Performance and Field Applications of LEADCAP WMA Technology

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Asphalt Industry in South Korea

- **In Korea, typically, hot-mix asphalt (HMA) industries consume large amount of fuel and discharge much green-house gas emission.**
  - 30 million tons of HMA are produced at 160℃ every year.
  - 260 million liter bunker C oil is consumed.
  - 0.8 million tons of CO_2 are emitted.
- **Therefore, asphalt industry needs alternative technology to replace hot-mix asphalt in order to reduce fuel consumption and gas emission.**
- **Warm-Mix Asphalt (WMA) is considered as an alternative green road technology to be replaced with HMA.**

Warm-Mix Asphalt Definition

In Korea, WMA technology should be able to reduce the production temperature by at least 30˚C (86˚F) than conventional HMA.

Hot-Mix Asphalt Pavement

Production Temperature

Construction Temperature

180°C (356°F)

160°C (320°F)

140°C (284°F)

120°C (248°F)

100°C (212°F)

80°C (176°F)

Warm-Mix Asphalt Pavement

Production Temperature

Construction Temperature

180°C (356°F)

160°C (320°F)

140°C (284°F)

120°C (248°F)

100°C (212°F)

80°C (176°F)

Warm Mix Asphalt Technology

LEADCAP

Basic LEADCAP WMA Additive

LEADCAP

- **From 2009, the Korea Institute of Construction Technology (KICT) developed a new warm-mix asphalt technology.**
- Named **"Low Energy and Low Carbon-Dioxide Asphalt Pavement (LEADCAP)"**
- **LEADCAP is an additive of a wax-based composition including a crystal controller and an adhesion promoter.**

LEADCAP Family

LEADCAP-B
(Base)

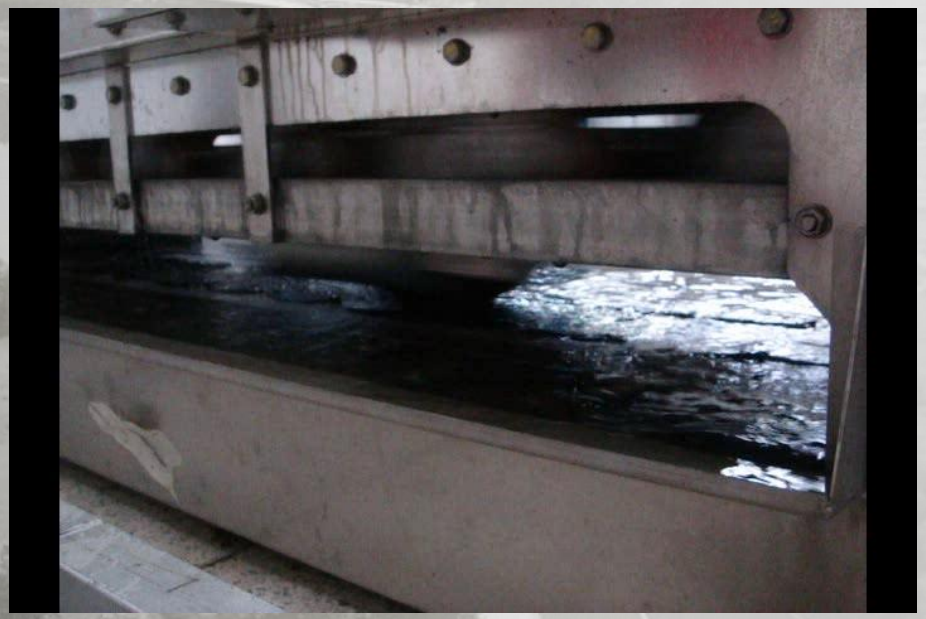
LEADCAP-M
(Modified)

LEADCAP-A
(Advanced)

Evaluation of Rutting Resistance

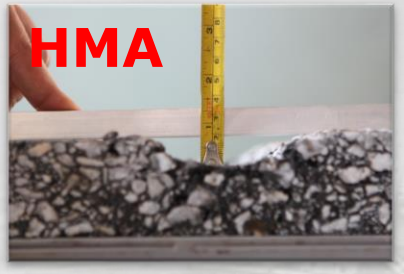
MMLS3 Test

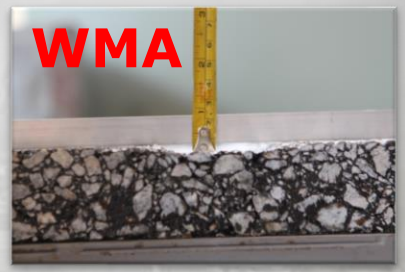
To evaluate rutting potential of LEADCAP WMA mixtures at wet condition, the mobile moving load simulator (MMLS3) test was conducted at wet condition at 50°C.

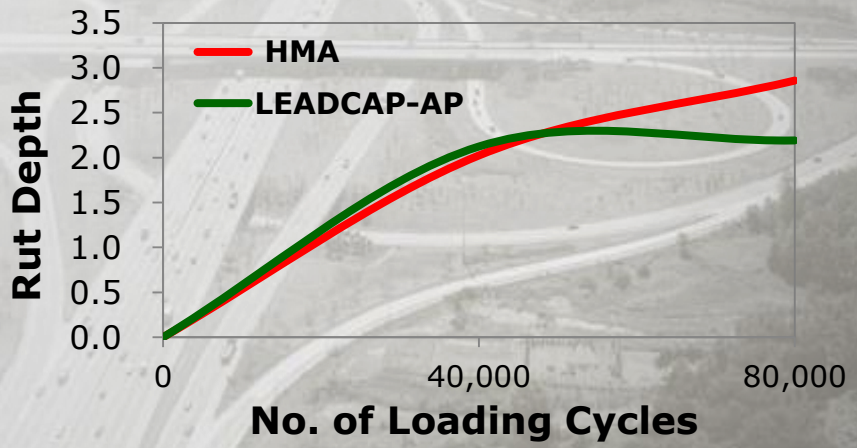


Rut Depth

LEADCAP WMA mixture would be more resistance to rutting than HMA mixture.



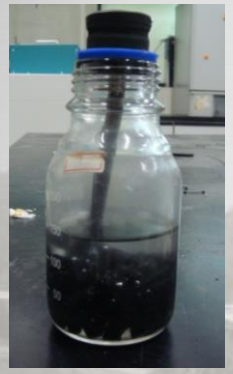




Evaluation of Stripping Resistance

Dynamic Immersion Test

Before



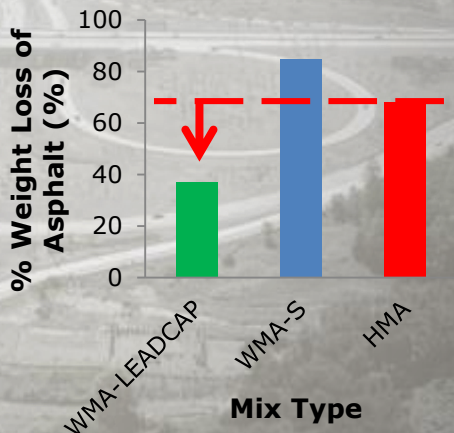
After

Stripping

WMA-LEADCAP

HMA

WMA-S Additive



Evaluation of Moisture Sensitivity

AASHTO T 283 Test

In order to evaluate moisture sensitivity of LEADCAP WMA mixtures, AAHTO T 283 test was conducted and tensile strength ratio (TSR) was computed.

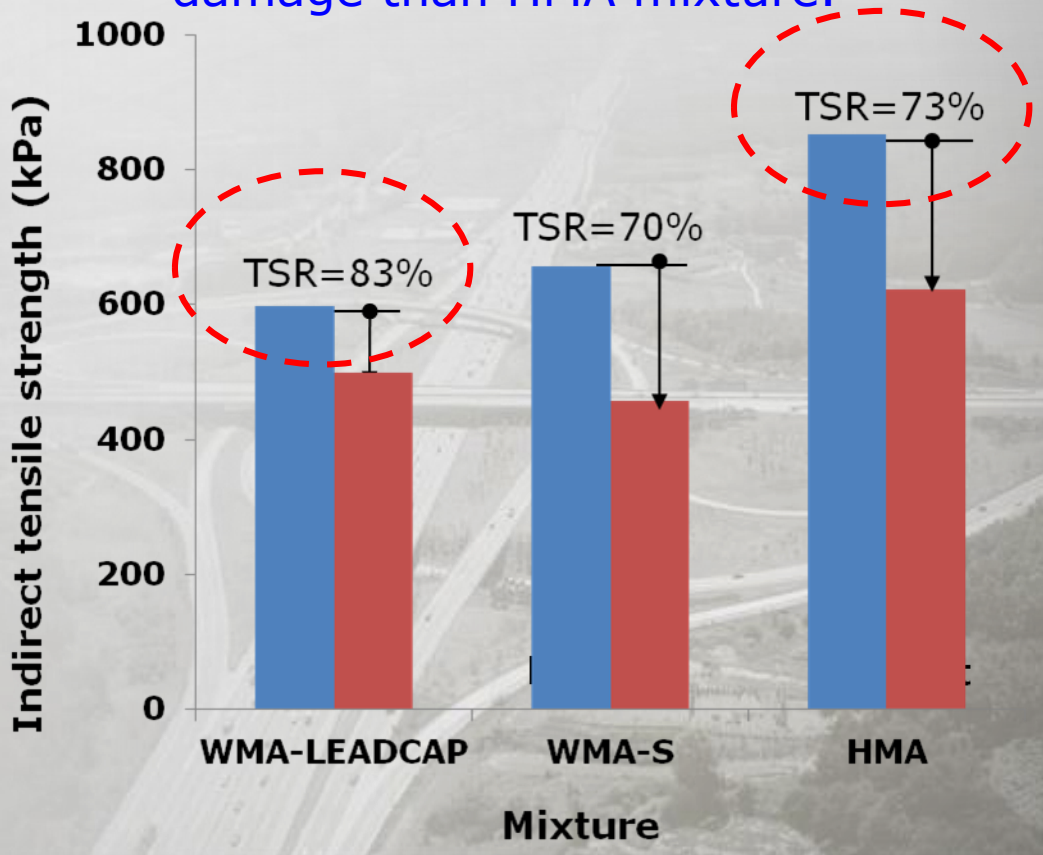
$$TSR(\%) = \frac{ITS_{Wet}}{ITS_{Dry}} \times 100$$

Dry Conditioned Specimen

Wet Conditioned Specimen

Tensile Strength Ratio

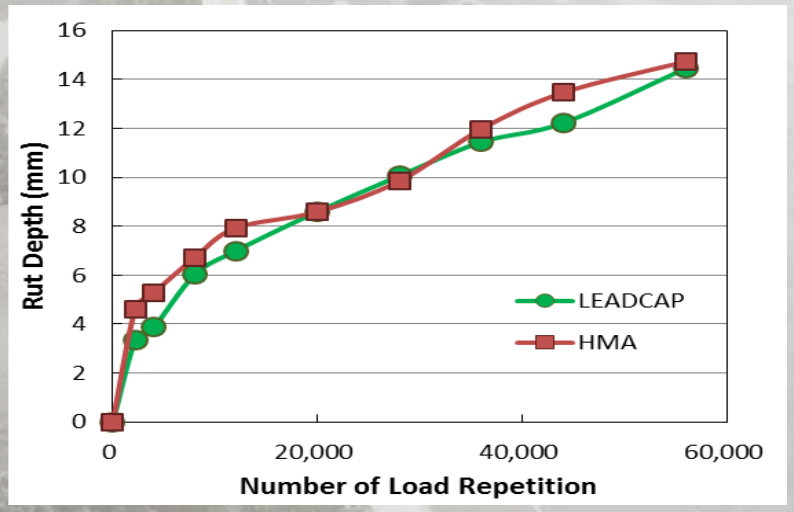
LEADCAP WMA mixture would be less sensitive to moisture damage than HMA mixture.



APT Evaluation

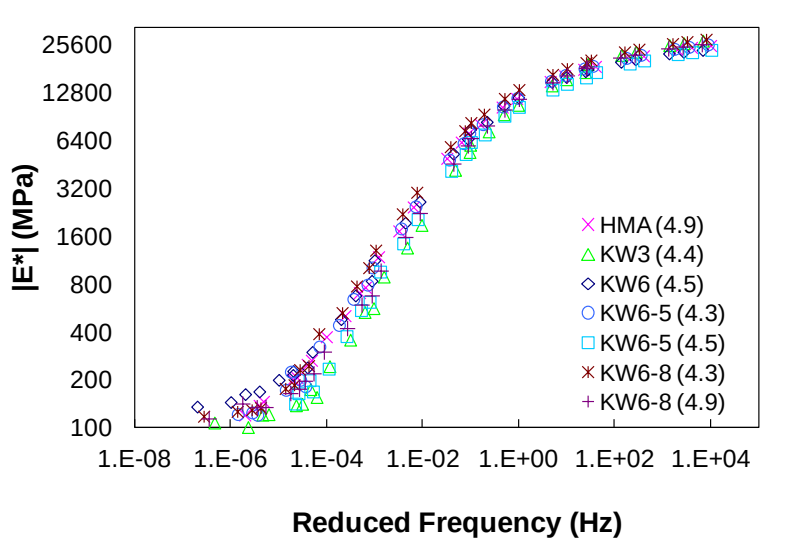
Accelerated Pavement Test

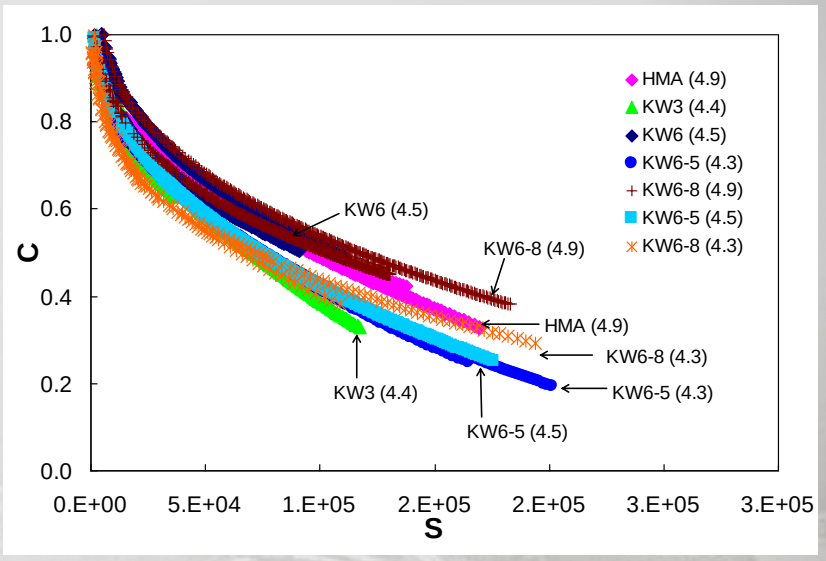
- Test Conditions
  - Mix : 19mm NMAS + PG64-22
  - Wheel Load : 3.4 ~ 12ton
  - Speed : 10km/h
  - Temp. : 40±2°C

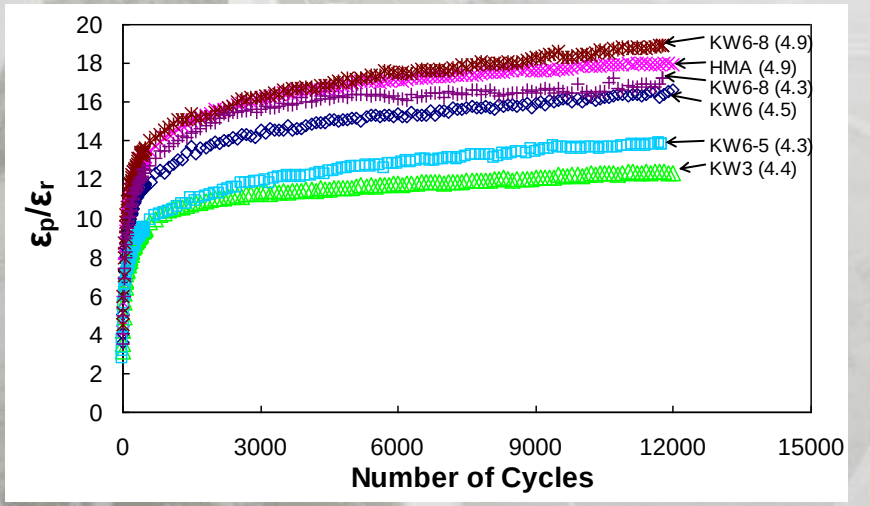


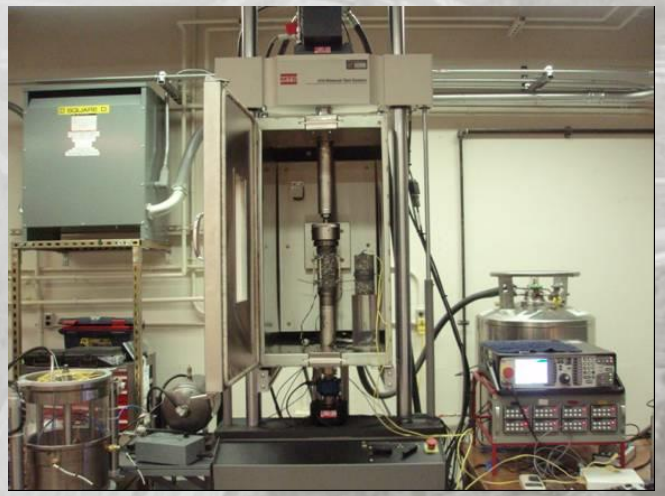
NCSU Research Results

Performed Dynamic Modulus, Direct Tension Fatigue, TRLPD Tests

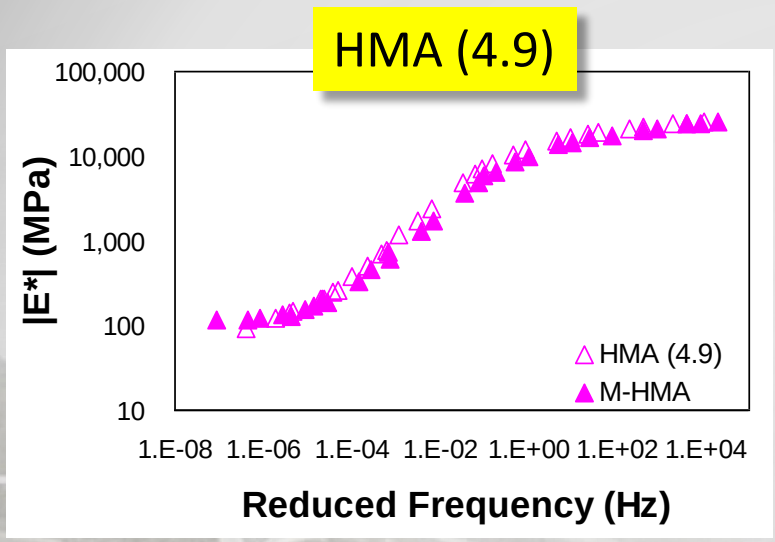


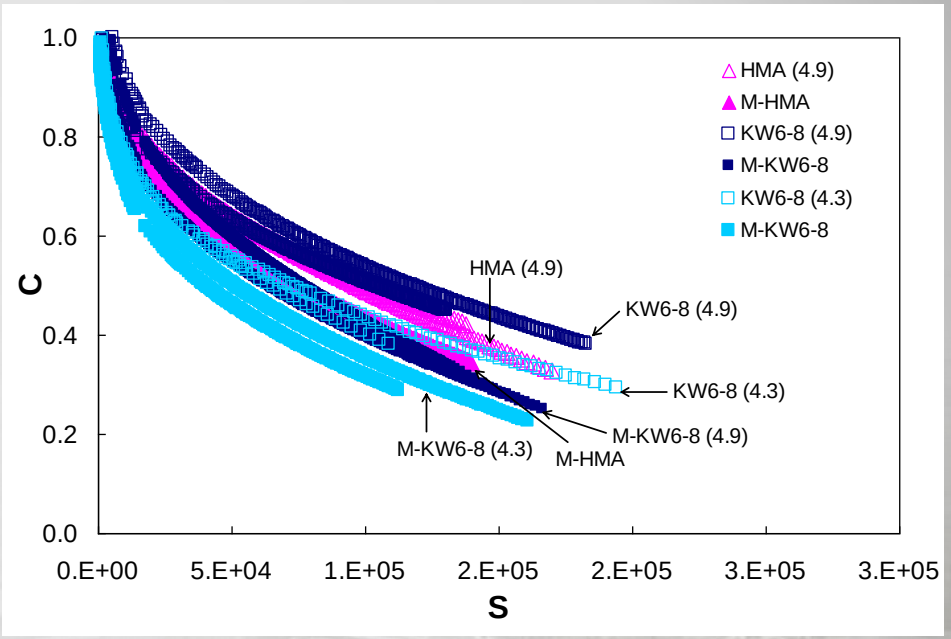


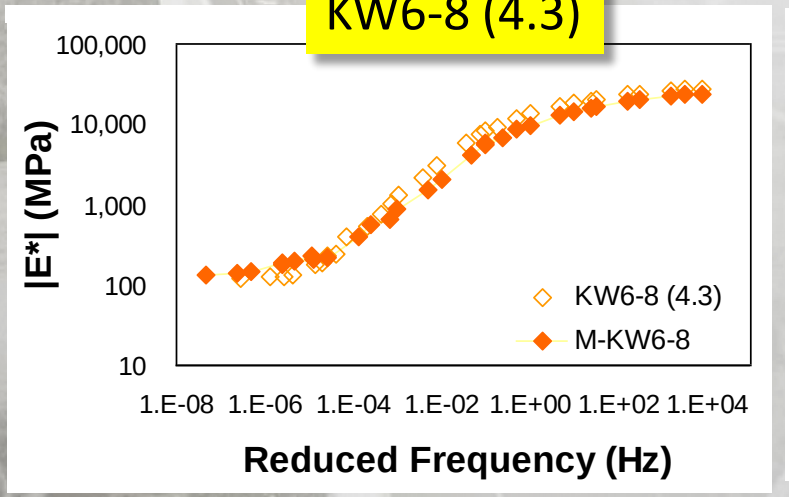


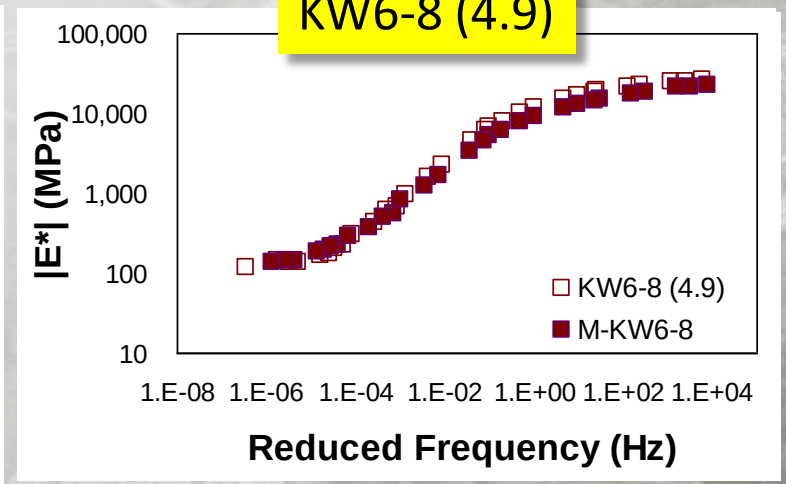


Effect of Moisture Conditioning

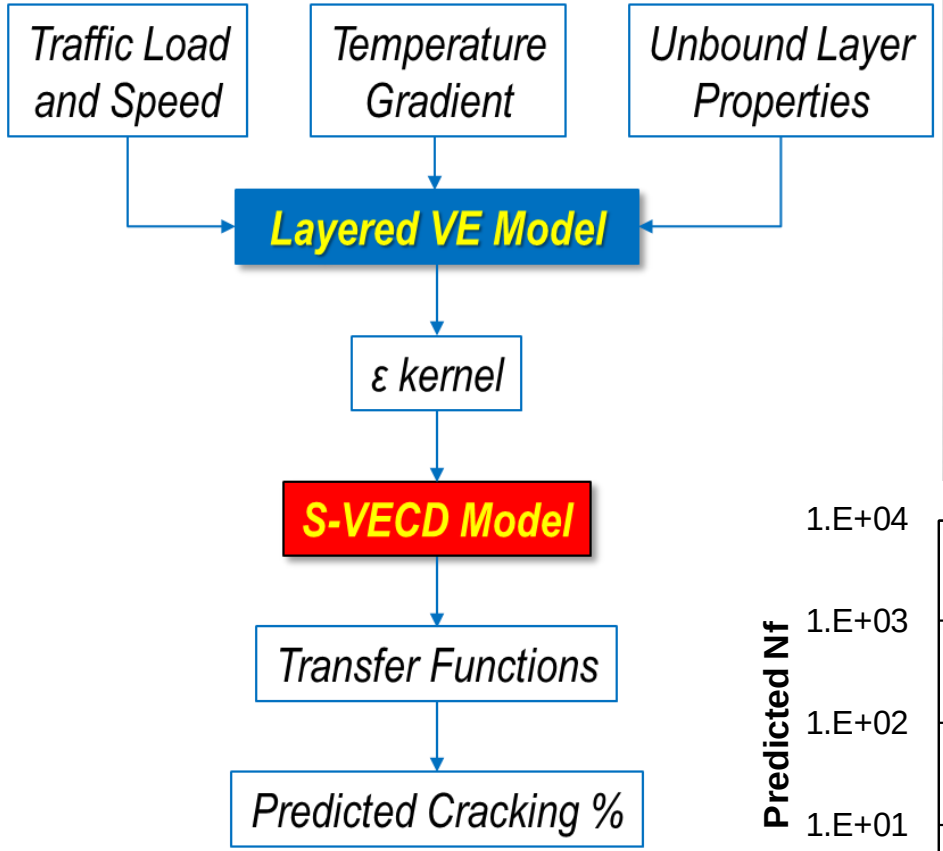


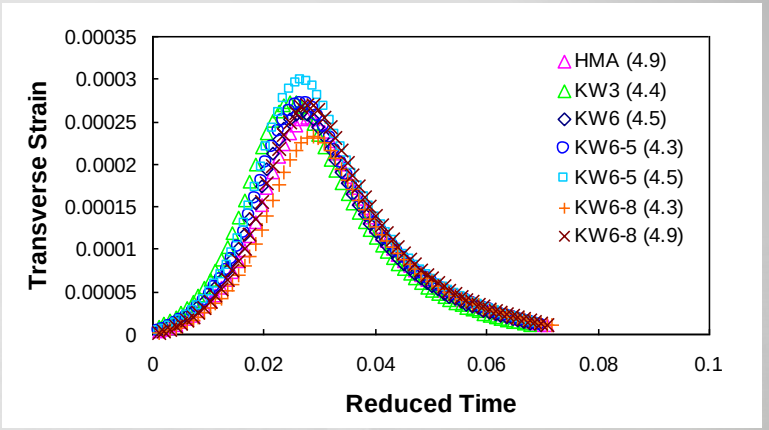


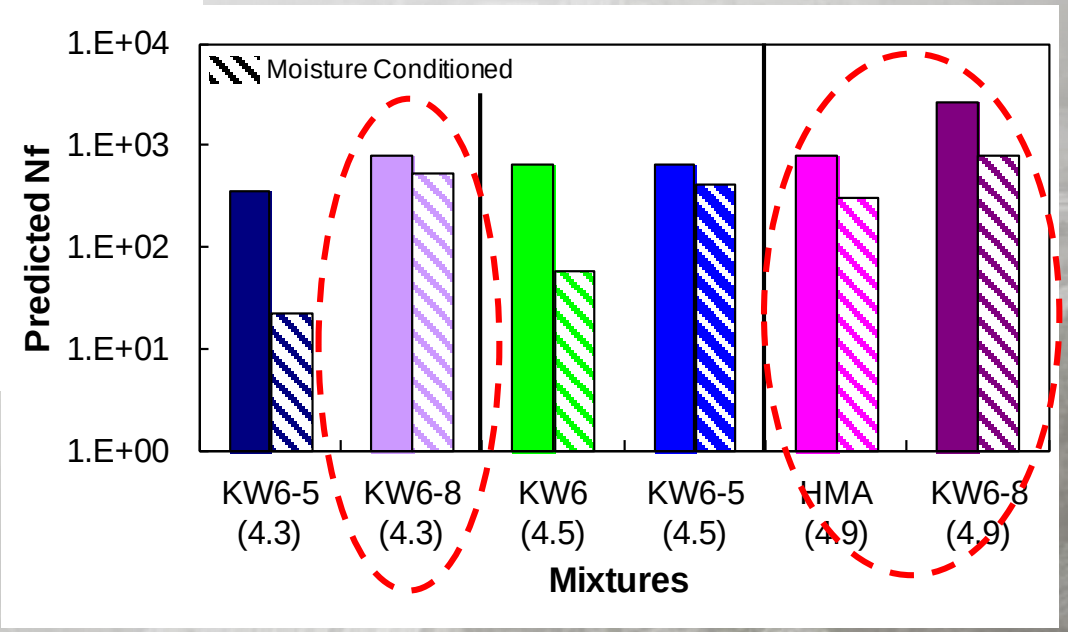




Layered VE + S-VECD Simulation







LEADCAP WMA Technology

Field Experiences

- Field Experiences in Korea
- Field experiences in Foreign Countries

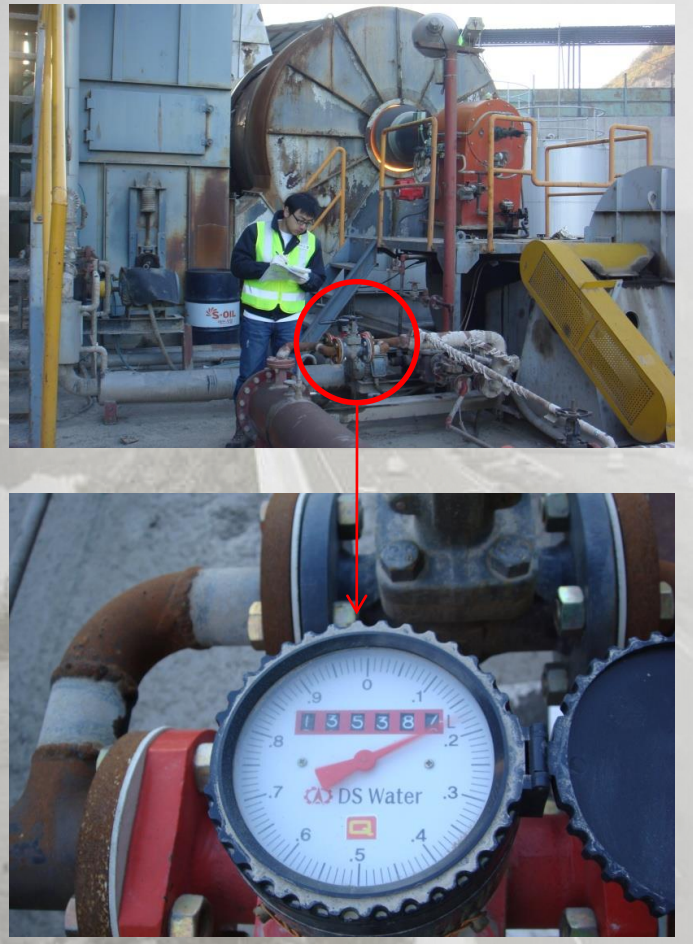
Field Experiences in Korea

Locations

No.	Date	Classification
1	2009. 11	Interstate Highway
2	2010. 06	Interstate Highway
3	2010. 10	Interstate Highway
4	2010. 10	City Road
5	2010. 10	APT Test Bed
6	2010. 11	Expressway
7	2010. 11	Expressway
8	2011. 10	Interstate Highway

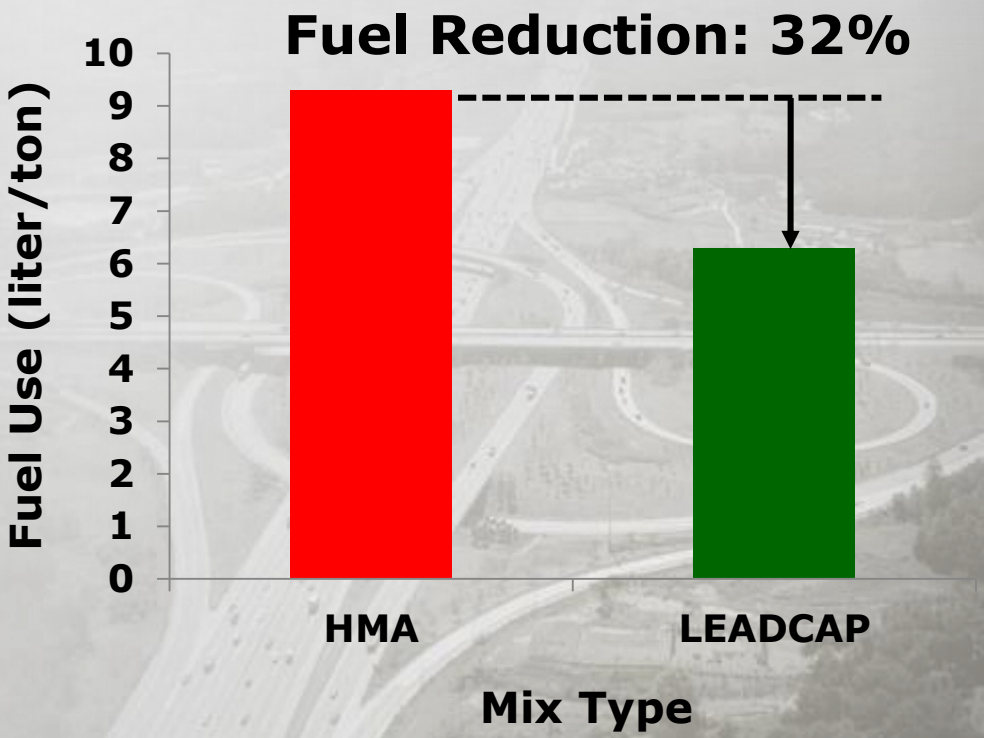
Energy Saving

Measurement



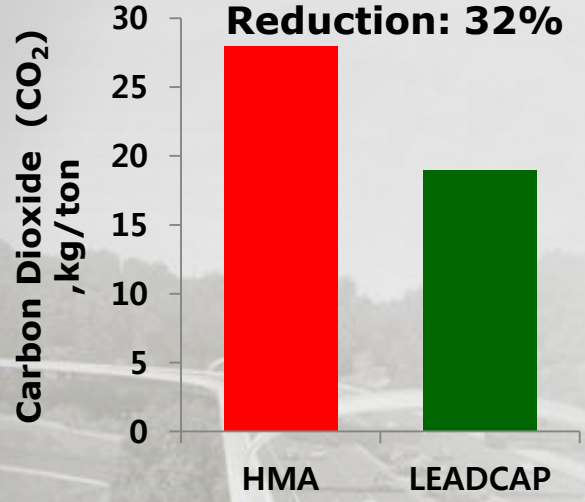
Fuel Consumption

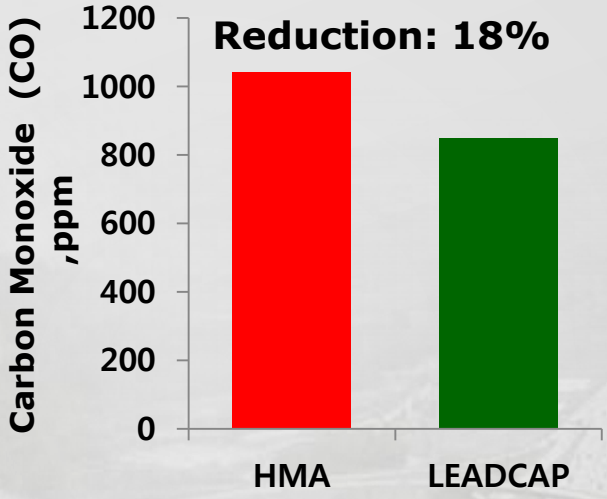
- Production Temperature of HMA: 160℃
- Production Temperature of WMA: 130℃

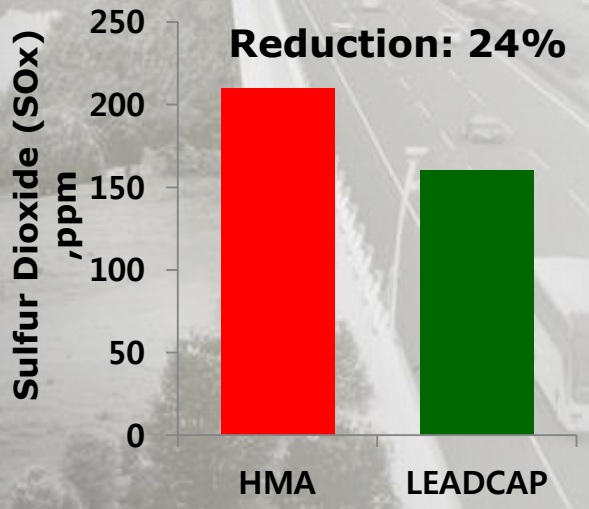


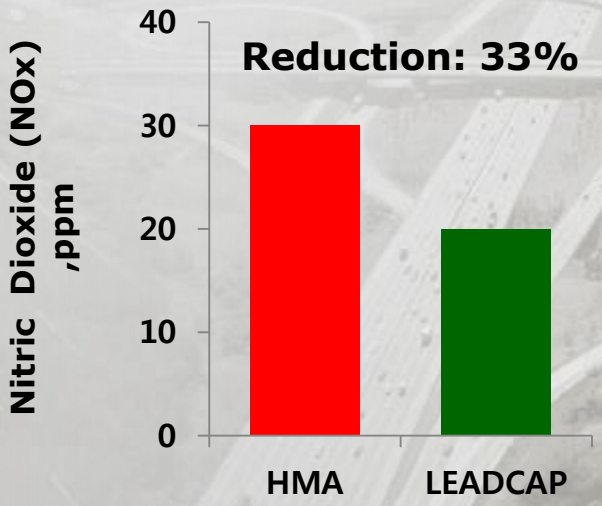
Reductions of Emissions

- CO_2, Co, NOx, SOx





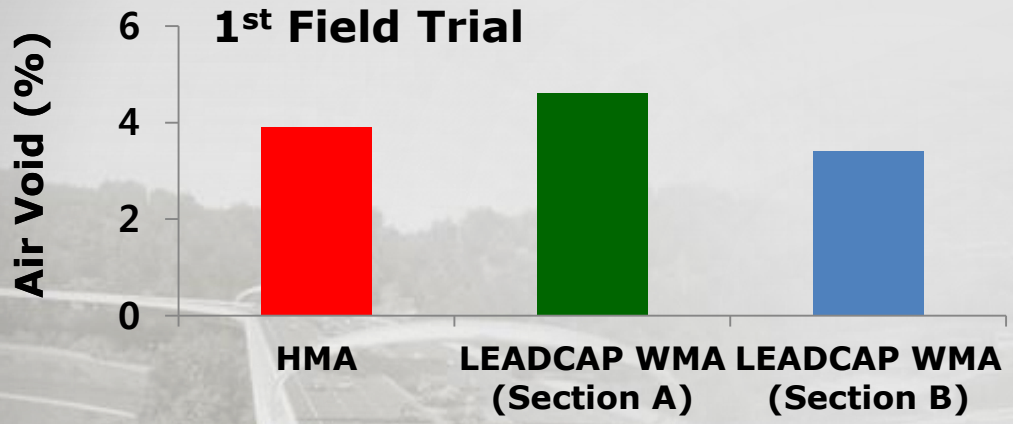


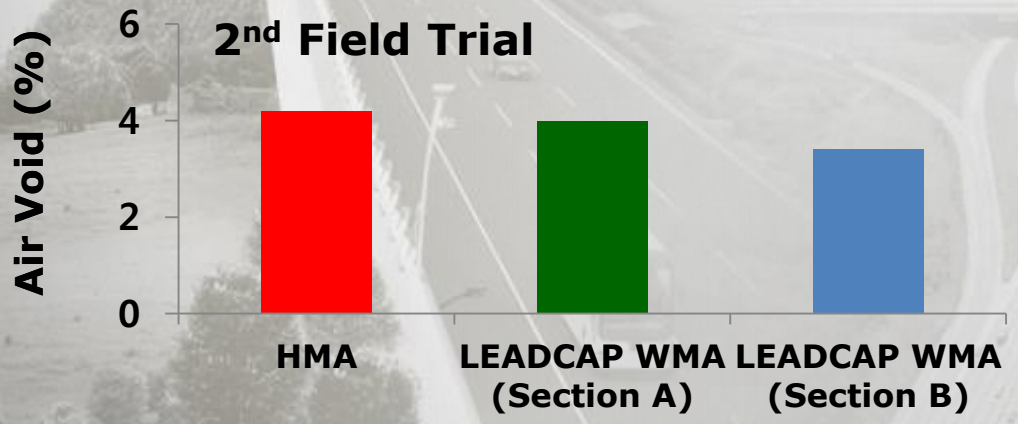


Field Air Voids

Air Void

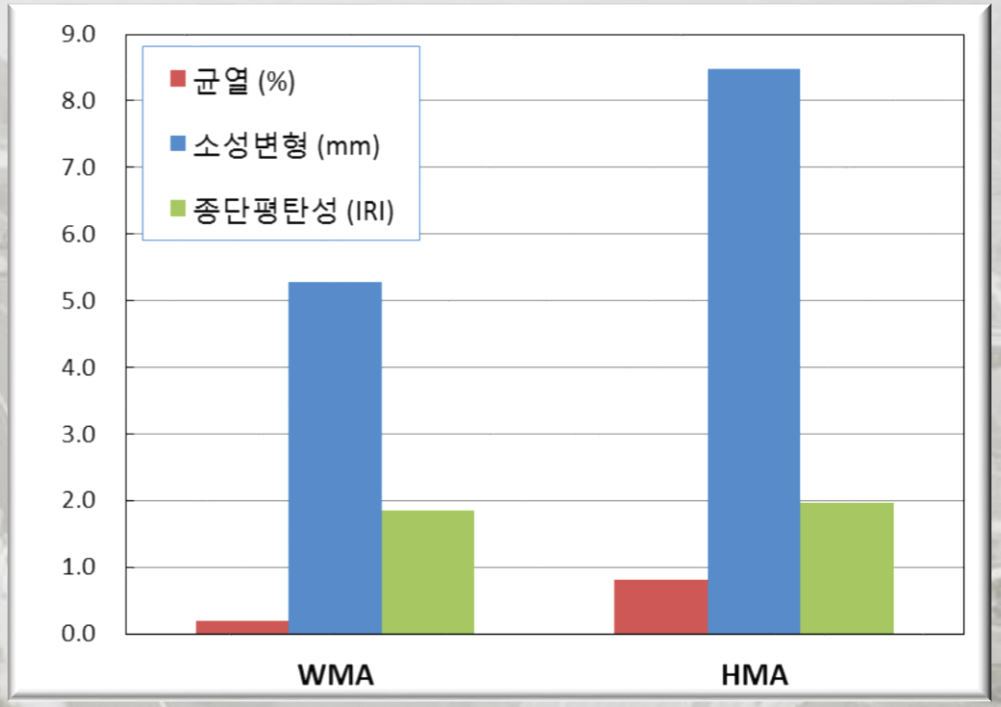
LEADCAP WMA pavement achieved a comparable air void as the control HMA pavement section





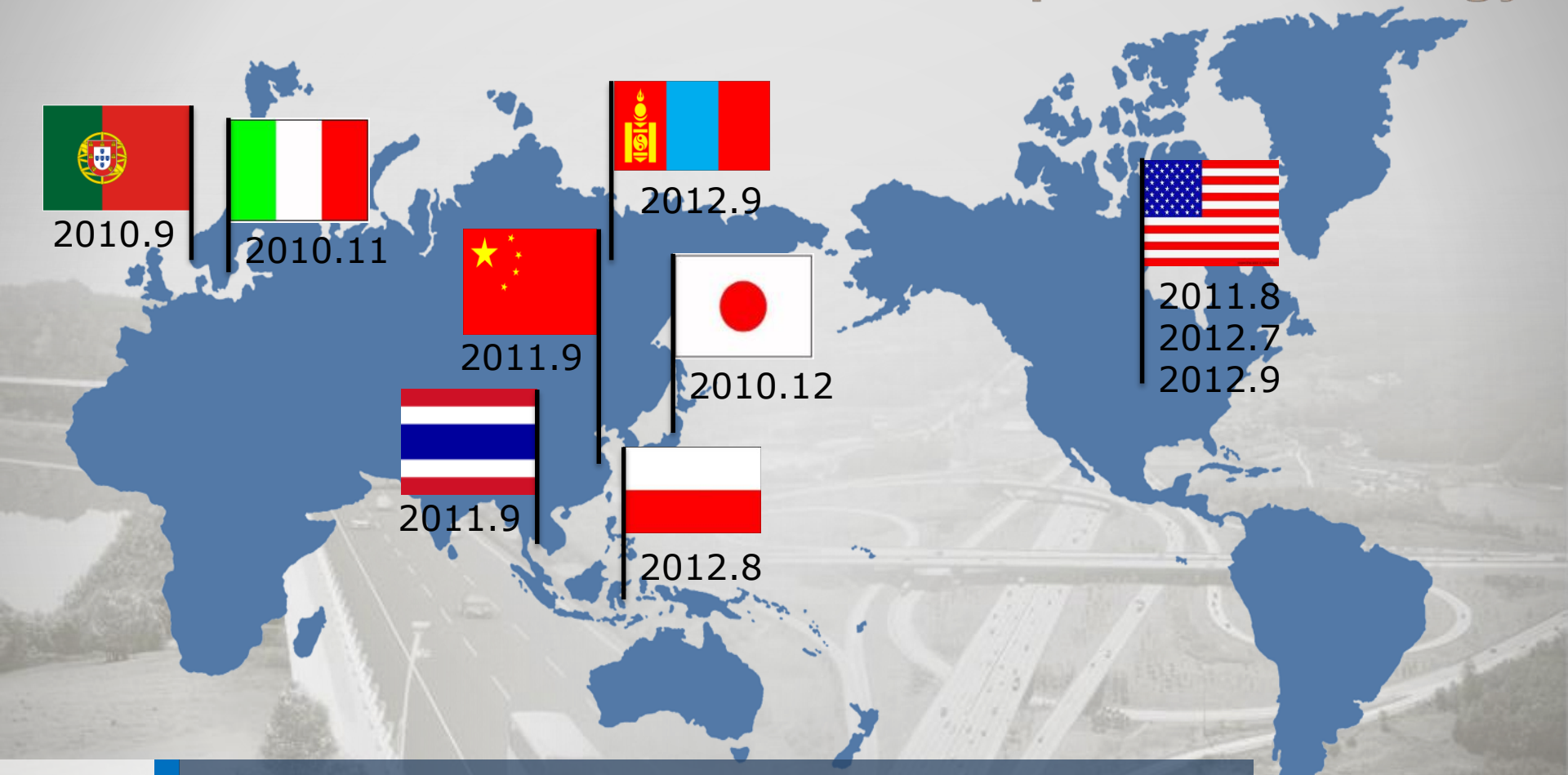
Comparison in Field Performance

- Four test sections (surface layers, total 11.7 km)
- Performed between 1 ~ 5 years
- Both show good condition, but WMA is generally better.



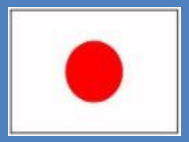
Field Experiences in Foreign Counties

Toward World Best Warm-Mix Asphalt Technology



8 Countries (Portugal, Italy, Japan, United States, Thailand, China, Indonesia, Mongolia)

Appling to Various Asphalt Mixtures

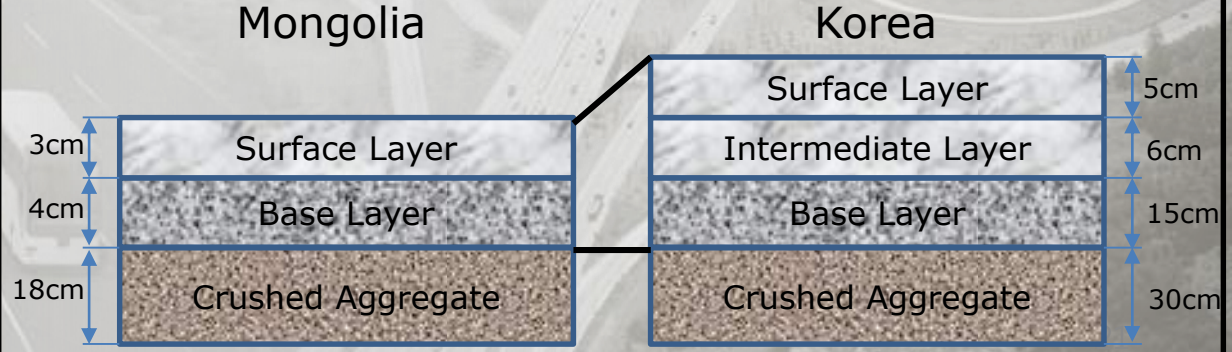
	 Portugal	 Italy	 Japan	 USA	 Thailand	 China	 USA
Weather Condition	2010.9. (fall)	2010. 11. (late fall)	2010.12. (winter)	2011. 8. (summer)	2011. 9. (summer)	2011. 9. (fall)	2012.7 (summer)
Mix Type	Dense-Graded Asphalt	Dense-Graded Asphalt	Porous Asphalt	Dense-Graded Asphalt	Dense-Graded Asphalt	Polymer-Modified SMA	Dense-Graded Asphalt
LEADCAP Type	LEADCAP 70	LEADCAP 70	LEADCAP64	LEADCAP64	LEADCAP64	LEADCAP64	LEADCAP64
RAP Use	0%	0%	0%	10%	0%	0%	25%
Plant Type	Batch 500T	Batch 50T	Batch 500T (30,000T)	Drum 350T	Batch 130T	Batch 400T	Drum 700T
Mixing Type with LEADCAP	Pre-mixed	Plant-mixed	Pre-mixed	Pre-mixed	Pre-mixed	Plant-mixed	Pre-mixed
Mixing Temp.	125±5℃	135±5℃	145±5℃	130±2℃	130±5℃	145±5℃	135±3℃
Compaction Temp.	120±5℃	120±5℃	140±5℃	120±5℃	120±5℃	140±5℃	125±3℃

Problems in Mongolian Roads

Early Failure after
1 year Service Life

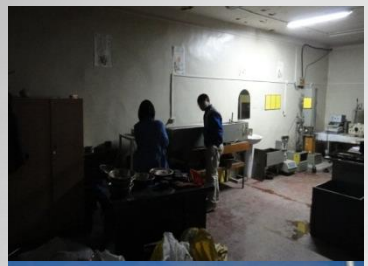
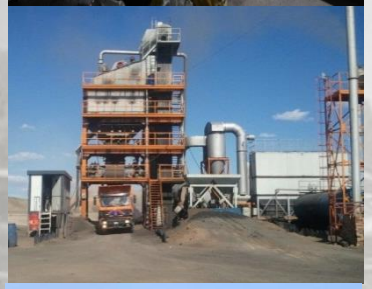
WMA +Polymer Modified Asphalt

Too thin asphalt layer leads to create crack faster and other distress



1st Field Construction in Mongolia

➢ Solid Type WMA Additive (SBS Modifer + LEADCAP)

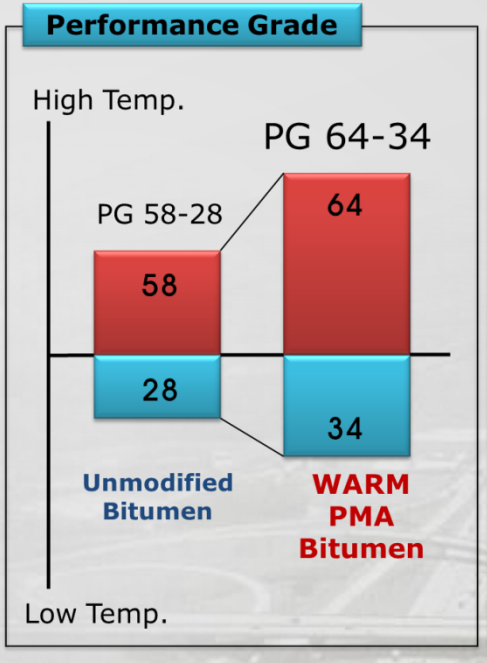
Condition	Information	
Location	**Ulaanbaatar City**	**Gobi Desert**
Weather Condition	2012.09 (Fall)	2012.09 (Fall)
Mix Type	13mm Dense-Graded Asphalt	19mm Dense-Graded Asphalt
Additive Type-1	LEADCAP-B	PM WMA-1
Additive Type-2	PM(Polymer Modified) WMA-1	PM WMA-2
RAP Use	0%	0%
Plant Type	Batch	Batch
Dosing Method	Plant-mixed	Plant-mixed
Mixing Temp.	140±5℃ (LEADCAP-B) 150±5℃ (PM WMA-1)	150±5℃ (PM WMA-1) 155±5℃ (PM WMA-2)
Compaction Temp.	130±5℃ (LEADCAP-B) 140±5℃ (PM WMA-1)	140±5℃ (PM WMA-1) 145±5℃ (PM WMA-2)

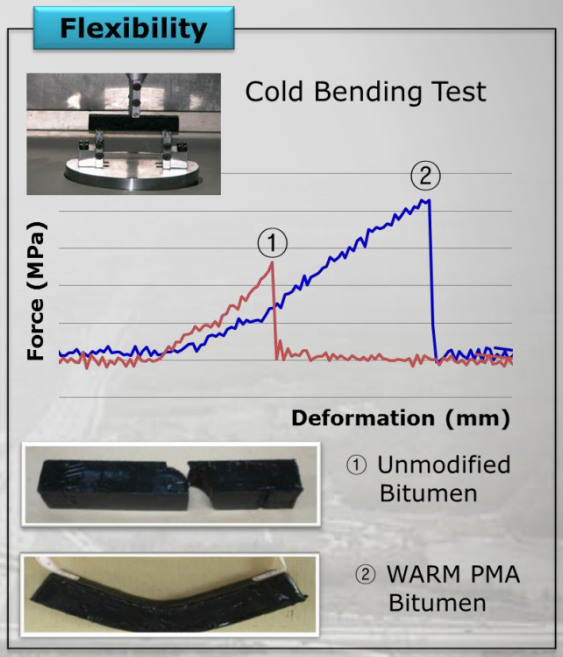



2nd Field Construction in Mongolia

➢ Liquid PWMA Additive (Liquid SBS Modifer + LEADCAP)

Condition	Information
Location	**Ulaanbaatar City**
Weather Condition	2013.10 (Fall)
Mix Type	Surface - 9.5mm DGA Base - 19mm DGA
Additive	Liquid PWMA
Dosage Rate	4% of AC
OAC	Surface – 6.3% Base – 5.4%
Plant Type	Batch
Dosing Method	Plant-mixed
Mixing Temp.	130 ± 5℃
Compaction Temp.	115 ± 5℃



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Toward World Best Technology..
Thank You