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# Semi-Rigid Pavement (SRP) Applications for Airfield, Road and Facility

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# 1. Introduction

## 1.1 Definition of semi-rigid pavement:

a. Composite pavement material consisting porous asphalt concrete (PA) with air voids between 25-30% (by Marshall mix design volume) and

b. Filled or flooded by special formulated high performance polymer modified cement mortar material, shortly called grouting material or grout.

## 1.2 Typical applications in Singapore and Malaysia:

a. Commonly as wearing course of the rigid and flexible pavements

b. As both binding and wearing courses for the pavements

## 1.3 Typical thickness of semi-rigid pavement construction:

a. Total thickness range: 50-150mm

b. Light to medium traffic (e.g. road junction): 50-75mm

c. Heavy traffic (e.g. apron, parking lot): 75-100mm

d. Special traffic (e.g. taxiway, apron): 100-150mm

# 1. Introduction

## 1.4 Comparisons of major properties between

a. Rigid pavement (e.g. cement concrete);

b. Flexible pavement (e.g. asphalt concrete); and

c. SRP

| Compared Properties | Rigid Pavement | Flexible Pavement | Semi-Rigid Pavement (SRP) |
|---|---|---|---|
| Resistance to rutting/deformation | √ | | √ |
| High skid resistance | | √ | √ |
| Resistance to petroleum products, oil and chemical | √ | | √ |
| Resistance to moisture damage | √ | | √ |
| Easy maintenance and repair | | √ | √ |
| Long life span | √ | | √ |
| High flexural strength | √ | | √ |
| No expansion joints required | | √ | √ |
| Installation and open to traffic | Weeks to months | Within hours | 8-12 hours |
| Low construction & maintenance costs | | √ | √ |

# 1. Introduction

## 1.5 Construction thickness per layer

a. Normally 50-75mm/layer

b. 100mm/layer may be still workable with full cautious

75mm cored sample


100mm cored sample

# 1. Introduction

## 1.6 SRP typical applications in Singapore and Malaysia:

a. Summary: SRP can function like concrete but repaired as asphalt concrete

b. Commonly used as the wearing course of both flexible and rigid pavements

c. Typical applications in

* Airfield parking apron
* Heavy loading and/or chemical impact platform or parking lot
* Heavy traffic road and junction
* Bus terminal
* Other heavy traffic areas

# 2. Key Properties and Requirements

## 2.1 Porous (Open) Asphalt Concrete

a. Main properties of PAC shall consist of *25-30% of air voids* (Marshall mix design volume).

b. The design of PAC must include the selection of *aggregate gradation*, *determination of bitumen content*, *mixing and compaction procedure*.

## 2.2 Grouting material

a. High performance polymer modified cement mortar material such as Chemilink SS-141 is specially designed for the semi-rigid pavement system.

b. Such material can be mixed with *a certain amount of water to form a free-flowing grouting material*.

c. Important factors for design of this polymer modified cementitious grouting material mainly include *fluidity and compressive/flexural strength* properties.

# 2. Key Properties and Requirements

## 2.2 Grouting material

d. Properties and requirements of the grouting material

| Properties | Curing time | General Requirement by Different Specifications* | Material Example (SS-141) | Remarks |
|---|---|---|---|---|
| Fluidity (workability) ASTM C939 | --- | 10-18sec | 10-22sec | * Refer to those from Singapore LTA & CAG |
| Compressive strength (BS EN 12390-3) | 12hrs | --- | 20-30MPa | |
| | 1day | ≥40MPa | 40-60MPa | |
| | 7days | --- | 70-90MPa | |
| | 28days | ≥90MPa | 90-130MPa | |
| Flexural strength (BS EN 12390-5) | 28days | 6-8MPa | 6-10MPa | |
| Setting time (EN 196-3) | --- | 4-8hrs | 4-8hrs | |

# 2. Key Properties and Requirements

## 2.3 Semi-Rigid Pavement (SRP)

a. SRP – a combination of porous asphalt concrete and grouting material

b. SRP major properties and requirements

| Properties | Curing Age | General Requirements by Different Specifications* | Project Example (with SS-141) | Remarks |
|---|---|---|---|---|
| Compressive strength (BS EN 12390-3) | 12hrs | --- | 3-5MPa | * Refer to those from Singapore LTA & CAG |
| | 1day | ≥5MPa | 5-8MPa | |
| | 7days | --- | 7-12MPa | |
| | 28days | 7-10MPa | 8-15MPa | |
| Flexural strength (BS EN 12390-5) | 28days | ≥3.5MPa | ≥3.5MPa | |
| Skid resistance (ASTM E303-93) | --- | 55-60BPN | 60-90BPN | |
| Curing time | --- | 4-8hrs | 4-8hrs | |
| Texture depth by sand patch method (BS 598:105:1990) | --- | 0.5-1.2mm | 0.5-1.2mm | |

# 3. Installation and Typical SRP Projects

## 3.1 Installation - Lay Porous Asphalt Concrete (PAC)

(a) Milling of Existing AC Surface

(b) Cleaning Milled Area

(c) Spraying Primer Coat

(d) Laying PAC to Designed Thickness


(e) Compaction

(f) Compacted PAC Surface (Air Void 25-30%)

# 3. Installation and Typical SRP Projects

## 3.1 Installation -Mix Grouting Material With Water

**(a) Mixing With Big Mixer (500kg powder/batch)**

**(b) Mixing With Medium Mixer (100kg powder/batch)**

**(c) Mixing With Hand Mixer (25kg powder/batch)**

# 3. Installation and Typical SRP Projects

## 3.1 Installation -Fill Grouting Material into PAC

(a) Filling the grouting material into PAC

(b) Spreading

(c) Vibration (optional)

(d) Surface just after Filling

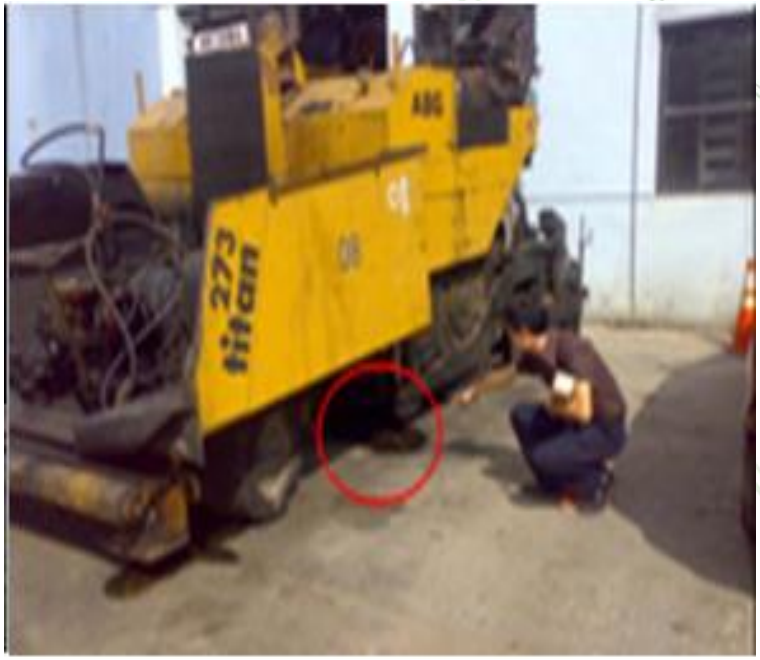
(e) Hardened Surface

# 3. Installation and Typical SRP Projects

## 3.2 Typical SRP projects (Singapore and Malaysia)

1) Heavy Loading Yard at AC Plant -2005 (thickness: 50mm)

**(a) Semi-Rigid Pavement after Hardened**

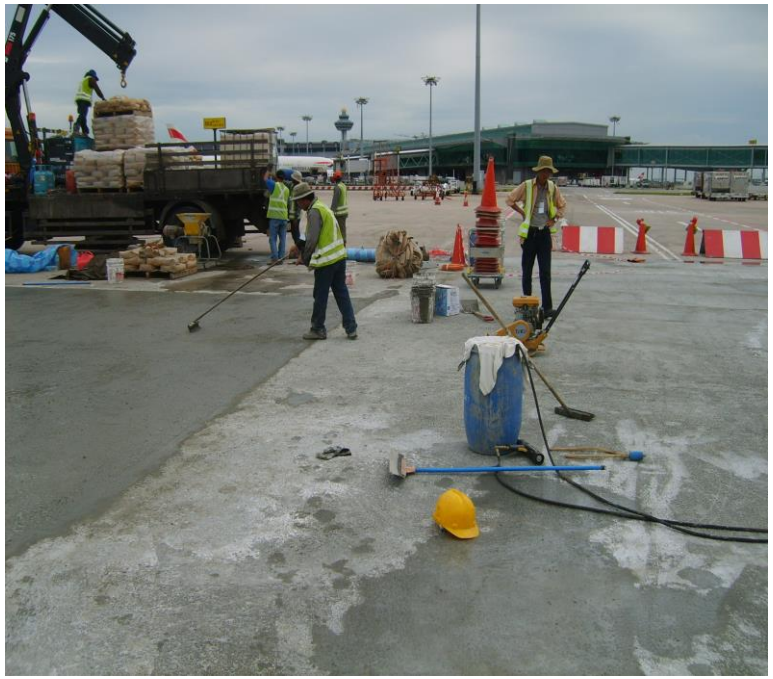



**(b) Good Ability to Chemical / Oil Attacks**

# 3. Installation and Typical SRP Projects

## 3.2 Typical SRP projects (Singapore and Malaysia)

2) Changi Airport Apron -2007 (thickness: 50mm)

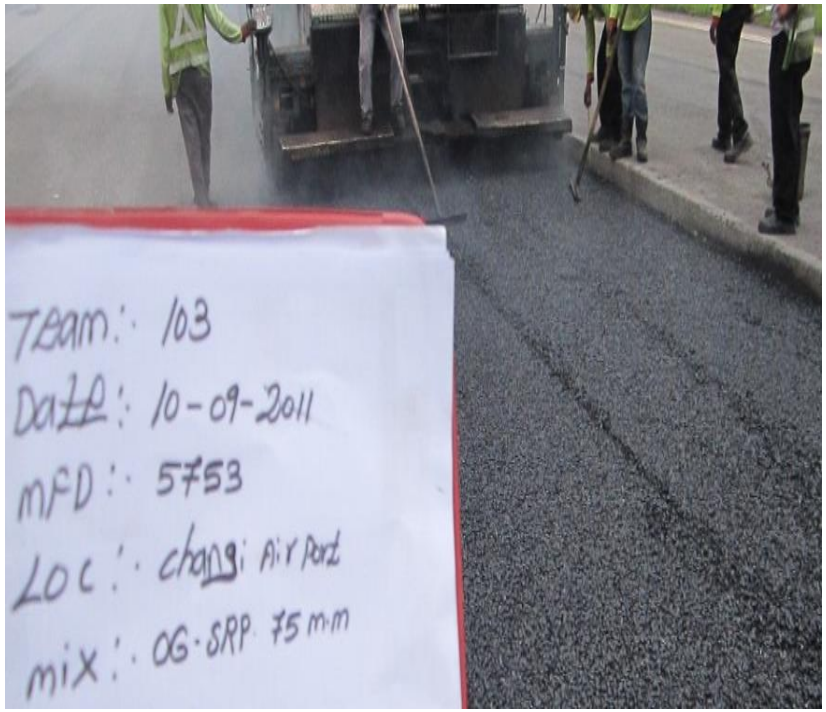



**Semi-rigid Pavement for Airport Parking Aprons**
**Construction in Progress**
**1st time used in parking apron in Singapore**

# 3. Installation and Typical SRP Projects

## 3.2 Typical SRP projects (Singapore and Malaysia)

3) Taxiway in Changi Airport -2011 (thickness: 150mm, 75mm/layer)




**(a) Laying Porous Asphalt Concrete (75mm/layer)**


**(b) Filling of Chemilink SS-141**

# 3. Installation and Typical SRP Projects

## 3.2 Typical SRP projects (Singapore and Malaysia)

4) Buona Vista Traffic Junctions to AYE (thickness: 50mm)

**Construction in Progress**

# 3. Installation and Typical SRP Projects

## 3.2 Typical SRP projects (Singapore and Malaysia)

5) Bus Depot of Tuas West MRT End -2016 (thickness: 100mm, 50mm/layer)

**(a) Filling Grouting Material onto PAC**

**(b) Bus Depot in Operation**

# 3. Installation and Typical SRP Projects

## 3.2 Typical SRP projects (Singapore and Malaysia)

6) Eastern End Junction of Nicoll Highway -2017 (thickness: 50mm)

**a. Mixing Grouting Material with Water**

**b. Public Traffic in Operation**

# 3. Installation and Typical SRP Projects

## 3.2 Typical SRP projects (Singapore and Malaysia)

7) Selangor Heavy Traffic Junctions -2017

(thickness: 50mm + 300mm rehabilitated base)

**Rehabilitated Base**

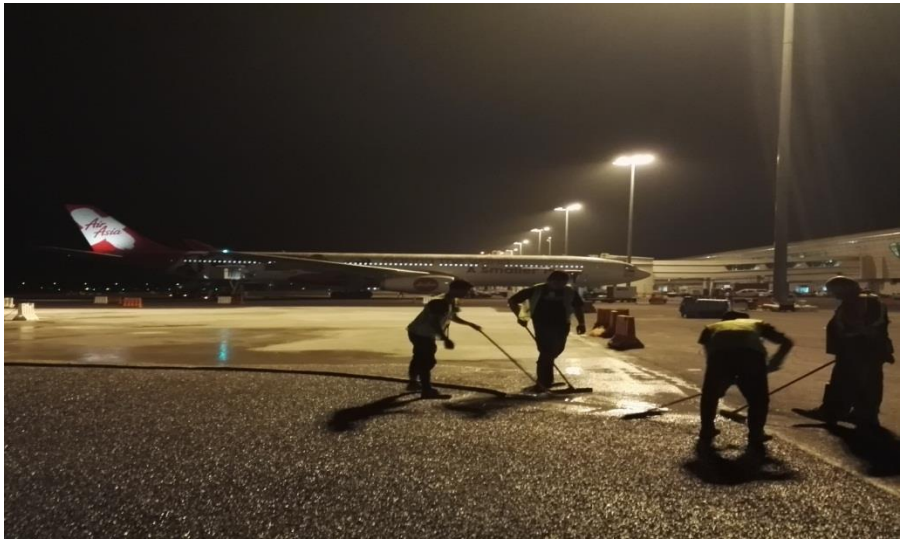
**Completion of Grout Filling**


**Immediate Opening to Public Traffic**

# 3. Installation and Typical SRP Projects

## 3.2 Typical SRP projects (Singapore and Malaysia)

8) Kuala Lumpur International Airport II: Parking Apron & Oil Platform -2018
(thickness: 75mm, 75mm/layer)



**a. Laying Grouting Material**

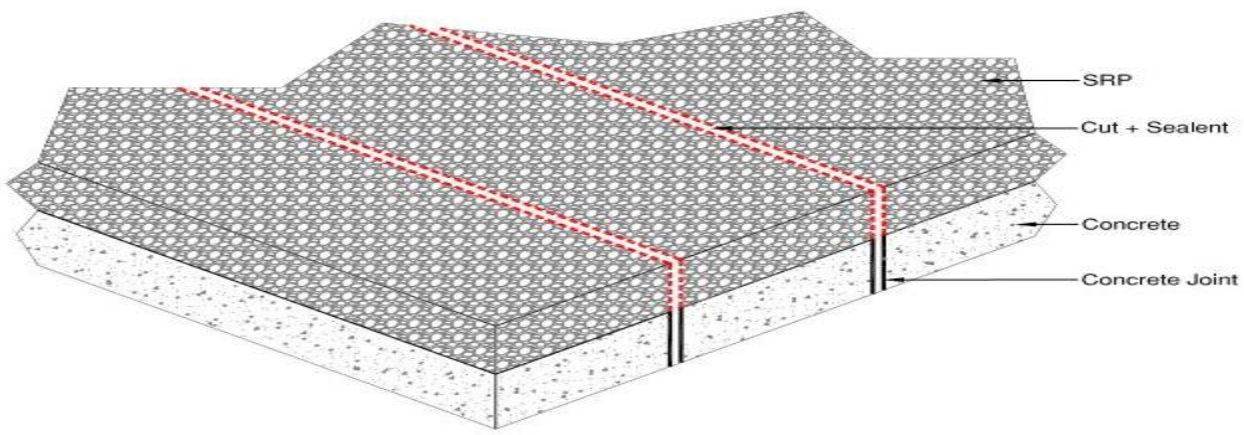
**b. Completion of Parking Apron & Oil Handling Platform**

# 3. Installation and Typical SRP Projects

## 3.3 SRP above rigid pavement (concrete) surfaces

1) General SRP structure on the top of concrete pavements (thickness: 50mm)

(Ulu Pandan Bus Depot, Phase-1, 2016)

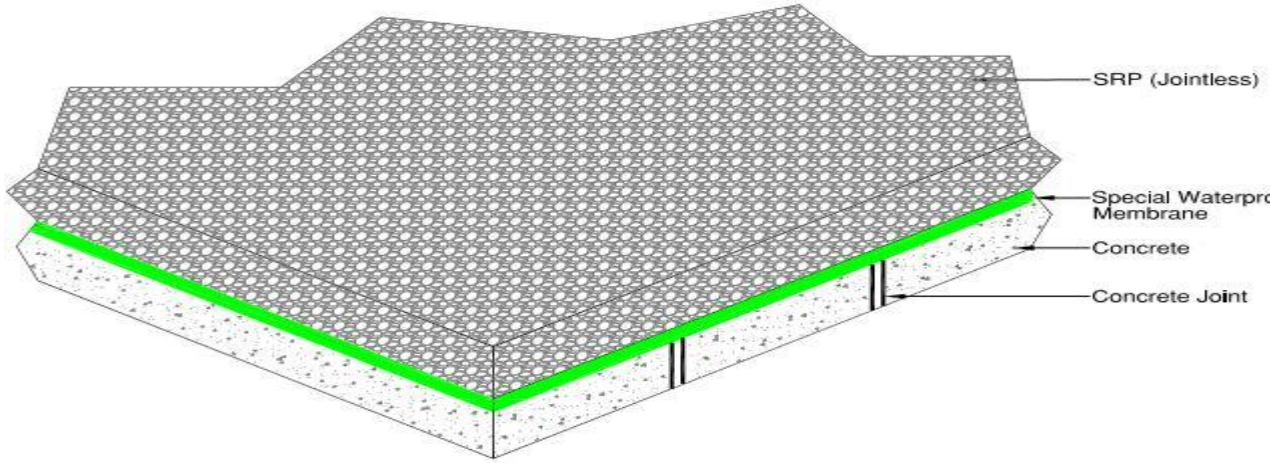


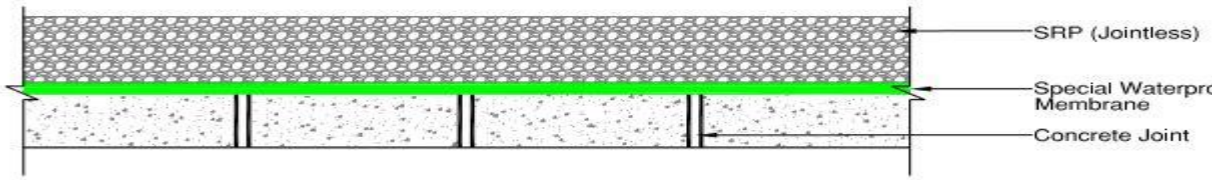

# 3. Installation and Typical SRP Projects

## 3.3 SRP above rigid pavement (concrete) surfaces

2) SRP on the roof concrete slabs of the building (thickness: 100mm, 50mm/layer)

(Bus Depot of Tuas West MRT End -2016)



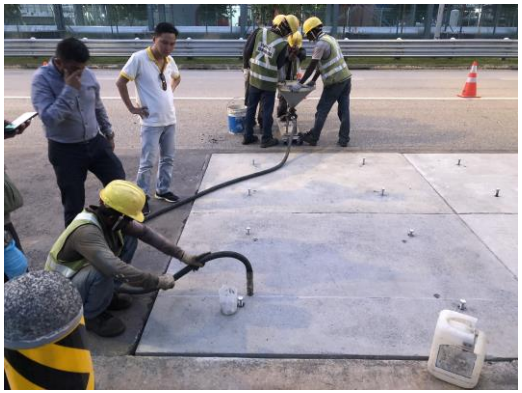

NOTE : Some Hairline Cracks May Happen.

# 3. Installation and Typical SRP Projects

## 3.4 Special use of grouting material below the concrete slab

Note: A new system called “Precast ECC Ultra-Thin White-Topping” developed by NTU-JTC has been used as road wearing course and the grouting material functions as a special binder between the precast slab and the road binding course.

**(a) Installing Precast Slab**

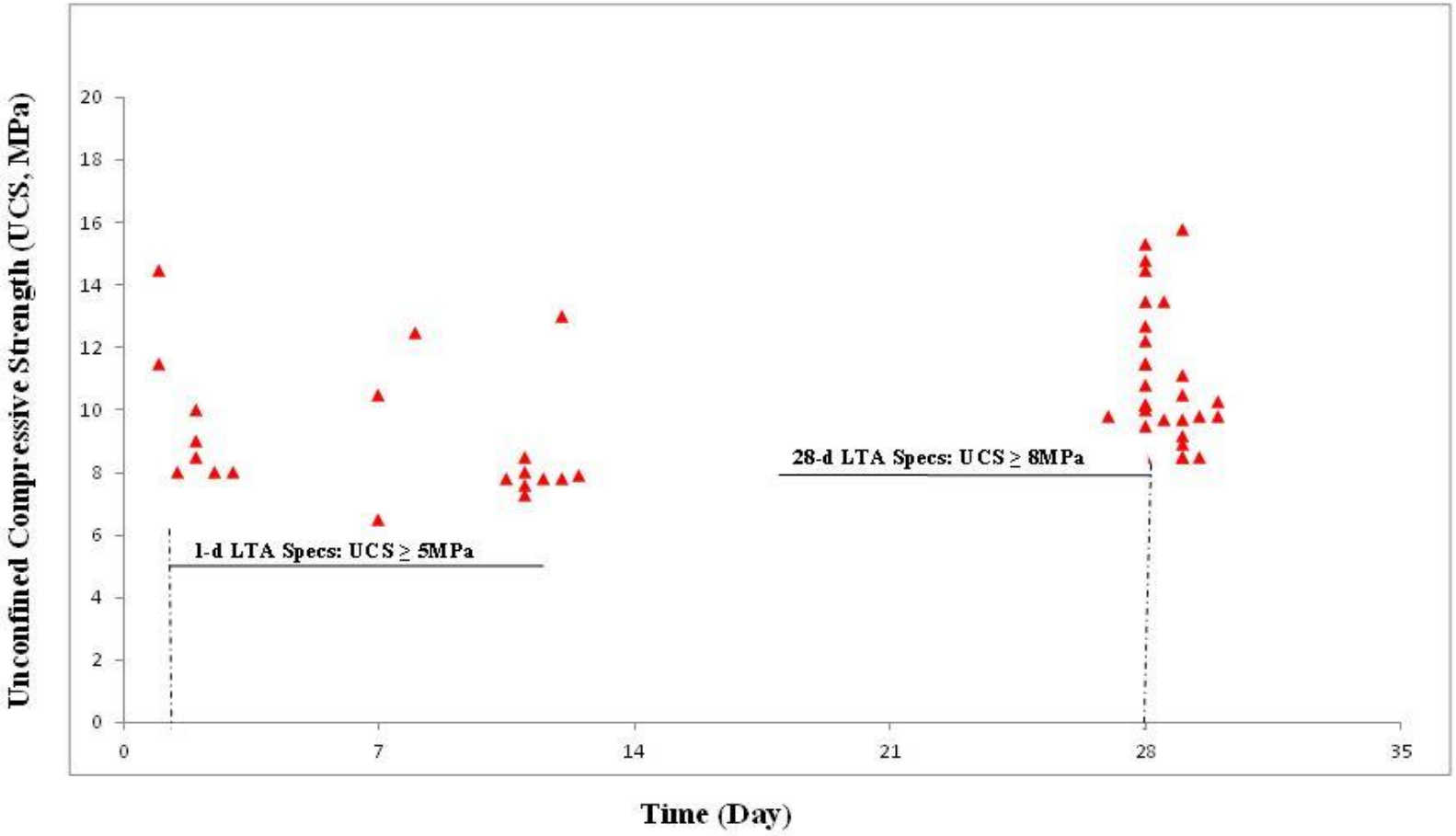


**(b) Grouting for Binding**


**(c) In Operations**

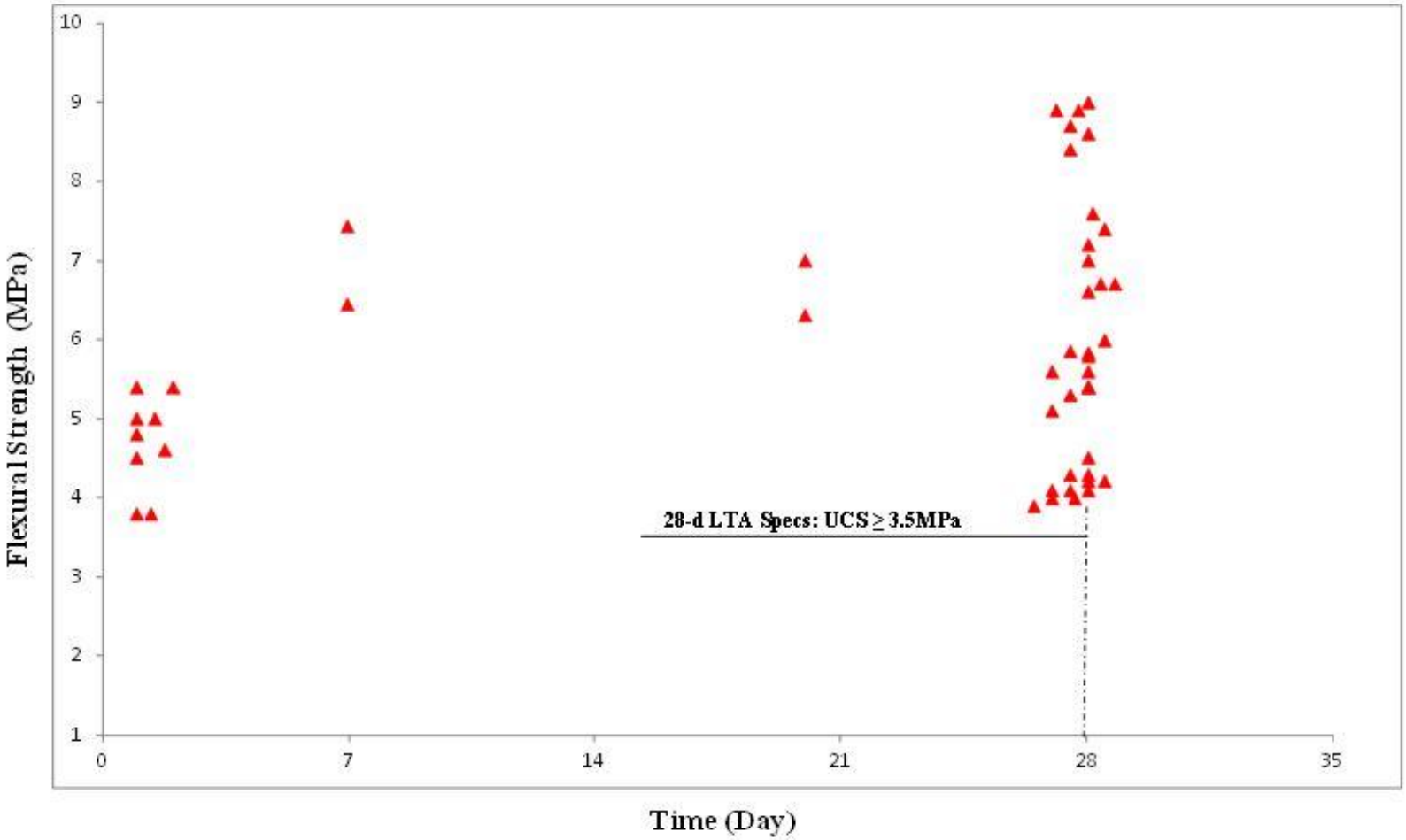
# 4. Selected SRP Performance Testing Results

## 4.1 Compressive Strength of SRP Formed by SS-141 (2005-2018)



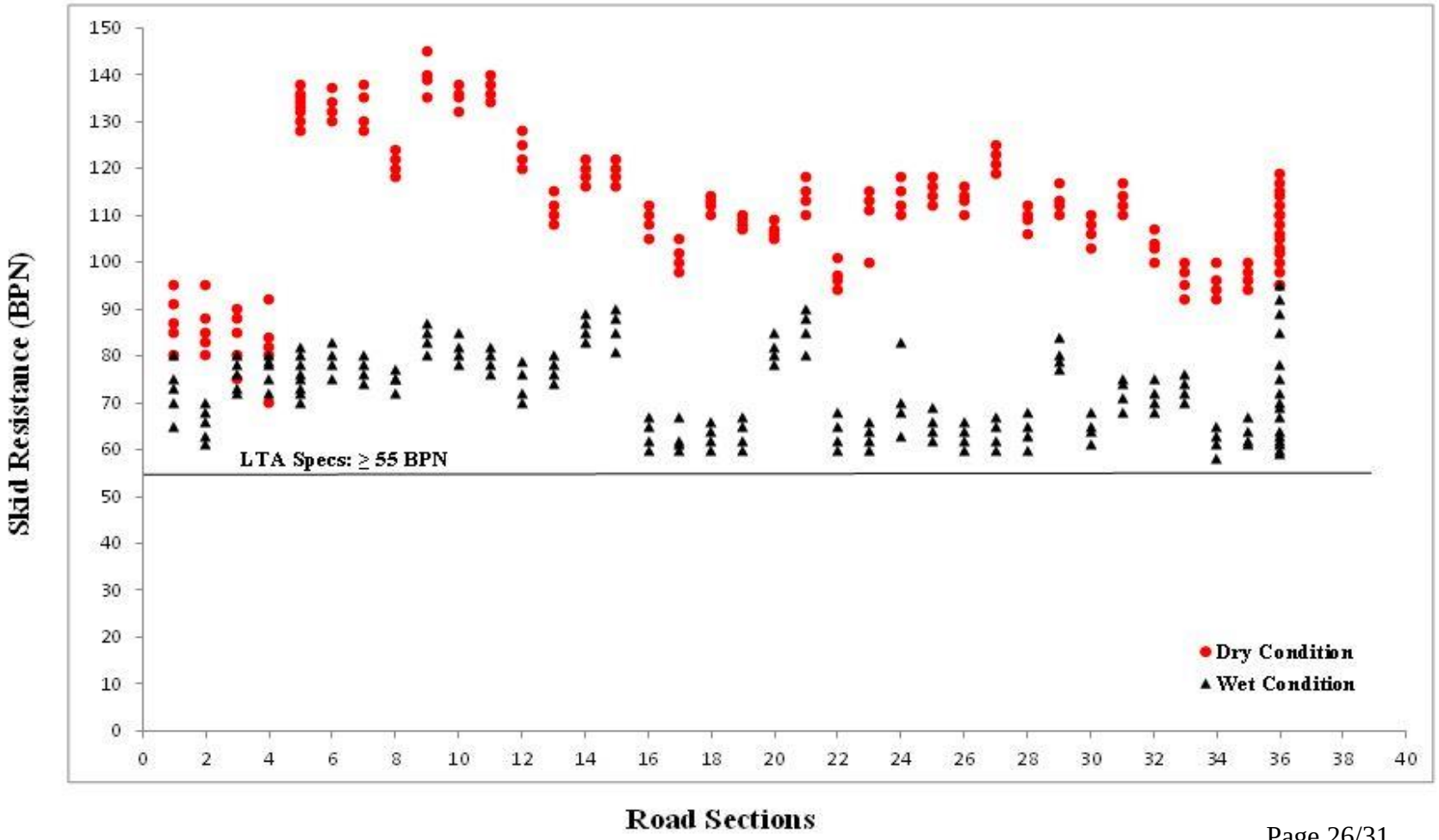
# 4. Selected SRP Performance Testing Results

## 4.2 Flexural Strength of SRP Formed by SS-141 (2005-2018)



# 4. Selected SRP Performance Testing Results

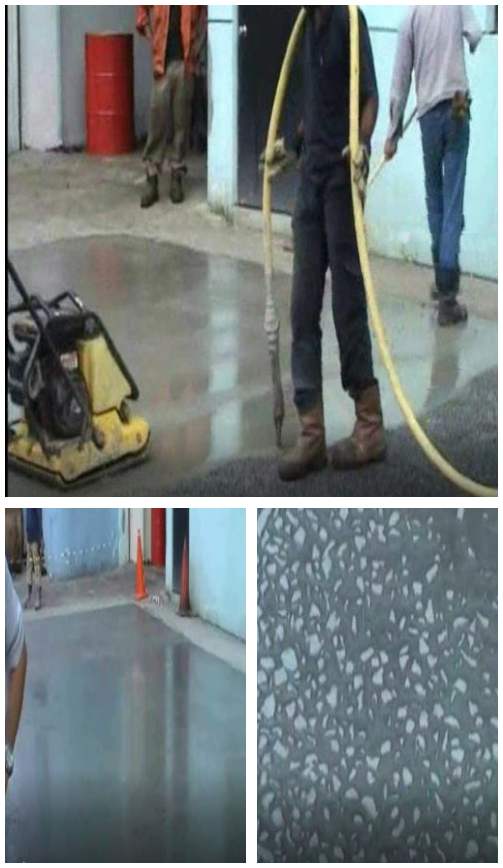
## 4.3 Skid Resistance of SRP Formed by SS-141 (2005-2018)



# 5. A Case Study on Durability of SRP

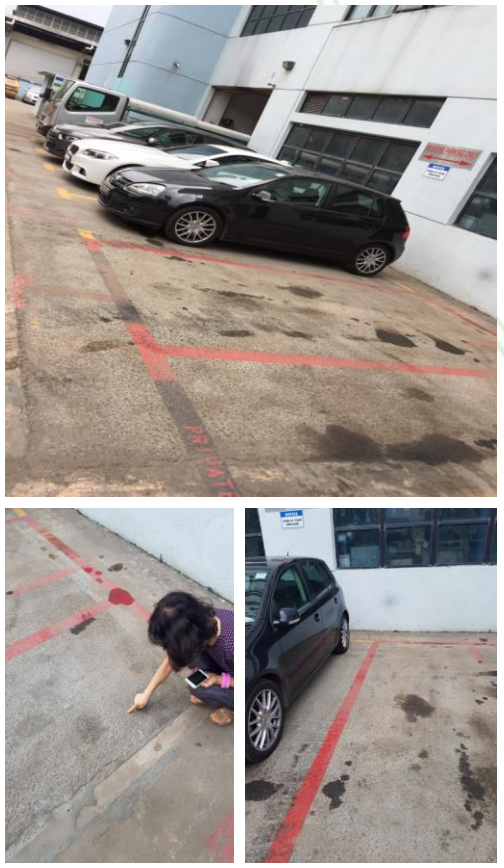
## 5.1 Heavy Loading Yard at AC Plant (2005 vs. 2017)

**2005**



**2007**

**2017**



In 2005, Semi-Rigid Pavement using Chemilink SS-141 as grouting material was introduced as wearing course in a heavy load parking area.

Twelve (12) years later, the Semi Rigid Pavement layer has being still performed well and all in good conditions.

# 5. A Case Study on Durability of SRP

## 5.2 Buona Vista Traffic Junctions to AYE (2011 vs. 2017)

**2011** **2017**



In 2011, Semi- Rigid Pavement was used as wearing course for several Traffic Junctions at South Buona Vista Road, Singapore.

Six years later, all junctions are still in good operational conditions and there are no defects on Semi-Rigid Pavement surface.

# 6. Conclusions

1) Semi-Rigid Pavement (SRP) can function like concrete but repaired as asphalt concrete and almost combining all advantages & benefits of both rigid and flexible pavements. A comprehensive introduction and applications of SRP have been presented and discussed in this paper.

2) SRP may be used as the wearing course for both rigid and flexible pavements. Some of selected project examples as commonly-used for flexible pavement are demonstrated, while special practice on the top of rigid pavement is discussed.

3) SRP has been widely used in this tropical region especially in Singapore and Malaysia for past more than 10 years and it is a proven systematic solution mainly for applications as pavement surface layer.

4) SRP can be much durable up to 10 years or even more, subject to the real operational usages. Further study on its long-term properties could disclose more characters for successive improvement of this system.

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