

2018透水铺装国际研讨会

排水沥青路面在中国高速公路的研究与实践

Study and practice of porous asphalt pavement in Chinese expressways

汇报人：曹东伟
Reporter: Cao Dongwei

交通运输部公路科学研究院

Research Institute of Highway Ministry of Transport

中路高科（北京）公路技术有限公司

Zhong Lu Gao Ke (Beijing) Road Technology Co. Ltd

2018年10月25日



研究团队介绍 Introduction of research team

中路高科（北京）公路技术有限公司

系交通运输部公路科学研究所属的科技型企业，领域是道路工程专业新结构、新材料、新工艺、新装备，致力于公路新兴产业技术研发、推广、应用并提供公路工程整体解决方案，是公路高品质新材料和新技术的引领者。

The company has long been committed to the research and development, promotion and application of highway new materials and emerging industry technologies and provides overall solutions for highway engineering. It is the leader of high-quality new materials and technologies for highways.

排水沥青路面研发团队系中路高科（北京）公路技术有限公司下属的专业科研和技术推广团队。为响应我国交通建设“安全环保、以人为本”的发展理念，公司组建的排水沥青路面研发团队历经15年潜心研究形成了排水沥青路面成套技术，并于2013年交通运输部获批《高速公路排水降噪沥青路面修筑技术》推广课题，明确加快排水沥青路面在我国的推广力度。团队积极进行该项科研成果转化和产业化，不断凝练核心技术，现已具有雄厚科研实力和丰富软硬件资源，能承担排水路面设计、材料、施工、试验检测与质量管理技术服务等系统业务，并承诺铺筑“路面结构”和“排水降噪功能”的双重耐久。

目录

Contents

- 一、背景介绍/Background Introduction
- 二、排水沥青路面技术研究/Technical research
- 三、工程实践应用/Engineering Practice Application
- 四、结语/Conclusion

一、背景介绍

Background introduction



我国公路网建设与改造规模庞大

➤品质工程--如何提高路面的品质，如何向社会提供**更安全、更舒适、更环保**的交通行业的新目标。

Quality Engineering - How to improve the quality of the road, how to provide the society with a new goal of safer, more comfortable and more environmentally friendly transportation industry.

➤平安交通—社会公众对服务功能需求不断升级，**安全、绿色、“以人为本”**。

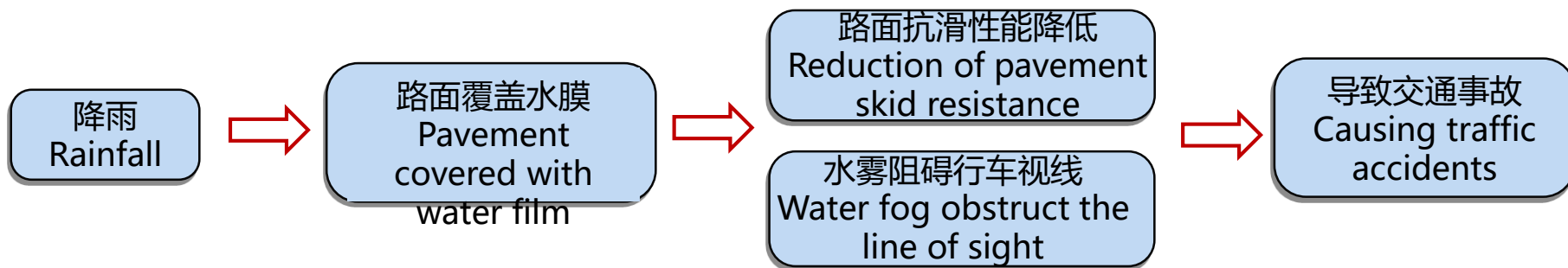
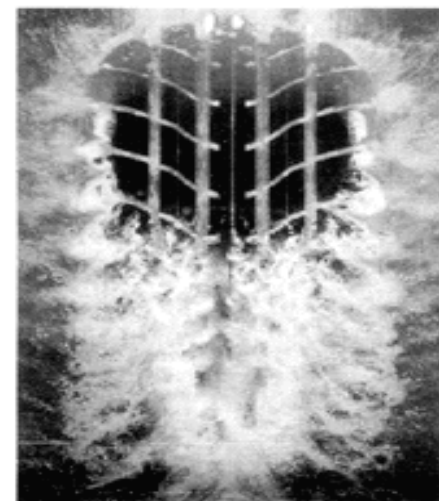
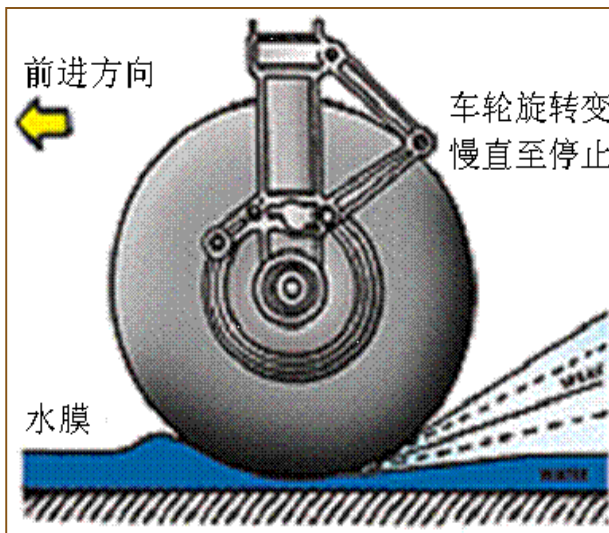
Safe Transportation - The public's demand for service functions continues to upgrade, safety, green, people-oriented.

一、背景介绍

Background introduction

➤ 降雨对交通出行安全影响巨大

Rainfall has great impact on traffic safety

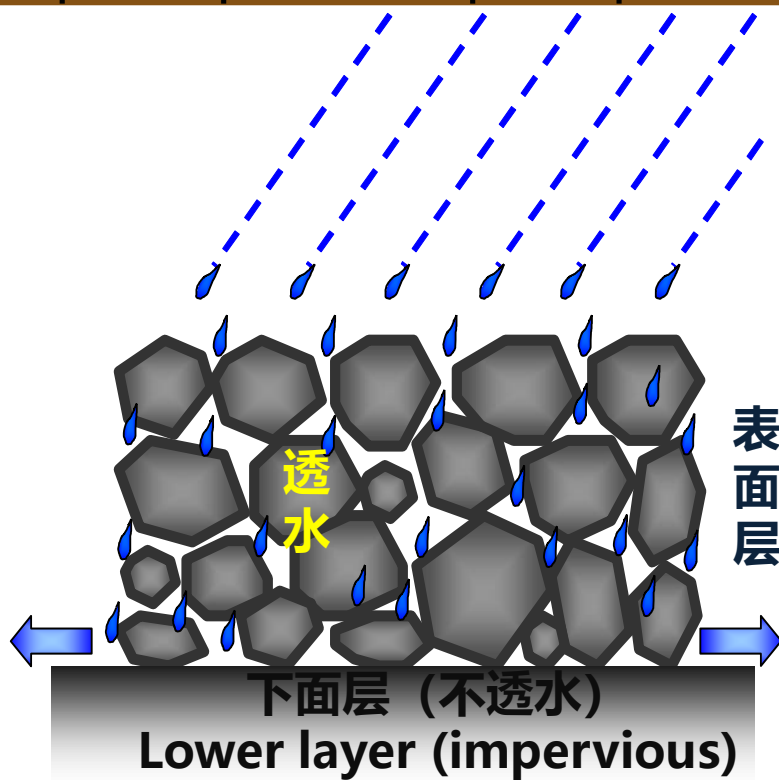


一、背景介绍

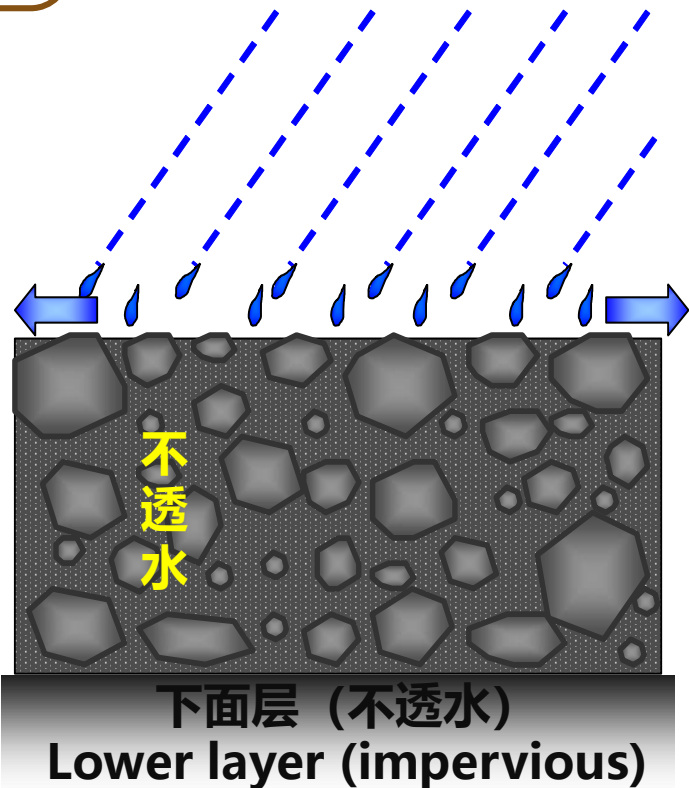
Background introduction

排水沥青路面原理

Principle of porous asphalt pavement



排水沥青路面
Porous asphalt pavement



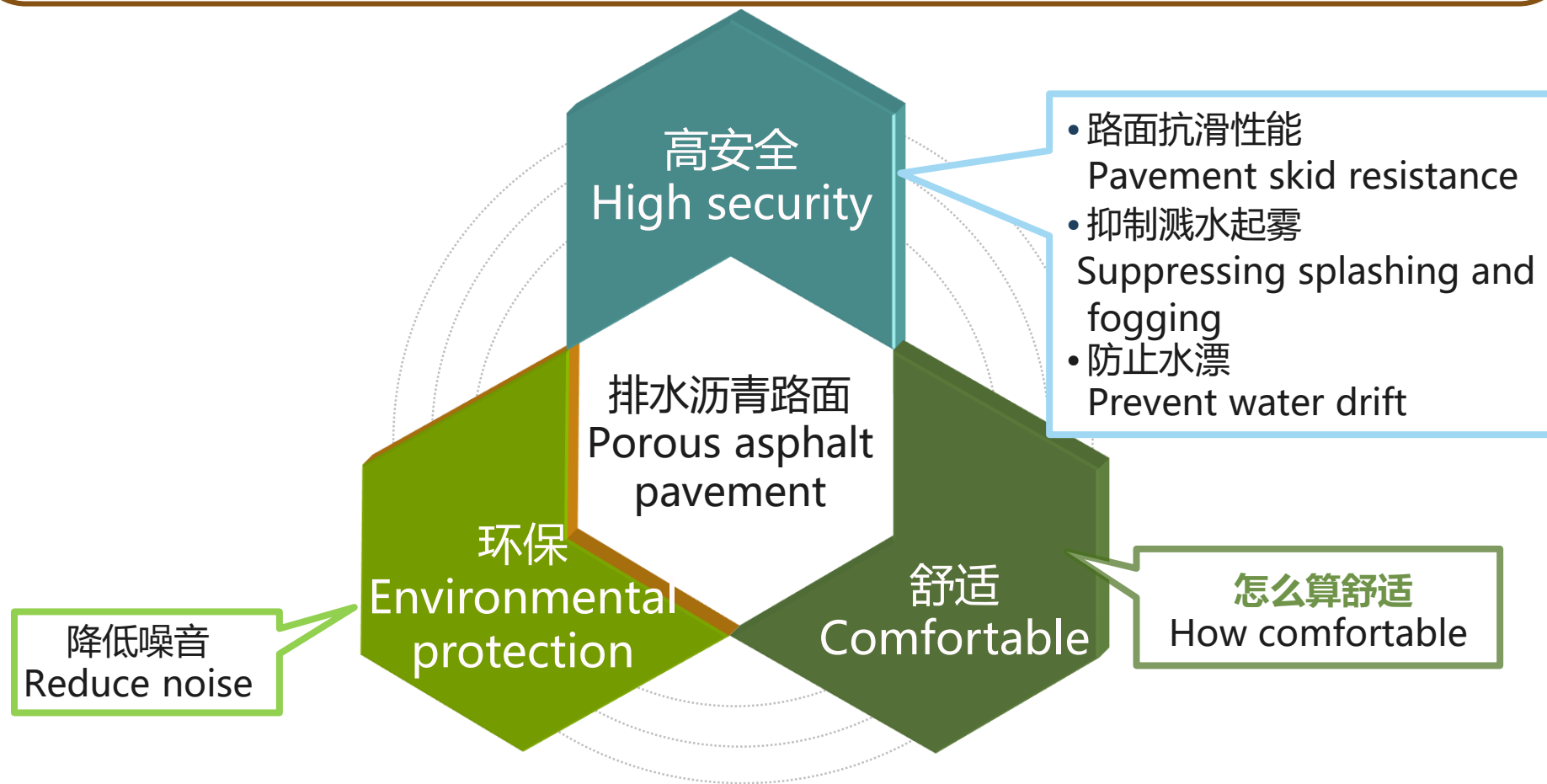
传统沥青路面
Traditional asphalt pavement

一、背景介绍

Background introduction

排水沥青路面是世界公认的高安全性、舒适性、环保性的功能路面

The porous asphalt pavement is recognized as a high functional, safe and environmental friendly pavement in the world.



一、背景介绍

Background introduction

日本
100%

Japan
100%

1987年的试验观测表明减少雨天事故80%、与晴天相当，称之为“超级路面”；1996年要求在所有新建和罩面高速强制应用，2005年时高速公路排水路面表层已达6500km，占比达80%以上。

Experiments in 1987 showed that the number of rain accidents was reduced by 80%, which was equal to that in sunny days. It was called "super pavement". In 1996, it was required to be compulsory applied in all newly built and covered highways. In 2005, the surface layer of Expressway Porous Pavement reached 6500 km, accounting for more than 80%.

美国
1万公里
U.S.A

10 thousand
kilometres

OGFC在全国都有广泛应用；从1998年，乔治亚州在所有州际公路铺装中使用排水沥青路面。

OGFC is widely used throughout the country; since 1998, Georgia has used porous asphalt pavements in all interstate pavements.

欧洲
10%~20%

Europe
10%~20%

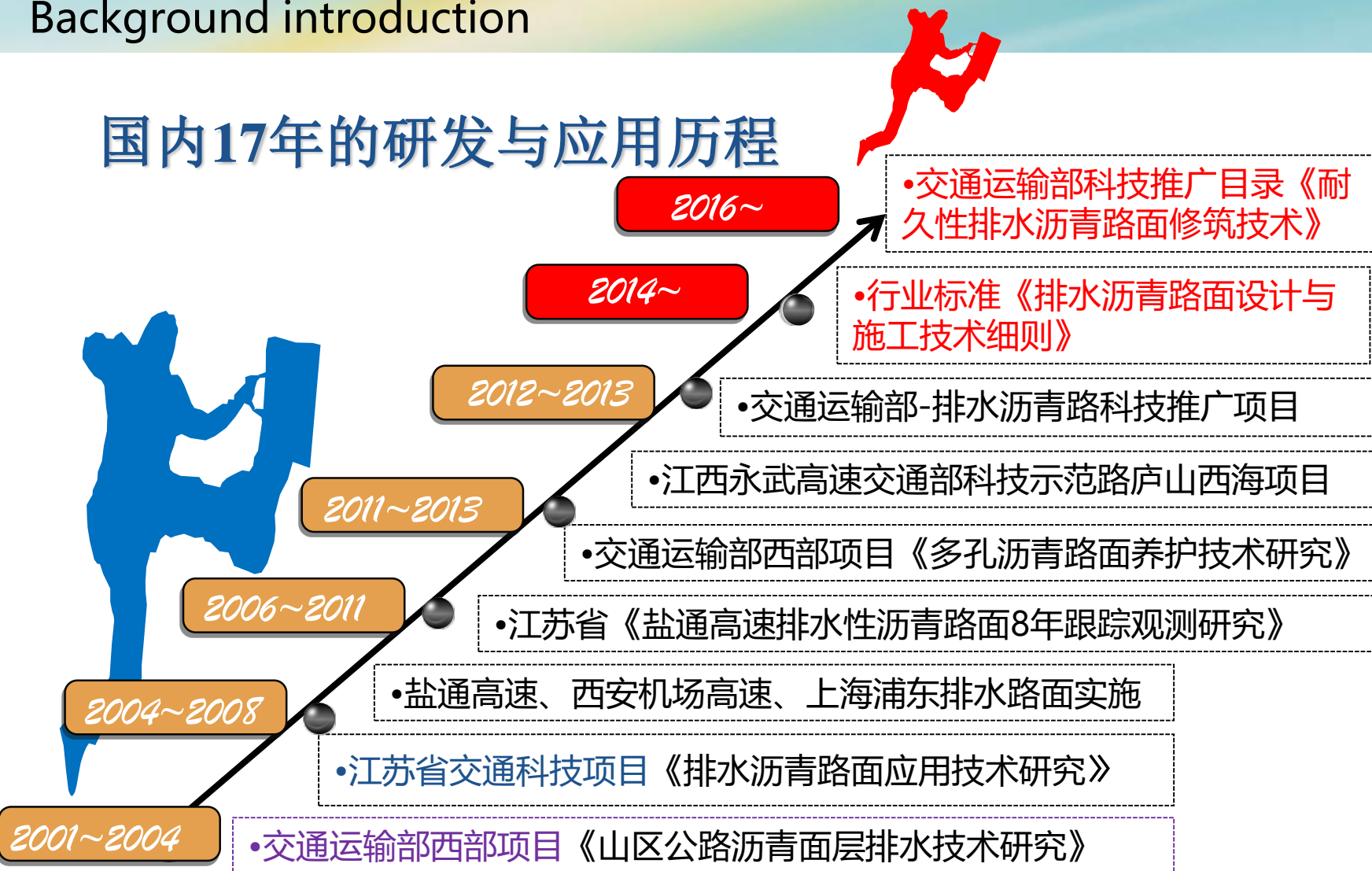
荷兰、比利时、丹麦在1990年开始修建排水沥青路面，近年开始双层排水降噪沥青路面。

The Netherlands, Belgium and Denmark began to construct porous asphalt pavement in 1990. In recent years, double-deck porous asphalt pavement has been used to reduce noise.

一、背景介绍

Background introduction

国内17年的研发与应用历程



目录

Contents

一、背景介绍/Background Introduction

二、排水沥青路面技术研究/Technical research

三、工程实践应用/Engineering Practice Application

四、结语/Conclusion

二、排水沥青路面技术研究

Research on Porous Asphalt Pavement Technology

主要内容

Main content

2.1 排水沥青路面结构设计

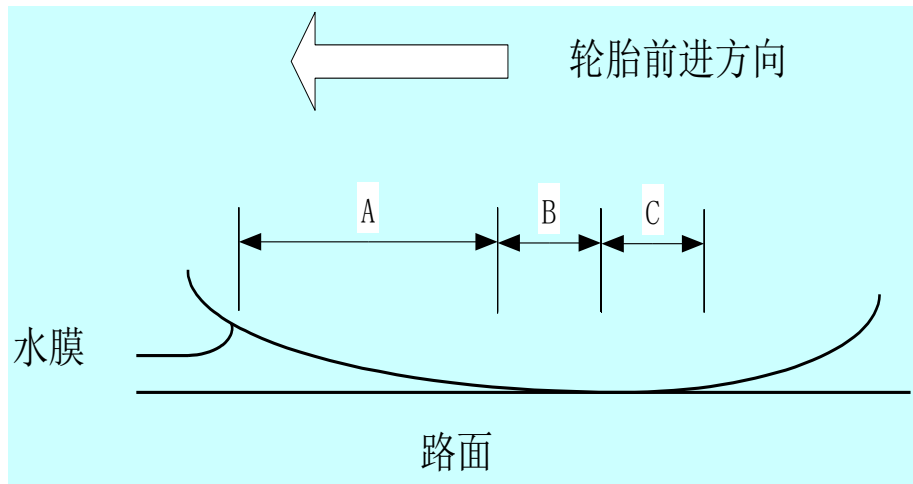
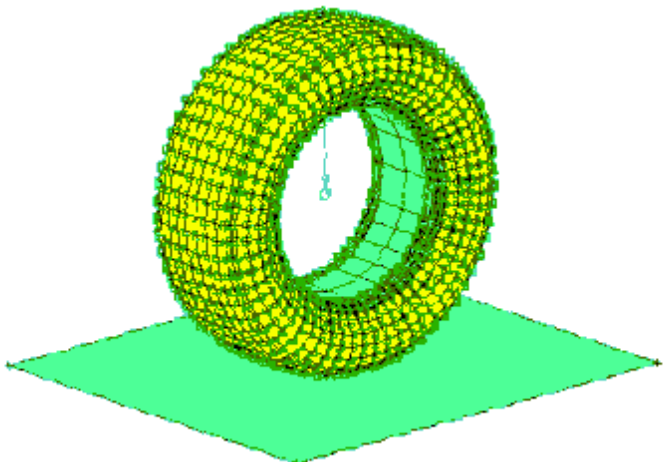
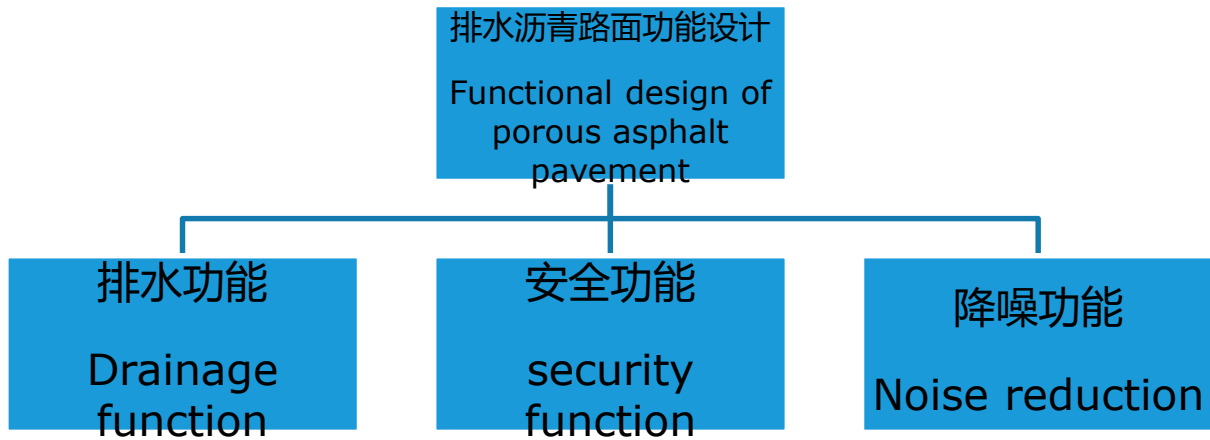
2.2 排水沥青路面关键材料

2.3 施工技术、质量管理技术及检测技术

2.4 排水沥青路面养护与维修技术

2.1.1 排水沥青路面功能设计与分析方法

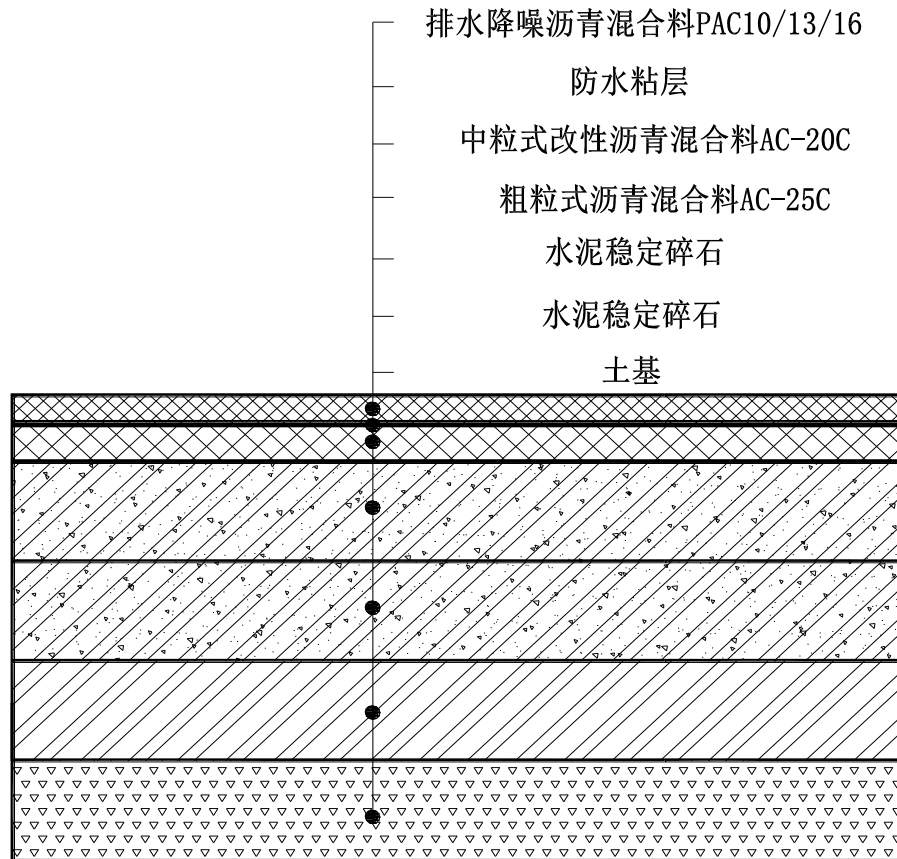
Functional design and analysis method of porous asphalt pavement



2.1.2 排水沥青路面结构设计 with 典型结构

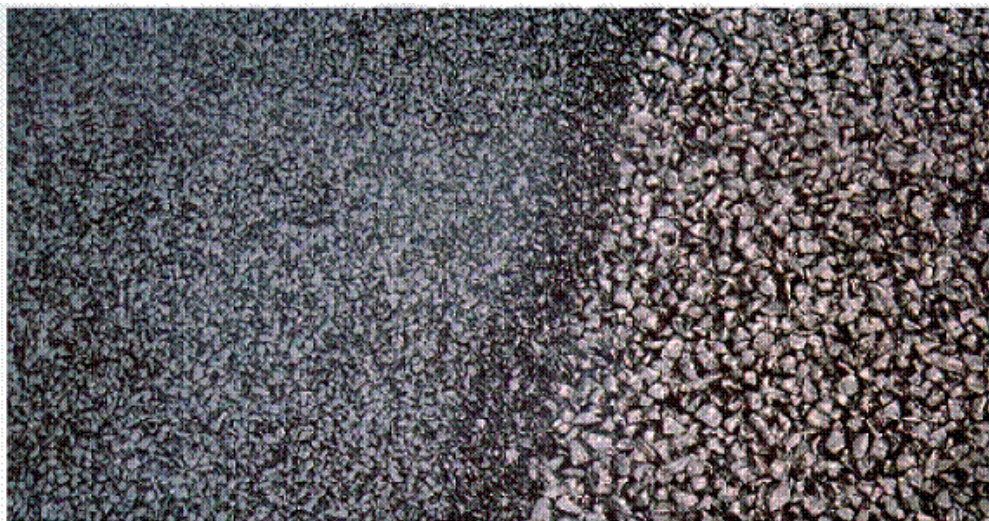
Structural design and typical structure of porous asphalt pavement

排水沥青路面典型结构 Typical structure of porous asphalt pavement



2.1.3 双层排水降噪的沥青路面结构

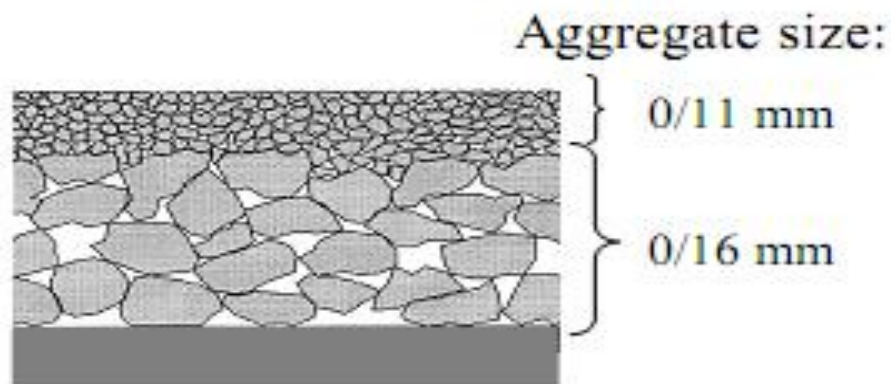
Two layer porous and noise reduction asphalt pavement structure



双层排水沥青路面结构

Double-layer porous asphalt pavement structure:

- 渗水系数可达6000ml/min以上
Water permeability coefficient can reach 6000ml/min or more;
- 可降低噪声8~10dB (A)
Can reduce noise by 8~10dB(A)



Two Layer Porous Asphalt

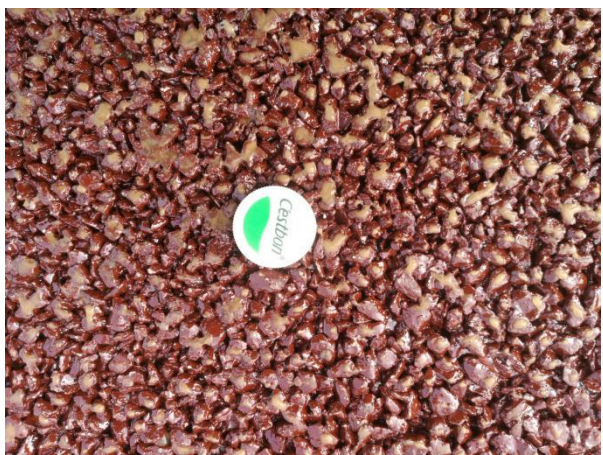
常用结构组合形式:

Common structural combination:

- PAC-10/PAC-16
- PAC-13/PAC-20

2.1.4 全透式路面设计方法

Fully transparent pavement design method



彩色透水面层铺装效果



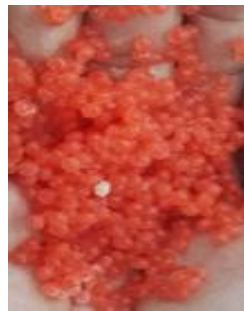
湖南芙蓉镇服务区彩色透水沥青路面

2.2.1 排水沥青路面专用改性沥青与HVA改性添加剂 Modified asphalt and HVA modified additive for porous asphalt pavement

适合高温重载的排水沥青路面专用高粘接材料自主开发 Self-developed high-bonding material for porous asphalt pavement suitable for high temperature and heavy load

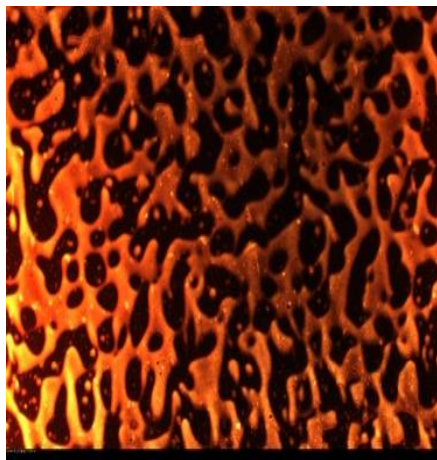
增强沥青与石料的粘合强度及各种稳定性、耐久性要求，满足排水沥青路面的抗水损害、抗飞散和抗车辙病害的技术标准，适应我国重载交通荷载条件和高低温恶劣环境条件。

Enhance the bonding strength and various stability and durability requirements of asphalt and stone, meet the technical standards of water damage, anti-scatter and anti-rutting diseases of porous asphalt pavement, adapt to China's heavy traffic load conditions and high and low temperature harsh environmental conditions .



2.2.1 排水沥青路面专用改性沥青与HVA改性添加剂

Modified asphalt and HVA modified additive for porous asphalt pavement



| 指标 | 单位 | 测试值 | 技术要求 | 试验方法 |
|--------------------|-------------------|--------|---------|-------------|
| 针入度 25°C, 100g, 5s | 0.1mm | 49 | ≥40 | T 0604-2011 |
| 软化点 $T_{R\&B}$ | °C | 100 | ≥90 | T 0606-2011 |
| 延度 5°C, 5cm/min | cm | 36 | ≥30 | T 0605-2011 |
| 60°C动力粘度 | Pa·s | 535561 | ≥200000 | T 0620-2000 |
| 布氏粘度 (170°C) | Pa·s | 1.072 | ≤3 | T 0625-2011 |
| 闪点 | °C | 290 | ≥230 | T 0611-2011 |
| 溶解度 | % | 99.8 | ≥99 | T 0607-2011 |
| 弹性恢复 25°C | % | 97.7 | ≥95 | T 0662-2000 |
| 离析 | °C | 2.5 | ≤2.5 | T 0661-2011 |
| 粘韧性 25°C | N·m | 26.8 | 25 | T 0624-2011 |
| 韧性 25°C | N·m | 22 | ≥20 | T 0624-2011 |
| 密度25°C | g/cm ³ | 1.040 | 实测记录 | T 0603-2011 |
| TFOT后残留物 | | | | T 0609-2011 |
| 质量变化 | % | -0.235 | ≤±0.6 | |
| 针入度比25°C | % | 83.7 | ≥80 | |
| 延度 5°C | cm | 28 | ≥20 | |

➤材料性能达到国外同类产品的水平，成本大幅降低30%。

The material performance has reached the level of similar foreign products, and the cost has been reduced by 30%.

2.2.2 排水沥青路面专用纤维

Porous asphalt pavement fiber

重载交通情况下宜使用纤维作为增塑稳定剂材料。
Fiber should be used as plasticizer stabilizer material in heavy traffic condition.



聚合物化学纤维
Polymer chemical fiber

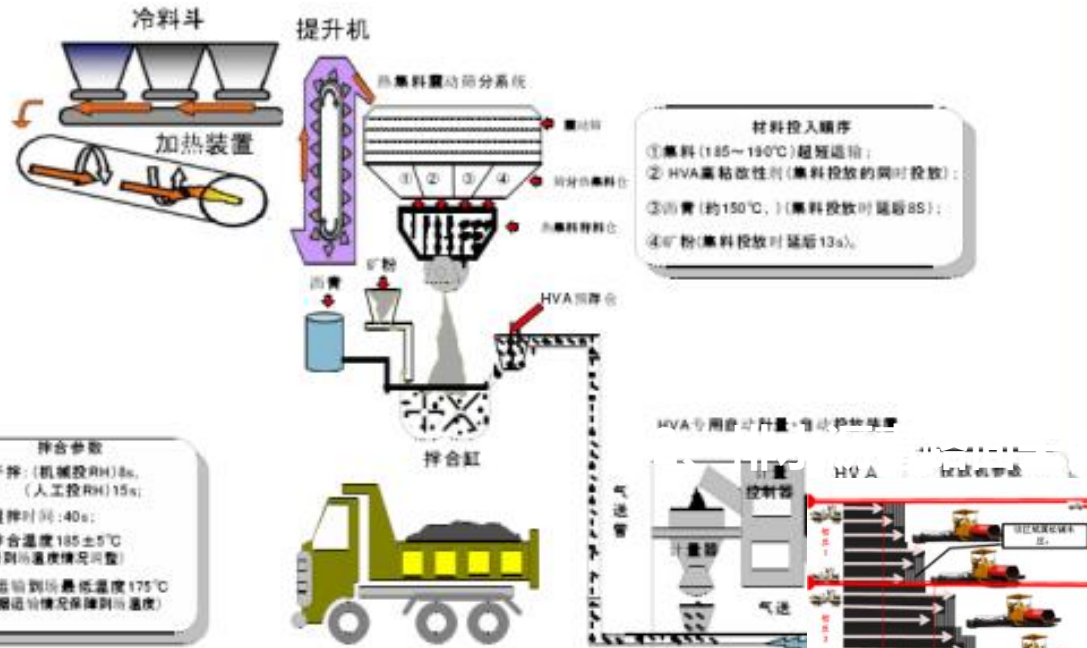


玄武岩纤维
Basalt fiber

2.3.1 排水沥青路面施工工艺

Construction technology of porous asphalt pavement

HVA高粘改性沥青混合料生产与施工流程

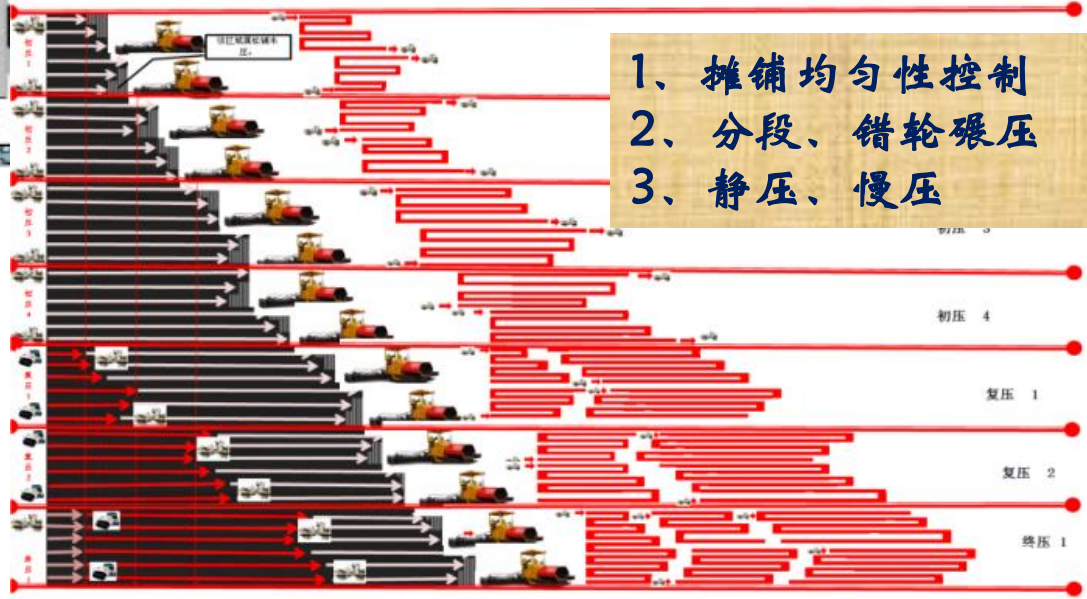


HVA高粘改性沥青混合料生产与施工流程

Production and construction process of HVA high grade modified asphalt mixture

拌合参数
 干拌: (机械投料) 8s,
 (人工投料) 15s;
 ②: 湿拌时间: 40s;
 ③: 拌合温度 185 ± 5°C
 (根据到场温度情况调整)
 ④: 出料到车最低温度 175°C
 (根据到场情况保障到场温度)

- 1、摊铺均匀性控制
- 2、分段、错轮碾压
- 3、静压、慢压



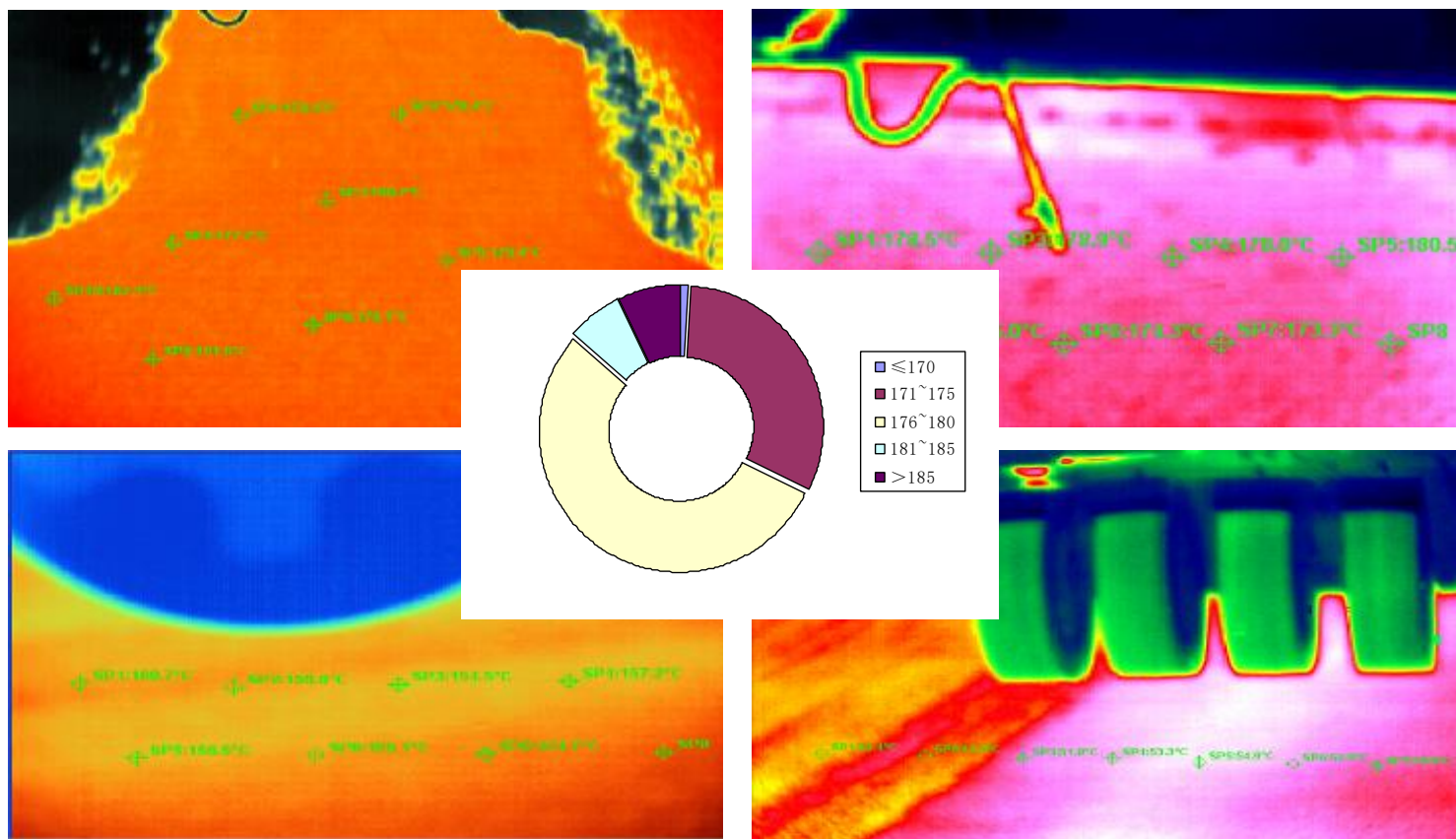
均匀化摊铺与均匀化碾压组合
 Homogenized paving and homogenizing rolling combination

2.3.2 排水沥青路面施工质量管理

Construction quality management of porous asphalt pavement

温度监测

Temperature monitoring



2.3.3 双层排水沥青路面施工技术

Two layer porous asphalt pavement construction technology



✓ 双层排水层同时摊铺；

Two porous layer paving at the same time

✓ 双层排水层单独摊铺。

Two porous layer paved separately.



2.3.4 排水沥青路面飞散评价方法及设备

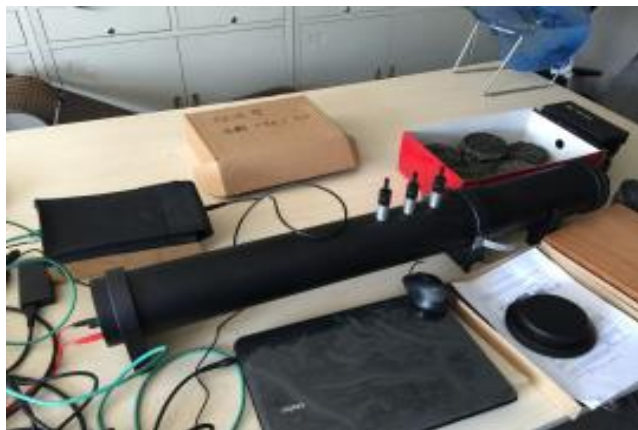
Porous asphalt pavement scattering evaluation method and equipment



通过试验轮的滚动摩擦，模拟减速和刹车等导致的大空隙路面受力情况，评价排水沥青路面抗飞散性能。

Through the rolling friction of the test wheel, the force of the large gap road surface caused by deceleration and braking is simulated, and the anti-scattering performance of the porous asphalt pavement is evaluated.

2.3.5 排水沥青路面噪声检测方法及设备 Porous asphalt pavement noise detection method and equipment



吸声系数测试驻波管
Sound absorption coefficient test standing wave tube



轮胎/路面噪声测试拖车
Tire/road noise test trailer



环境噪声测试仪
Environmental noise tester



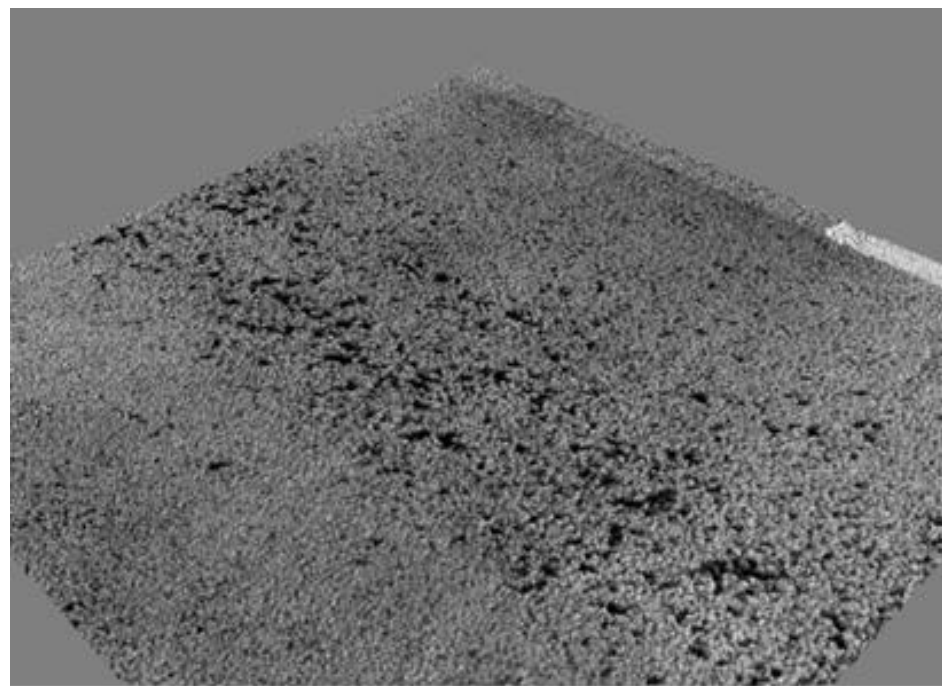
吸声系数测试仪
Sound absorption coefficient tester

2.3.6 排水沥青路面3D激光路面飞散病害检测方法及设备

Porous asphalt pavement 3D laser pavement scattering disease detection method and equipment



扫描设备
Scanning device



3D激光排水沥青路面扫描图像
3D laser porous asphalt pavement scanning
image

2.4 排水沥青路面养护与维修技术

Maintenance and repair technology of porous asphalt pavement



功能性养护技术研究

Functional conservation technology research

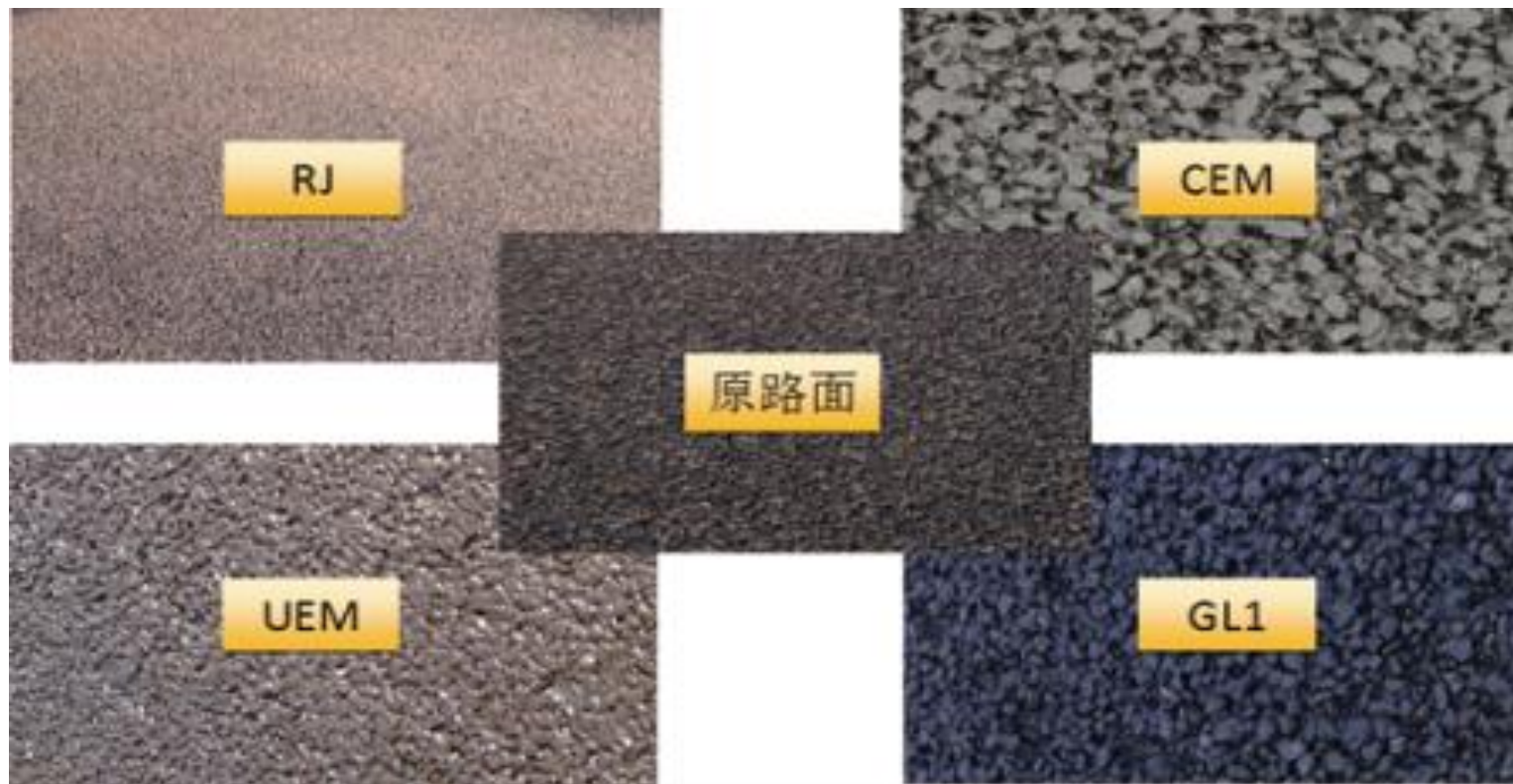


预防性养护技术

Preventive maintenance technology

2.4 排水沥青路面养护与维修技术

Maintenance and repair technology of porous asphalt pavement



预防性养护后排水沥青路面不同预防性养护材料表面对比
Surface contrast of different preventive maintenance materials for porous asphalt pavement after preventive maintenance

2.4 排水沥青路面养护与维修技术

Maintenance and repair technology of porous asphalt pavement



现场热补技术

On-site thermal compensation technology



排水沥青路面冷补技术

Porous asphalt pavement cold repair technology



小段落再生修补

Small paragraph regeneration repair



厂拌再生技术

Plant mixing technology

目录

Contents

一、背景介绍/Background Introduction

二、排水沥青路面技术研究/Technical research

三、工程实践应用/Engineering Practice Application

四、结语/Conclusion

3.1 排水沥青路面工程实践应用

Practical application of porous asphalt pavement engineering



石家庄东三环、南三环
East Third Ring Road and South
Third Ring Road, Shijiazhuang

江苏盐通、盐靖、宁宿徐高速
Jiangsu Yat Tong, Yan Jing,
Ning Su Xu Expressway



四川遂资、遂广遂西高速
Sichuan's Sui and Sui Guang Sui
West Expressway



江西庐山西海高速
Jiangxi Mount Lu West Sea Expressway

排水沥青路面在我国的工程实践逐渐增多，已经在江苏、四川、江西、河北、安徽、山东、浙江、湖南、云南、重庆、福建等地实践应用，并将在多个省市得到进一步建设和推广。

Porous asphalt pavement engineering practice in China has gradually increased, and has been applied in Jiangsu, Sichuan, Jiangxi, Hebei, Anhui, Shandong, Zhejiang, Hunan, Yunnan, Chongqing, Fujian and other places, and will be further constructed and promoted in many provinces and cities.

3.1 排水沥青路面工程实践应用

Practical application of porous asphalt pavement engineering

排水沥青路面工程案例

- 2003 年重庆渝邻高速排水沥青路面工程
- 2005 年江苏盐通高速公路排水沥青路面工程
- 2008 年江苏宁杭二期高速公路排水沥青路面工程
- 2010 年南京南站机场高速公路排水沥青路面工程
- 2011 年江西永武庐山西海旅游高速公路排水降噪沥青路面科技示范工程
- 2013 年安徽宣宁高速公路排水沥青路面工程
- 2013 年四川遂资高速公路排水沥青路面科技示范工程
- 2014 年江苏盐靖高速公路旧路改造加铺排水沥青罩面工程
- 2015 年江苏宁宿徐高速公路旧路改造加铺排水沥青罩面工程
- 2015 年四川遂广高速公路排水沥青路面工程
- 2015 年湖南龙永高速公路排水沥青路面工程
- 2015 年河北石家庄东三环南三环排水沥青路面工程
- 2015 年江苏沿海高速我国首次排水沥青路面预防性养护技术工程应用
- 2016 年江苏宁宿徐高速公路旧路改造加铺排水沥青罩面工程
- 2016 年江苏宁宿徐高速公路双层排水沥青路面工程
- 2016 年山东青岛中德生态园海绵城市排水沥青路面工程
- 2016 年江苏盐靖高速公路旧路改造加铺排水沥青路面工程
- 2016 年浙江金丽温高速公路旧路加铺排水沥青路面工程
- 2017 年石家庄和平西路改建排水沥青路面工程
- 2017 年江苏宁宿徐高速公路旧路改造加铺排水沥青罩面工程
- 2017 年江苏盐靖高速公路旧路改造加铺排水沥青罩面工程
- 2017 年江苏盐通高速公路排水沥青路面厂拌热再生工程
- 2017 年湖南芙蓉镇服务区彩色全透式海绵铺装工程
- 2017 年南宁绕城高速公路西段水泥混凝土改造加铺排水沥青路面工程施工图设计项目



3.1 排水沥青路面工程实践应用

Practical application of porous asphalt pavement engineering

工程实践应用案例一 Engineering Practice Application Case 1

盐通高速K367+222~K350+202，长约17km,当时是我国南方最大的排水路面工程，重点解决高温重载条件下排水沥青修筑技术。

Yantong Expressway K367+222~K350+202, about 17km long, was the largest porous pavement project in southern China, focusing on the construction of drainage asphalt under high temperature and heavy load conditions.

| | | |
|-----|------|---------------|
| | | 防水粘结层 |
| 上面层 | 4cm | PAC13 |
| 中面层 | 6cm | Super ppave20 |
| 下面层 | 8cm | Super ppave25 |
| 基层 | 38cm | CTB |
| 底基层 | 20cm | LFS |
| 路基 | | |



盐通高速排水沥青2014年路面现状---雨天路面状况

3.1 排水沥青路面工程实践应用

Practical application of porous asphalt pavement engineering

工程实践应用案例二

Engineering Practice Application Case 2

石家庄和平西路高架桥层排水沥青路面雨雪天气效果对比
Comparison of rain and snow weather on Porous Asphalt Pavement of viaduct in Heping West Road, Shijiazhuang



➤ 排水沥青路面雨天效果
Porous asphalt pavement rain effect

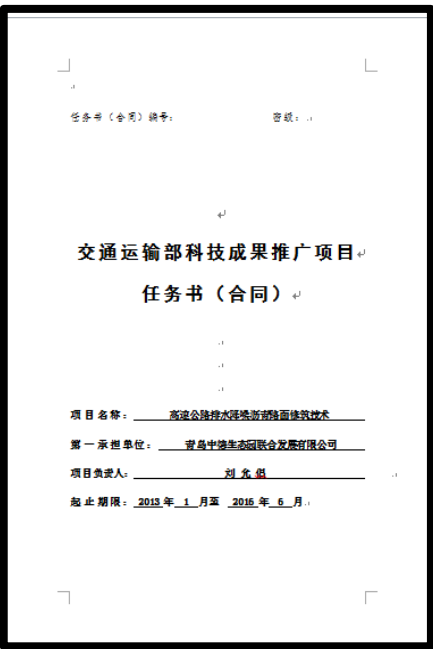


➤ 排水沥青路面雪天效果
Porous asphalt pavement snow effect

3.1 排水沥青路面工程实践应用

Practical application of porous asphalt pavement engineering

我国排水沥青路面的体系化、技术标准及推广平台 Systematization, technical standard and popularization platform of porous asphalt pavement in China



3.2 排水沥青路面应用的安全效果

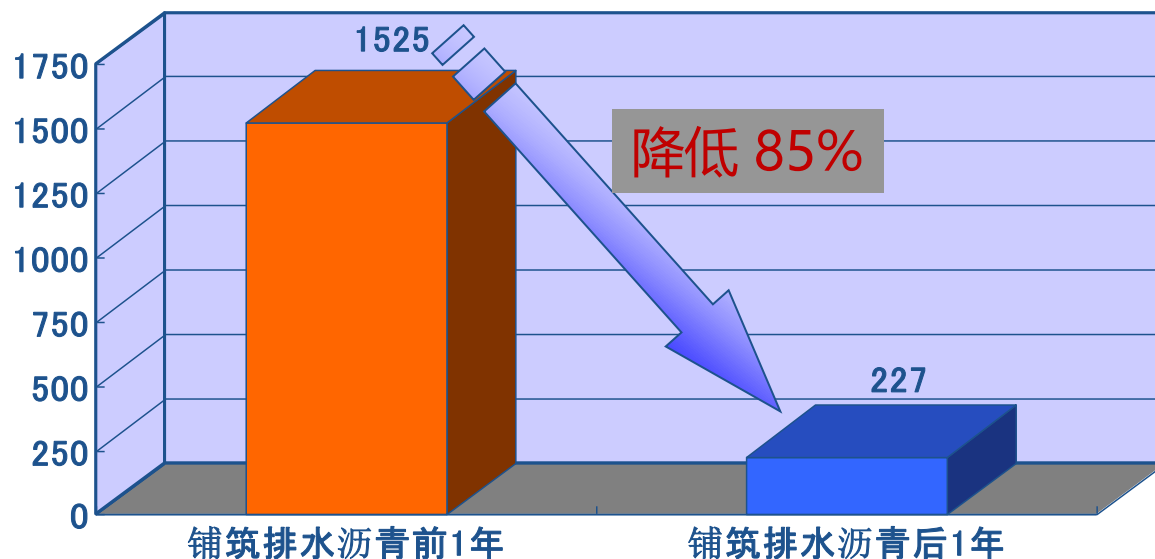
Safety effect of application of porous asphalt pavement

排水沥青路面降低交通事故

Porous asphalt pavement reduces traffic accidents

日本道路公团调研结果表明：
应用排水沥青路面事故率降低了85%，并将其作为最有效的雨天安全技术措施。

The results of the investigation by the Japanese Road Corporation show that the accident rate of porous asphalt pavement is reduced by 85%, and it is regarded as the most effective safety technical measure in rainy days.

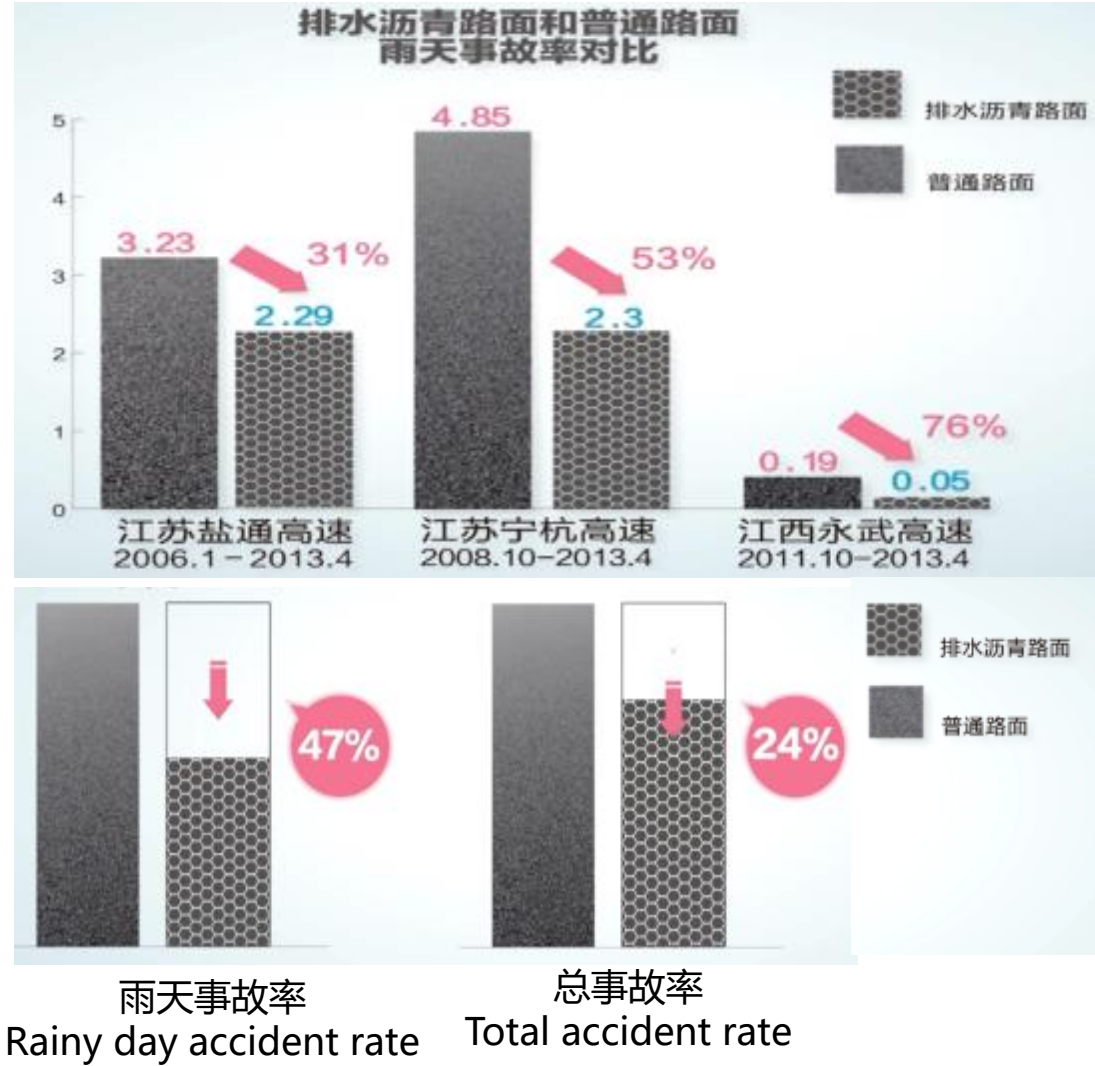


3.2 排水沥青路面应用的安全效果

Safety effect of application of porous asphalt pavement

盐通、宁杭、永武三条高速公路总事故率排水路面比普通路面平均降低4%，雨天事故率平均降低47%。

The total accident rate of Yantong, Ningxia-Hangzhou and Yongwu expressways is 4% lower than that of common roads, and 47% lower in rainy days.



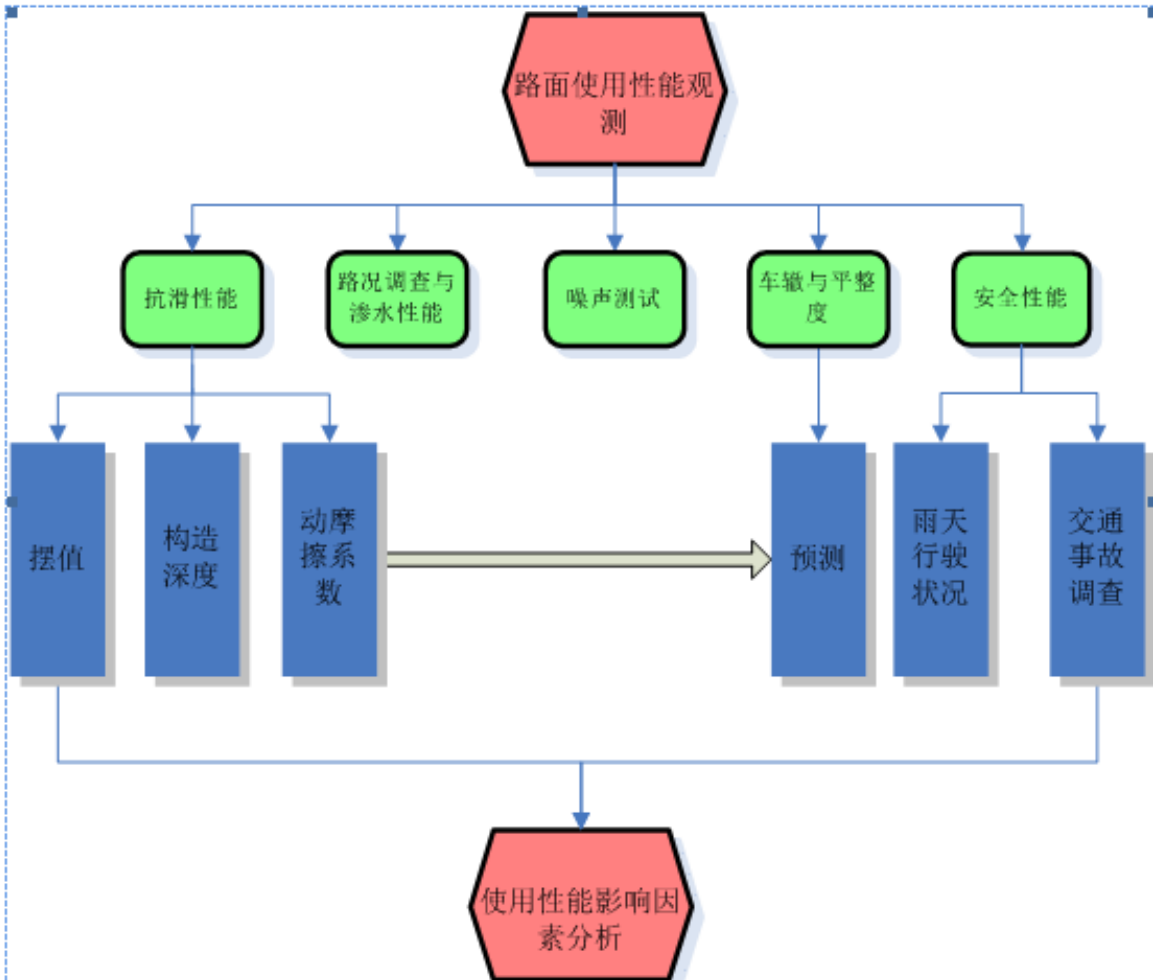
3.3 排水沥青路面长期性能观测

Long term performance observation of porous asphalt pavement

盐通高速排水沥青路面长期性能观测

Long term performance observation of asphalt pavement at salt Tong Expressway

- 每年观测两次
Two times a year
- 结构耐久性
Structural durability
- 功能耐久性
Functional durability



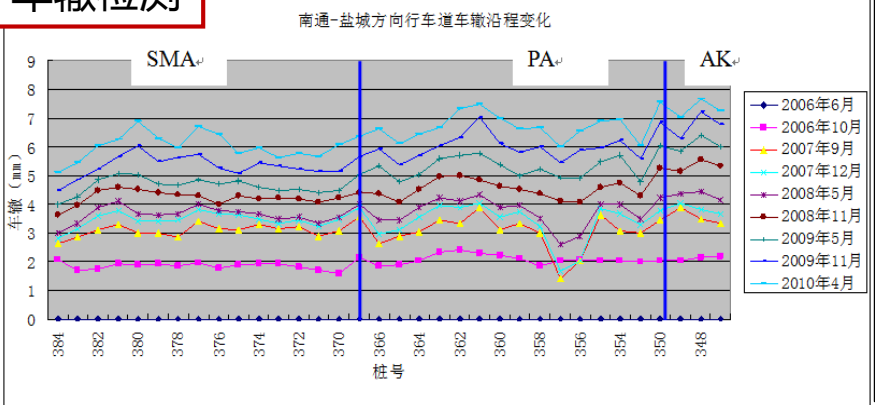
3.3 排水沥青路面长期性能观测

Long term performance observation of porous asphalt pavement

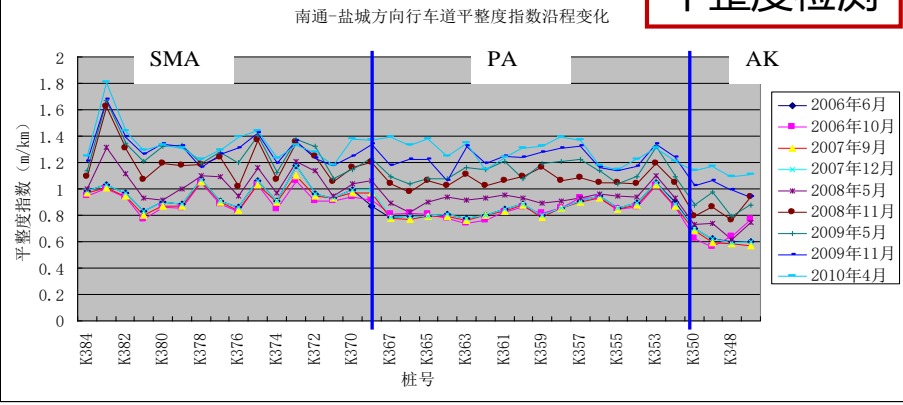
盐通高速 8年跟踪检测指标

工程观测

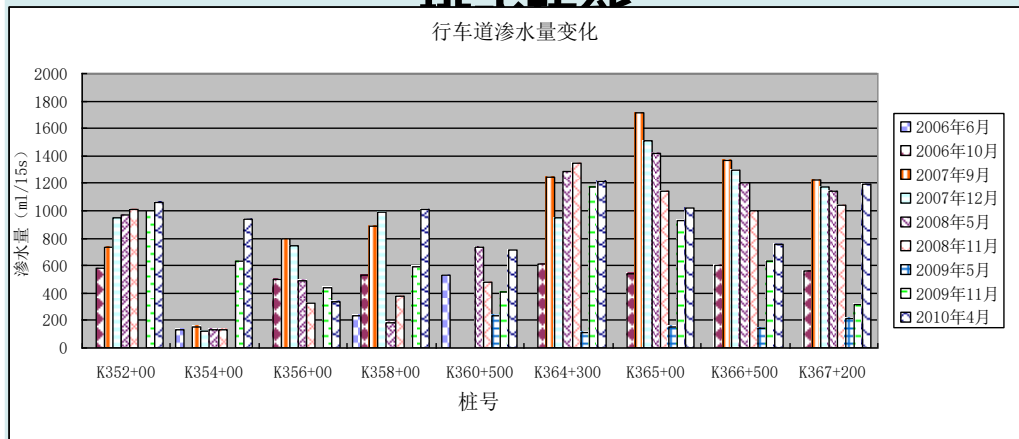
车辙检测



平整度检测



排水性能



盐通高速公路排水沥青路面8年跟踪观测：结构和使用功能的双重耐久

8 years tracking observation of drainage asphalt pavement on Yan Tong expressway: Double durability of structure and function

3.3 排水沥青路面长期性能观测

Long term performance observation of porous asphalt pavement

➤ 盐通高速排水沥青路面空隙堵塞观测与研究



盐通高速公路排水沥青路面2014年现场观测：
部分（以紧急停车带为主）
空隙堵塞，但总体排水效
果良好



3.3 排水沥青路面长期性能观测

Long term performance observation of porous asphalt pavement

盐通高速2013年3月份检测指标

(PCI/RQI/RDI/SRI四种路况指数均在90分以上)

透水路面试验段路面状况明细 (连通K1110-1127)

| 起点桩号 | 长度 (m) | MQI | 路面 | 路面 | | | | |
|------------------|--------|-------|-------|-------|-------|-------|-------|-------|
| | | | PQI | PCI | RQI | RDI | SRI | |
| K0+000 ~K1+000 | 1000 | 97.20 | 96.00 | 98.46 | 95.75 | 91.68 | 94.85 | |
| K1+000 ~K2+000 | 1000 | 97.25 | 96.07 | 98.84 | 95.82 | 91.71 | 93.91 | |
| K2+000 ~K3+000 | 1000 | 96.47 | 96.23 | 99.02 | 95.63 | 92.89 | 93.9 | |
| K3+000 ~K4+000 | 1000 | 95.52 | 96.30 | 98.7 | 95.99 | 93.45 | 93.43 | |
| K4+000 ~K5+000 | 1000 | 96.58 | 96.20 | 98.45 | 95.92 | 93.36 | 93.71 | |
| K5+000 ~K6+000 | 1000 | 96.23 | 96.39 | 98.46 | 96.03 | 94.1 | 94.06 | |
| K6+000 ~K7+000 | 1000 | 97.54 | 96.49 | 98.84 | 95.88 | 94.09 | 94.28 | |
| K7+000 ~K8+000 | 1000 | 96.93 | 96.68 | 99.02 | 96.06 | 93.81 | 95.3 | |
| K8+000 ~K9+000 | 1000 | 96.77 | 96.36 | 98.57 | 96.01 | 93.29 | 94.66 | |
| K9+000 ~K10+000 | 1000 | 97.35 | 96.22 | 98.57 | 96.13 | 92.44 | 94 | |
| K10+000 ~K11+000 | 1000 | 97.44 | 96.35 | 99.71 | 95.35 | 92.73 | 93.99 | |
| K11+000 ~K12+000 | 1000 | 95.66 | 96.08 | 99.02 | 96.02 | 92.03 | 92.15 | |
| K12+000 ~K13+000 | 1000 | 95.52 | 96.19 | 99.02 | 95.98 | 92.6 | 92.53 | |
| K13+000 ~K14+000 | 1000 | 96.62 | 96.83 | 100 | 96.03 | 93.55 | 93.82 | |
| K14+000 ~K15+000 | 1000 | 95.58 | 96.35 | 98.36 | 95.78 | 93.8 | 95.39 | |
| K15+000 ~K16+000 | 1000 | 94.82 | 96.54 | 99.02 | 96.03 | 93.36 | 94.68 | |
| K16+000 ~K17+000 | 1000 | 96.12 | 95.88 | 100 | 95 | 93.94 | 87.85 | |
| 平均值 | 17000 | 96.45 | 96.30 | 98.94 | 95.85 | 93.11 | 93.85 | |
| 全线上行 | | | 96.82 | 95.9 | 99.08 | 95.49 | 91.43 | 93.14 |
| 全线下行 | | | 95.87 | 95.95 | 98.99 | 95.49 | 92.19 | 92.85 |

目录

Contents

一、背景介绍/Background Introduction

二、排水沥青路面技术研究/Technical research

三、工程实践应用/Engineering Practice Application

四、结语/Conclusion

四、结语

Conclusion

1 我国的研究和应用表明，排水沥青路面可降低雨天事故率40%以上，降低3-8分贝，是国际公认的高性能沥青路面类型。

The research and application in China show that the porous asphalt pavement can reduce the rain accident rate by more than 40% and 3-8 dB. It is internationally recognized as a high performance asphalt pavement type.

2 经过近17年研究应用,已攻克了应用排水沥青路面的多项技术瓶颈，成为一种成熟可靠的工程技术。工程实践表明即使对于重交通高速公路，耐久性可以达到10年以上。

After nearly 17 years of research and application, it has overcome many technical bottlenecks in the application of porous asphalt pavement and become a mature and reliable engineering technology. Engineering practice shows that even for heavy traffic freeway, durability can be more than 10 years.

3 排水沥青路面修建成本比SMA低，施工工艺简单，对工程进度基本上没有影响。

The construction cost of porous asphalt pavement is lower than SMA, and the construction technology is simple, which has no effect on the project schedule.

4 排水沥青路面将引领路面服务功能升级，必然在我国获得推广应用。交通运输部通过推广课题、技术标准规范等正在推动该技术的普及。

The porous asphalt pavement will lead the upgrading of pavement service function, and it will be widely applied in China. The Ministry of transport is promoting the popularization of the technology through the promotion of subjects and technical standards.

致谢

- 交通运输部科技司
- 交通运输部公路局
- 交通运输部交通科技项目管理中心
- 江苏交通控股有限公司
- 江苏省交通工程建设局（江苏省高速公路建设指挥部）
- 江西省交通运输厅
- 四川省交通运输厅
- 石家庄市交通局环城公路建设指挥部
- 江西省交通运输厅永修至武宁高速公路建设项目办公室
- 安徽省高速公路控股集团有限公司
- 四川遂资高速公路有限公司
- 江苏宁靖盐高速公路有限公司
- 江苏沿海高速公路管理有限公司
- 江苏宁宿徐高速公路有限公司
- 江苏宁杭高速公路有限公司
- 中德联合集团有限公司
- 四川遂广遂西高速公路有限责任公司
- 湖南永龙高速公路建设开发有限公司

欢迎交流探讨!



交通运输部公路科学研究院
RESEARCH INSTITUTE OF HIGHWAY MOT



中路高科(北京)公路技术有限公司
ZHONG LU GAO KE (BEIJING) ROAD TECHNOLOGY Co.Ltd