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TYPICAL APPLIATIONS OF SEMI-RIGID PAVEMENT

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CHEMILINK
ZERO WASTE ENGINEERING

Table of Contents

1. Introduction

1.1 Typical pavement design for road construction:

- Flexible pavement (Asphalt concrete pavement)
- Rigid pavement (Cement concrete pavement)
- Semi-rigid pavement (Asphalt concrete filled with cementitious grouting material)

Compared Properties	Asphalt Concrete Pavement (AC)	Cement Concrete Pavement (CC)	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	Within hours	0.5~3.0 months	Within 24 hours
Low construction and maintenance costs	√		√

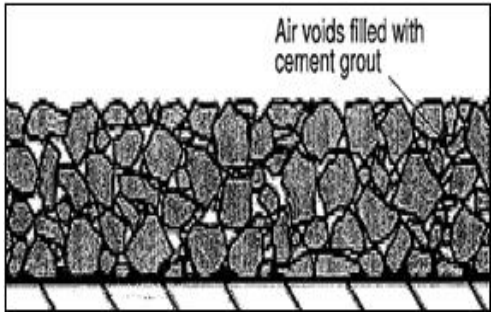
1. Introduction

1.2 Definition of semi-rigid pavement:

- It is a composite pavement material consisting of porous asphalt concrete (PAC) with ***air voids content of 25-30%*** (by Marshall mix design volume).
- And is filled or flooded with specially formulated ***high performance polymer modified cementitious grouting material***.

1.3 Typical thickness of semi-rigid pavement constructed in Singapore:

- Traffic light intersection (junction): ***50mm***
- Heavy loading infrastructure such as taxiway, airport parking apron or MRT & bus deport: ***100~150mm @ Single or double layers of 50-75mm per layer.***



(a) Porous Asphalt Concrete (PAC)

(b) Polymer Modified Cementitous Grouting Material filling into PAC

(c) Semi-Rigid Pavement (Cored Sample)

2. Semi-Rigid Pavement Components and Properties

2.1 Porous Asphalt Concrete (PAC) - in Singapore

- **Main properties of PAC shall consist of *25-30% of air voids* (Marshall mix design volume).**
- **The design of PAC must include the selection of *aggregate gradation*, *determination of bitumen content, mixing and compaction procedure*.**

a. Component of PAC

Components	% by weight
1. Aggregates	92.9%
2. Filler	3.0%
3. Polymer Modified Bitumen	3.6 ~ 4.6%

c. Particle size distribution of aggregate

Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
19	100	2.36	1~10
13.2	85~100	0.6	0~8
9.5	27~53	0.3	0~5
6.3	1~15	0.075	0~3

b. Properties of coarse aggregate used for PAC

Properties	Value	Testing method
1. Impact Value	≤ 25%	BS 812 part 112:1985
2. Crushing Value	≤ 25%	BS 812 part 1101985
3.Water Absorption	≤ 1%	BS 812 part 2:1975
4. Flakiness Index	≤ 25%	BS 812 part 105.1: 985
5. Elongation Index	≤ 30%	BS 812 part 105.2: 985
6. LA Abrasion Value (500 revolutions)	≤ 20%	SS 73:1974
7. Silt content of aggregate in Hot Bin(by weight)	≤0.3%	BS 812 part 1:1975

2. Semi-Rigid Pavement Components and Properties

2.2 Polymer Modified Cementitious Grouting Material

- **Chemilink SS-141 is specially designed for the semi-rigid pavement system.**
- **Polymer modified cement mortar shall be mixed with *a certain amount of water to form a free-flowing grouting material*.**
- **Important factors for design of polymer modified cementitious grouting material: *Fluidity and Compressive/Flexural strength* properties.**

Properties	Curing time	Chemilink SS-141	Specs from LTA[a]	Project tender document [b]	Project tender document [c]
1. Flow Value by P-Funnel	---	**11-27sec**	10-18 Sec	10-14sec	10-14sec
2. Compressive strength (BS EN 12390-3:2002)	12-hrs	20-30MPa	---	---	---
	1-day	**55-85MPa**	40MPa	---	---
	7-days	100-120MPa	---	---	≥ 40MPa
	28-days	**110-130MPa**	90MPa	40-50MPa	---
3. Flexural strength (BS EN 12190)	28-days	**7-15MPa**		6-8MPa	≥ 6MPa
4. Setting time (BS EN 196-3: 1995)	---	**2-3hr; 3-6hr; 6-8hr**	4-8hrs	2-3hrs	2-3hrs

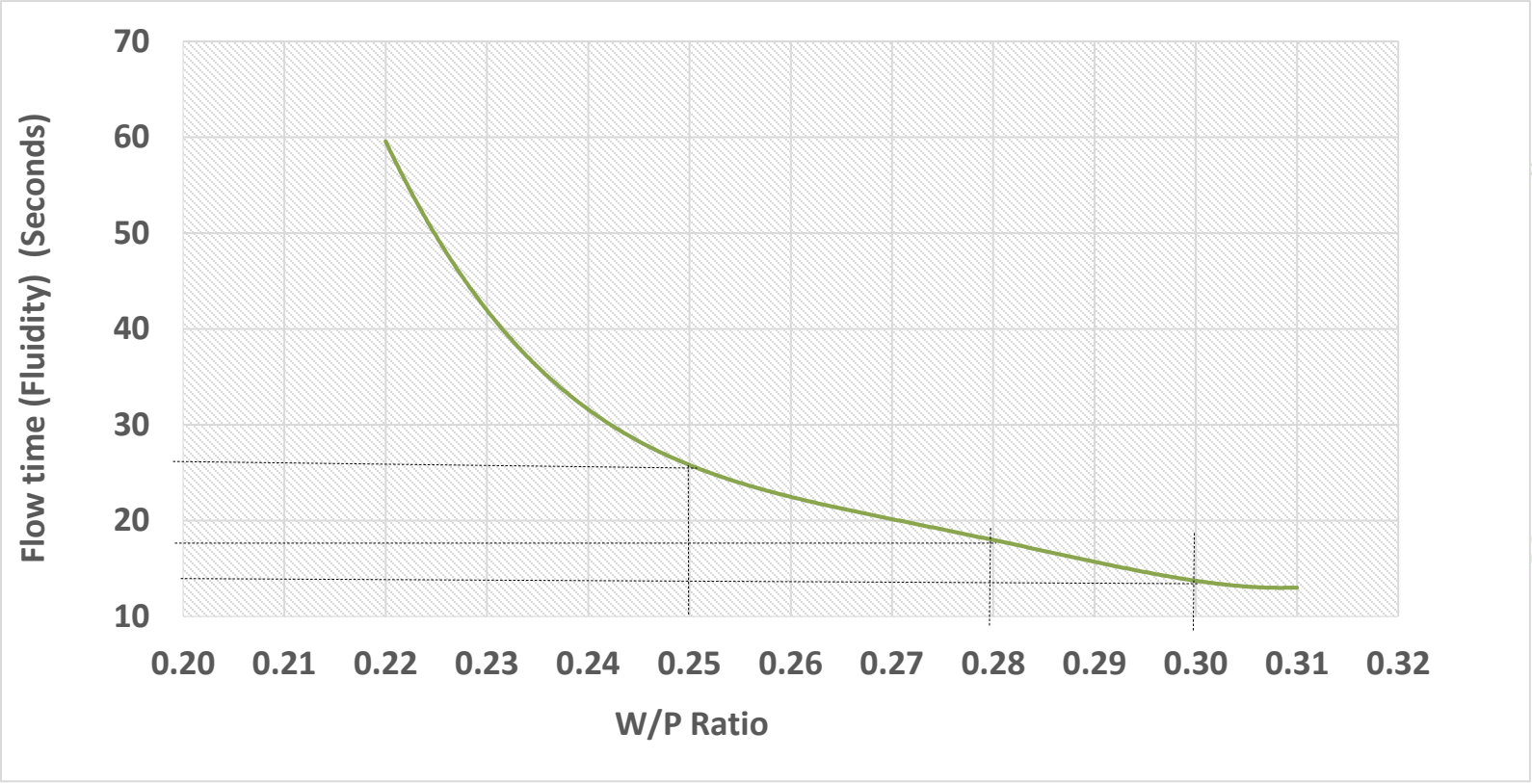
Notes:

(a) Specs for semi-rigid pavement, December 2015
(b) Project Tender Specification by LTA PS-13-16
(c) Project Tender Specification by Changi Airport Group "Technical Specification for Taxiways".

2. Semi-Rigid Pavement Components and Properties

2.2 Polymer Modified Cementitious Grouting Material

- **Fluidity of Chemilink SS-141**



Flow time (Fluidity) of SS-141 at different water/powder (W/P) ratio

2. Semi-Rigid Pavement Components and Properties

2.2 Polymer Modified Cementitious Grouting Material

- **Fluidity of Chemilink SS-141**

W/P: 0.25, Fluidity: 27 sec, thickness: 80mm

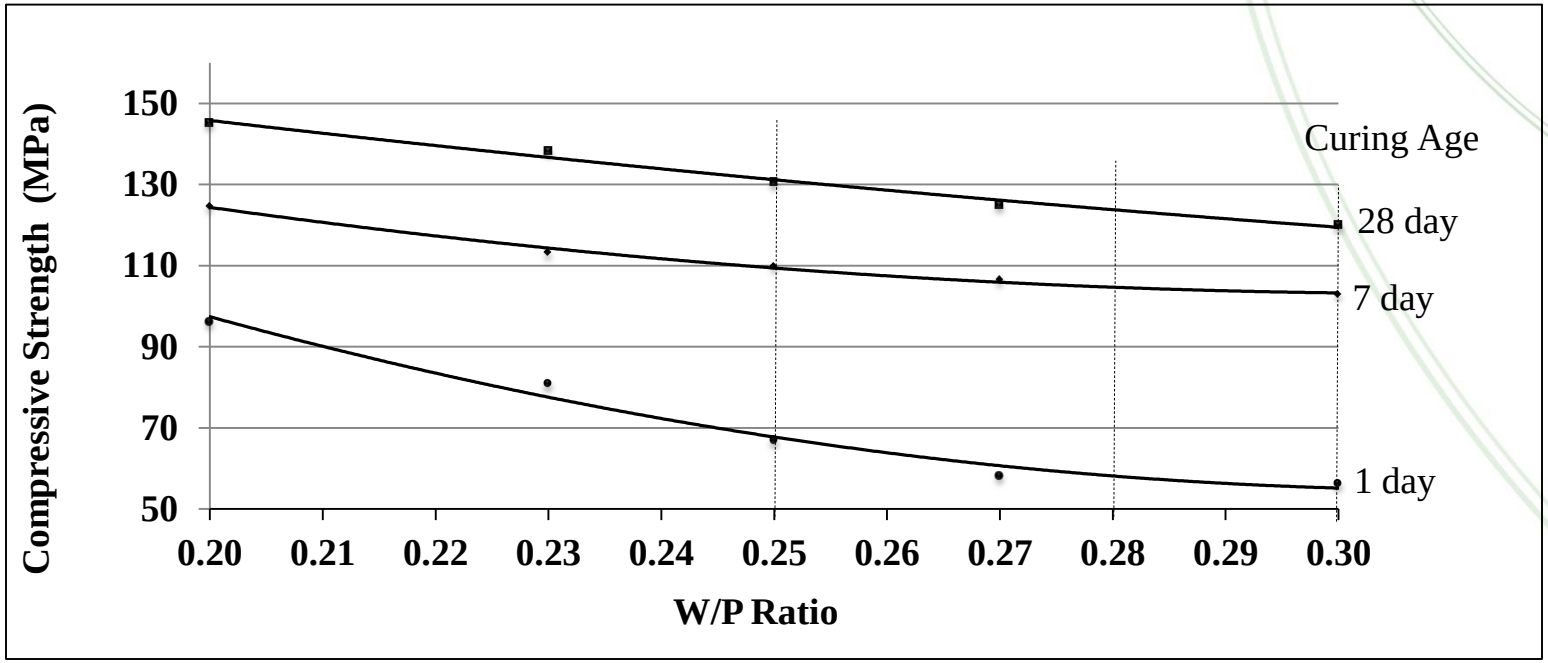
W/P: 0.28, Fluidity: 18sec, thickness: 100mm

The fluidity of SS-141 is 11-27 seconds, but the spec in project tender document from LTA and Changi Airport Group is 10-18 / 10-14 seconds. According to our experiments and practices, the requirement of 10-18 seconds on the fluidity is neither necessary nor practical for SS-141 because SS-141 with less than 27 seconds of fluidity can fully fill the voids of PAC even up to 100mm deep

2. Semi-Rigid Pavement Components and Properties

2.2 Polymer Modified Cementitious Grouting Material

- **Compressive strength of Chemilink SS-141**



Compressive Strength of SS-141 at Different W/P Ratio & Curing Age

2. Semi-Rigid Pavement Components and Properties

2.3 Semi-Rigid Pavement Properties

Properties	Curing time	Chemilink SS-141	Specs from LTA [a]	Project tender document [b]	Project tender document [c]
1. Compressive strength (BS EN 12190)	12-hrs	3-5 MPa	----	---	---
	1-day	5-7 MPa	5 MPa	---	---
	8-days	9-12.5 MPa	---	---	---
	28-days	10-14.5 MPa	8 MPa	≥ 7 MPa	7-10 MPa
2. Skid resistance (ASTM E303)	---	60-90 BPN	55 BPN	≥ 55 BPN	≥ 60 BPN
3 Texture depth by sand patch method		0.5-1.2mm	0.5-1.2mm		

Notes:

(a) Specs for semi-rigid pavement, December 2015

(b) Project Tender Specification by LTA PS-13-16

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3. Construction of Semi-Rigid Pavement

3.1 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. Construction of Semi-Rigid Pavement

3.2 Mix Polymer Modified Cementitious 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. Construction of Semi-Rigid Pavement

3.3 Fill Polymer Modified Cementitous 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. Construction of Semi-Rigid Pavement

3.4 Semi-Rigid Pavement Field Testing

a. Thickness of SRP and fluidity of polymer modified cementitious grouting material

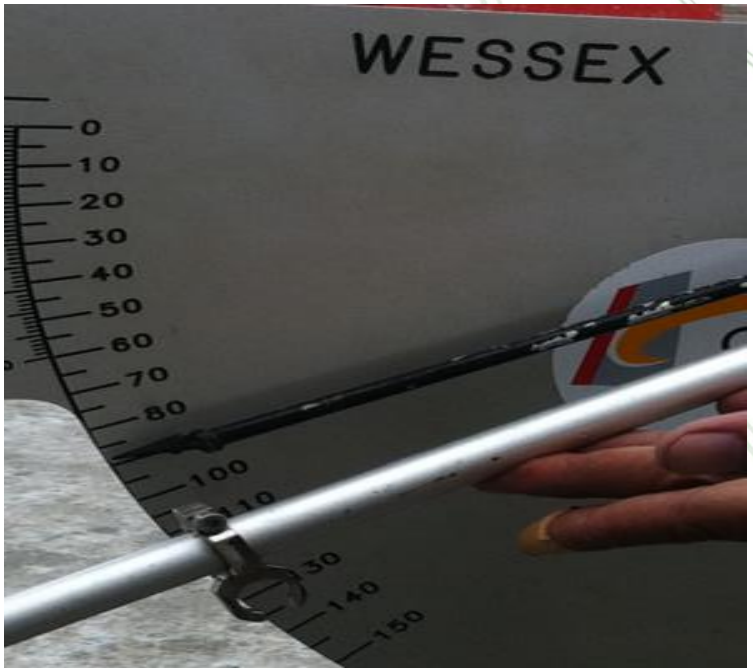
(a) Sample Coring

(b) Thickness Measuring & Fluidity Checking

3. Construction of Semi-Rigid Pavement

3.4 Semi-Rigid Pavement Field Testing

b. Skid Resistance Test by ASTM E303



Skid Resistance Measurement by ASTM E303

3. Construction of Semi-Rigid Pavement

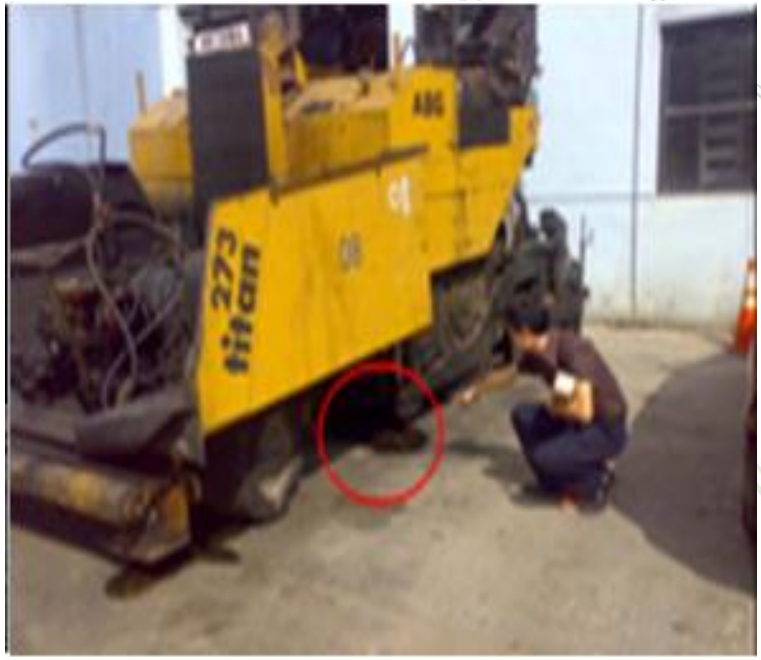
3.5 Semi-Rigid Pavement Lab Testing

Compressive Strength Testing

4. Case Studies For Roads and Airfields

4-1. Asphalt Concrete Plant (Industrial Loading Yards) -2005

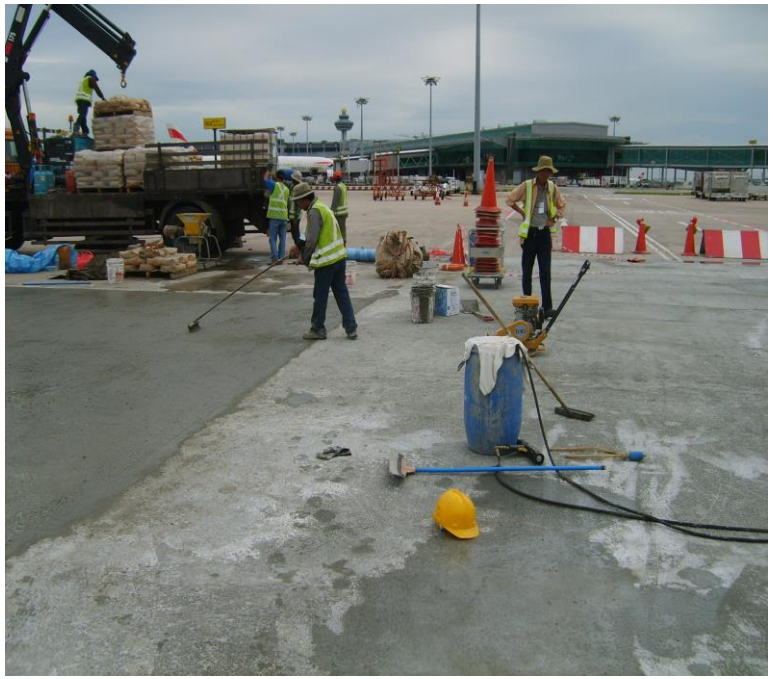
(a) Semi-Rigid Pavement after Hardened



(b) Good Ability to Chemical / Oil Attacks

4. Case Studies For Roads and Airfields

4-2. Changi International Airport Parking Aprons -2007



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

4. Case Studies For Roads and Airfields

4-3. Improvement and Resurfacing Works for Parallel and Runway Entry Taxiway at Changi Airport -2010

(a) Construction in Progress

(b) Cored Sample (75mm thick)

4. Case Studies For Roads and Airfields

4-4. Heavy Traffic Roads and Junctions

4-4-1. Sungei Kadut Street 1 - 2010

(a) Construction in Progress

(b) Opened to Traffic

4. Case Studies For Roads and Airfields

4-4. Heavy Traffic Roads and Junctions

4-4-2. South Buona Vista Road and Junction - 2011

(a) Construction in Progress

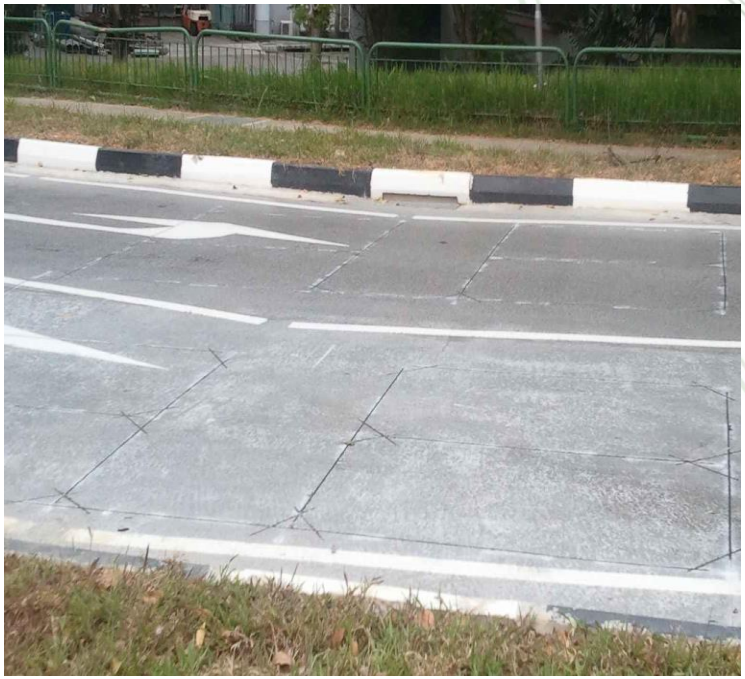
(b) Opened to Traffic

4. Case Studies For Roads and Airfields

4-4. Heavy Traffic Roads and Junctions

4-4-3. Toa Payoh Lorong1 and Lorong4 Junction - 2014

(a) Construction in Progress

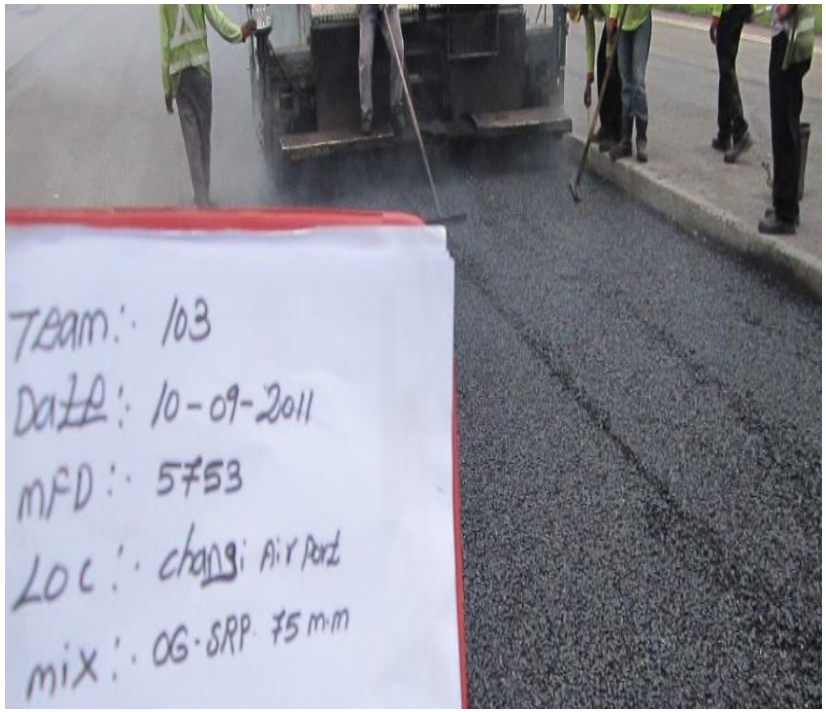


(b) Opened to Traffic

4. Case Studies For Roads and Airfields

4-5. Junction of Taxiways in Singapore Changi International Airport -2011

- **Design thickness: 150mm of semi-rigid pavement constructed in 2 layers (75mm / layer)**



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

(b) Filling of Chemilink SS-141

4. Case Studies For Roads and Airfields

4-6. Tuas West MRT Extension - 2016, project is ongoing

- **Design thickness: 100mm of semi-rigid pavement constructed in 2 layers (50mm / layer)**

(a) Mixing Chemilink SS-141 with Water

(b) Filling Chemilink SS-141 into PAC

5. Conclusions

- **Applications of semi-rigid pavement (SRP) have become more and more popular for civil infrastructure , the semi-rigid pavement has successfully been applied for *roads, airport parking aprons, MRT/Bus Deport and industrial heavy loading yards in Singapore for past years*.**

- **Chemilink SS-141 is the high performance polymer modified cementitious grouting material for the semi-rigid pavement system.**

- **Properties of SS-141 polymer modified cementitious grouting material are:**

  a. **Compressive strength:**
     - ***1-day: ≥ 55MPa***
     - ***28-days: ≥ 110MPa***
  b. **Flexural strength: *7 - 15MPa (28-days)***
  c. **Optimum water/powder ratio: *0.25 - 0.30* based on weather condition and speed of mixer**

5. Conclusions

- **Properties of *semi-rigid pavement* using SS-141 as grouting material are:**
  - **Compressive strength:**
    - ***5 - 7MPa (1-day)***
    - ***10 - 14.5MPa (28-day)***
  - **Surface skid resistance : 60-90 BPN**

- **The properties and performances of SS-141 polymer modified cementitious grouting material can be adjusted in order to meet different design requirements for semi-rigid pavement at different conditions.**

- **SS-141 with a wide range of fluidity (11~27S) can fully penetrate into PAC (porosity 25~30% by volume) up to 100mm deep to form a thicker semi-rigid pavement to save construction cost and time, while a typical basic design thickness is 50mm.**

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Thank You for Your Attention!