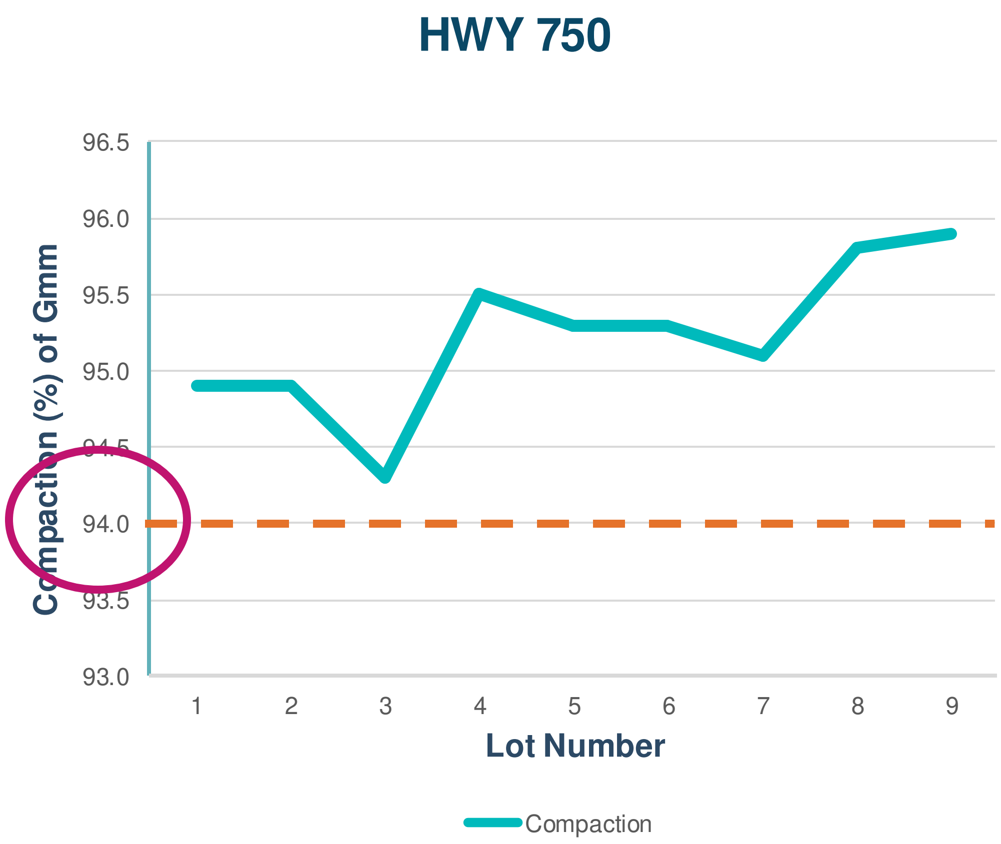


"Compaction is the most important factor in the performance of an HMA pavement."

- HMA Paving Handbook, US Army Corps of Engineers

PERFORMANCE-BASED RECYCLING
QUALITY CONTROL FROM TWO PROJECTS IN ALBERTA





PERFORMANCE-BASED RECYCLING
RUT TESTING FROM TWO PROJECTS IN ALBERTA

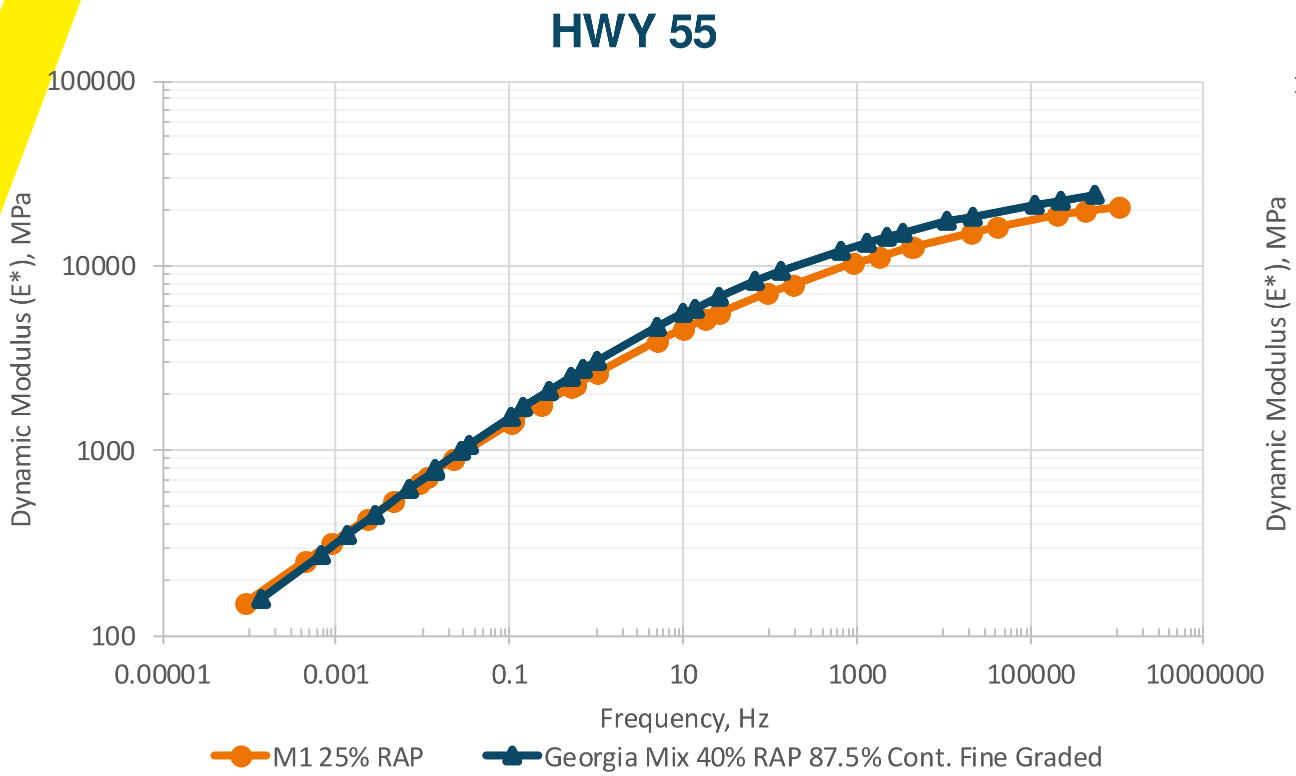
HWY 55

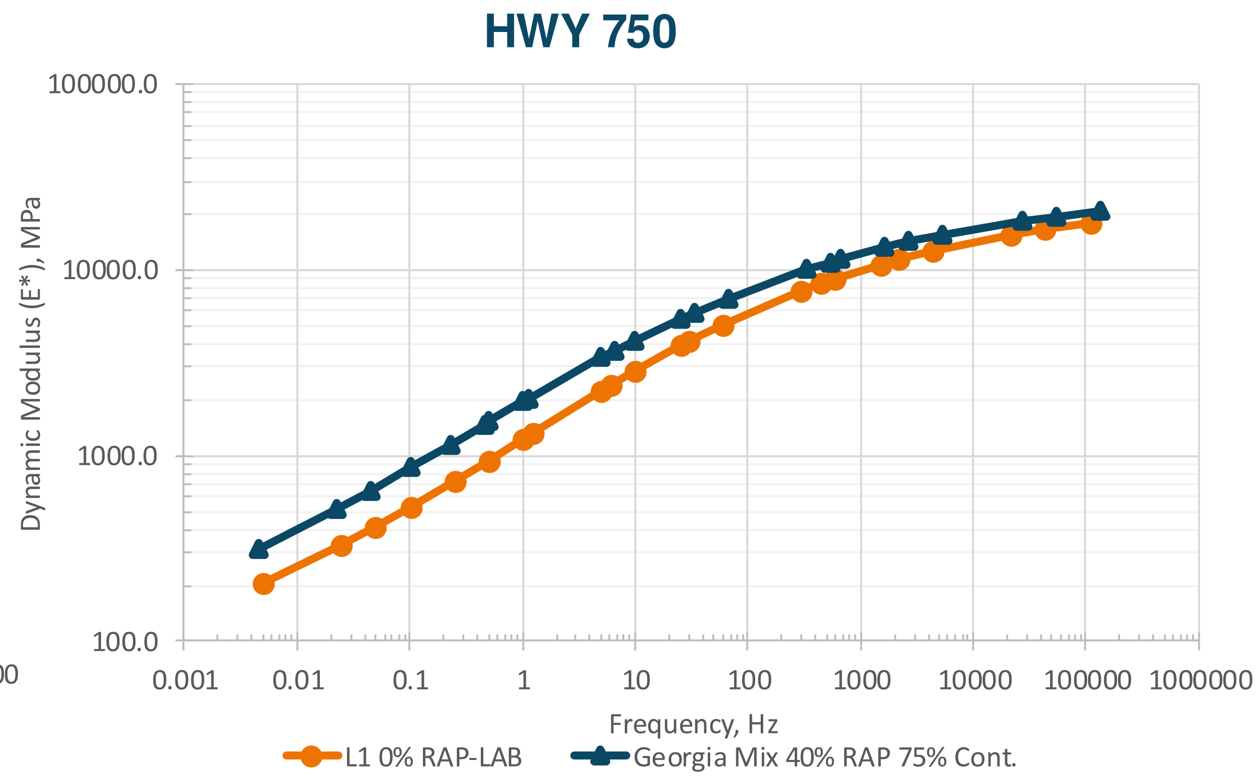
Mix Type	Air voids (%)	Test Temp. (°C)	Failure reason	SIP*	Number of passes at 12.5 mm rutting	Rutting @ 20000 passes
Reference Mix (M1)	7	45	Maximum rutting	NA	19362	NA
	7	45	Maximum passes	NA	NA	11.77
Georgia Method Mix with 40% RAP	6	45	Maximum passes	NA	NA	4.15
Rejuvenator Mix with 40% RAP	7	45	Maximum passes	NA	NA	4.71

HWY 750

Mix Type	Air voids (%)	Test Temp. (°C)	Failure reason	SIP*	Number of passes at 12.5 mm rutting	Rutting @ 20000 passes
Reference Mix (L1)	7	40	Maximum rutting	10619	15390	NA
	7	40	Maximum passes	18390	NA	9.45
Georgia Method Mix with 40% RAP	6	40	Maximum passes	NA	NA	3.74

PERFORMANCE-BASED RECYCLING
RUT TESTING FROM TWO PROJECTS IN ALBERTA





Parameter	HWY 55 Mixes		HWY 750 Mixes	
	Reference Mix (M1)	Georgia Method Mix with 40% RAP	Reference Mix (L1)	Georgia Method Mix with 40% RAP
Dynamic Modulus (MPa) 21°C/10HZ	4584	5340	2575	3792

PERFORMANCE-BASED RECYCLING
FATIGUE TESTING FROM TWO PROJECTS IN ALBERTA

Parameter	HWY 55 Mixes		HWY 750 Mixes	
	Reference Mix (M1)	Georgia Method Mix with 40% RAP	Reference Mix (L1)	Georgia Method Mix with 40% RAP
Fatigue resistance (µdef) 10°C/25HZ	131	131	124	126

PERFORMANCE-BASED RECYCLING

ESTIMATED CARBON FOOTPRINT CRADLE-TO-GATE

HWY 55 Mixtures	CO2 (kg/t)	Carbon Reduction
M1 with 25% RAP (Reference)	55.3	0.0%
Georgia Method Mix with 40% RAP	51.5	6.9%
Rejuvenator Mix with 40% RAP	47.4	14.4%

HWY 750 Mixtures	CO2 (kg/t)	Carbon Reduction
L1 with 0% RAP (Reference)	70.7	0.0%
Georgia Method Mix with 40% RAP	52.1	26.4%

7

Closing the loop

CLOSING THE LOOP

WHY RECYCLING ?

- Airport pavements are different than roadway pavements and the distinctions relate to speed, loading, tire pressure, movement, occupancy, and wandering
- Dysfunctions are associated with shearing, rutting, punching, durability and friction
- Surfacing pavement materials are usually specific to airport pavement while base asphalt mixes are not significantly different from their roadway counterparts
- Recycling is allowed but not as a common practice: nearly never in Canada, only in base mixes for FAA funded airports, never in France
- Recycling is under the label "sustainability" in the Asphalt Paving Canadian National Master Specification
- Recycling is an opportunity and the 40% RAP mixes could be used to build airport pavements
- Compared to traditional asphalt mixes CAOC mixes are more compact, and they offer improved rutting resistance, equivalent cracking resistance, comparable fatigue life and higher dynamic modulus
- CAOC mixes exhibit similar surface texture and appearance to the standard mix
- Recycling reduces the carbon footprint of airport pavement

➡ **RECYCLING IS AN OPPORTUNITY**

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