

# What's new with Concrete Pavements?

95<sup>th</sup> AASHTO Subcommittee on Materials Meeting

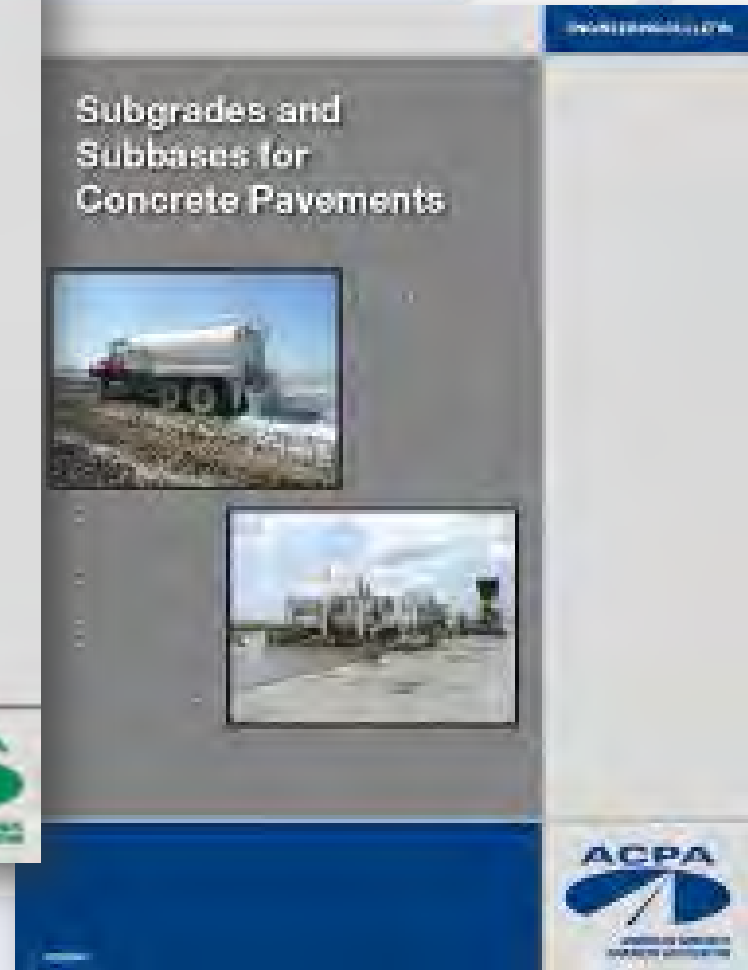
Anchorage, Alaska

August 4<sup>th</sup>, 2009



Leif Wathne

# Two New Engineering Bulletins...



95<sup>th</sup> AASHTO Subcommittee on Materials

# Subgrades and Subbases

# Subgrades and Subbases

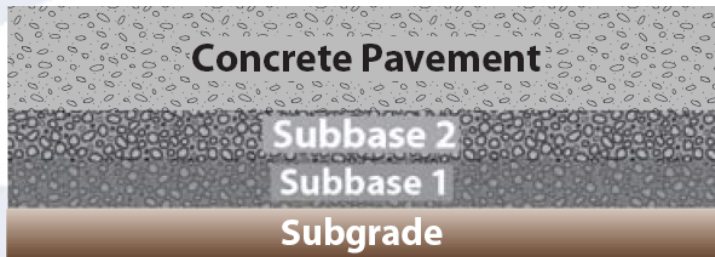
- Roadbed (subgrade and subbase) design is key to long-term performance and smoothness of concrete pavements.

- Terminology
- Design Principles
- Subgrades
- Subbases

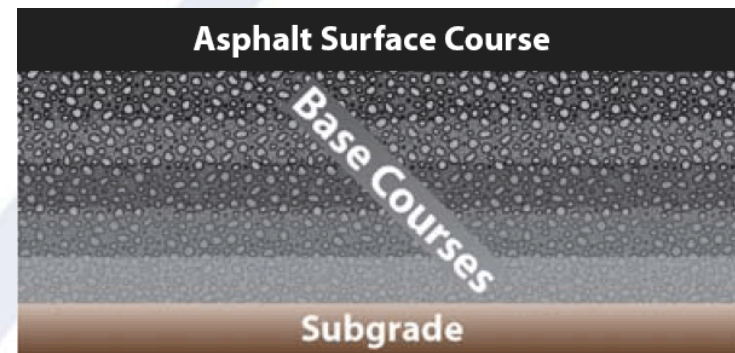


# Terminology

- A **concrete pavement** structure typically consists of a concrete surface and **subbase**(s) placed upon a prepared **subgrade**.
- A “**base**” is part of an **asphalt pavement** structure, while a **subbase** is an optional element of a concrete pavement structure.



Concrete Pavement Structure



Asphalt Pavement Structure

# Terminology

- Why the difference in terminology?
  - **Pressures** imposed on a **base** (under asphalt) are dramatically **different** than those imposed on a **subbase** (under concrete) due to differences in moduli (stiffness).
  - Material requirements for a subbase may be relaxed when compared to a base.

95<sup>th</sup> AASHTO Subcommittee on Materials

...OK... now what about  
Permeable Subbases?

# Permeable Subbases

- Also known as open-graded (OGB/OGDL) or drainable subbases.
- Permeability about 350 ft/day (107 m/day) or greater in laboratory tests.
  - Typically, however, permeability ranges from closer to 1,000 ft/day (305 m/day) to up to 20,000 ft/day (6,100 m/day) in laboratory tests.
- Crushed stone (sometimes stabilized with cement or asphalt) with a reduced amount of fines to create a mixture with many large voids to easily drain water.
- Became popular in the 1990s.. 60% agencies use (2005).



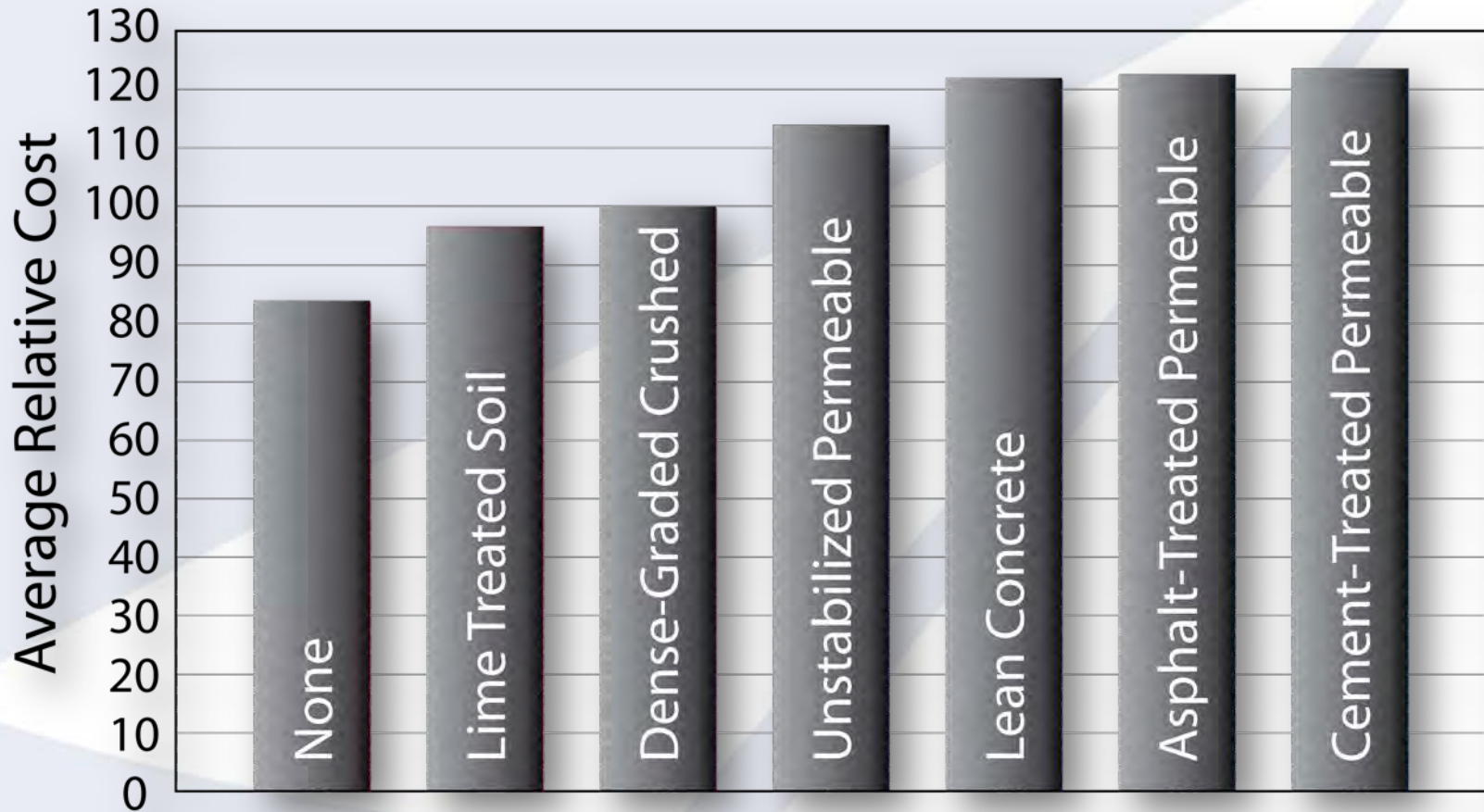
# Permeable Subbase Gradations

		Percent Passing						
	Sieve Size	Free-Draining	Unstabilized Permeable			Stabilized Permeable		
Gravel	2 in.	-	-	100	-	-	-	-
	1 1/2 in.	-	-	-	100	-	-	100
	1 in.	100	100	-	95-100	100	100	95-100
	3/4 in.	-	-	52-100	-	90-100	90-100	-
	1/2 in.	60-90	-	-	60-80	-	35-65	25-60
	3/8 in.	-	-	35-65	-	20-55	20-45	-
Sand	<b>No. 4</b>	<b>35-60</b>	<b>-</b>	<b>8-40</b>	<b>40-55</b>	<b>20-55</b>	<b>0-10</b>	<b>0-10</b>
	No. 8	-	10-35	-	5-25	0-5	0-5	0-5
	No. 10	-	-	-	-	-	-	-
	No. 16	-	-	0-12	0-8	-	-	-
	No. 30	10-35	-	0-8	-	-	-	-
	No. 40	-	-	-	-	-	-	-
	No. 50	-	0-15	-	0-5	-	-	-
	<b>No. 200</b>	<b>0-15</b>	<b>0-6</b>	<b>0-5</b>	<b>-</b>	<b>-</b>	<b>0-2</b>	<b>0-2</b>
	<i>Permeability (feet/day)</i>	<b>150</b>	<b>500</b>	<b>1,000</b>	<b>2,000</b>	<b>18,000</b>	<b>15,000</b>	<b>20,000</b>

# Permeable Subbases

- Problematic history due to:
  - Instability as a construction platform – anchor, smoothness...
  - Loss of support due to breakdown and compaction of the aggregate – point-to-point contact, crushing
  - Early age cracking due to mortar penetration – restraint...
  - Potential for increased curling.
  - Loss of support and decreased permeability due to infiltration of fines from below – filter fabric
  - Problems associated with an edge drainage system – no maintenance, clogging...
  - Increased cost without a comparable increase in pavement life/performance.

# Increased Cost



Is cost justified? (8-15yrs)

95<sup>th</sup> AASHTO Subcommittee on Materials

SO... what is one to do?

# Free-Draining Subbases!

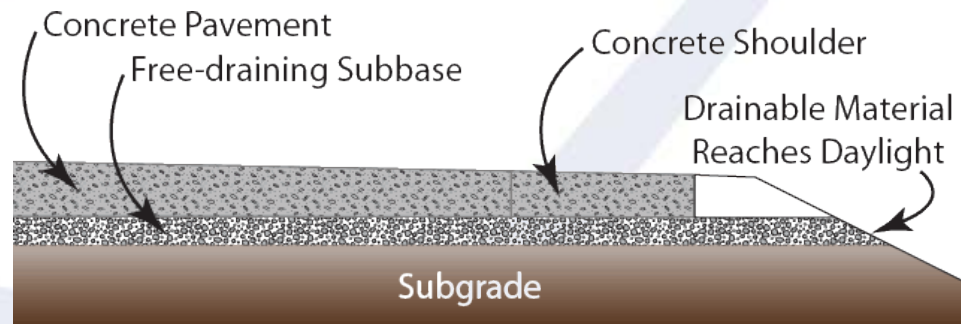
- Permeability between 50 and 150 ft/day (15 and 46 m/day) in laboratory tests.
- Increased sand and fines provide the requisite stability to effectively resist many of the problems associated with more open-graded, permeable subbases.

# Free-Draining Subbases

- Will be more stable during construction activities.
- Will mitigate the mechanism of support loss by increasing the points of contact between aggregate particles and reducing point-to-point bearing pressures between particles.
- Will mitigate mortar intrusion because the surface of a free-draining subbase will not be as open.
- Will not be prone to infiltration of fines from below.

# Daylighting the Subbase

- Water and any free material that finds its way into the free-draining subbase will have many paths to follow that could potentially lead out of the pavement structure.
- No regular scheduled maintenance is required for a daylighted subbase.



# Summary

- Permeable subbases are no longer recommended for concrete pavement structures!
- Free-draining, daylighted subbases are a reasonable alternatives to rapidly draining permeable subbases with edge drainage systems.



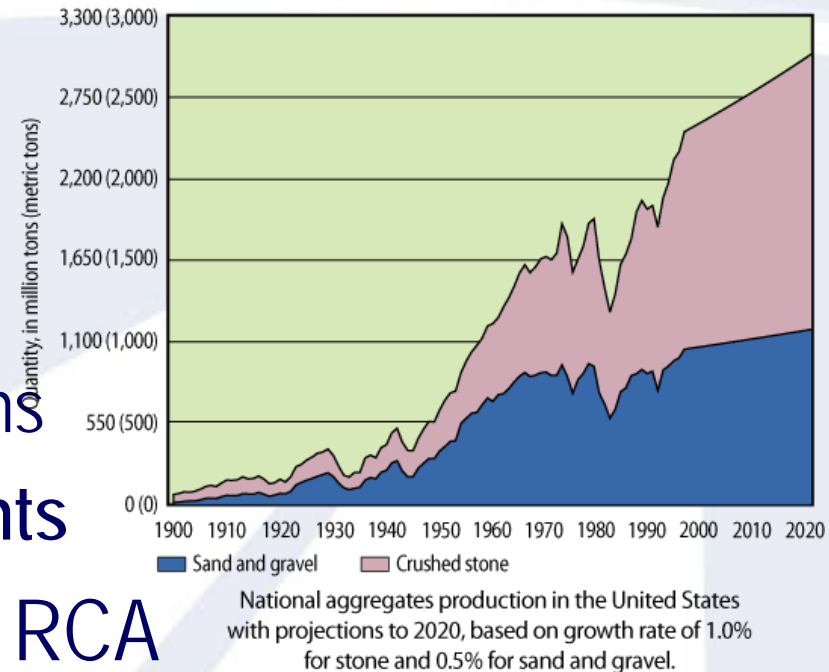
95<sup>th</sup> AASHTO Subcommittee on Materials

# Recycling Concrete Pavements



# Recycling Concrete Pavements?

- What and Why?
  - Economics (scarce, haul)
  - Sustainability Considerations
  - Performance Improvements
- Production & Properties of RCA
- Uses of RCA
- Properties of RCA Concrete
- Performance
- How-To Recommendations



# Pavement Performance Improvements

- Foundation stability; angular, rough texture and secondary cementing action.
- Concrete strength; substitution of RCA for virgin aggregate can potentially increase strength.
- A proven technology; 41 states allow RCA to be used in applications such as subbases, paving layers, rip-rap, embankment, etc.



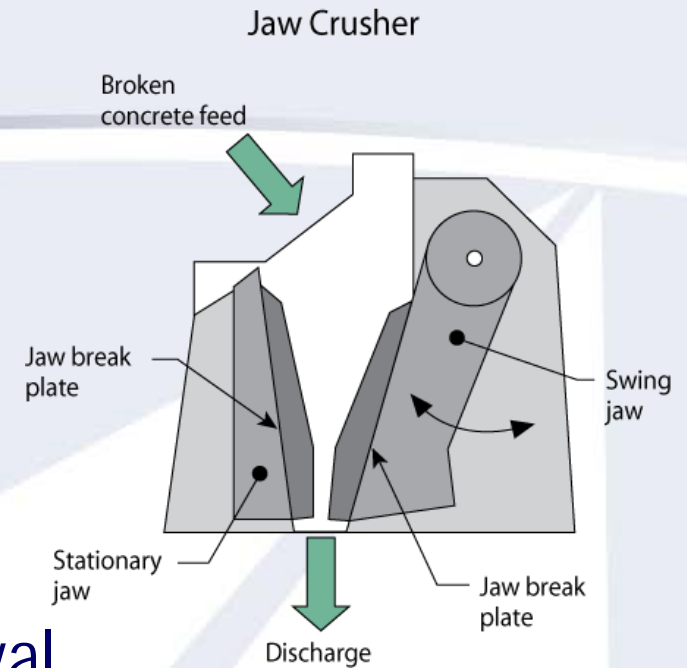
100Mtons/yr (USGS, '02)

95<sup>th</sup> AASHTO Subcommittee on Materials

# Production, Properties and Uses of RCA

# Production of RCA

- Typical steps:
  - Evaluation of source concrete.
  - Pavement preparation.
  - Pavement breaking and removal.
  - Removal of embedded steel
  - Crushing and sizing.
  - Beneficiation.
  - Stockpiling.



- Also covers in-place concrete recycling

# Properties of RCA

Property	Virgin Agg.	RCA
Shape and Texture	Well –rounded; smooth to angular/rough	Angular with rough surface
Absorption Capacity	0.8% – 3.7%	3.7% – 8.7%
Specific Gravity	2.4 – 2.9	2.1 – 2.4
L.A Abrasion	15% – 30%	20% – 45%
Sodium Sulfate	7% – 21%	18% – 59%
Magnesium Sulfate	4% – 7%	1% – 9%
Chloride Content	0 – 2 lb/yd <sup>3</sup>	1 – 12 lb/yd <sup>3</sup>

# Uses of RCA

- Granular subbase/backfill
- Cement-stabilized subbase
- **Concrete mixtures**
- Asphalt paving mixtures and asphalt-treated subbases
- Other applications



95<sup>th</sup> AASHTO Subcommittee on Materials

# Properties of Concrete with RCA



# Fresh (Plastic) Properties

Property	Coarse RCA	Coarse and Fine RCA
Workability	Similar to slightly lower	Slightly to significantly lower
Finishability	Similar to more difficult	More difficult
Water bleeding	Slightly less	Less
Water demand	Greater	Much greater
Air content	Slightly higher	Slightly higher

# Hardened Properties

Property	Coarse RCA	Coarse and Fine RCA
Compressive strength	0% to 24% less	15% to 40% less
Tensile strength	0% to 10% less	10% to 20% less
Strength variation	Slightly greater	Slightly greater
Modulus of elasticity	10% to 33% less	25% to 40% less
CTE	0% to 30% greater	0% to 30% greater
Drying shrinkage	20% to 50% greater	70% to 100% greater
Creep	30% to 60% greater	30% to 60% greater
Permeability	0% to 500% greater	0% to 500% greater
Specific gravity	0% to 10% lower	5% to 15% lower

# Hardened Properties

Property	Coarse RCA	Coarse and Fine RCA
Freeze-thaw durability	Depends on air voids	Depends on air voids
Sulfate resistance	Depends on mixture	Depends on mixture
ASR	Less susceptible	Less susceptible
Carbonization	Up to 65% greater	Up to 65% greater
Corrosion rate	May be faster	May be faster

# ... also included in EB043P...

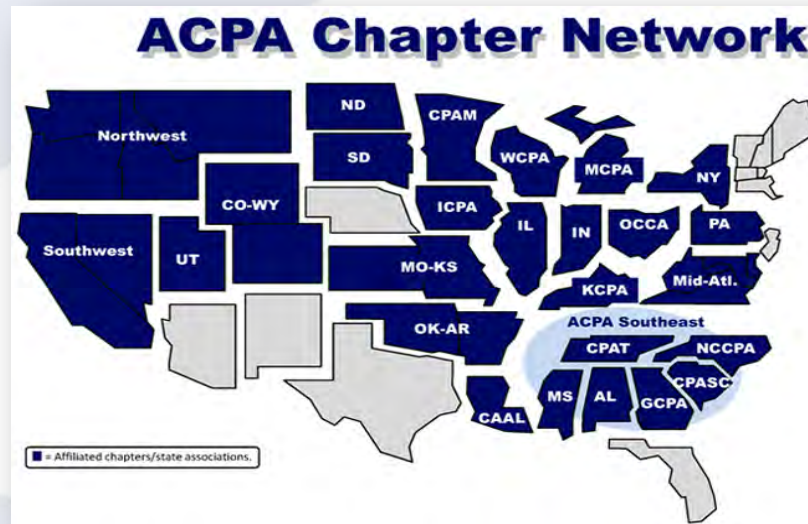
- Additional chapters on:
  - Performance of Concrete Pavements Constructed using RCA
  - **Recommendations for Using Recycled Concrete**
- Appendices:
  - Guidelines for Removing and Crushing Existing Concrete Pavement
  - Guidelines for Using RCA in Unstabilized (Granular) Subbases
  - Guidelines for Using RCA in Concrete Paving Mixtures
  - Relevant AASHTO/ASTM Standards
  - Glossary of Terms and Index



# Interested in either?



- Visit our bookstore at :  
[www.acpa.org](http://www.acpa.org) or [www.pavement.com](http://www.pavement.com)
- Contact one of our ACPA Chapters/Paving Associations  
[www.pavement.com/chapters/allchaps.asp](http://www.pavement.com/chapters/allchaps.asp)



- OR...call us at 847.966.2272

**THANK YOU!**

**Questions or comments?  
[lwathne@acpa.org](mailto:lwathne@acpa.org)**