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The Semi-Rigid Pavement with Higher Performances for Roads and Parking Aprons

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ZERO WASTE ENGINEERING

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1. Introduction

1.1 Typical of pavement design for road construction:

- **Flexible pavement (Asphalt concrete pavement)**
- **Rigid pavement (Cement concrete pavement)**
- **Semi-rigid pavement (Asphalt concrete filled with cement mortar)**

Compared properties (selected properties)	Flexible Pavement	Rigid Pavement	Semi-Rigid Pavement (SRP)
1. Resistance to rutting/deformation	Poor	Good	Good
2. Skid resistance properties	Good	Poor	Good
3. Resistance to petroleum products, oil and chemical	Poor	Good	Good
4. Resistance to moisture damage	Poor	Good	Good
5. Maintenance and repair	Easy	Difficult	Easy
6. Life span	Lower	Higher	High
7. Flexural strength properties	Low	High	High
8. Expansion joint	Not required	Required	Not required
9. Installation and open to traffic	Within hours	0.5-3.0 months	Within 24 hours
10. Construction and maintenance costs	Lower const. cost; High maint. cost	Higher const. cost; Low maint. cost	Low const. cost; Low maint. cost

1. Introduction

1.2 Definition of semi-rigid pavement:

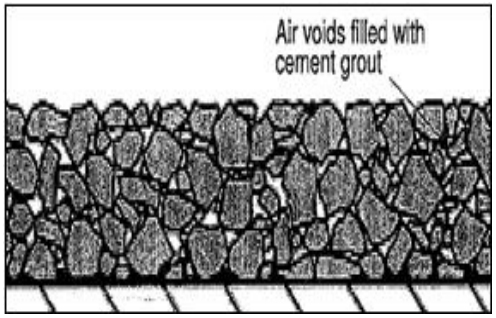
- Composite pavement material consisting porous asphalt concrete (PA) with ***air voids between 25-30%*** (by Marshall mix design volume).
- Filled or flooded by special formulated ***high performance polymer modified cement*** mortar material.

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

a. Traffic light intersection (junction): ***50mm***

b. Heavy loading infrastructure such as taxiway or airport parking aprons:

Single or double layers of 50-75mm.



(a) Porous Asphalt Concrete (PAC)

(b) Polymer Modified Cement Mortar

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

a. Component of PAC

Components	% by weight
1. Bitumen 60/70 pen	3.6-4.6%
2. Lime filler (hydrated lime)	4.0%
3. Cellulose fibers	0.2%
4. Crushed aggregate	91.7%

b. Coarse aggregate properties

Properties	Allowable value	Testing method
1. Crushing value	< 20%	BS 812 part 110
2. Flakiness index	< 20%	BS 812 part 105
3. LA abrasion (500 revolution)	< 20%	SS 73:74
4. Silt content of aggregate by weight	< 0.3%	BS 812 part 1

Design Guideline (in Singapore):

Code of Practice for Works on Public Streets 10th March 2009 Revision 2 Section 9.6 for Material Specifications and Quality Control

2. Semi-Rigid Pavement Components and Properties

2.2 Polymer Modified Cement Mortar Properties

- **Chemilink SS-141 has specially been designed for the semi-rigid pavement system.**
- **Polymer modified cement mortar shall be mixed to designed *water to from a free-flowing grouting mortar*.**
- **Important factors for design of modified cement mortar: *Flow time and Compressive/Flexural strength* properties.**

Properties	Curing time	Chemilink SS-141	Code of practice for works (a)	Project tender document (b)	Project tender document (c)
1. Fluidity/Workability ASTM C939	---	13-27sec	---	10-14sec	10-14sec
2. Compressive strength (BS EN 12390)	12-hrs	20-30MPa	---	---	---
	1-day	**55-85MPa**	**≥ 55MPa**	---	---
	7-days	100-120MPa	---	---	≥ 40MPa
	28-days	**120-140MPa**	**≥ 110MPa**	40-50MPa	---
3. Flexural strength (BS EN 12190)	28-days	**7-15MPa**	**≥ 15MPa**	6-8MPa	≥ 6MPa
4. Setting time (EN 196-3)	---	**2-3hr; 3-6hr; 6-8hr**	8-12hrs	2-3hrs	2-3hrs

Notes:

(a) Code of Practice for Works on Public Streets 10th March 2009 Revision 2 Section 9.6 for Material Specifications and Quality Control
(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

2.3 Semi-Rigid Pavement Properties

Properties	Curing time	Chemilink SS-141	Code of practice for works [a]	Project tender document [b]	Project tender document [c]
1. Compressive strength (BS EN 12190)	12-hrs	3-5MPa	---	---	---
	1-day	6-8MPa	---	---	---
	8-days	9-12.5MPa	---	---	---
	28-days	**10-14.5MPa**	7-10MPa	≥ 7MPa	7-10MPa
2. Flexural strength (BS EN 12190)	**28-days**	**6-7MPa**	≥ 3.5MPa	≥ 3MPa	≥ 3.5MPa
3. Skid resistance (ASTM E303)	---	**60-90 BPN**	---	≥ 60BPN	---
4. Curing time	---	**4-8 hrs**	---	4-8 hrs	4-8 hrs

Notes:

(a) Code of Practice for Works on Public Streets 10th March 2009 Revision 2 Section 9.6 for Material Specifications and Quality Control

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

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3. Construction of Semi-Rigid Pavement

3.1 Laying of Porous Asphalt Concrete (PAC)

(a) Milling of Existing AC Surface

(b) Spraying Primer Coat

(c) Laying PAC to Design Thickness

(d) PAC Surface after Compaction (Air Voids 25-30%)

3. Construction of Semi-Rigid Pavement

3.2 Mixing of Polymer Modified Cement Mortar

(a) Loading the Mortar into Big Mixer

(b) Mixing the Mortar with Water

(c) Loading the Mortar into Small Mixer

(d) Mixing the Mortar with Water

3. Construction of Semi-Rigid Pavement

3.3 Filling of Polymer Modified Cement Mortar into PAC

(a) Filling the Mortar into PAC

(b) Leveling and Vibration (if needed)

(c) Surface just after Filling

(d) Hardened Surface

3. Construction of Semi-Rigid Pavement

3.4 Semi-Rigid Pavement Field Testing

a. Thickness depth and workability of polymer modified cement mortar

(a) Sample Coring

(a) After Coring

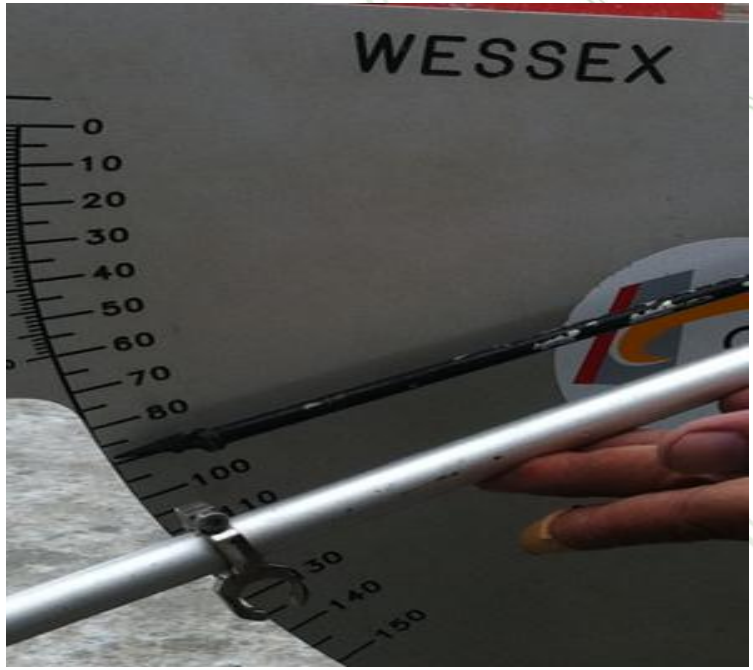
(c) Labeling of Sample Location

(d) Thickness Measurement of the Sample

3. Construction of Semi-Rigid Pavement

3.4 Semi-Rigid Pavement Field Testing

b. Skid Resistance Measurement by ASTM E303

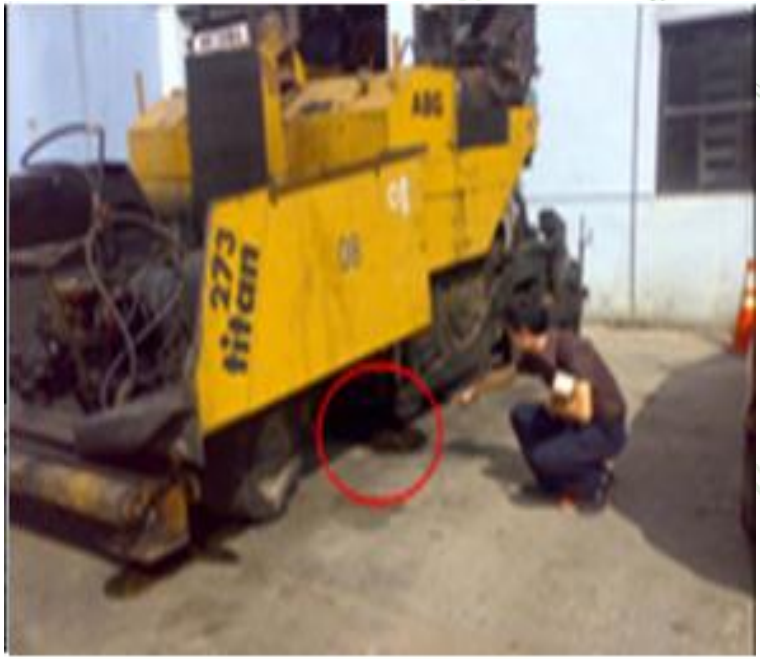


Skid Resistance Measurement by ASTM E303

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 Aprons Construction in Progress

4. Case Studies For Roads and Airfields

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

(a) Semi-rigid Surface after Hardened

(b) Thickness Measurement of the 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) Heavy Traffic Road in Use

4. Case Studies For Roads and Airfields

4-4. Heavy Traffic Roads and Junctions

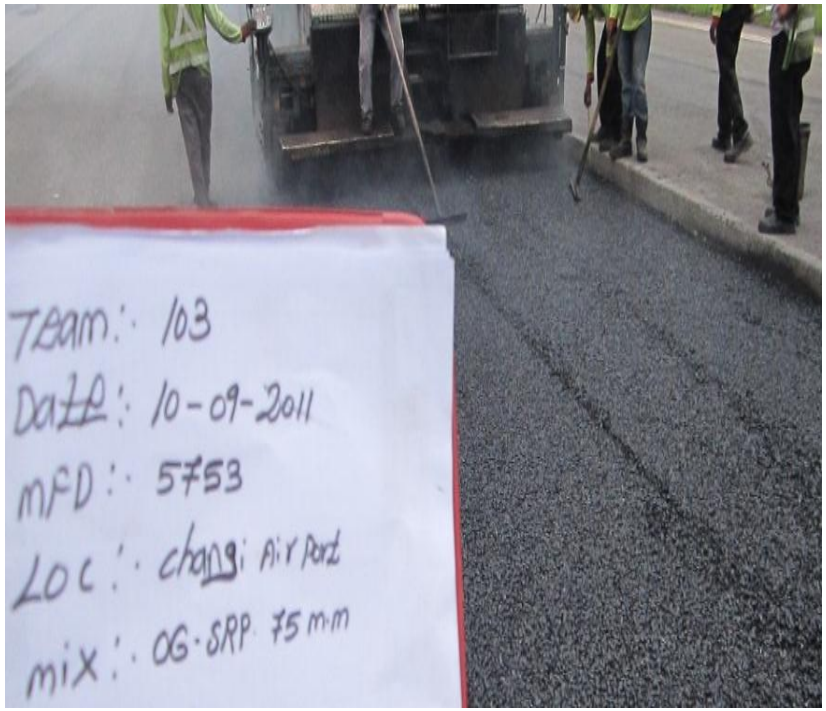
4-4-2. South Buona Vista Road and Junction - 2011

Construction in Progress

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 per layers)**



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

(b) Filling of Chemilink SS-141

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 per layers)**

Project Completion

5. Conclusions

1) **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, parking aprons and industrial heavy loading yards in Singapore for past years*.**

2) **Chemilink SS-141 is the high performance polymer modified cement mortar for the semi-rigid pavement system.**

3) **The engineering properties of SS-141 polymer modified cement mortar includes:**

   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***

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5. Conclusions

4) **The engineering properties of *semi-rigid pavement* by using SS-141 includes:**

   a. **Compressive strength:**
      - ***6 - 8MPa (1-day)***
      - ***10 - 14.5MPa (28-day)***
   b. **Flexural strength: *6 - 7MPa (28-day)***

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

6) **From Construction experience, SS-141 polymer modified cement mortar with good workability can penetrate into 75mm of porous asphalt concrete for semi-rigid pavement, while typical design thickness is *50mm*.**

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Thank You for Your Attention!