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Mendoza - Argentina

Practice on the Active De-icing pavement in China

Yiqiu Tan
Harbin Institute of Technology

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Content

- Introduction
- Problems and Challenges
- Active de-icing pavement

  Rubber particles Pavement

  Energy conversion pavement

  Low freezing point asphalt pavement

  De-icing sand seal for asphalt pavement

Introduction

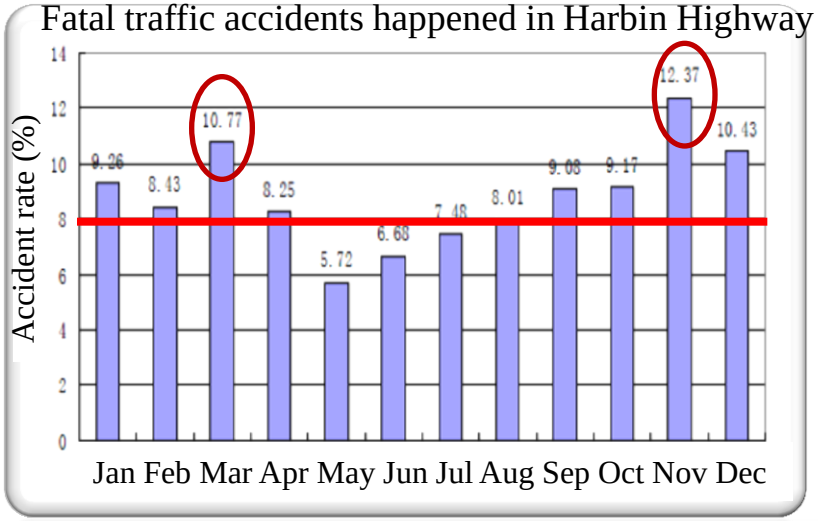
❖ Road—The important component of infrastructures

- Bottom boundary of urban landscape
- Important carrier of logistics
- Social service function

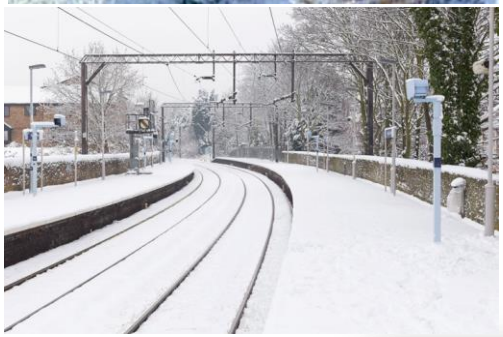
Provide a fast and safe transportation

Introduction

- **Icy pavement influences the efficient, fast and safe transportation**



Airport



Railway

Introduction

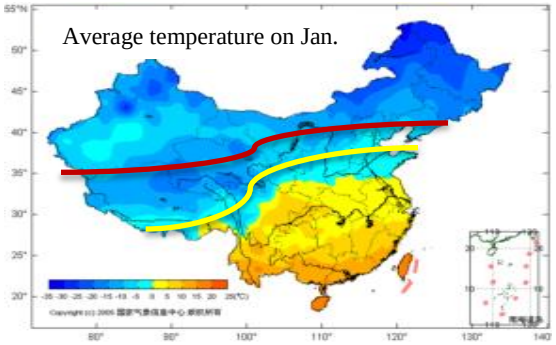
❖ Special road section is the traffic choke point in winter

- Tunnel Entrance
- Large longitudinal slope bridge approach
- road intersection

Introduction

❖ Icy pavement has a wide influence range in China

- In China, most regions (85% national territorial area) are located in middle, high latitudes and high altitudes
- The environmental temperature is low and the region effected by snow or ice is extensive
- snowfall conditions are complicated



Snowfall area is extensive.

The northern ice and snow

The southern freezing rain

Problems and challenges

❖ Conventional de-icing technology have some problems

Hazardness

Shortcomings

- ice in texture is difficult to clean
- Ice-pavement bond tightly.
- Have effect on skip
- Pavement is passive

Manual methods

Mechanical methods

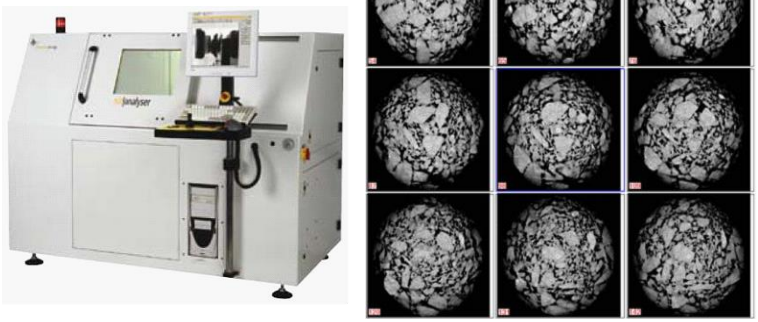
Snow-melting Agent

Anti-icing technology

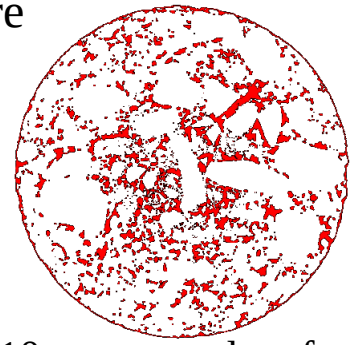
Problems and challenges

❖ Voids in the surface result in bonding between ice-pavemt

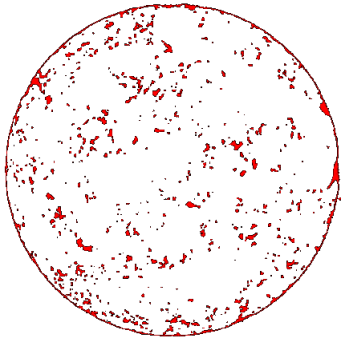
- Voids within 20mm to the road surface are large and connected
- Anti freeze-thaw property is awful
- Ice adhesion to pavement surface tightly



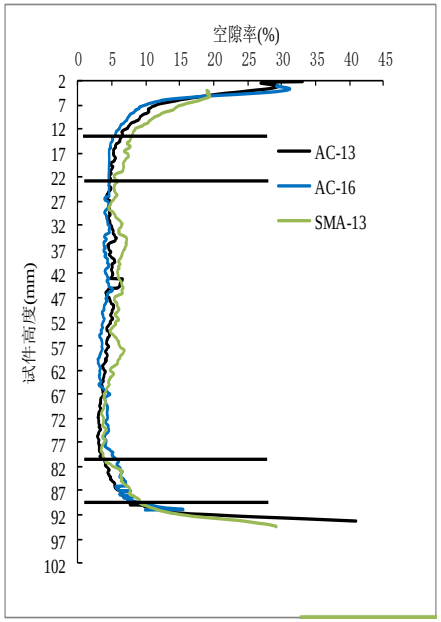
Computer tomography scan by industrial CT



10mm to road surface



50mm to road surface



Distribution of air voids along thickness direction

Challenge： Actively prevent the bond between ice and pavement by improving the pavement surface performance

Part 1

Rubber particles pavement(RPP)

——improve the physical and mechanical properties of asphalt pavement surface

- **Work mechanism**
- **Material design**
- **Anti-ice performance**
- **Application cases**

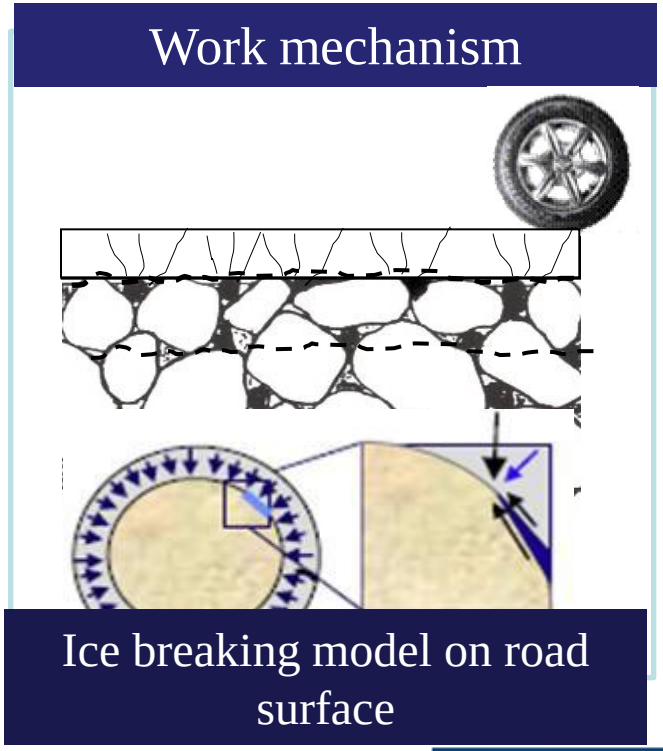
Rubber particles pavement

RPP: The crumb rubber was added to the asphalt mixture to replace some aggregates, or adhesion to the surface of pavement as the chip seal

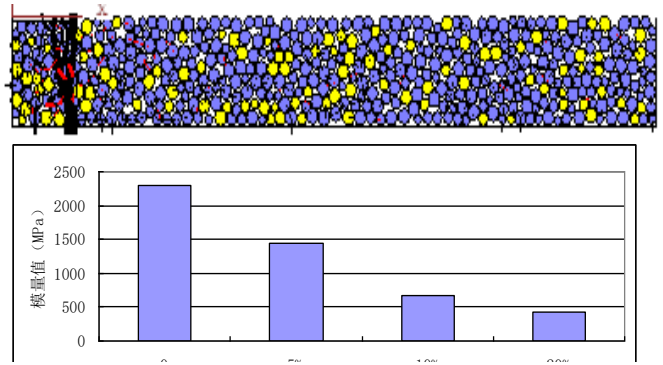
Rubber particles

Work mechanism

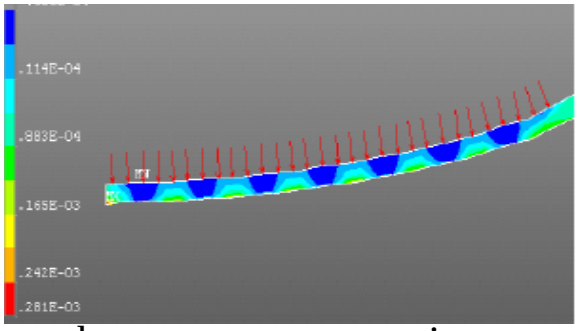
- The elastic deformation of rubber asphalt mixture is improved
- The rubber particles make intensity of the ice film on pavement surface uneven
- big difference on stiffness between rubber and aggregate, make the ice film broken under loading



Ice breaking model on road surface



Discrete element model（DEM) results

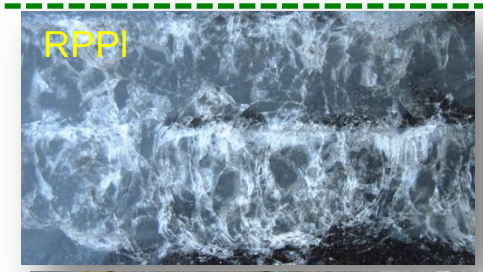


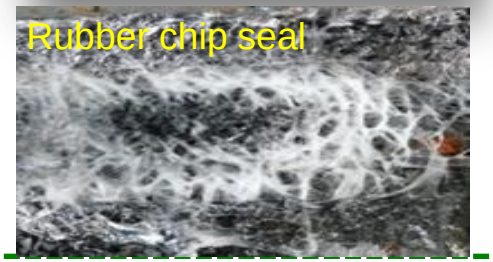
shear tress concentration

De-icing performance

- Rubber particles reduces the adhesion between ice and pavement

De-icing ability



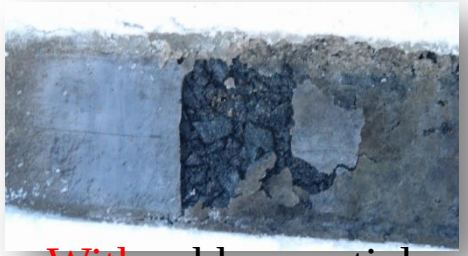


Comon pavement

With rubber particles Without rubber particles

The de-icing ability of RPP is the efficient within -10°C, the ice layer is less than 1cm

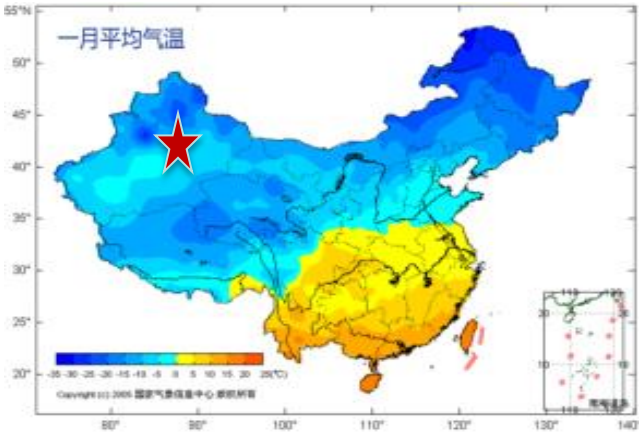
Anti-snow compaction



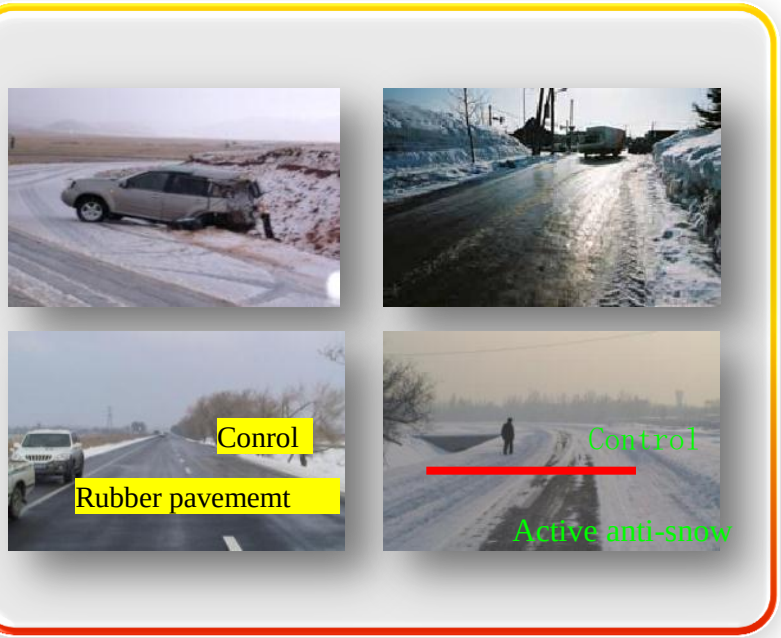
With rubber particles Without rubber particles

Application cases

- RPP in Xinjiang——The first active anti-ice pavement using paving materials (In 2003, 7.8km)



	Active anti-snow	Control
De-icing ratio	62	23
Friction coefficient	59	32



The de-icing ratio is up to 62%. The friction coefficient increased by 84%. The driving safety was improved.

Application cases

RPP

the snow on road was loose.

No ice film on the surface

Common pavement

the snow compacted to road tightly

Ice film

Part 2

Energy conversion pavement(ECP)

——improve the temperature in pavement by heat flow

- Work mechanism
- Simulation analysis
- Operation strategy and design method
- Application Case

Work mechanism

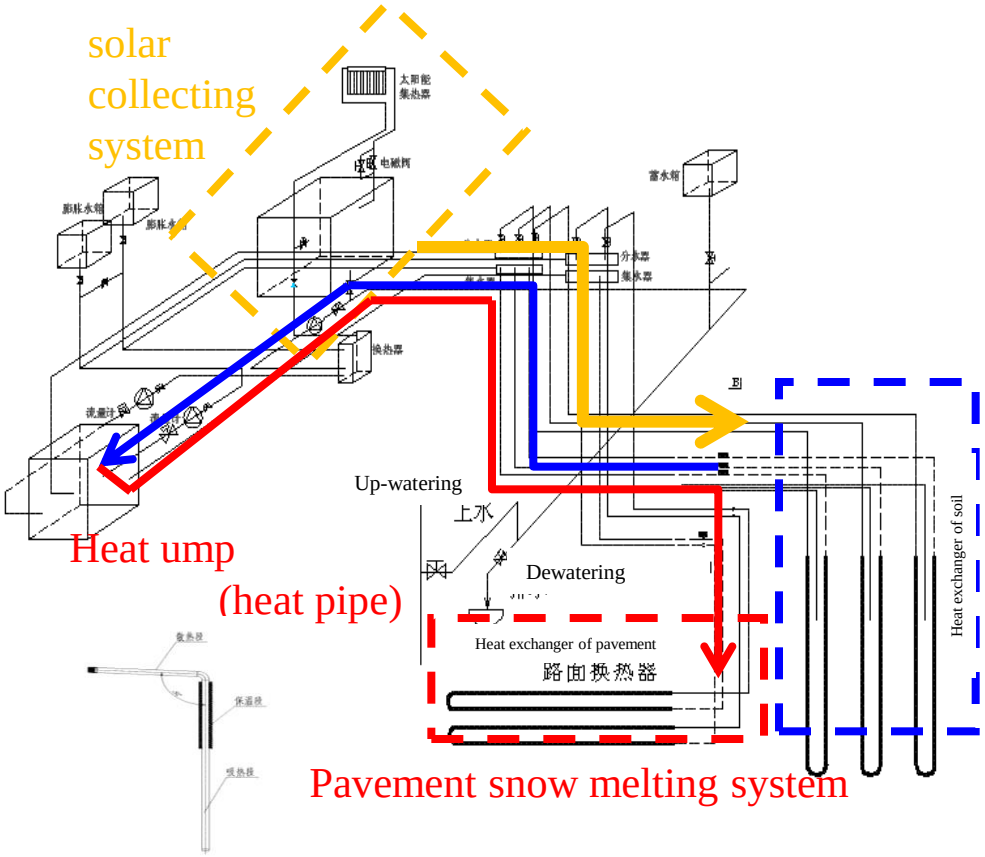
Energy transfer：heat pump、heat pipe technology (soil-pavement)

Purpose

Solar heat collecting system

Soil

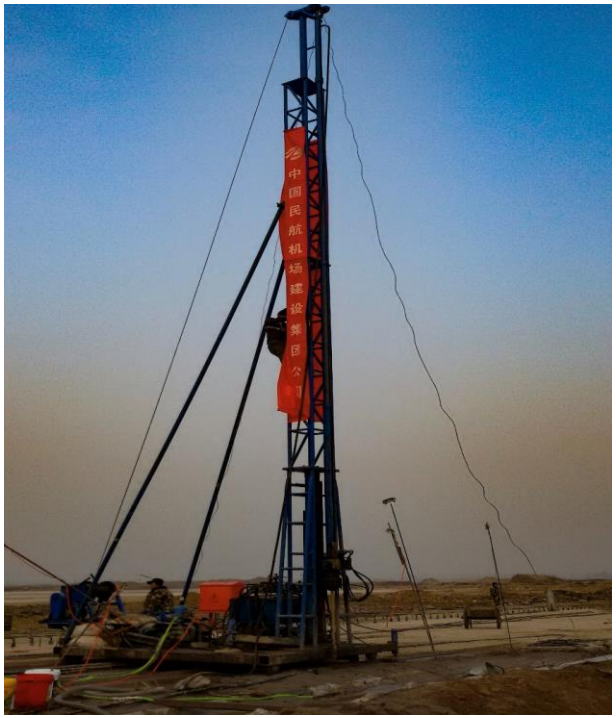
Pavement snow-melting system



ECP Used in bridge deck Heilongjiang in 2010

Application cases

Construction processure of ECP on the airport runway

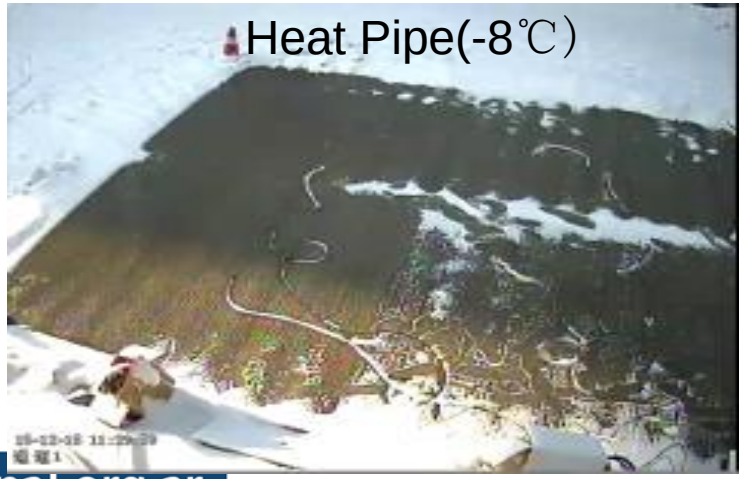


Punching

Application cases

- **ECP was used in the station site of new capital airport (under construction)in 2016**

Heat pump



Part 3

Low freezing point pavement(LFPP)

——change the adhesion between pavement and ice layer

- **Materials development**
- **Performance evaluation**
- **Application cases**

LFPF materials development

Low freezing point pavement(LFPP)

Using low freezing point fillers(LFPF) to replace mineral fillers in the asphalt mixture for pavement

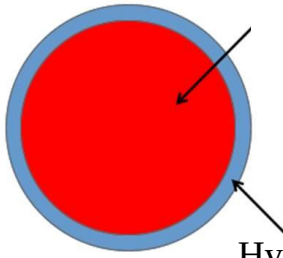
- **According to the snowfall features of different areas in China, two kinds of LFPF were selected.**

- ✓ Snowfall temperature range：-4℃~-23℃
- ✓ Snowfall frequency：1~34 times/year

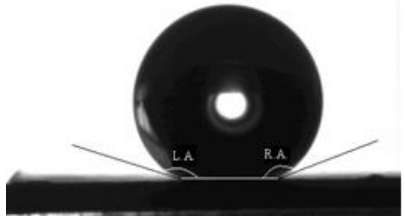
Low freezing point agents	Freezing point (℃)
A (inorganic)	-10
B (inorganic)	-20
C (organic)	-15
D (organic)	-25
F (organic)	-20

Low freezing point fillers(LFPF)

- **Using hydrophobic agent to construct the core-shell structure.**



Core-shell structure schematic diagram

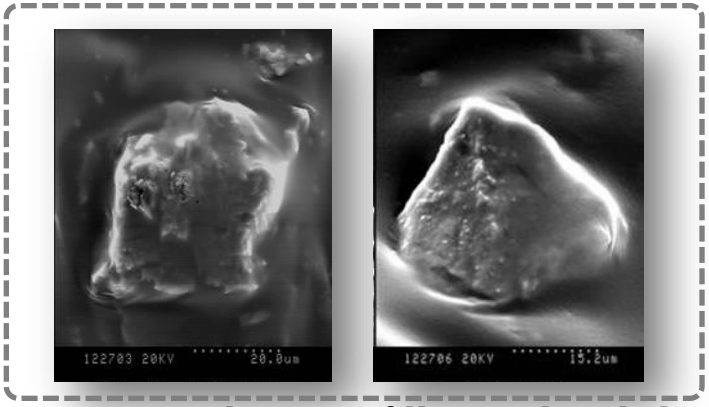


Hydrophobic effect

LFPF materials development

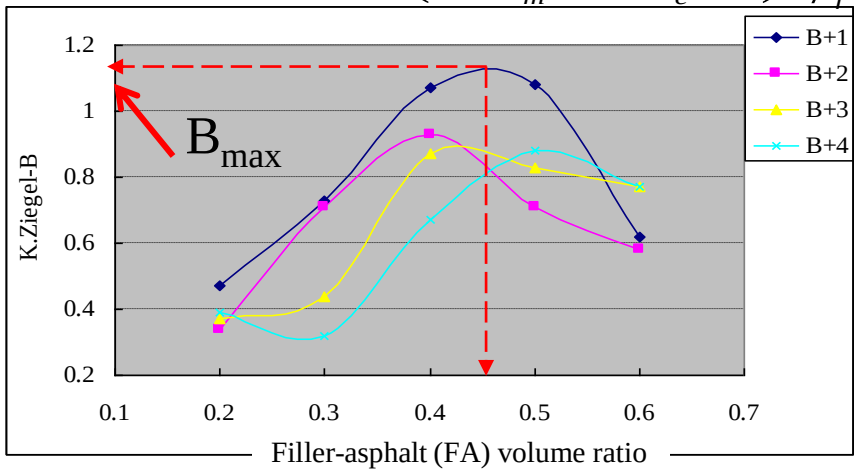
Asphalt mixture with LFPF

- Feasibility of replacing the mineral fillers



Interaction between fillers and asphalt

$$B = (\tan\delta_m / \tan\delta_c - 1) / \phi_f$$



Performance of mixture with LFPF compared with the control mixture

Content of low freezing point fillers	High temperature performance	Low temperature performance			Moisture resistance
	Time/mm	P_B(kN)	(με)	S_B(MPa)	TSR(%)
0	1860	999.9	2365.3	3354.2	80.12
LFPF	1964	1131.1	2426.4	3680.9	79.58

Performance evaluation

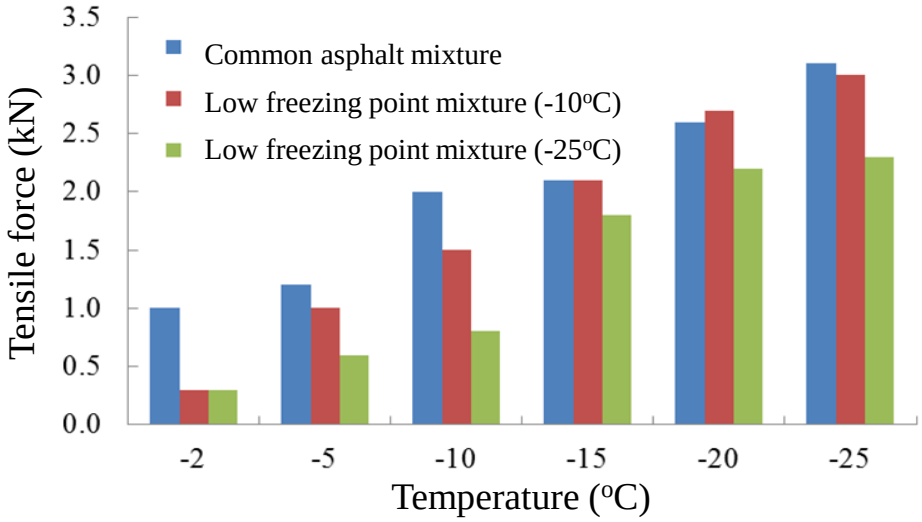
LFPF mixture can reduce the adhesion between ice-pavement

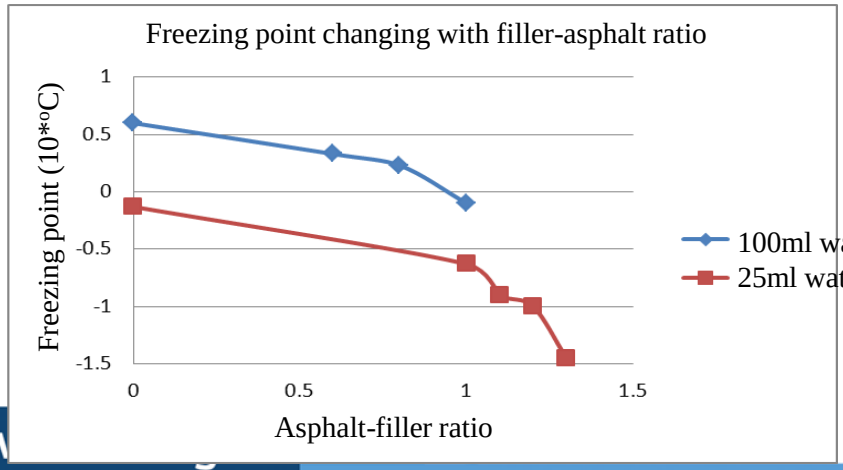
LFPF mixture
No adhesion

Common mixture:
Good adhesion

The device evaluating the adhesion property between ice and asphalt mixture

The effective temperature can reach -25℃

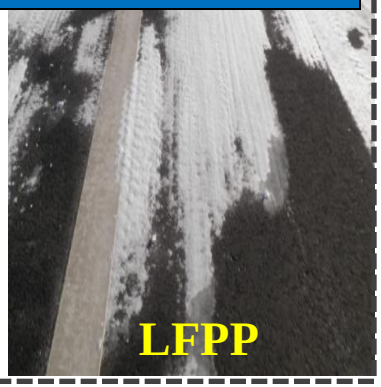




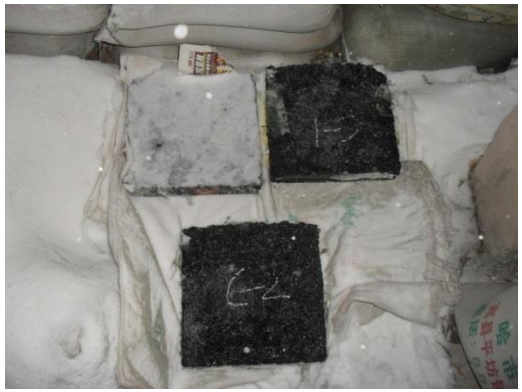
Application cases

- DaGuang Exp.Highway（2010）
- 108 National highway, Beijing section reconstruction（2013）
- Yantai in Shandong Province（2013，2014）
- The ring Exp. way in Harbin (2015）

Snow-melting performance



Durability



Application cases

Harbin, 2015

Part 4

de-icing sand seal for asphalt pavement

——decrease the bond between ice and pavement for in-service road

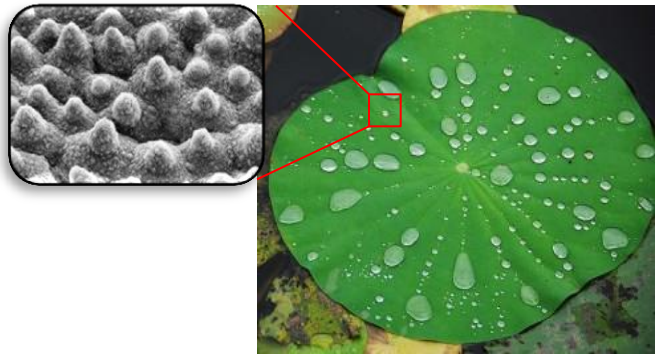
- Working mechanism
- Materials development
- Performance evaluation
- Application

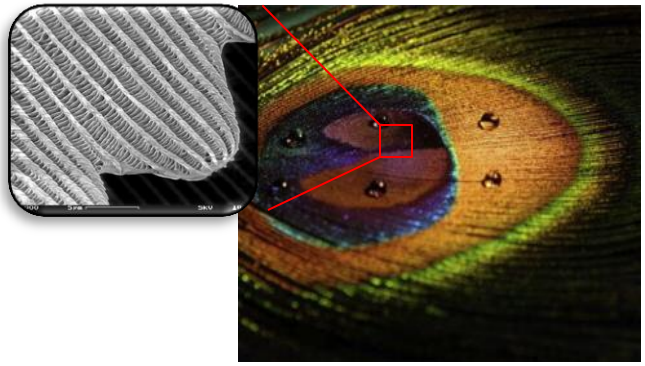
Working mechanism

Hydrophobic surface + LFPF

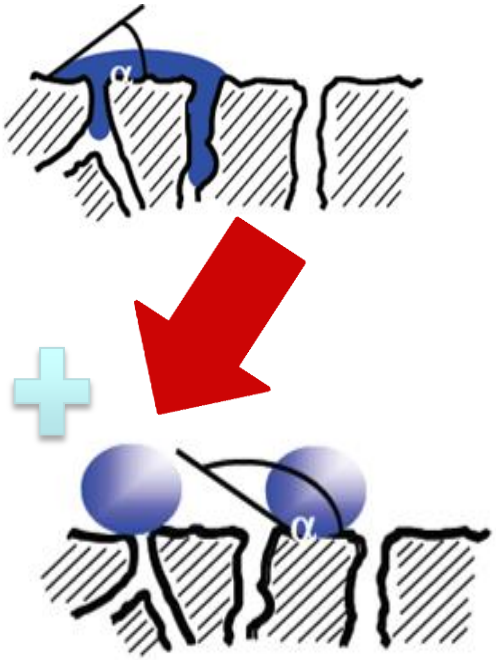
Hydrophobic：Decreasing the surface free energy

LFPF：prevent icing





Hydrophobic of Lotus and feather

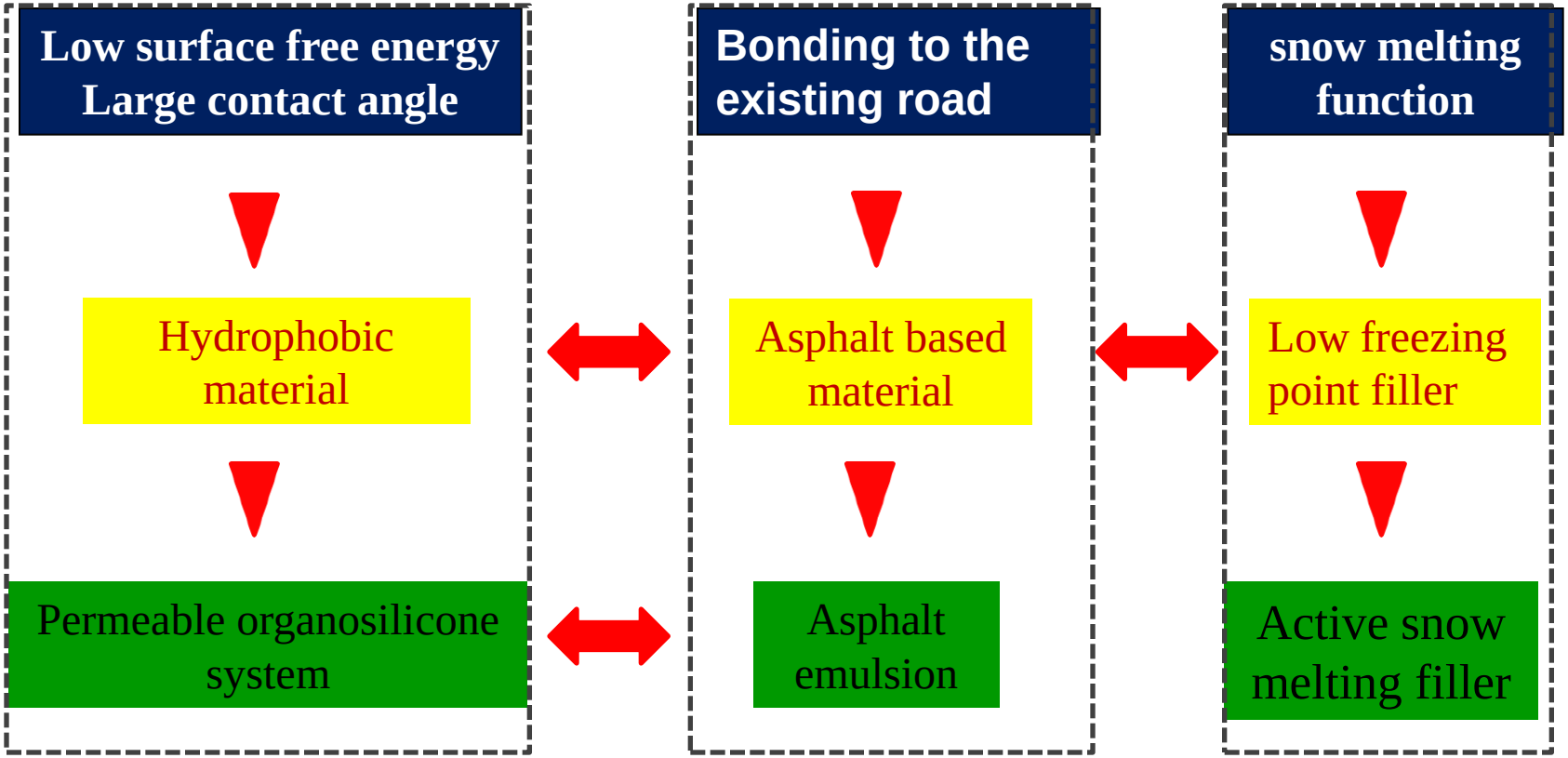


Objectives

- **Improve the hydrophobic characteristic on pavement surface**
- **Reduce the freezing point**
- **Improve infiltration capacity**

Development of Prevention materials

Consist of Materials



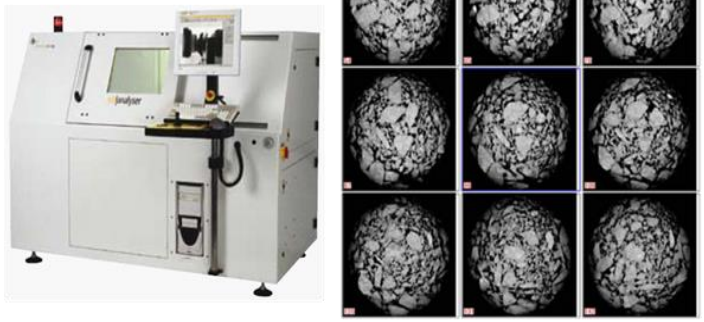
Development of protective materials

Hydrophobic material

Common asphalt mixture

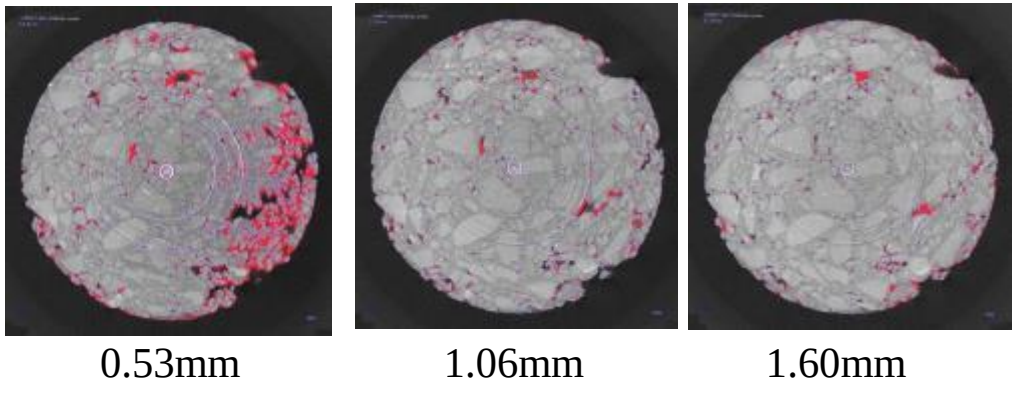
Performance evaluation

- **Penetration**



Computer tomography scan by industrial CT

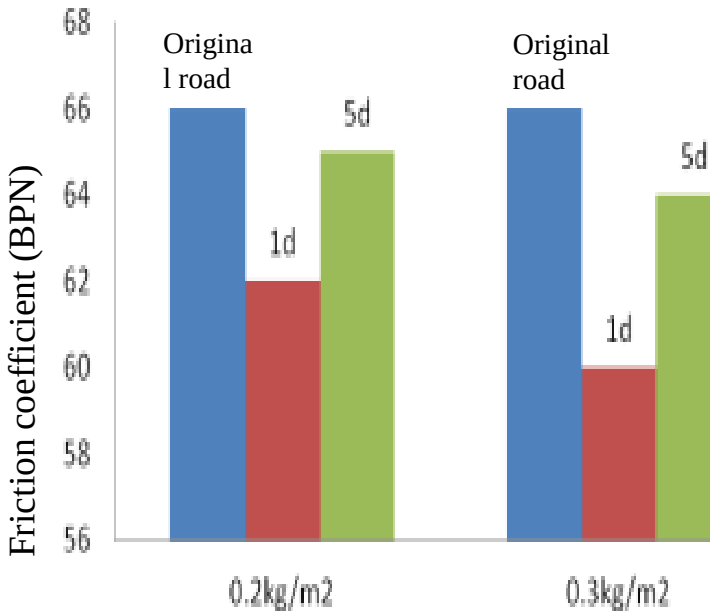
Penetration depth>3mm



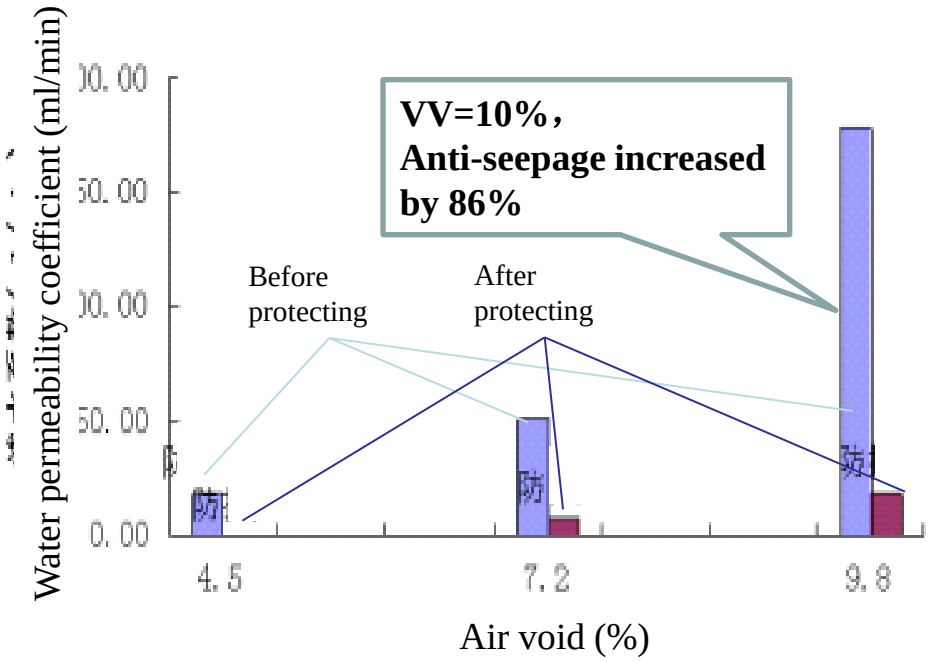
Cross-section diagram of protective material Penetration

Performance evaluation

Skid resistance and anti-seepage performance



Skid resistance—BPN



Air void—anti-seepage performance

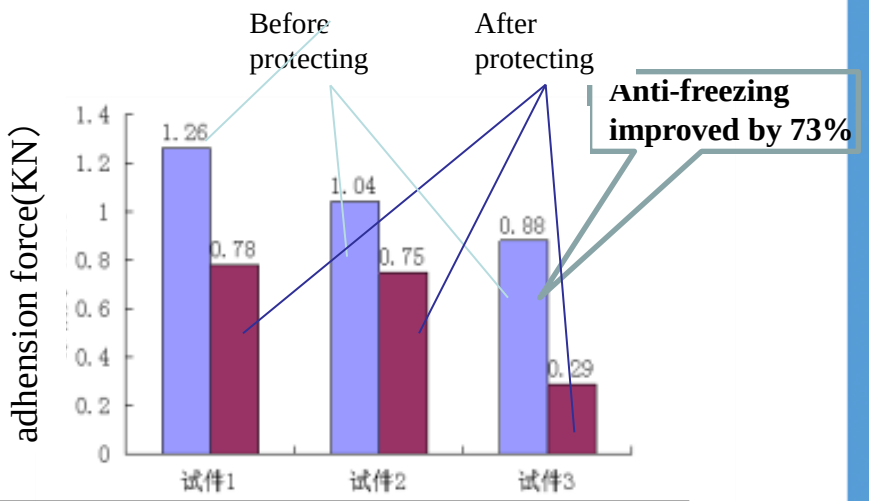
Performance evaluation

Anti-icing performance

The adhesive force tester

Conmmon pavement

Protected pavement



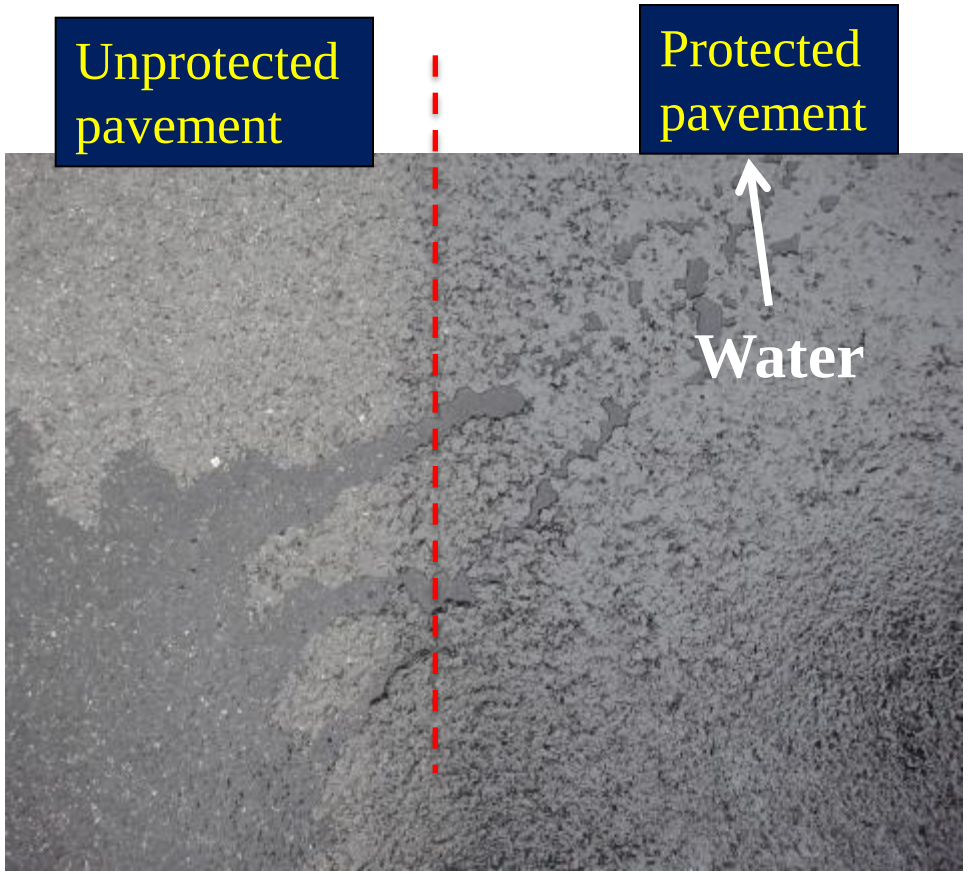
Anti-freezing performance was improved. The adhesion force between ice and pavement was effectively decreased.

Performance evaluation

- Surface hydrophobic characteristic

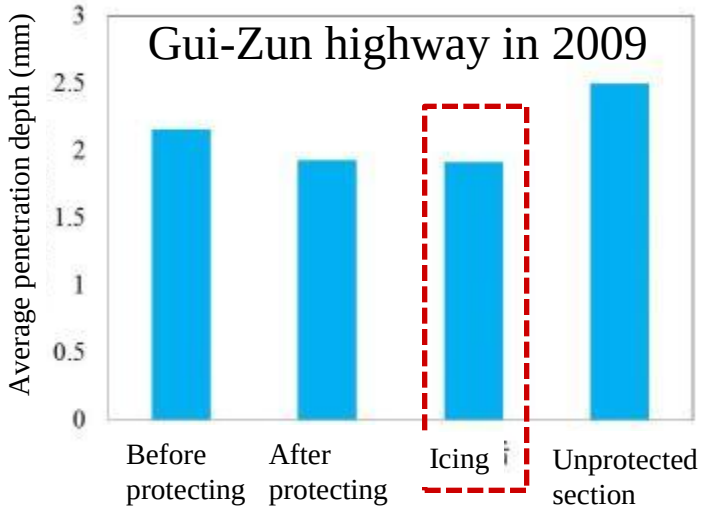
LFSG

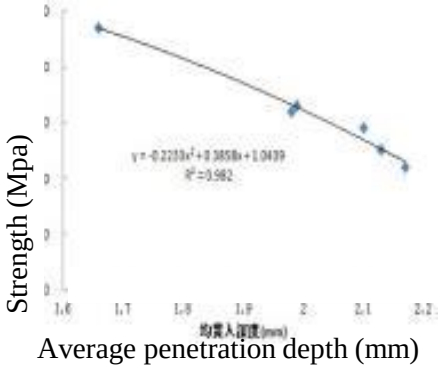
Unprotected pavement

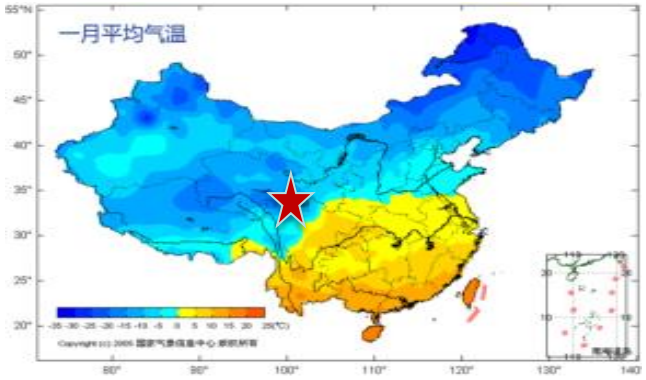


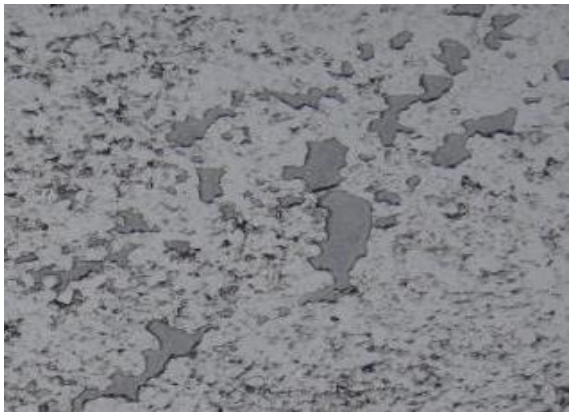
Application cases

Hydrophobe low freezing point protective technology



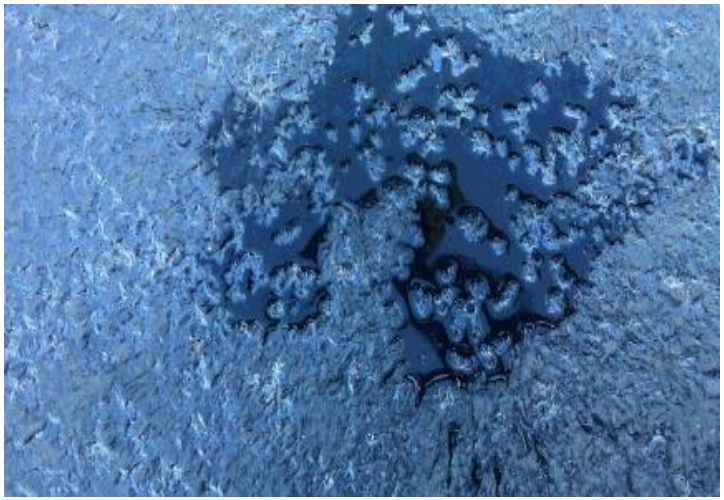






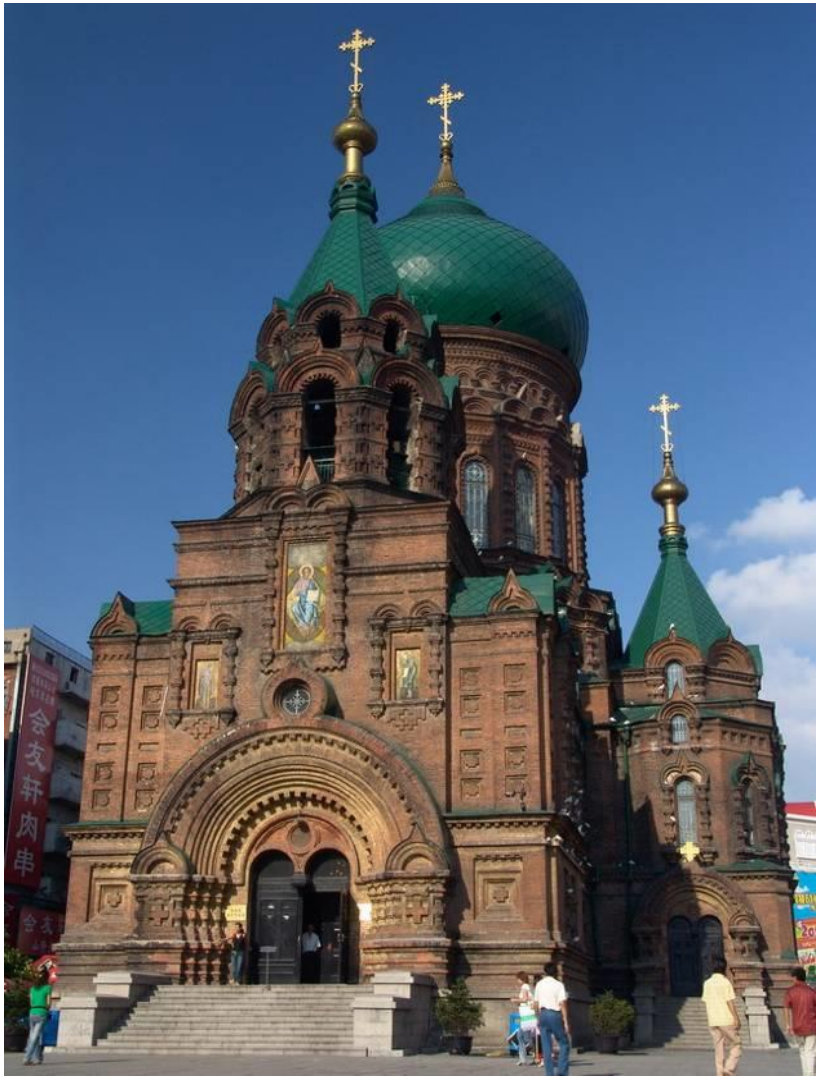
Hydrophobe effect

Application cases



Application cases

Harbin City




北岛观景

Yiqiu Tan

Tel：+86 13904637262

+86 0451-86283090

Email：yiqiutan@163.com