August 6, 2014

Alkali-Silica Reaction in concrete pavement

at Gimpo international Airport

a maintenance case using HMA overlays

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FAA Worldwide Airport Technology Transfer Conference

Korea Airports Corporation

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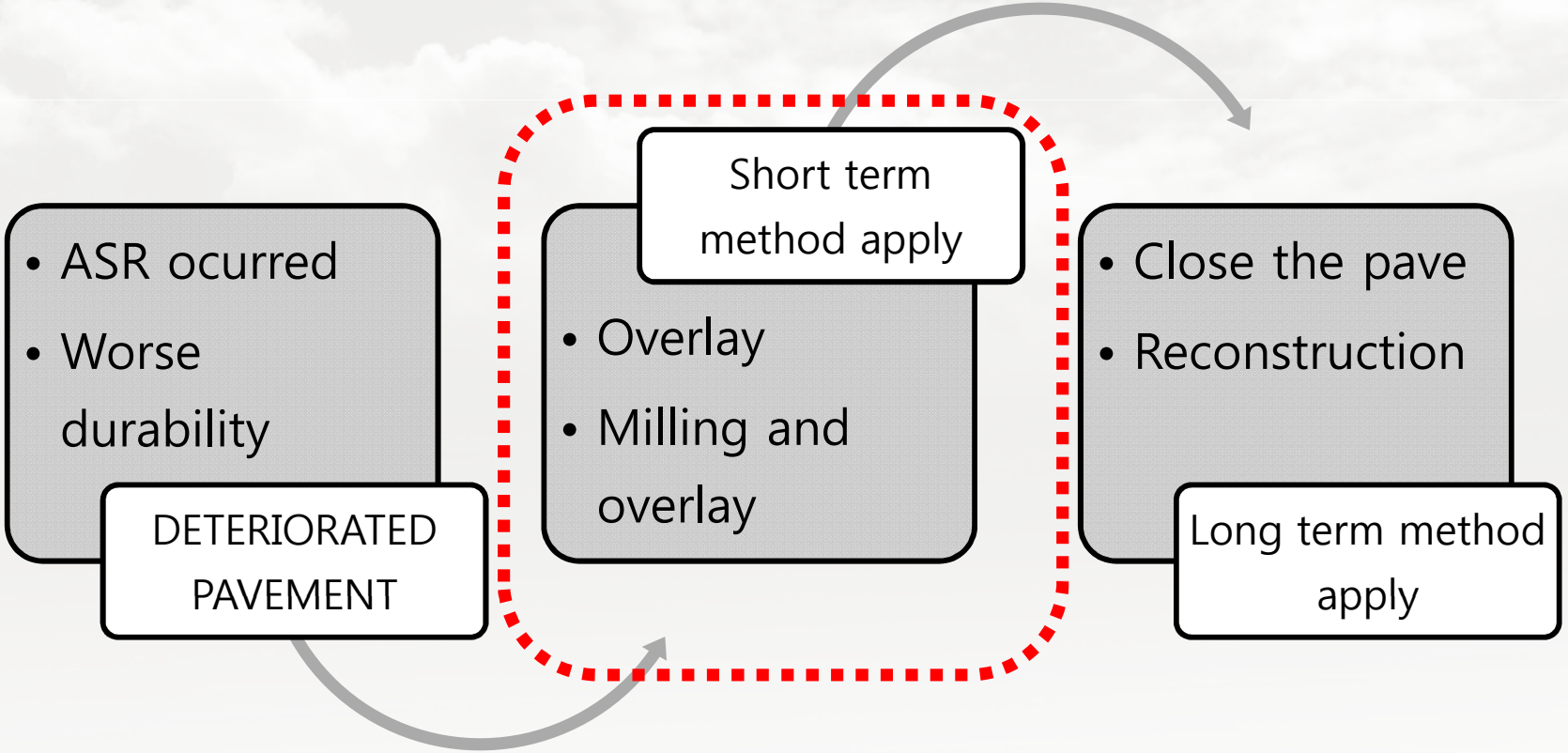
Research Overview

Research overview



- ASR concrete pavement needs to be replaced to maintain
- Greater demands for using maintenance repair types in contrast to complete replacement

Research overview

- **Evaluation of the pavement performance**

Pre-site survey(Surface defects, HWD test)

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Test construction

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Site survey(Surface defects, HWD test)

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Analysis of survey data and monitoring of pavement performance

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Evaluation of pavement performance

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Repair of test construction

Research overview

The site construction location

Construction year

☞ Runway threshold concrete pavement: operated for 13 years from 1996, Thickness = 40cm

☞ The end of Taxiway concrete pavement: operated for 14 years from 1995, Thickness=40cm

Research overview

Pavement condition

The entire map cracking

The longitudinal cracking

- The pavement required either reconstruction of entire pavement layer or repairs of the partial pavement layer
- The entire reconstruction was not feasible
- 4 different types of overlays were carried out to extend the pavement life

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The Site construction and material test

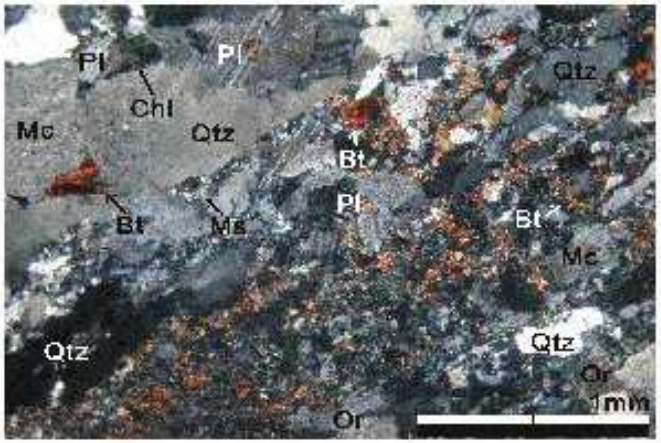
The Site Construction and Material Test

Result of indoor laboratory ASR testing

- Distress data collection throughout site investigation with the naked eye
- Lithological Aggregation analysis
- Investigation of the reaction product from extracted cores
- Microscope investigation inside pavement
- EDX(Energy Dispersive X-ray Spectroscopy) Analysis with reaction product

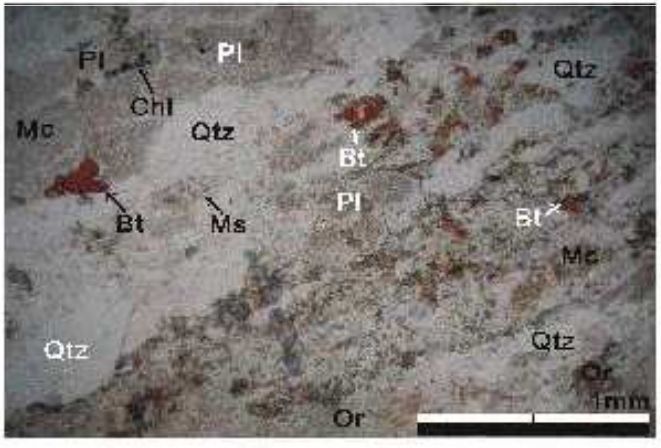
The Site Construction and Material Test

Result of indoor laboratory ASR testing



Cross nicol(40X)

Lithological analysis



Open nicol(40X)

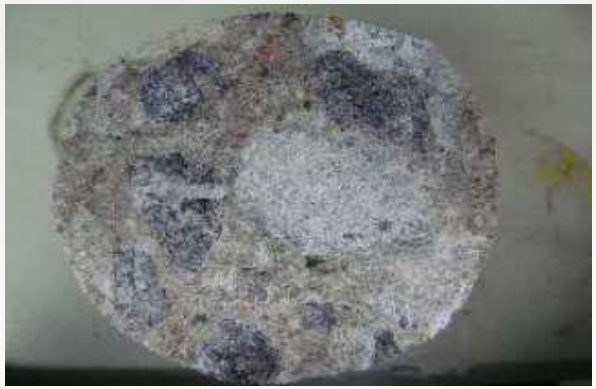
- Metamorphic rock such as quartz feldspar gneiss, banded gneiss and garnet biotite gneiss.
- Most of the quartz was fine-grained ~ neutrality-grained crystal of the subhedral or oval shape
- showing undulatory extinction and suture texture

The Site Construction and Material Test

- **Result of indoor laboratory ASR testing**

The surface condition

Parallel crack



Aggregate reaction product in the parallel crack area

The Site Construction and Material Test

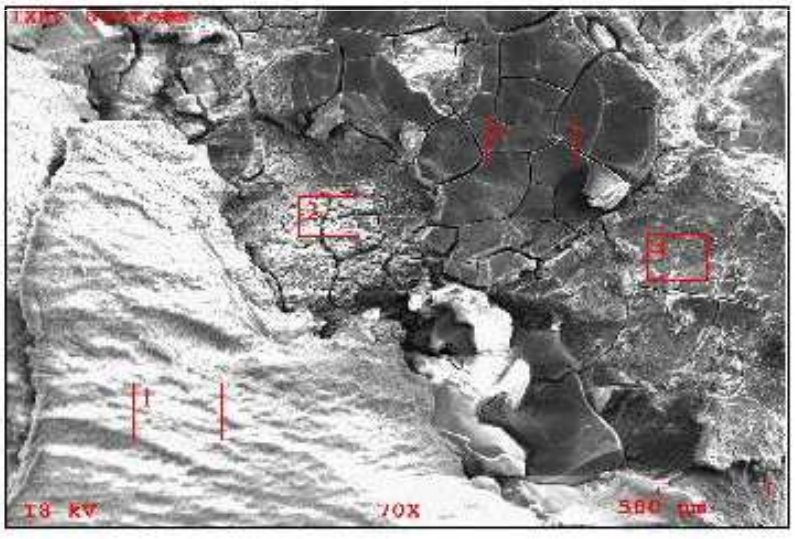
- **Phase-contrast microscope observation**


Reaction product within air-void(40X)

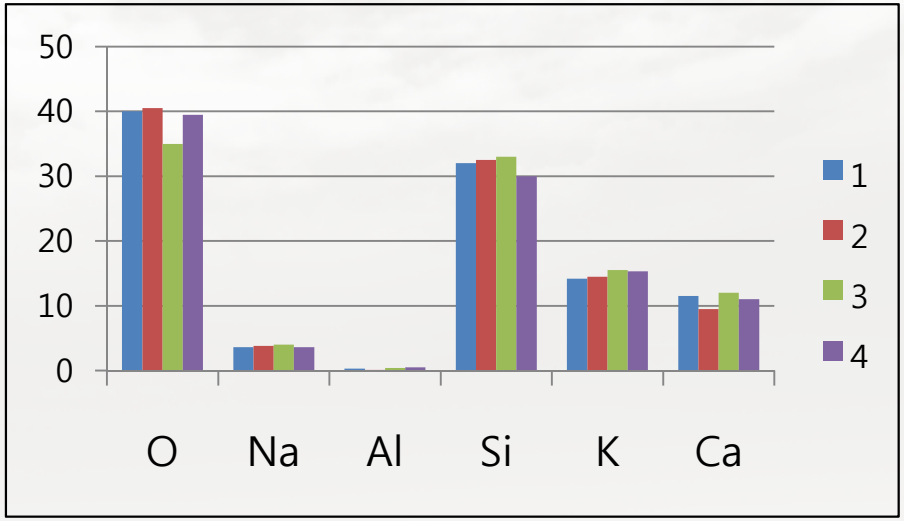

Aggregate reaction product within aggregate boundaries

The Site Construction and Material Test

Result of indoor laboratory ASR testing



The spectrum of white product in SEM Survey (70X)



The spectrum of white product

Product order

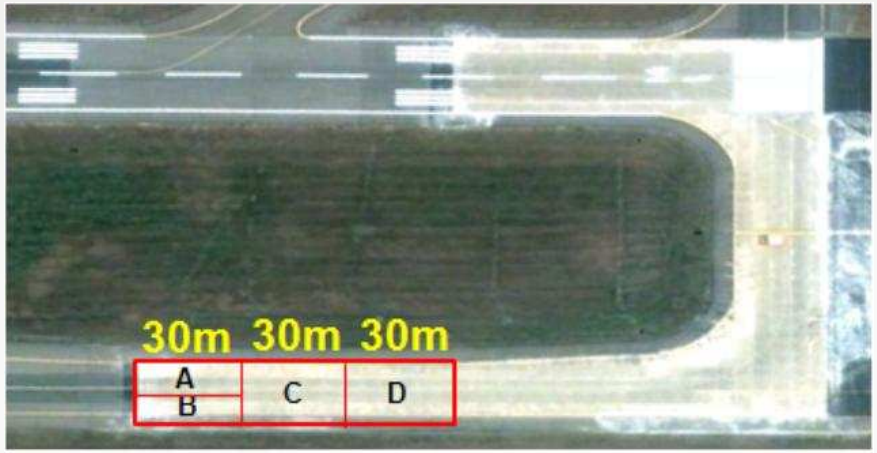
- Si > K > O > Ca

Site Construction and Material Test

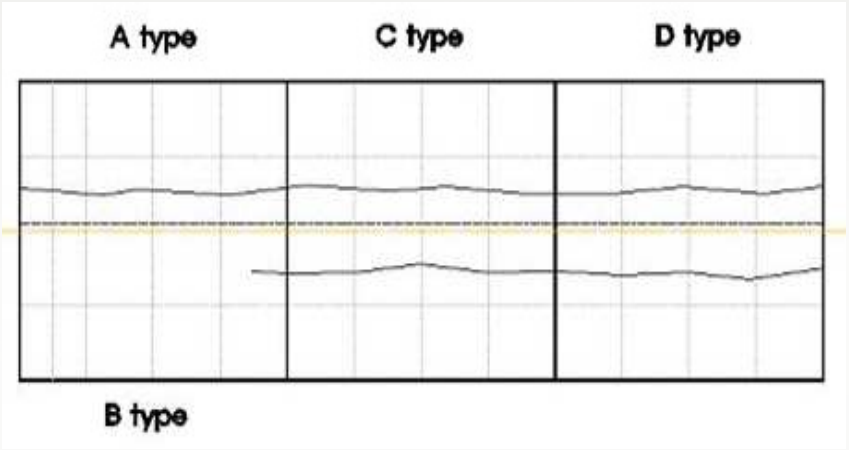
Considering of the construction

- The elevation differences between site construction and the connected existing taxiway pavement
- The surface of the concrete pavement weakened and was generating F.O.D
- Milling and overlays instead of overlays

Site size



Test construction site

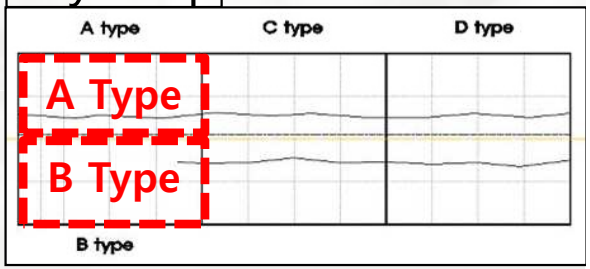


Longitudinal cracking

Site Construction and Material Test

- **Applied Each types of milling and overlays**

Key map

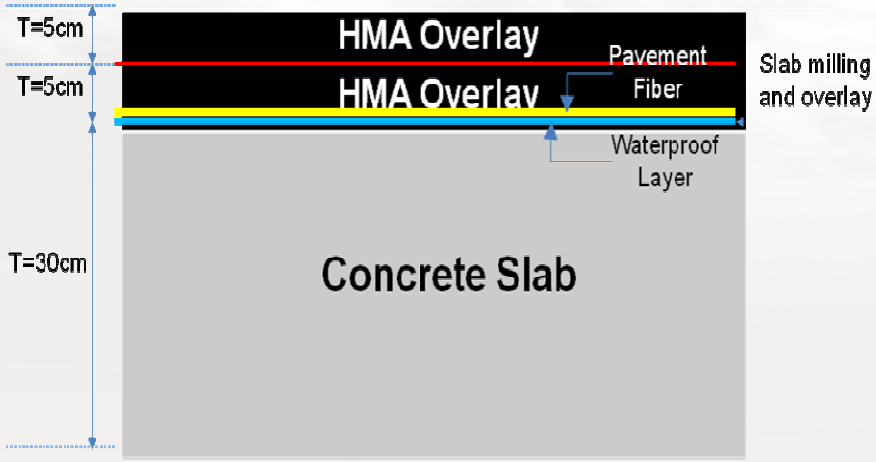


A Type Structure

B Type Structure

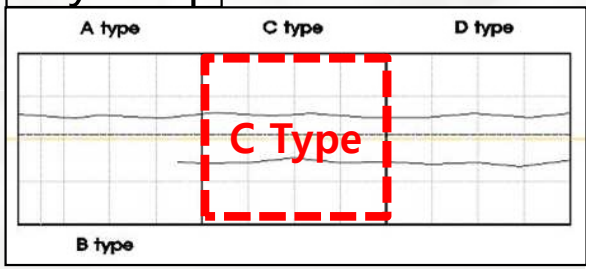
Site Construction and Material Test

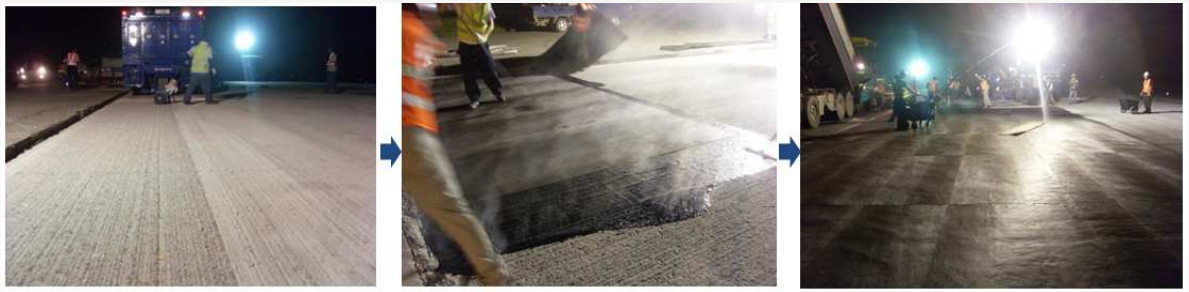
- **Applied Each types of milling and overlays**



C Type Structure

Key map



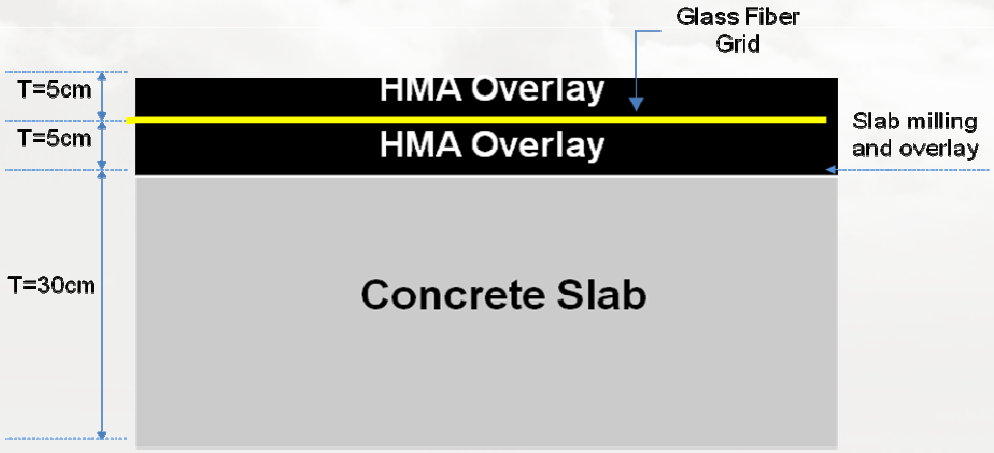


<Vacuum Cleaning> < Waterproof Layer > < Pavement Fiber layer>

C Type pavement construction process

Site Construction and Material Test

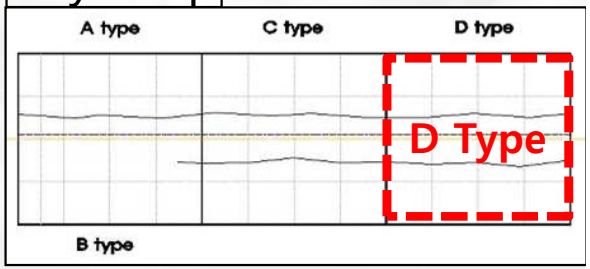
Applied Each types of milling and overlays



D Type Structure

D Type pavement construction process

Key map



Site Construction and Material Test

Design Criteria

Property	A-Type (HMA)	B-Type (CRM)	C-Type (HMA+Water proof layer)	D-Type (HMA+Glass fiber grid)
Air Void(%)	2.8~4.2	3.0~5.0	2.8~4.2	2.8~4.2
Theoretical Maximum Density(g/cm³)	2.44	2.53	2.49	2.48

Material property test result

Property	A-Type (HMA)	B-Type (CRM)	C-Type (HMA+Water proof layer)	D-Type (HMA+Glass fiber grid)
Air Void(%)	5.51	6.23	6.71	5.85
Density(g/cm³)	2.30	2.36	2.32	2.33

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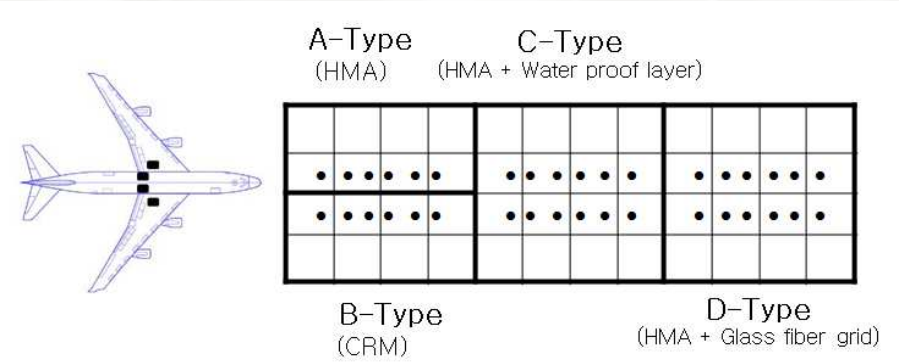
Monitoring results of performance

Monitoring results of performance

Load Transfer Efficiency Test



Test period

- Before the construction: 23rd July, 2010
- After the construction: 5th May, 201
- The time period of potholes occurring: 17th August, 2013

Monitoring results of performance

Acknowledgement of the Load Transfer Efficiency Test

- The joint reflection cracks develop
- Pavement temperature change affected
- Milling slabs weaken structurally

Load Transfer Efficiency Test

$$LTE(\%) = \frac{\Delta_{unload}}{\Delta_{load}} \times 100$$

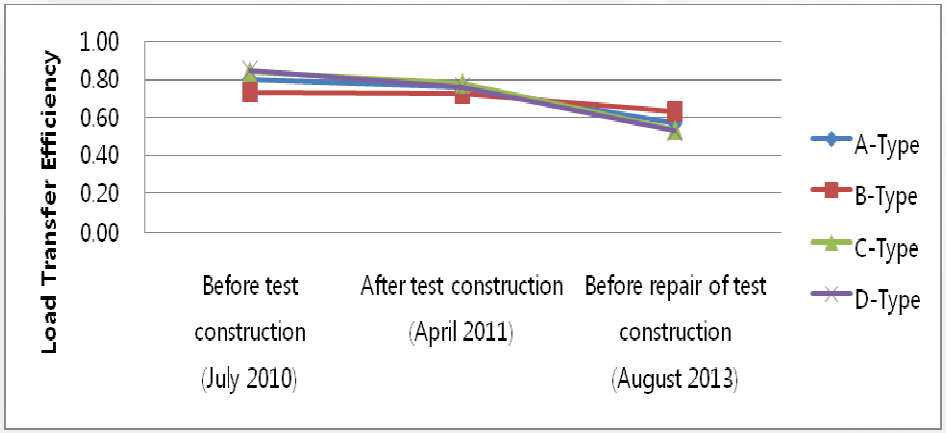
Δ_{unload} where, LTE : Deflection ration caused by load transfer, %

Δ_{load} : Deflection at the unloaded side of the slab joint

: Deflection at the loaded side of the slab joint

Monitoring results of performance

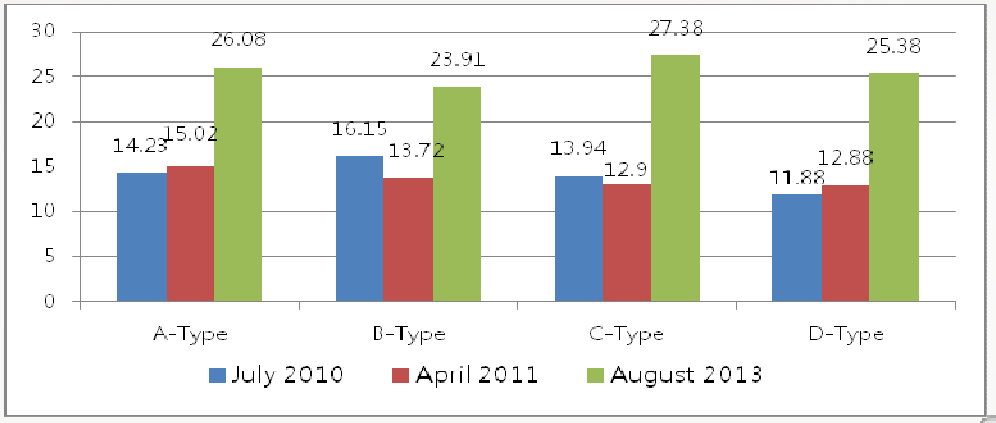
Decline of the load transfer efficiency



- decreased considerably in contrast to the before test construction
- The decline of B-Type was smaller than the other type

Do deflection data

- B-Type deflection was recorded the highest as 16.15 mils when measuring in April 2011
- The lowest as 23.91 mils when measuring in August 2013



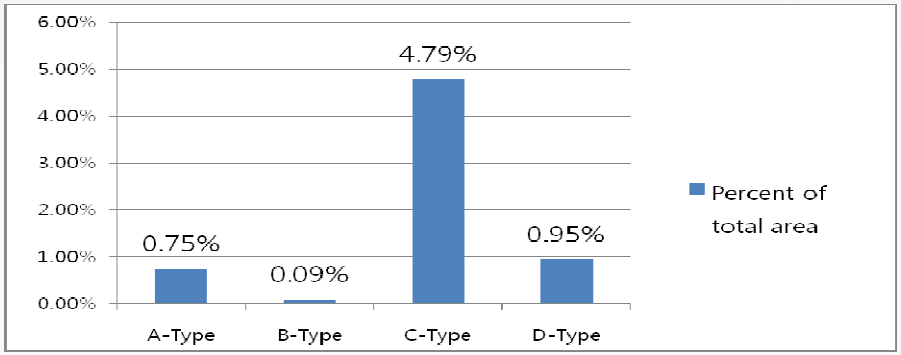
Monitoring results of performance

Partial repairs of the potholes area



Repair rate in the deteriorated section

- B-type was the lowest repair rate than the others
- B-type strong against rutting and fall slightly against top-down cracks



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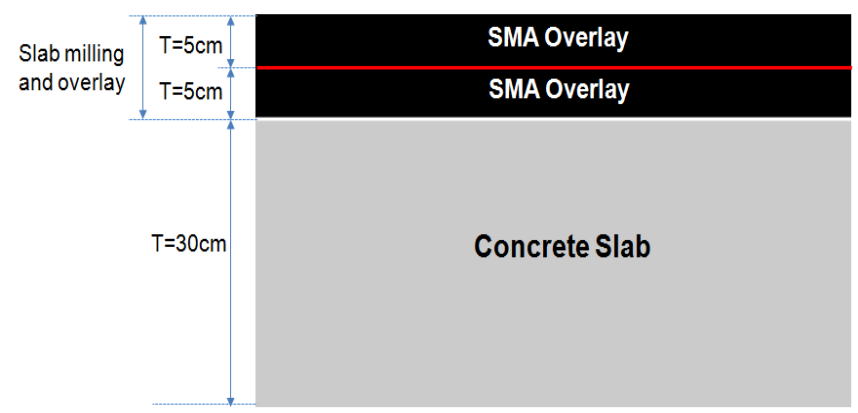
The Second Site Construction

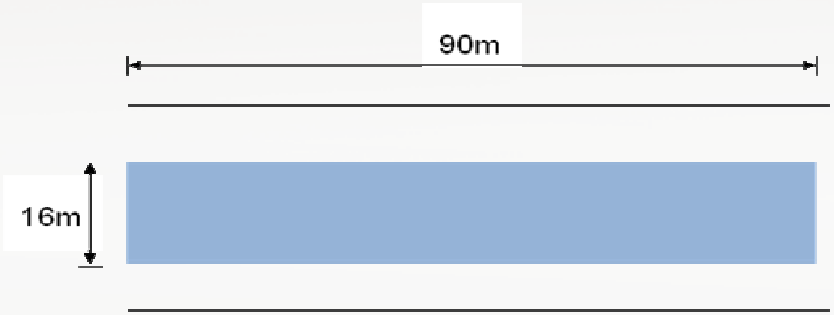
The Second Site Construction

Pavement structure



- The second overlay was each consisted of 13mm and 10mm maximum size of coarse aggregate
- Asphalt binder: SBS Polymer Modified Asphalt(PG76-22)

Pavement size



The Second Site Construction

Comparison of core sample with SMA and HMA

Material Test of the Second site construction

Air Void(%)	13mm	5.1~6.6
	10mm	3.3~3.8
Density(G/cm3)	13mm	2.33~2.36
	10mm	2.36~2.36
Maximum Theoretical Density(g/cm3)	13mm	2.496
	10mm	2.446
Asphalt content(%)		5.53

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Conclusions

Conclusions

- the deterioration of the structure damage due to ASR and existing longitudinal cracks accelerated the defects
- damaged slabs were deteriorated further as a result of milling of the slab
- To carry out overlay instead of milling and overlay are more effective except for elevation problem and surface distress.
- The discovery that the dowels were too high in the pavement may affect to deteriorate the pavement when the slabs were thinned

Conclusions

- There is a limit for HMA overlay to protect rainfall infiltration from the concrete pavement
- Milling and overlay on the impermeable concrete slab will make the occurrence of premature defects
- The management of the air voids in the overlay right after construction is important factor
- It needs to study further so that we define an exact boundary or range of the air voids that result in suitable performance