China Experience of Implementation and Development of Superpave in China

CAO Rongji, Ph.D

Chief Engineer, JSTI Group.

Director，National Laboratory for Advanced Road Materials

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1. Introduction
2. What we have learnt
3. Typical Superpave projects
4. Summary

1. Introduction

- **SHRP (STRATEGIC HIGHWAY RESEARCH PROGRAM)**

  - **1987-1993, $150 million, conducted by FHWA and TRB**
  - **The goal of the SHRP asphalt research was the development of a system that would relate the material characteristics to pavement performance.**
  - **The final product of the SHRP asphalt program is *Superpave*.**

Superior Performing Asphalt Pavements

- **Asphalt binder specification**
- **Aggregate tests and specifications**
- **HMA design and analysis system**
- **Computer software**

1. Introduction

Prof. Jia Yu

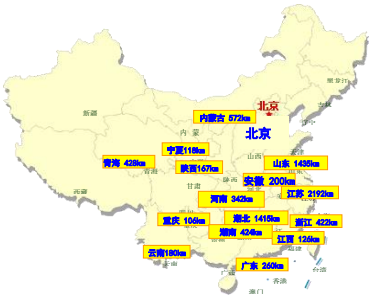
- **History of Superpave in China**

Technology introduction — 1995

The first trial Road — 2000

Large scale application — 2005

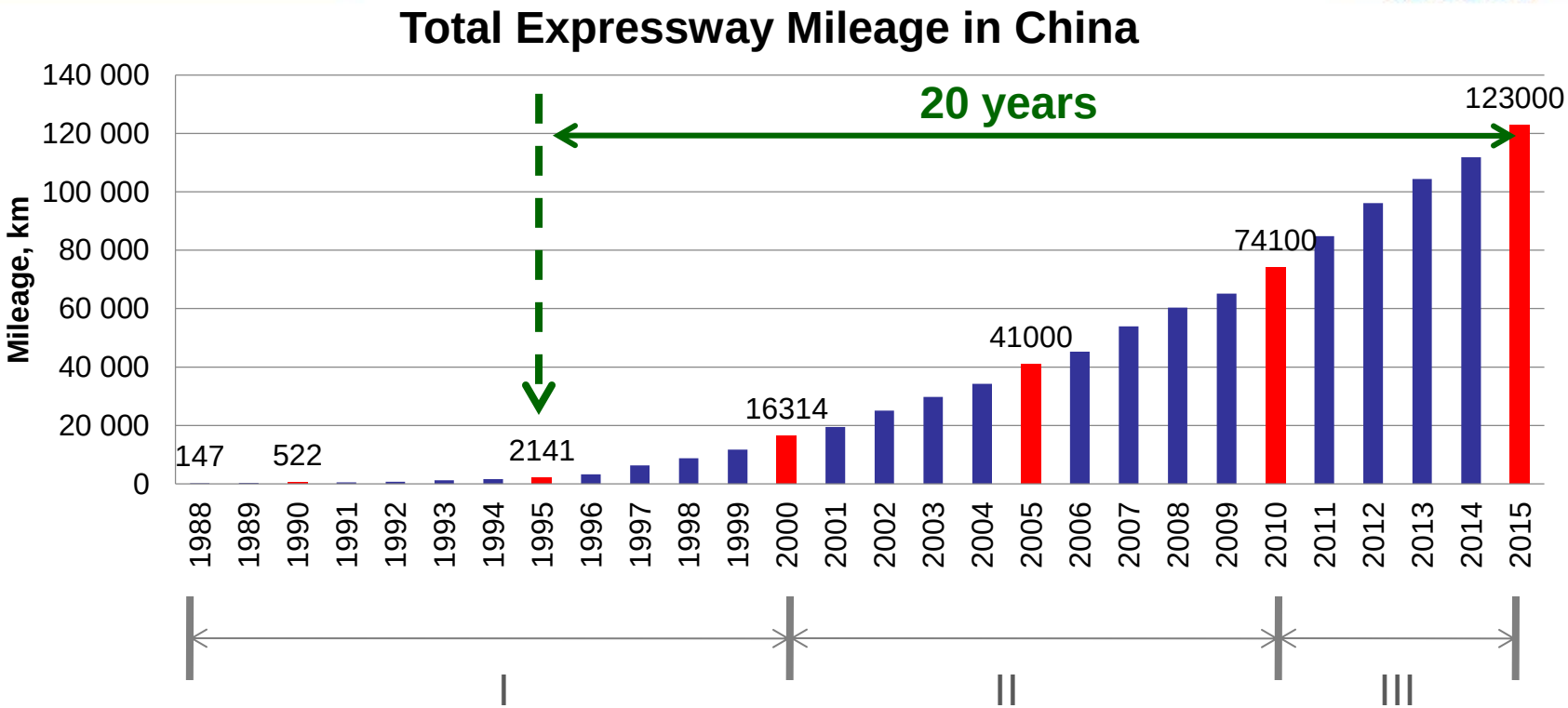
Innovation — 2010



National Expressway Network

“7918” project, Total 85 000km

1. Introduction



Pavement Premature Failure
(moisture, rutting)

QC/QA
Durability

Safety
Environment-friendly
Long life pavement

1. Introcudtion

- **The first Superpave test road in Jiangsu**
  - **2000, Yinbin Road, Huaian, 7km**
    - **Sup-13 in surface course**
    - **Sup-20 in Binder course**

First Superpave test road,(2000)

Map of Yingbin road

1. Introduction

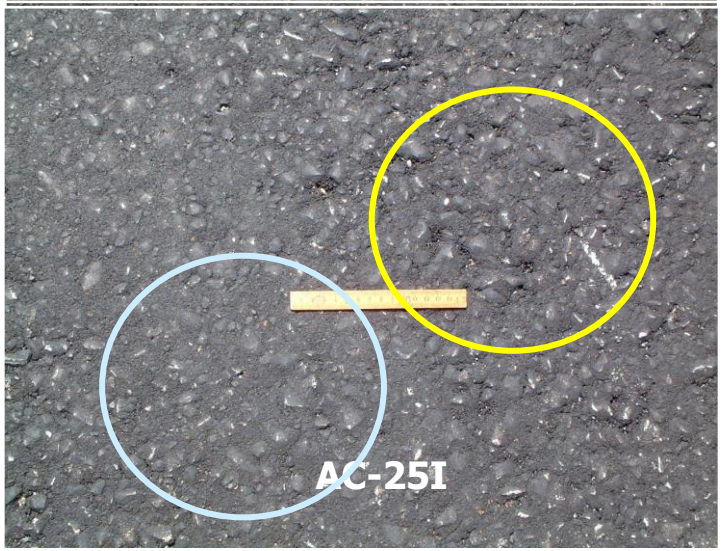
- **The first Superpave test road in Expressway, Jiangsu**
  - **2001, Expressway G30, 6km, Xuzhou**
  - **Sup-20 in binder course**
  - **Sup-25 in base course**

Prof. Lin Xiuxian in Lianxu Expressway (2001)

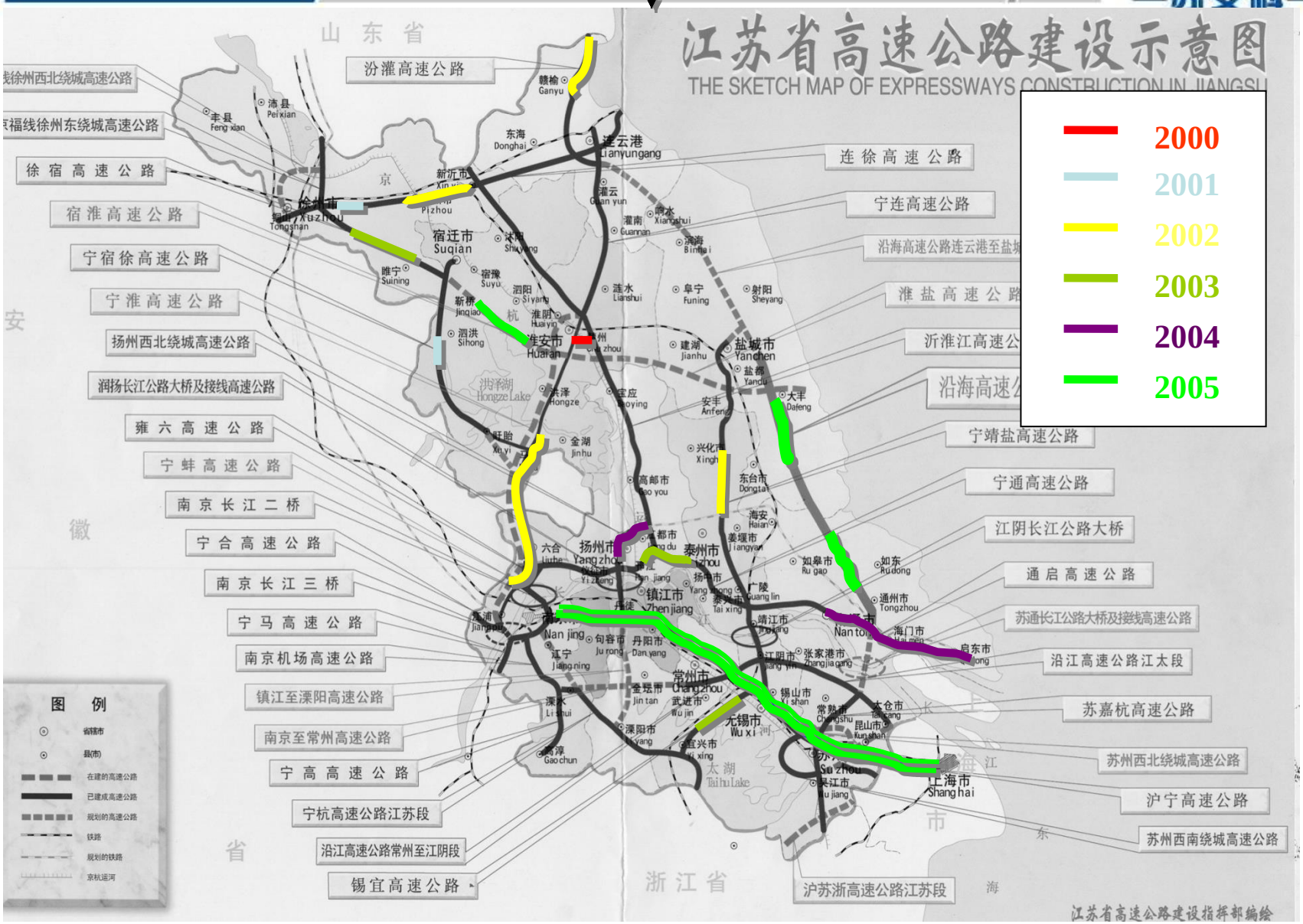
Superpave siminar in Lianxu Expressway(2001)

Superpave Mix

- Advantages
  - Good rutting resistance
  - Pavement texture uniform
  - Almost the same cost as conventional mixture
- Disadvantages
  - Change minds
  - New test equipments needed
  - Compaction /Permeable
  - Lack of performance tests



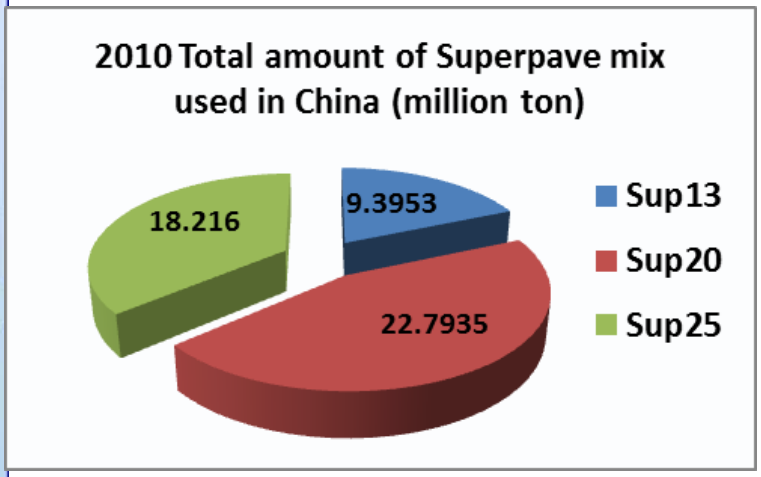
1. Introduction



1. Introduction

- **Application of Superpave technology in China**

18 Provinces, over 10000km



1. Introduction

Gerry Huber
(Heritage Research Group)

John D'Angelo (FHWA)

Suzanne Logan (KOCH)

Ray Bonaquist (AAT)

1. Introduction

- **Specification**
  - Metrological Verification Regulation of SGC，JJG087-2008
  - Standard Specification for Construction of Jiangsu Province Expressway Asphalt Pavements DB32/T1246—2008
  - Industry Standard of Gyratory Compactor, JT/T724-2008
  - Standard Specification for Superpave Construction in Shandong，DB 37/T 1722-2010
  - Standard Specification for Superpave Construction in Jiangsu, DB/T1087-2015
  - Standard Specification for Construction of Chongqing Expressway Asphalt Pavements CQJTG/T A01-2015
- **Publication**
  - Superpave Technology Guideline , 2003
  - Superpave Fundamental Reference manual, 2005
- **Equipments**
  - >250 SGC
  - >40 sets of Binder equipments

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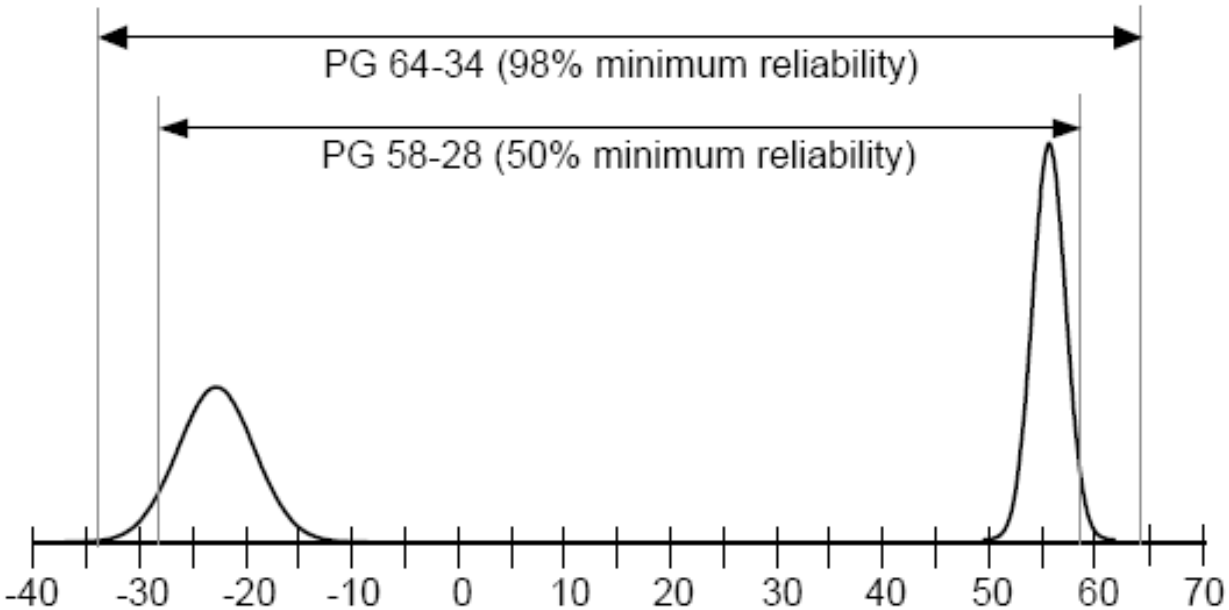
2. What we have learnt from Superpave

- Asphalt Binder
- Mix Design
- Performance tests
- Construction

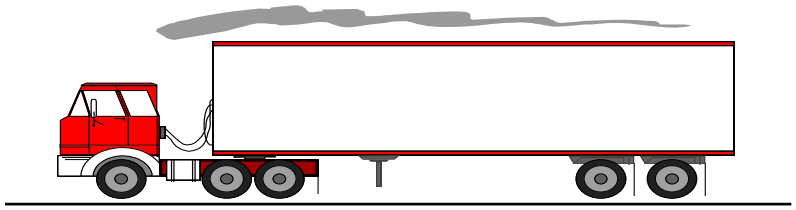
Asphalt Binder

- **Selection of asphalt binder**



➢ **In China, binder grade usually jump several levels compare with the calculation result by LTPP equation.**

- **Temperature**
- **Truck overload**
- **Supply condition**



Asphalt Binder

- **Selection of asphalt binder**

PG grade based the LTPP equations

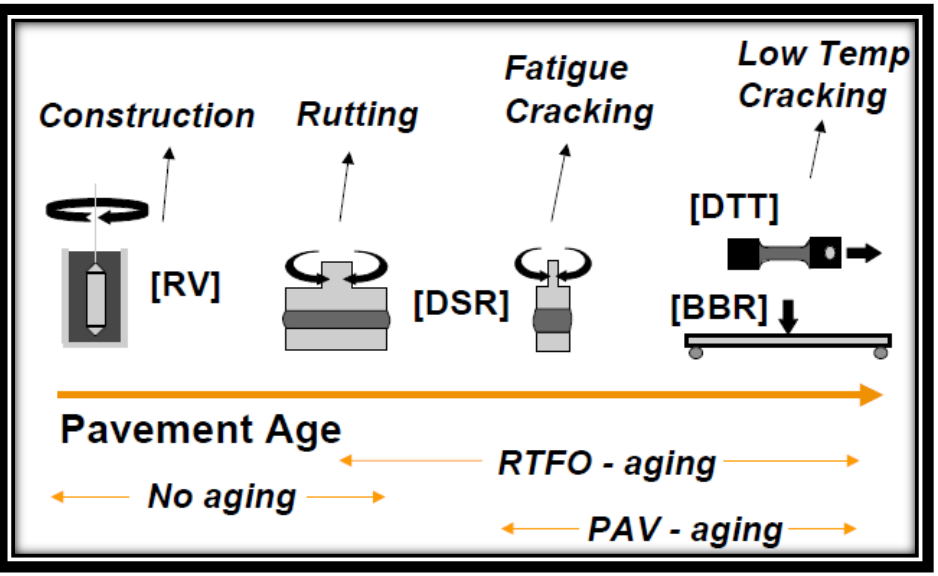
Prov.	JiangSu	Chong qing	Sichuan	Zhejian g	Heilong jiang	Jiangxi	Guang dong	Anhui	Yun nan	Qinghai	Shanxi
Base course	PG58-10	PG58-4	PG58-4	PG58-10	PG52-28	PG58-4	PG58-4	PG58-10	PG58-4	PG58-22	PG58-16
Binder course	PG64-10	PG64-4	PG64-4	PG64-16	PG58-28	PG64-10	PG64-4	PG64-10	PG58-4	PG64-22	PG58-22
Surface course	PG70-16	PG70-10	PG70-10	PG70-16	PG64-28	PG70-10	PG70-10	PG70-16	PG64-10	PG70-28	PG64-22

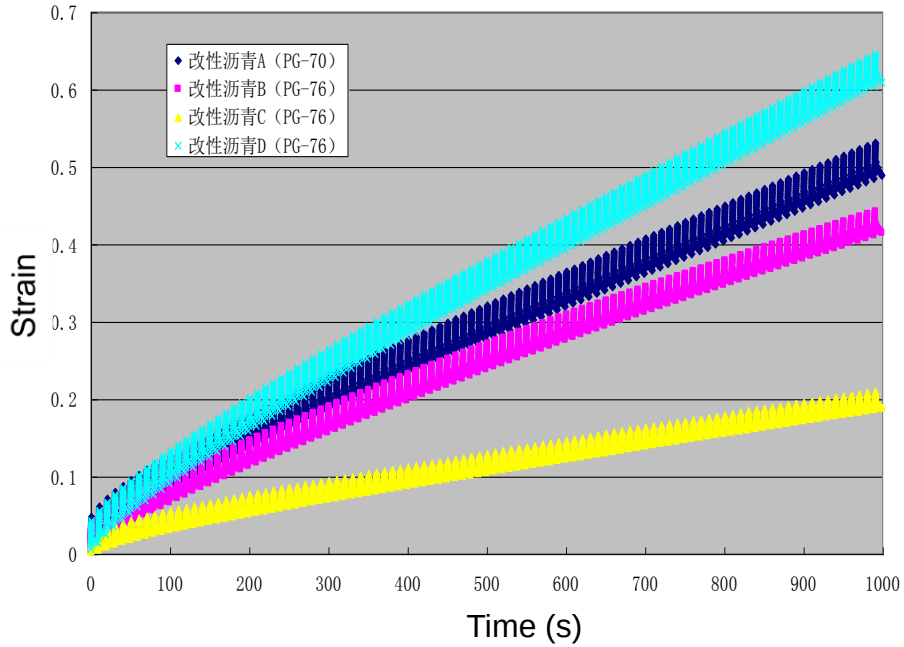
PG grade after adjustment

Prov.	JiangSu	Chong qing	Sichuan	Zhejian g	Heilong jiang	Jiangxi	Guang dong	Anhui	Yun nan	Qinghai	Shanxi
Base course	PG64-22	PG64-22	PG64-22	PG64-22	PG58-22	PG64-22	/	PG64-22	PG64-22	PG58-22 PG64-22	/
Surface course Binder course	PG70-22 PG70-28 PG76-22	PG70-22 PG76-22 PG76-28	PG70-28 PG76-28 PG76-22	PG70-28 PG76-28 PG76-22	PG70-22 PG70-28	PG76-28	PG76-28	/	/		PG70-28

Asphalt Binder

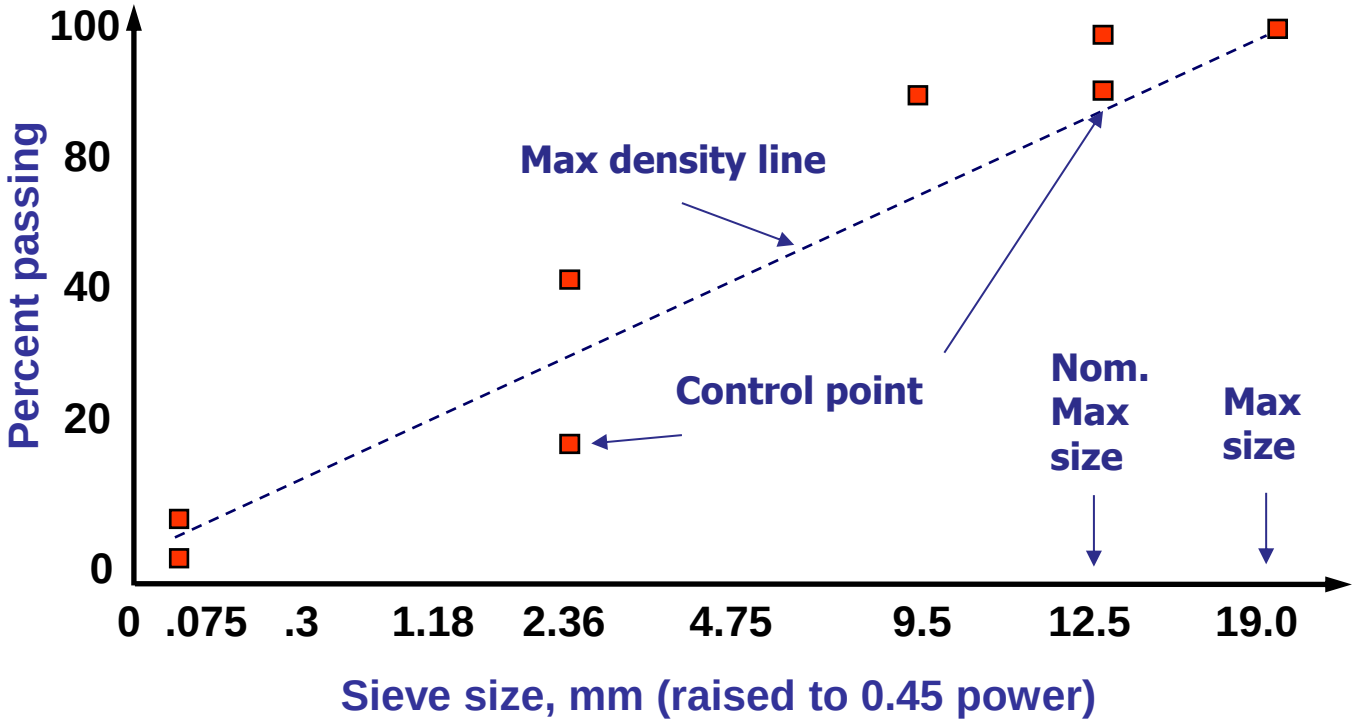
- **Binder Spec.**
  - **Pen. → Pen. + PG**
  - **Pmb**
    - Standard Method of Test for Multiple Stress Creep Recovery (MSCR) (AASHTO T350-14)





Mixture Design

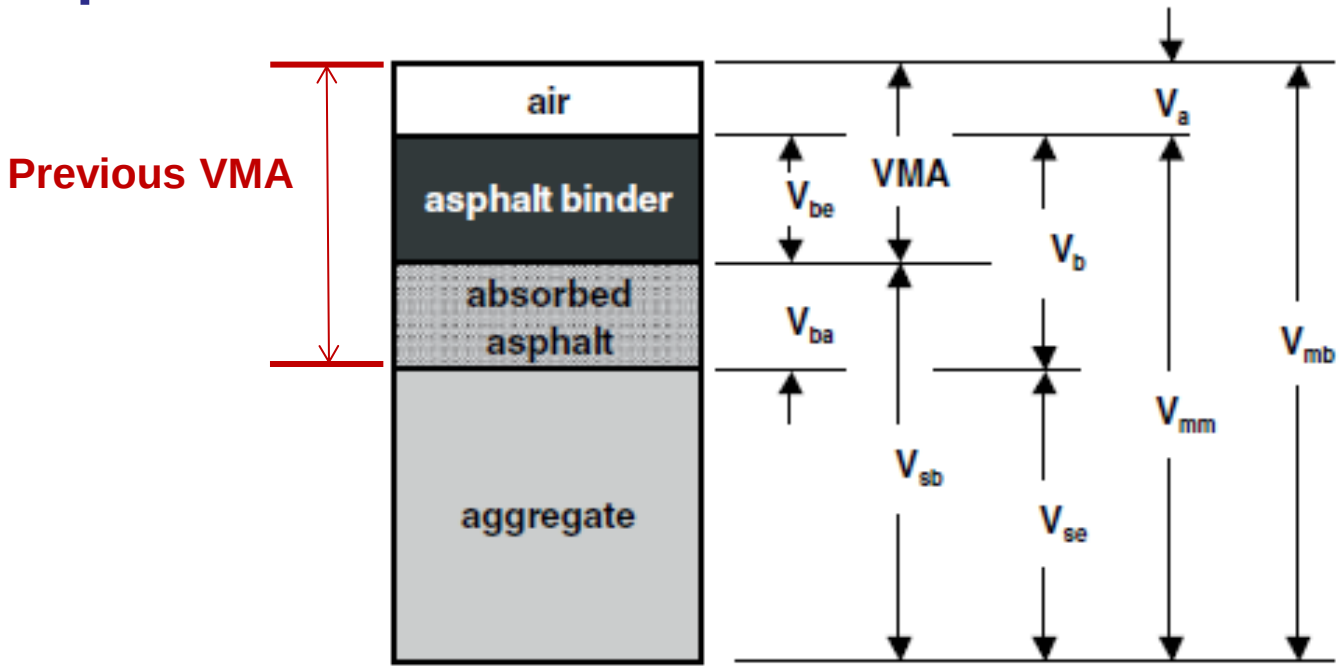
- **Selection of Aggregate gradation**



- use semilogarithmic chart → x-coordinate，use 0.45 power
  use maximum density line
- Use middle range of gradation → Optimize between coarse, fine and middle gradations

Mixture Design

- **Volumetric properties**

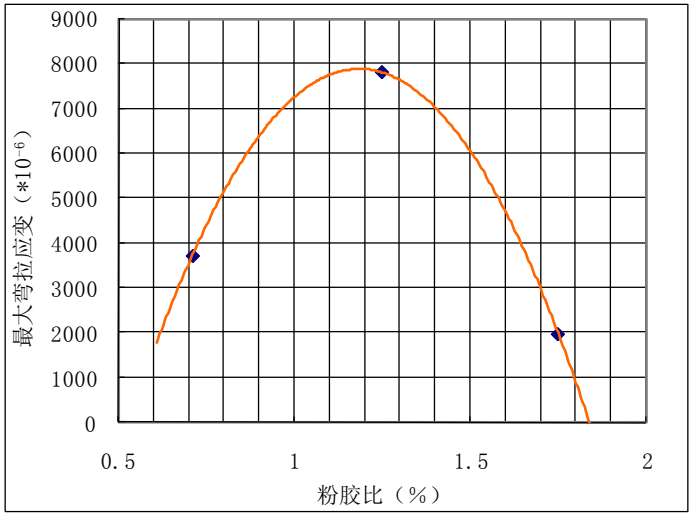


JTJ 032-1994		JTG F40-2004
binder content V_b	→	**effective binder content V_{be}**
VMA＝ Vba + Va		VMA＝Vbe+Va

Mixture Design

➢ Dust Proportion

$$DP = \frac{P_{0.075}}{P_{be,estimated}}$$



$P_{0.075}$: mass of the material passing 0.075mm ;

$P_{be,estimated}$: effective asphalt binder content

Gradation type	DP range
coarse gradation	0.8~1.6
Fine gradation	0.6~1.2

Mixture Design

- Introduced rice test (AASHTO T209)
  - Standard Method of Test for Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt
  - Help to Improve pavement density.

Pavement density of A

Percent passing	Air viod Requirement %	Spec.
100%	-	JTJ032-1994
30%	3-8	JTG F40-2004
10%	3-7	Jiangsu Spec. 2001

Calculate → Measure

Mixture Design

- **SGC Compaction level**

  - **According to the table, most of pavement in China need to choose N_{design}=125, because of the high traffic volume.**
  - **Actually, in most case N_{design}=100**

Design ESAL（millions）	Compaction parameters		
	$N_{initial}$	N_{design}	N_{max}
<0.3	6	50	75
0.3<3	7	75	115
3<30	8	100	160
≥30	9	125	205

List of Compaction Parameters

Province	Compaction parameter			Typical projects
	$N_{initial}$	N_{design}	N_{max}	
Jiangsu	8	100	160	Ninghuai, Lianyan, Huning, Zhenli Expressway
Hubei	9	125	205	Wuhuang Expressway
Inner Mongolia	8	100	160	Shideng, Chitong Expressway
Shanghai	8	100	160	Huning, Jiajin Expressway
Hunan	8	100	160	Changyong airport Expressway, Leiyi, Hengzao Expressway
Tianjin	8	100	160	Jinji Expressway, Jingshen Expressway maintenance project
Jiangxi	8	100	160	Ganding, Shiji Expressway
Shandong	8	100	160	Qingyin, Weiru, Rongwu Expressway
Fujian	8	100	160	Zhangzhou-Longyan Longyan section, Luoyuan-Changle B2 section
Guangdong	8	100	160	Kaiyang, Dongguan Urban Expressway
Shanxi	8	100	160	Mianxian-Ningqiang, Xian-Baoji Expressway
Sichuan	8	100	160	Chengnan Expressway
Chongqing	8	100	160	Shuijie Expressway, Chongqing External Ring western section
Xinjiang	8	100	160	External Ring of Urumchi
Henan	8	100	160	Fuxiang, Shangzhou Expressway
Qinghai	8	100	160	Pingan-Adai Expressway, Mangge second-class highway
Zhejiang	8	100	160	Songpu, Shenjiahu, Huangqunan Expressway
Ningxia	8	100	160	Tongyan Expressway

Mixture Design

- A failure Case
  - Superpave Volumetric design + Marshall compaction
  - 4% design air viod
  - 75 blows/side with Mashall compaction
- 1 year later
  - 2~6 cm Rutting

Performance Tests

- Superpave Volumetric design + Performance tests
- Superpave performance test
  - AASHTO T 283, Standard Method of Test for Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage
  - AASHTO TP 79-15 , Determining the Dynamic Modulus and Flow Number for Asphalt M ixtures Using the Asphalt Mixture Performance Tester (AMPT)
- High temperature
  - Wheel track test (T0719)
- Low temperature
  - Beam Bending Test (T0728)

Performance tests

- High Temperature Performance
- Wheel Track Tests
  - T0719, JTJ052-2000
  - 0.7 Mpa, 60℃
  - Dynamic stability , passings/mm

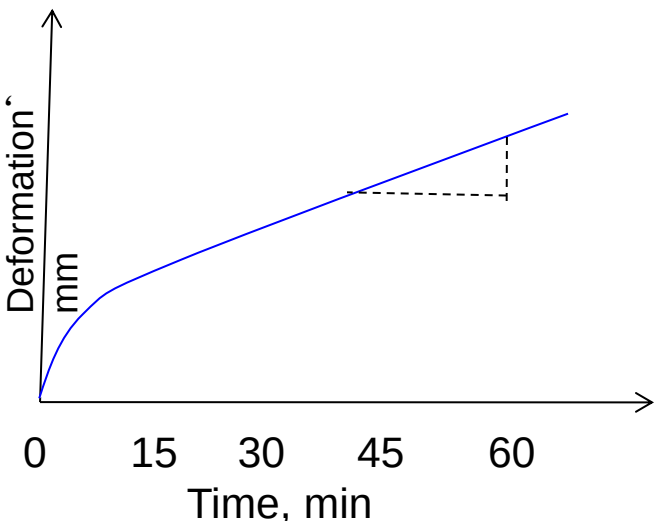


表 5.3.4-1　沥青混合料车辙试验动稳定度技术要求

气候条件与技术指标		相应于下列气候分区所要求的动稳定度(次/mm)									试验方法
七月平均最高气温(℃)及气候分区		>30				20~30				<20	
		1.夏炎热区				2.夏热区				3.夏凉区	
		1-1	1-2	1-3	1-4	2-1	2-2	2-3	2-4	3-2	
普通沥青混合料,不小于		800		1000		600	800			600	T 0719
改性沥青混合料,不小于		2400		2800		2000	2400			1800	
SMA混合料	非改性,不小于	1500									
	改性,不小于	3000									
OGFC混合料		1500(一般交通路段)、3000(重交通量路段)									

Performance tests

- Low temperature performance
- Beam Bending Test
  - T0728 (JTJ052, 2000)
  - -10℃
  - specimens size
    - 300mmX45mmX30mm.
  - Failure strain, $u\varepsilon$

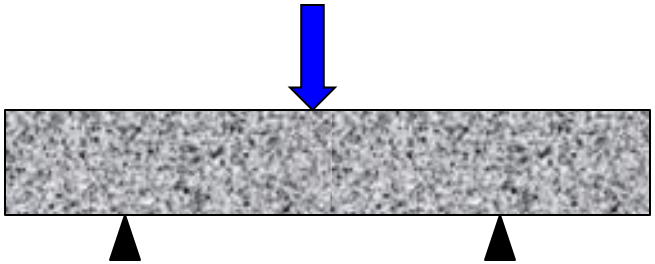


表 5.3.4-3 沥青混合料低温弯曲试验破坏应变(με)技术要求

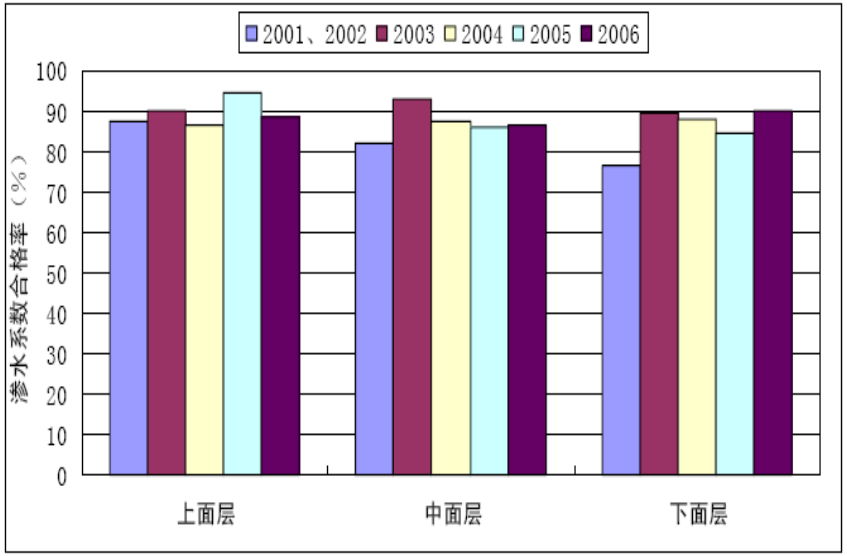
气候条件与技术指标	相应于下列气候分区所要求的破坏应变(με)									试验方法
年极端最低气温(℃)及气候分区	< -37.0		-21.5 ~ -37.0			-9.0 ~ -21.5		> -9.0		
	1.冬严寒区		2.冬寒区			3.冬冷区		4.冬温区		
	1-1	2-1	1-2	2-2	3-2	1-3	2-3	1-4	2-4	
普通沥青混合料,不小于	2600		2300			2000				T 0728
改性沥青混合料,不小于	3000		2800			2500				

Construction

- **Field compaction**
  - ➢ **Superpave mix requires more compaction energy**
    - **Using more angular and coarser aggregates**
  - ➢ **Recommended Compactors (11.75m, 3 lanes)**
    - **3~4 steel wheel rollers (12~15 tons)**
    - **3 rubber roller (25 tons)**
  - ➢ **Pavement density**
    - **93-97% of Maximum theoretic density**

Construction

- Pavement permeability Test (T 0971—2008)
  - Permeability Coefficient
    - JTG F40-2004
      - <200 ml/min
    - Jiangsu
      - Sup-25：≤ 60ml/min
      - Sup-20：≤ 50ml/min



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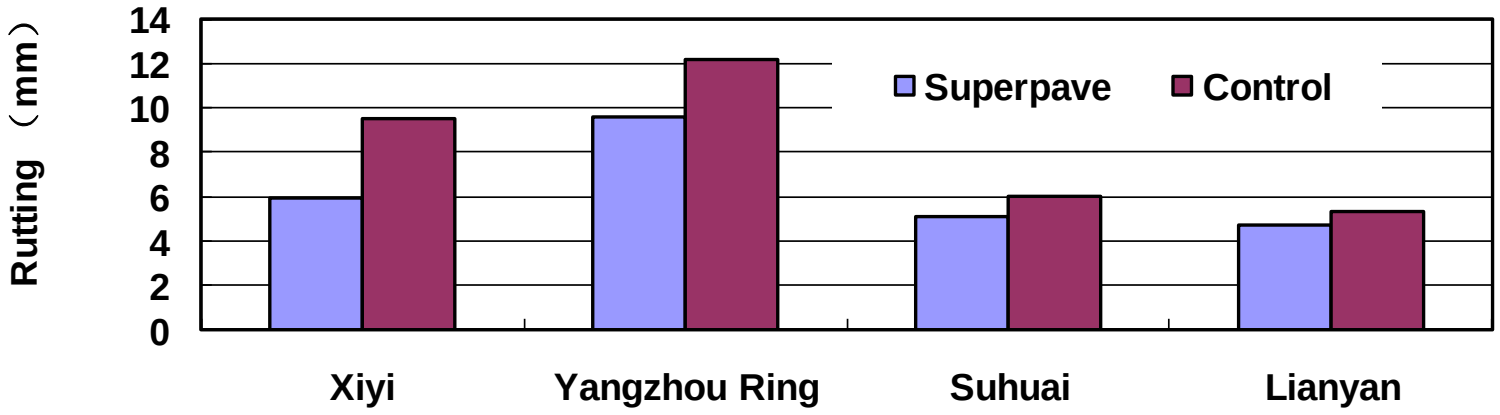
3. Typical projects

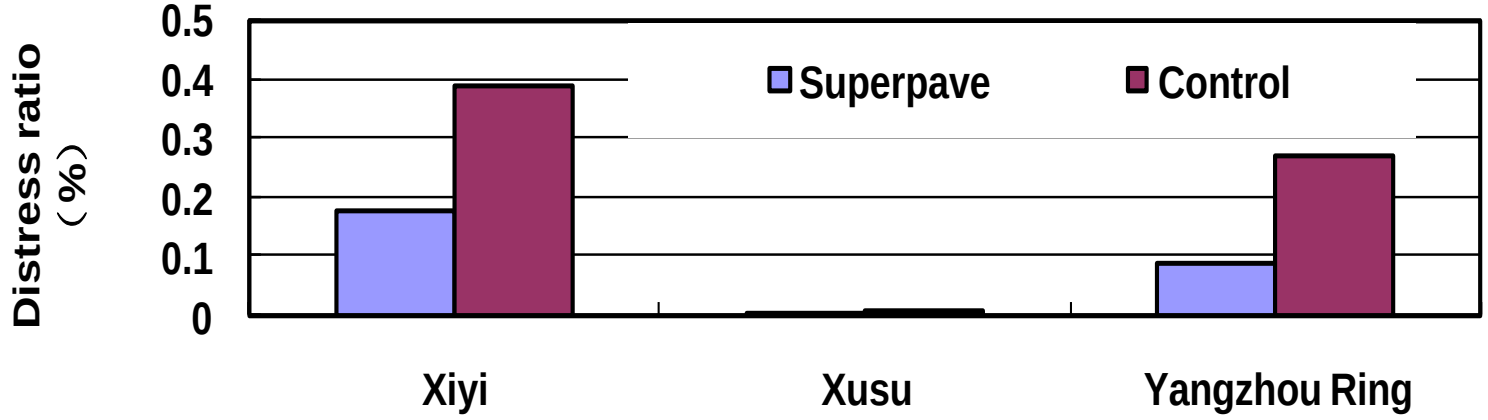
- **Typical Superpave roads**
  - Service life (8-12years)

Name of road	Open Time	Pavement structure			
		Surface course	Binder course	Base course	Base
Huning	2005.11	SMA-13S	Sup20	Sup25	CTB
Xiyi	2003.1	Sup-13	Sup20	Sup25	CTB
Yangzhou NW ring	2004.10	SMA-13	Sup20	Sup25	CTB
Suhuai	2005.11	SMA-13S	Sup20	Sup25	CTB
Lianyan	2006.7	SMA-13S	Sup20	Sup25	CTB
Zhenli	2007.10	SMA-13S	Sup20	Sup25	CTB

3. Typical Superpave projects

- **Comparison of Superpave and other types of pavement**





3. Typical Superpave projects

- Pavement performance compare
  - Jiangsu LTPP program
  - Highway performance assessment standards(JTG H20-2007)

Pavement Combination	PCI	RQI	RDI	SRI	PSSI
AC+AC+AC	90.34	94.47	79.40	96.48	97.63
SMA+AC+AC	94.69	95.59	87.60	97.86	97.99
SMA+SUP+SUP	94.58	95.30	93.80	96.69	98.36

RDI—rutting depth index

4. Summary

- Superpave technology has been introduced to China for more than 20 years, we have experienced the introduction of equipment, technology digestion, pilot projects, widely promotion and technical improvement process, Superpave technology promotes the progress of asphalt pavement technology in China.
- Superpave asphalt binder specification has been accepted by most highway agencies.
- The Superpave mixture method is used in nearly 20 provinces, its idea influenced the revise of asphalt pavement specification in China. Many provinces have included Superpave in local specification.
- SMA + Superpave structure has become one of the most typical structures of heavy traffic highway asphalt pavements.

4. Summary

- There are more than 250 SGC, and more than 40 sets of Superpave Blinder equipments in China. The product standard and product verification regulation of SGC were laid down.
- Superpave pavements have been built in China for 16 years, and has been implemented over10,000 km, the LTPP study shows that Superpave pavement has a good road performance, especially the resistance to rutting.
- Superpave has been integrated into China's asphalt pavement technology and refined together.

Thank you!

crj@jsti.com