Seminar on Soil Sub-grade Stabilization
Organizer by: Jambatan Kerja Raya Malaysia, Road Engineering Association of Malaysia
15 July 2008, Legend Hotel, Kuala Lumpur, Malaysia

Chemilink™
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Chemilink Stabilization Technologies for Roads & Airfields

Dr Wu Dong Qing

Tan Poi Cheong

Chemilink Technologies Group, Singapore

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1. Introduction

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- Conventional pavement construction methods cannot commonly meet the latest requirements. Stronger pavements with bounded materials have to be used for heavier loadings with higher frequency
- New construction methods such as "floating" semi-rigid platform have to used for pavement over the weak soil region
- Local soils have to be used for the regions lacking of the quarries and for environment protection
- Faster construction method is always top important for airfields, especially for the airports under operations
- In-situ soil stabilization is an proven solution with overall cost effectiveness

1. Introduction

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Key Advantages of Chemical Stabilization:

- ❖ Higher strength to meet for different requirement
- ❖ Better volume stability, lower permeability and longer durability
- ❖ Forms a semi-rigid platform so as to deliver a lot of engineering benefits
- ❖ Most soils or construction wastes can be chemically stabilized
- ❖ Simple and fast construction

2. Chemical Stabilizing Agent

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Chemical-Soil Stabilization –

Mixing proper chemicals with in-situ soils to improve/strengthen the soil properties through chemical reactions for engineering purposes

Common Chemical Reaction involved:

- Cementation
- Hydration
- Ion exchange
- Flocculation
- Precipitation Polymerisation
- Oxidation
- Carbonation

2. Chemical Stabilizing Agent

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Commonly Used Chemical Stabilizing Agents:

- Cement
- Lime
- Bituminous Materials
- Fly-ash
- Modified Cementitious Chemical – Chemilink
- Liquid form Stabilizing Agents

2. Chemical Stabilizing Agent

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2-1 Cement

- Generally, it is effective for granular soils but ineffective for cohesive soils
- Applicable ranges:

  1) Liquid Limit: <40-45%

  2) Plastic Limit: <18-20%

  3) Coefficient of Uniformity: >5-10

  4) Grain Size Distribution

2. Chemical Stabilizing Agent

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2-1 Cement

- Advantages:

  1) Low cost

  2) Simple construction

- Disadvantages:

  1) Serious shrinkage

  2) Limited ranges of application

  3) Unsuitable for high in-situ moisture content

2. Chemical Stabilizing Agent

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2-2 Lime

- Suitable for clayey soil
- Used for sub-grade and sub-base or other pavement layers with lower bearing capacity requirements.
- Frequently used as a preparative measure for subsequent treatment with other chemical stabilization

2. Chemical Stabilizing Agent

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2-2 Lime

- ❖ **Advantages:**
  1) Reducing the plasticity index,
  2) Decreasing the clay content substantially
  3) Accelerating the breaking up of clay clods during mixing
  4) Drying out the water from wet soils
  5) Reducing the shrinkage and swelling
- ❖ **Disadvantages:**
  1) Low Durability
  2) Lower strength increment compared with cement stabilization

2. Chemical Stabilizing Agent

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2-3 Other Chemical Agents --Bituminous Materials

- can be used to construct base courses, sometimes to form surface courses
- Advantage:

  -- Waterproof → maintain low moisture content
- Disadvantages:

  -- High cost

  -- Causing Pollution

2. Chemical Stabilizing Agent

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2-3 Other Chemical Agents –Fly-ash

- by-product of power plants fuelled by pulverized coal
- reacts with Lime in the presence of water, setting and hardening similarly to hydraulic binder
- often used with Lime to stabilize the soils

2. Chemical Stabilizing Agent

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2-4 Modified Cementitious Chemical

- Chemilink Stabilizing Series Products

❖ polymer modified cementitious chemical agent in fine powder form

❖ designed for soil stabilization especially for sandy and clayey soils under tropical conditions and environment

❖ have been tried, verified and widely applied in South East Asia Countries and China Since 1994

2. Chemical Stabilizing Agent

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2-4 Chemilink Stabilizing Series Products

Basic Functions:

- ❖ To increase and maintain the soaking strengths
- ❖ To form a semi-rigid platform
- ❖ To decrease the permeability and compressibility
- ❖ To improve the long-term performance

2. Chemical Stabilizing Agent

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2-4 Chemilink Stabilizing Series Products

Special Functions:

- ❖ **Wider application ranges for different soils**
- ❖ **Faster chemical reaction for higher initial strengths**
- ❖ **Breaking up of clay clods for applying to wider soil range**
- ❖ **Quickly drying out of the water from the wet soils**
- ❖ **Water retention and shrinkage compensation against cracks**
- ❖ **Semi-waterproofing**

2. Chemical Stabilizing Agent

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2-5 Liquid Form Stabilizing Agents

- generally for non-bearing purposes, such as dust control
- A chemical-base agent is often designed for a specific soil type
- Limited solid content and limited applicable soil ranges
- Ineffective in soaking strengths/stabilities
- Making compactions more difficult for wet soils
- Poor Durability

3. Designs and Applications of Stabilization

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3 -1. Materials Design

Key Component – Dosage Design

Design Criteria includes:

1) Strength

- UCS (Unconfined Compressive Strength)
- CBR (California Bearing Ratio)
- MR (Resilient Modulus)

2) Durability

- Dry-wet cycle
- Hot-cold cycle

3. Designs and Applications of Stabilization

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3 -1. Materials Design

General Guideline

❖ **Sub-base Course:**

CBR ≥ 30%; and/or UCS ≥ 0.7-1.5 MPa

❖ **Base Course:**

CBR ≥ 80-90%, and/or UCS ≥ 2MPa

3. Designs and Applications of Stabilization

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Country	Curing Time (day)	Curing Condition	UCS (MPa)	Road Grade / Function	Remarks
Australia	7	-	3.0	-	
Brunei	7	Wet-air: 6d Soaking: 1d	2.0 0.7 ~ 1.5	All/Base All/Sub-base	Or per design
Canada	7	Soaking	2.1	-	
China	7	Wet-air: 6d Soaking: 1d	3.0 ~4.0 2.0 ~ 3.0 2.0 1.5	High/Base Low/Base High/Sub-base Low/Sub-base	UCS=5~6 for high road grade with more or very heavy loading
Ex-SU	28	Soaking	7.5 6.0 4.0 2.0	Highest/Base High/Base Low/Base All/Sub-base	
France	7	-	4.0 ~5.0 1.5	M./Base M./Sub-base	M. – Medium
Germany	-	-	3.0 ~ 10.0	-	
Japan	7	Wet-air: 6d Soaking: 1d	3.0 ~ 4.0 2.5 1.5 ~ 2.0 0.7 ~ 1.3	Highest/Base High/base Low/base All/Sub-base	
New Zealand	7	-	1.72	-	
Spain	7	-	6.0 2.5	All/Base All/Sub-base	
UK	7	-	4.5 ~ 15.5	-	
California Washington - US	7	Wet-air -	5.2 5.8	- -	

Table 1. Design requirements on UCS for Cement Stabilized Soils in various countries

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3. Designs and Applications of Stabilization

3-2. Application Method of Chemical Stablization

3-2-1 In-situ Recycling Method


Mechanical Spreading


Mixing by Stabilizer


Compaction 1


Manual Spreading


Mixing by Rotorvator


Compaction 2

3. Designs and Applications of Stabilization

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3-2. Application Method of Chemical Stabilization

3-2-2 Central-Plant Mixing Method

Central Mixing Plant and the Mixture after Compaction

4. Case Studies of Chemilink Stabilization/Recycling

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Family of SS-108 Sub-series

There are several products from SS-108 Sub-series targeting for different usage/requirements

- ❖ Normal Road (Urban Road/City Road)
- ❖ Low Cost Road (Rural Road/Access Road)
- ❖ High Profile (Highway/Airway)

4. Case Studies of Chemilink Stabilization/Recycling

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4-1. Brunei First Trial Project (1995)

- Base Course - In-situ clayey soils stabilized by Chemilink SS-108
- Sub-Base Course - Silty soils stabilized by Chemilink SS-108

M/P Test		Plate Loading Test			In-Situ CBR Test (%)	UCS Test (MPa)
No. of Blows	Depth of Penetration (mm)	Peak Pressure (MPa)	Settlement Recorded (mm)	Modulus Of S/R, K (MPa/m)		
300	6.3	1.72	7.44	522.62 (Max. 812.48)	100 (Max. 129)	2.04 (Max. 2.67)

1) M/P Test - Dynamic Mackintosh Probe Test
2) Modulus of S/R - The Modulus of Sub-grade Reaction
3) UCS Test - Unconfined Compressive Strength Test

Table 2. Average Testing Data for Brunei Trial Project

4. Case Studies of Chemilink Stabilization/Recycling

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4-1. Brunei First Trial Project (1995)

a) Stabilized Samples

b) Stabilized Road (on the left) vs. Old Road

c) Stabilized Surface after 10 Years

Photo 1. First Chemilink Trial Project in Brunei

4. Case Studies of Chemilink Stabilization/Recycling

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4-2. Malaysia Trial Project (1995)

- Organized by federal Public Work Department (JKR) and its research institute (IKRAM)
- Located at Alor Gajah, Melaka
- Base Course -

  In-situ clayey soils stabilized by Chemilink SS-108
- Sub-Base Course -

  In-situ clayey soils stabilized by Chemilink SS-108
- Construction Method – Simple way of in-situ mixing
- CBR (4-day, soaking) >110%

4. Case Studies of Chemilink Stabilization/Recycling

4-2. Malaysia Trial Project (1995)

a) Road Surface

b) Stabilized Road

Photo 2. Malaysia Trial Porject (taken after 1 year)

4. Case Studies of Chemilink Stabilization/Recycling

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4-3. Shipyard Project (Indonesia, 1997)

❖ Construction Speed - 8,000m²/day/team (300mm deep)

a) Manual Spreading and Mechanical Mixing

b) Compaction

Photo 3. Chemilink Stabilization in Progress for Indonesia Shipyard Project

4. Case Studies of Chemilink Stabilization/Recycling

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4-4. Junjungan Road Project (Brunei, 1998)

Chemilink stabilization has a similar immediate cost with that of conventional design but has superior quality and durability with less road maintenance.

Photo 4. Junjungang Road (after more than 4 yrs)

4. Case Studies of Chemilink Stabilization/Recycling

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4-5. Jalan Tutong Widening, Phase II (Brunei, 1998)

Photo 5. Jalan Tutong Widening, Phase II (after more than 4 yrs)

4. Case Studies of Chemilink Stabilization/Recycling

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4-6. Jalan Tutong Widening, Phase III (Brunei, 1998)

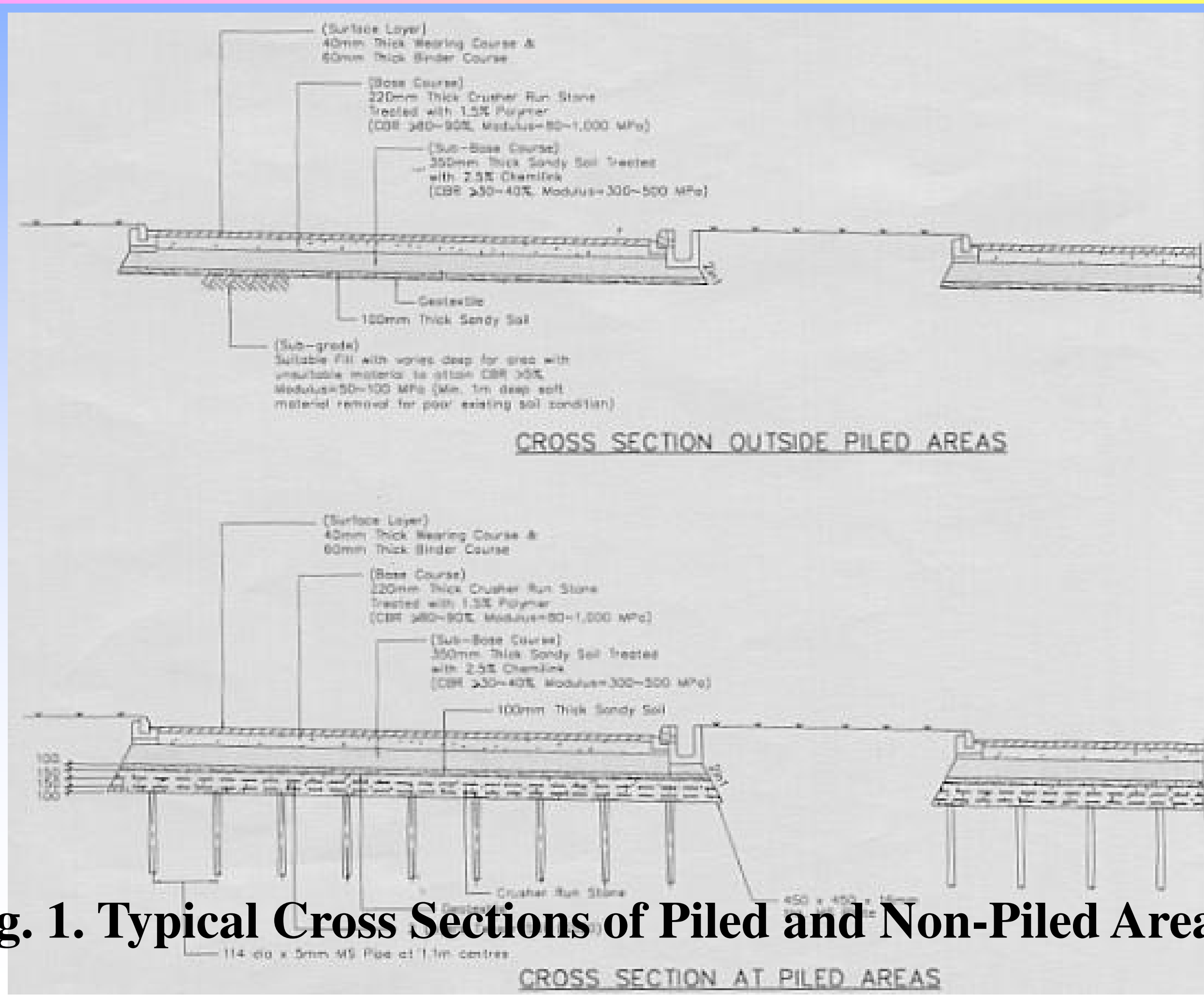

Fig. 1. Typical Cross Sections of Piled and Non-Piled Areas

4. Case Studies of Chemilink Stabilization/Recycling

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4-6. Jalan Tutong Widening, Phase III (Brunei, 1998)

Products	Sample No.	UCS Test (MPa)		In-Situ CBR Test (%)	DOC Test (%)	Remarks
		4-day soaked	Unsoaked			
2.5% Chemilink SS-108 with sandy soils	129~163	1.3	1.62	81.25	> 97	Sub-base
1.5% Polyroad with crasher run	63~121	1.19	1.52	184.26	> 99	Base

Notes:

1) The samples used for UCS tests were made in Lab using the mixtures from site
2) In-site CBR tests were normally conducted after 2-4 curing days
3) DOC means the Degree of Compaction

Table 3. Average Testing Results for Jalan Tutong Widening, Phase III

4. Case Studies of Chemilink Stabilization/Recycling

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4-6. Jalan Tutong Widening, Phase III (Brunei, 1998)

Products	Location-1 CH 2870~71 K (MPa/m)	Location-2 CH 2960~61 K (MPa/m)	Location-3 CH 3391 K (MPa/m)	Average Modulus of Sub-grade Reaction K, (MPa/m)
2.5% Chemilink SS-108 with sandy soils	895	564	894	784
1.5% Polyroad with crasher run	501	623	508	544

Table 4. Plate Loading Test Data for Jalan Tutong Widening, Phase III

4. Case Studies of Chemilink Stabilization/Recycling

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4-6. Jalan Tutong Widening, Phase III (Brunei, 1998)

a) Opened Road Cross Section

b) Road after 2-year completion

Photo 6. Jalan Tutong Widening, Phase III

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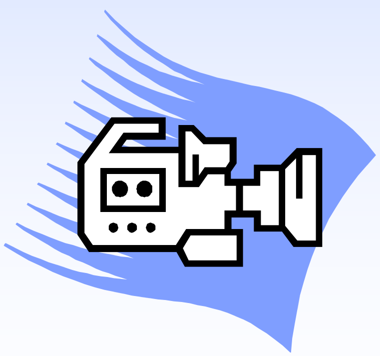
4. Case Studies of Chemilink Stabilization/Recycling

4-6. Jalan Tutong Widening, Phase III (Brunei, 1998)

VIDEO ON OPENING ROAD CROSS SECTION



4. Case Studies of Chemilink Stabilization/Recycling

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4-7. Reconstruction of Jalan Lamunin (Brunei, 2002)

Finish Road Surface of Jalan Lamunin

4. Case Studies of Chemilink Stabilization/Recycling

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4-7. Reconstruction of Jalan Lamunin (Brunei, 2002)

Table 5. Grain Size Distributions of Used Crusher Runs

BS Sieve Size (mm)	Total Passing Percentage (%) Type A	Type B	Remarks
50.0	100	100	Type A: local crusher run.
37.5	100	98.3	MDD=2.055 t/m³ and
20.0	63.3	75.2	OMC=7.6%
10.0	50.5	54.4	
5.0	38.5	37.6	Type B: local crusher run mixed with
2.36	27.6	31.3	tiling.
0.425	11.1	14.8	MDD=2.175 t/m³ and
0.075	4.1	2.0	OMC=7.5%

Table 6. UCS Results (MPa) of SS-111 Stabilised Crusher Runs

Curing Time (day)	Crusher Run Type	SS-111 Dosage (%) 2.0	2.5	3.0	3.5
7	A	1.7	2.0	2.1	2.8
	B	2.6	2.7	2.9	4.4
28	A	2.3	2.6	3.1	3.4
	B	3.2	3.7	4.4	5.3

* Specification: UCS (7-d) ≥ 2.0MPa

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4. Case Studies of Chemilink Stabilization/Recycling

4-8. China Low Cost Rural Road

4-8-1. New Xiaoxian Road (Inner Mongolia, China)

* 0.2m deep as Base only / 3% SS-108 / Clayey Silt / (Surface AC 40mm)

National Research Project

Manually Spreading

4. Case Studies of Chemilink Stabilization/Recycling

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4-8. China Low Cost Rural Road

4-8-1. New Xiaoxian Road (Inner Mongolia, China)

* 0.2m deep as Base only / 3% SS-108 / Clayey Silt / (Surface AC 40mm)

Mixing by Rotorvator

Spreading chips on the surface

4. Case Studies of Chemilink Stabilization/Recycling

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4-8. China Low Cost Rural Road

4-8-1. New Xiaoxian Road (Inner Mongolia, China)

* 0.2m deep as Base only / 3% SS-108 / Clayey Silt / (Surface AC 40mm)

Compaction

Road in Use

4. Case Studies of Chemilink Stabilization/Recycling

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4-8. China Low Cost Rural Road

4-8-1. New Xiaoxian Road (Inner Mongolia, China)

* 0.2m deep as Base only / 3% SS-108 / Clayey Silt / (Surface AC 40mm)

Central Mixing Plant

4. Case Studies of Chemilink Stabilization/Recycling

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4-8. China Low Cost Rural Road

4-8-1. New Xiaoxian Road (Inner Mongolia, China)

* 0.2m deep as Base only / 3% SS-108 / Clayey Silt / (Surface AC 40mm)

Road after years

4. Case Studies of Chemilink Stabilization/Recycling

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4-8. China Low Cost Rural Road

4-8-1. New Xiaoxian Road (Inner Mongolia, China)

* 0.2m deep as Base only / 3% SS-108 / Clayey Silt / (Surface AC 40mm)

Chemilink stabilized base after years

4. Case Studies of Chemilink Stabilization/Recycling

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4-8. China Low Cost Rural Road

4-8-2. Jintang Road (Sichuan, China)

* 0.15m deep as Base / 0.15m Sub-base with lime & fly ash/ Silty soil / (10mm x 2 chip seal)

Scarifying

Manually Spreading

4. Case Studies of Chemilink Stabilization/Recycling

Chemilink™
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4-8. China Low Cost Rural Road

4-8-2. Jintang Road (Sichuan, China)

* 0.15m deep as Base / 0.15m Sub-base with lime & fly ash/ Silty soil / (10mm x 2 chip seal)

Mixing by Rotorvator

Compaction

4. Case Studies of Chemilink Stabilization/Recycling

Chemilink™
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4-8. China Low Cost Rural Road

4-8-2. Jintang Road (Sichuan, China)

* 0.15m deep as Base / 0.15m Sub-base with lime & fly ash/ Silty soil / (10mm x 2 chip seal)

Chips on the surface

Mixing by other means

4. Case Studies of Chemilink Stabilization/Recycling

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4-8. China Low Cost Rural Road

4-8-2. Jintang Road (Sichuan, China)

* 0.15m deep as Base / 0.15m Sub-base with lime & fly ash/ Silty soil / (10mm x 2 chip seal)

Road after years

4. Case Studies of Chemilink Stabilization/Recycling

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4-8. China Low Cost Rural Road

4-8-2. Jintang Road (Sichuan, China)

* 0.15m deep as Base / 0.15m Sub-base with lime & fly ash/ Silty soil / (10mm x 2 chip seal)

Road surface after years

Chemilink stabilized base after years

4. Case Studies of Chemilink Stabilization/Recycling

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4-8. China Low Cost Rural Road

4-8-3. Longquan Road (Chengdu City, China) (By Plant Mixing)

* 0.2m deep as Base only / 3% SS-108 / Silty Sand / (30mm AC Surface) / by Central Mixing Plant

After Curing

In Use

4. Case Studies of Chemilink Stabilization/Recycling

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4-9. New Well Road for Caltex, Sumatra, Indonesia

* 0.2m deep as Base only /1% SS-108 /No AC Surface

Subgrade Condition

The Sub-grade

Scrarifyng

Scarifying

4. Case Studies of Chemilink Stabilization/Recycling

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4-9. New Well Road for Caltex, Sumatra, Indonesia

* 0.2m deep as Base only /1% SS-108 /No AC Surface

Dropping The Jumbo Bag

Spreading – big bag

Small Bag Placing

Spreading – small bag

4. Case Studies of Chemilink Stabilization/Recycling

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4-9. New Well Road for Caltex, Sumatra, Indonesia

* 0.2m deep as Base only /1% SS-108 /No AC Surface

Recycling First Passing

Mixing by Stabilizer

Moisture Spraying

Adding Water

4. Case Studies of Chemilink Stabilization/Recycling

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4-9. New Well Road for Caltex, Sumatra, Indonesia

* 0.2m deep as Base only /1% SS-108 /No AC Surface

Compaction

End of trial section (well pad)

Compaction

Treated and Untreated Roads

4. Case Studies of Chemilink Stabilization/Recycling

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4-9. New Well Road for Caltex, Sumatra, Indonesia

* 0.2m deep as Base only /1% SS-108 /No AC Surface

The Road in Use on the 80th day

4. Case Studies of Chemilink Stabilization/Recycling

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4-10. Singapore Changi International Airport (2005)

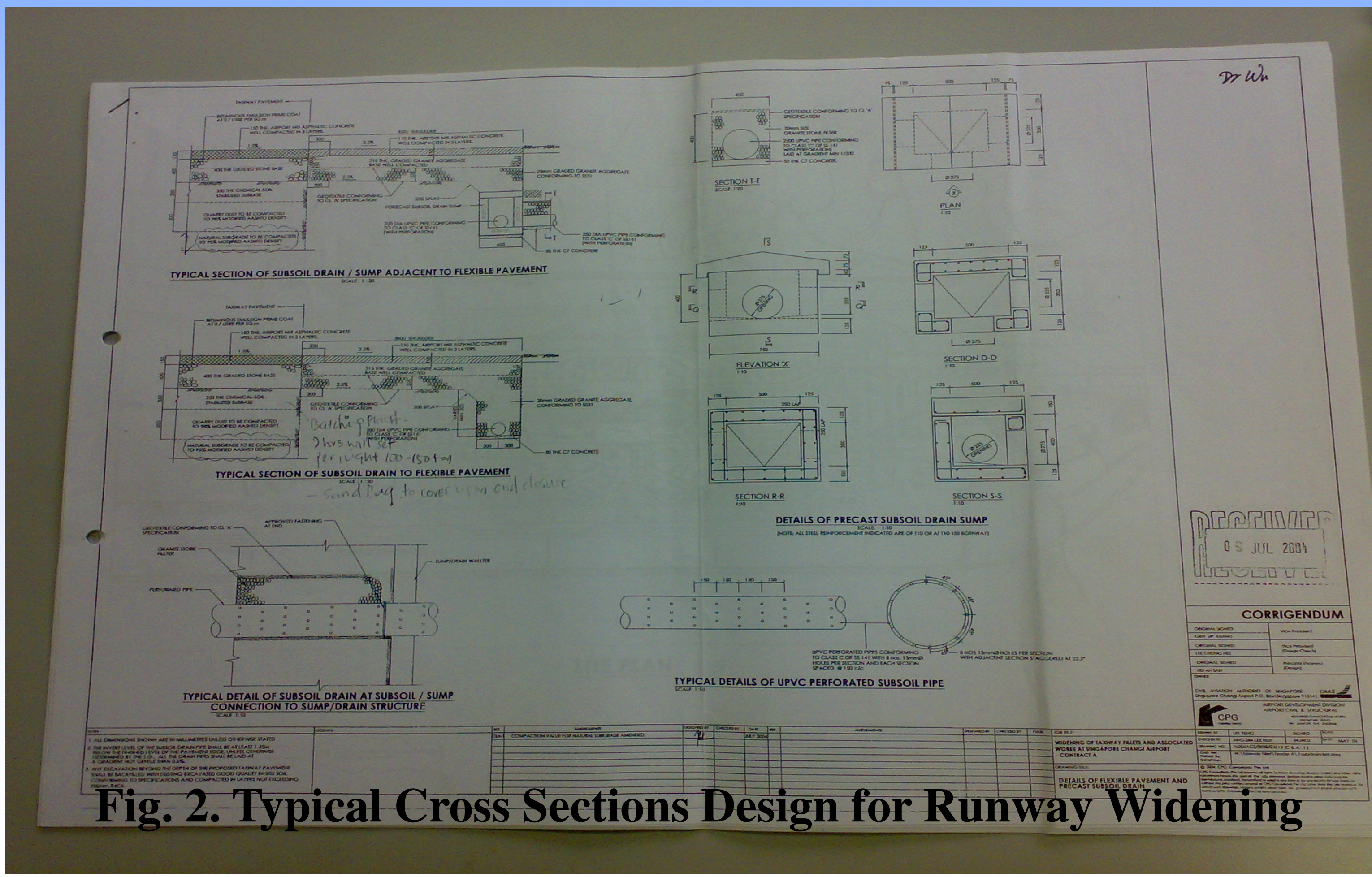

Fig. 2. Typical Cross Sections Design for Runway Widening

4. Case Studies of Chemilink Stabilization/Recycling

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4-10. Singapore Changi International Airport (2005)

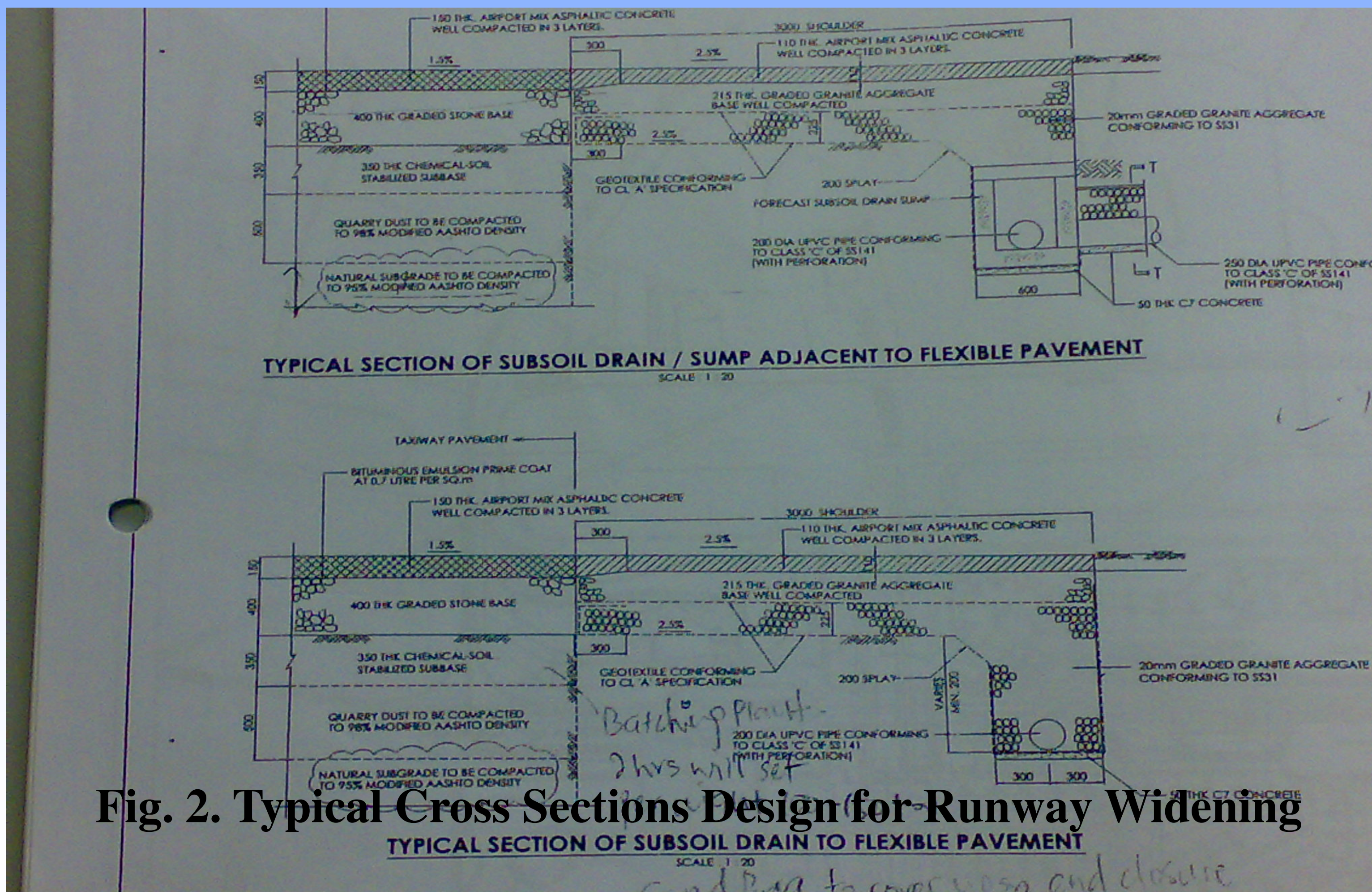

Fig. 2. Typical Cross Sections Design for Runway Widening

4. Case Studies of Chemilink Stabilization/Recycling

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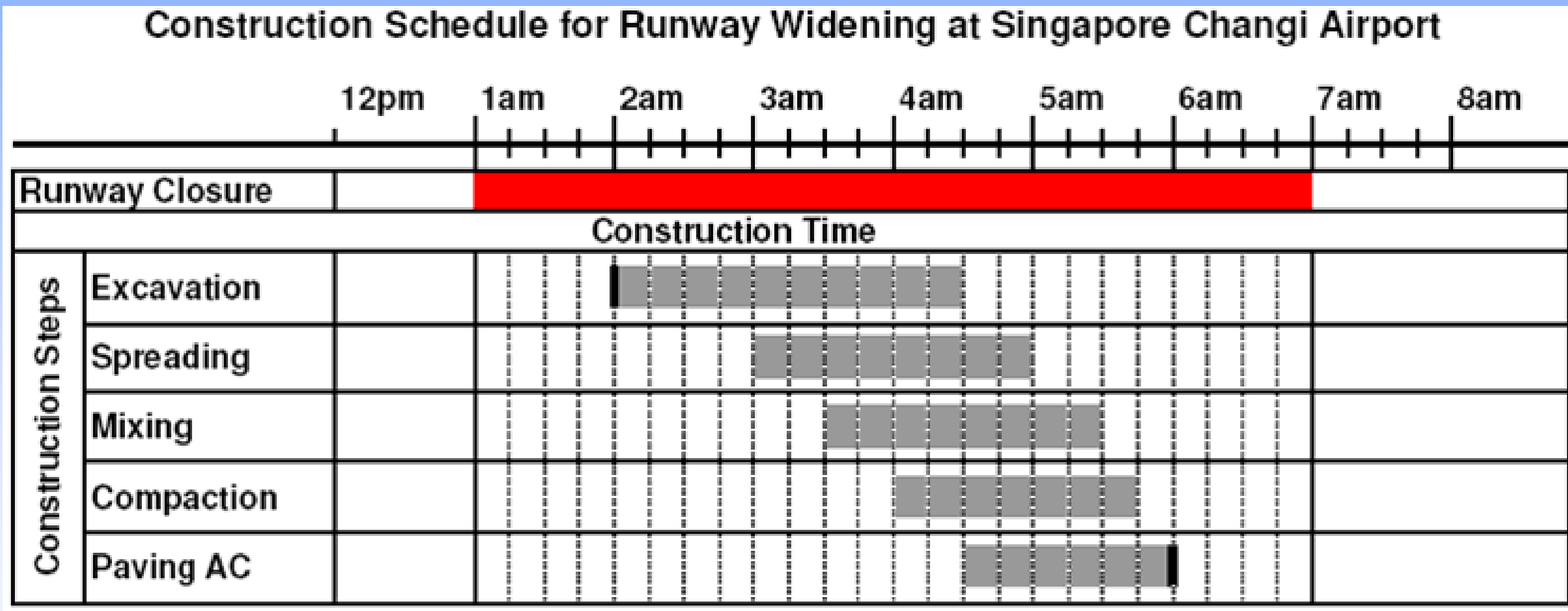
4-10. Singapore Changi International Airport (2005)



Notes:
Runway Closure Time : 1:00am ~ 7:00am
Effective Construction Time : 2:00am ~ 6:00am
Average Area per 4 Working Hours: 250m by 4.5m or 225m2/hour

Fig. 3. Typical Daily Construction Schedule

4. Case Studies of Chemilink Stabilization/Recycling

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4-10. Singapore Changi International Airport (2005)

a) Spreading

b) In-situ Mixing

c) Compaction

Photo 7. Stabilization Work in Changi International Airport

4. Case Studies of Chemilink Stabilization/Recycling

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4-10. Singapore Changi International Airport (2005)

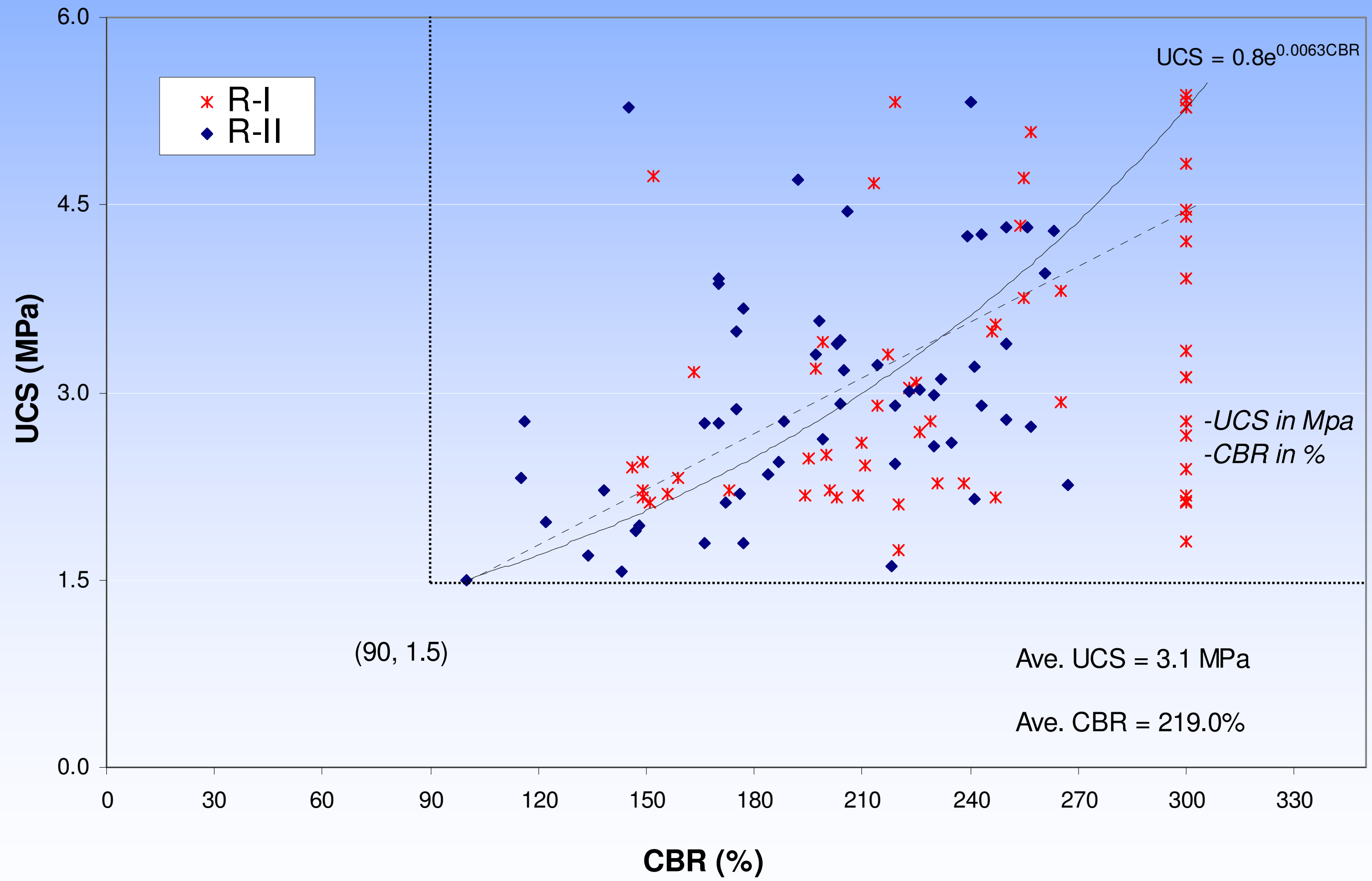

Fig. 4. UCS and CBR Testing Results for Runway-I and Runway-II

4. Case Studies of Chemilink Stabilization/Recycling

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4-10. Singapore Changi International Airport (2005)

Photo 8. Completion of Runway Widening in Changi International Airport Runway I (after 3 years)

4. Case Studies of Chemilink Stabilization/Recycling

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4-10. Singapore Changi International Airport (2005)

Photo 9. Completion of Runway Widening in Changi International Airport Runway II (after 3 years)

4. Case Studies of Chemilink Stabilization/Recycling

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4-11. Sultan Ismail International Airport (Malaysia, 2007)

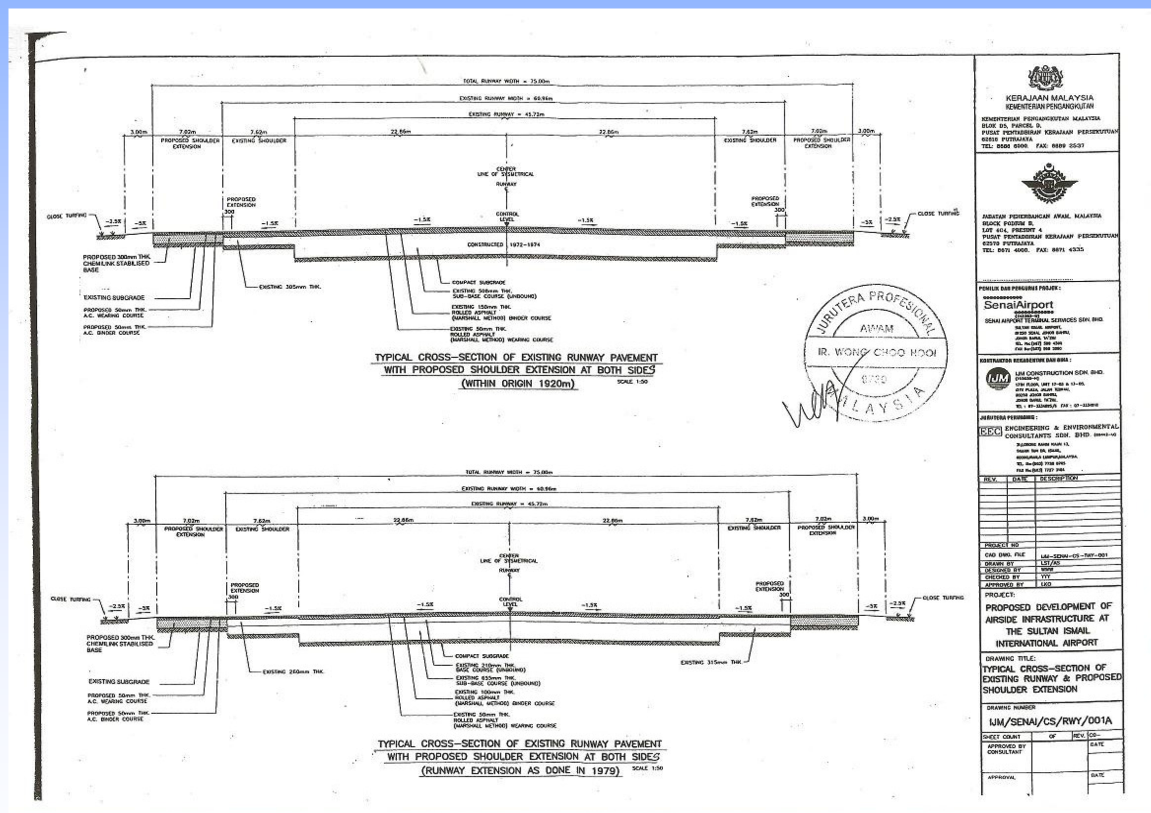

Fig. 4. Cross Section of Existing Runway Shoulders vs. Widened Section by Chemical Stabilization

4. Case Studies of Chemilink Stabilization/Recycling

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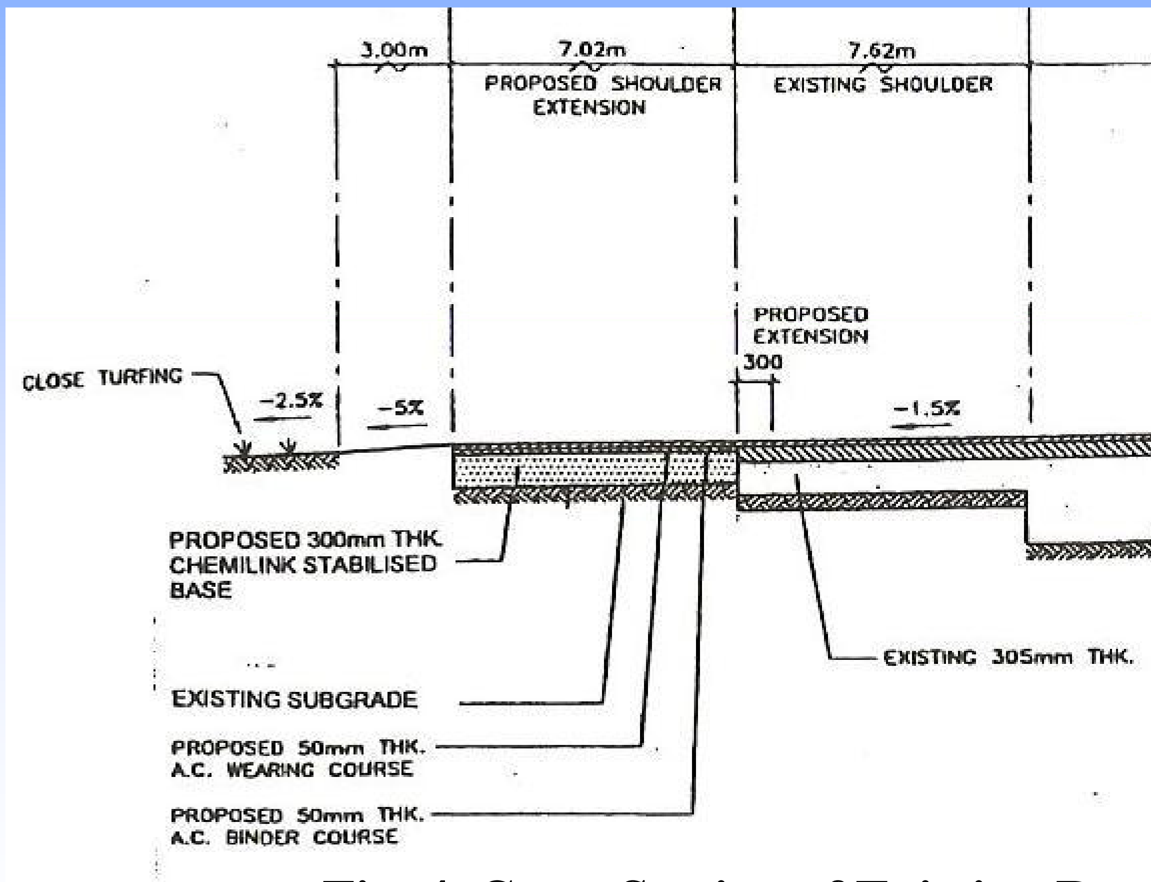
4-11. Sultan Ismail International Airport (Malaysia, 2007)



- ❖ A polymer modified cementitious chemical stabilizing agent be used for base course topped by asphalt concrete
- ❖ Offering comprehensive advantages and benefits

Fig. 4. Cross Section of Existing Runway Shoulders vs. Widened Section by Chemical Stabilization

4. Case Studies of Chemilink Stabilization/Recycling

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4-11. Sultan Ismail International Airport (Malaysia, 2007)

a) Excavation

b) Spreading

Photo 10. Stabilization Work in Sultan Ismail International Airport

4. Case Studies of Chemilink Stabilization/Recycling

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4-11. Sultan Ismail International Airport (Malaysia, 2007)

c) In-Situ Mixing

d) Compaction

Photo 10. Stabilization Work in Sultan Ismail International Airport

4. Case Studies of Chemilink Stabilization/Recycling

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4-11. Sultan Ismail International Airport (Malaysia, 2007)

e) Paving Asphalt Concrete

f) Completion of Widening

Photo 10. Stabilization Work in Sultan Ismail International Airport

4. Case Studies of Chemilink Stabilization/Recycling

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4-11. Sultan Ismail International Airport (Malaysia, 2007)

SENAI AIRPORT RUNWAY SHOULDER WIDENING
Soil Investigation Summary

NO	LOCATION	DEPTH (mm)	INSITU MC (%)	OMC (%)	MDD (Mg/m3)	LL (%)	PI (%)	CLAY&SILT (%)	SAND (%)	GRAVEL (%)
		150~450 mm	depth at 350mm							
6	P6	350	23.59	15.00	1.74	73	36	54.80	32.40	12.80
7	P7	350	30.08	22.00	1.49	88	37	78.80	19.20	2.00
8	P8	350	41.63	18.00	1.54	76	31	70.40	2.60	27.00
11	P11	350	27.38	19.00	1.68	62	33	66.80	33.20	0.00
12	P12	350	38.74	19.00	1.55	79	46	82.70	17.20	0.10
13	P13	350	21.37	17.00	1.71	56	23	62.20	30.60	7.20

Challenges:

- **High clay content**
- **High moisture content**
- **High Liquid Limit and Plastic Limit**

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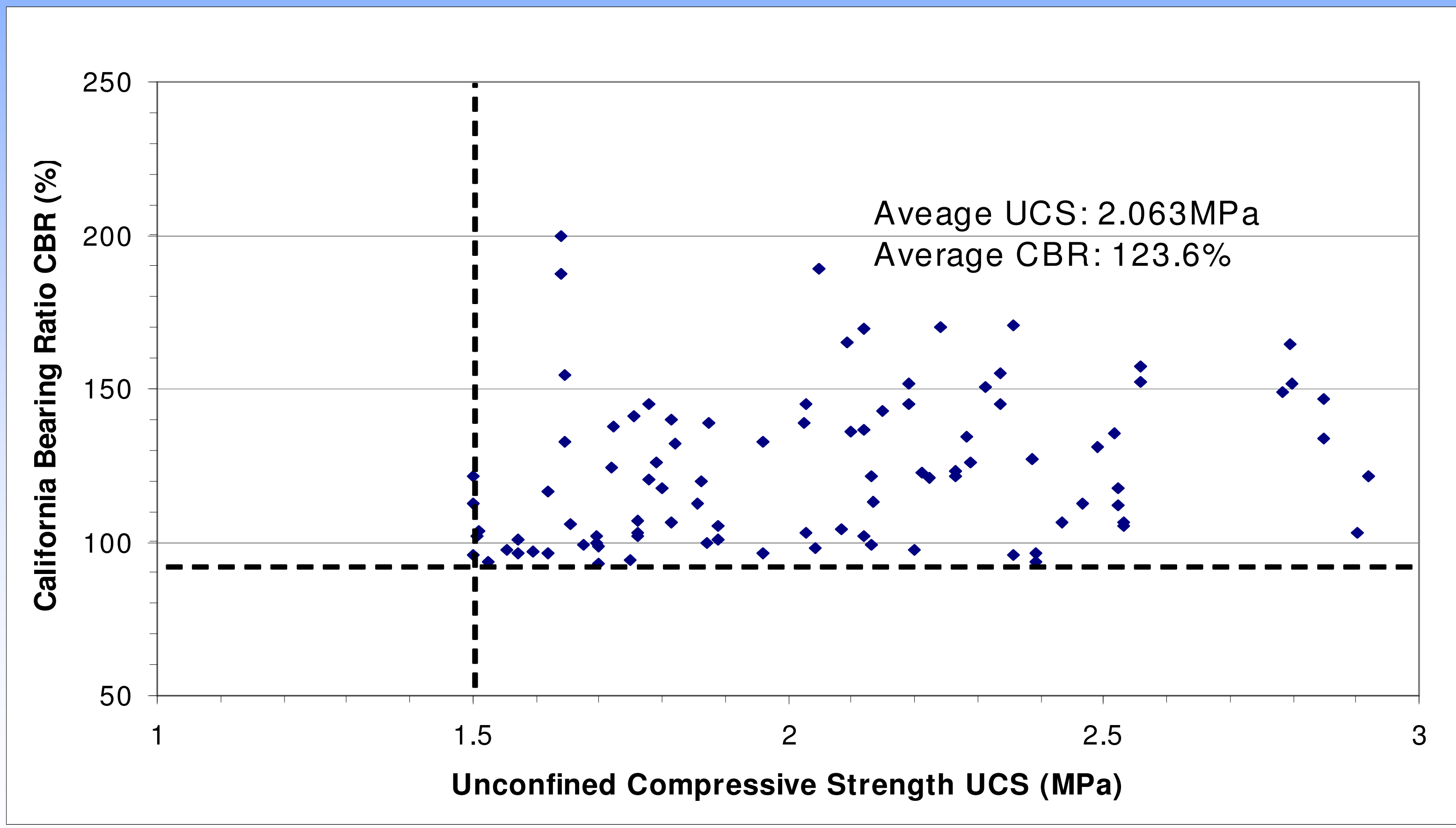

Fig. 6. UCS and CBR Testing Results

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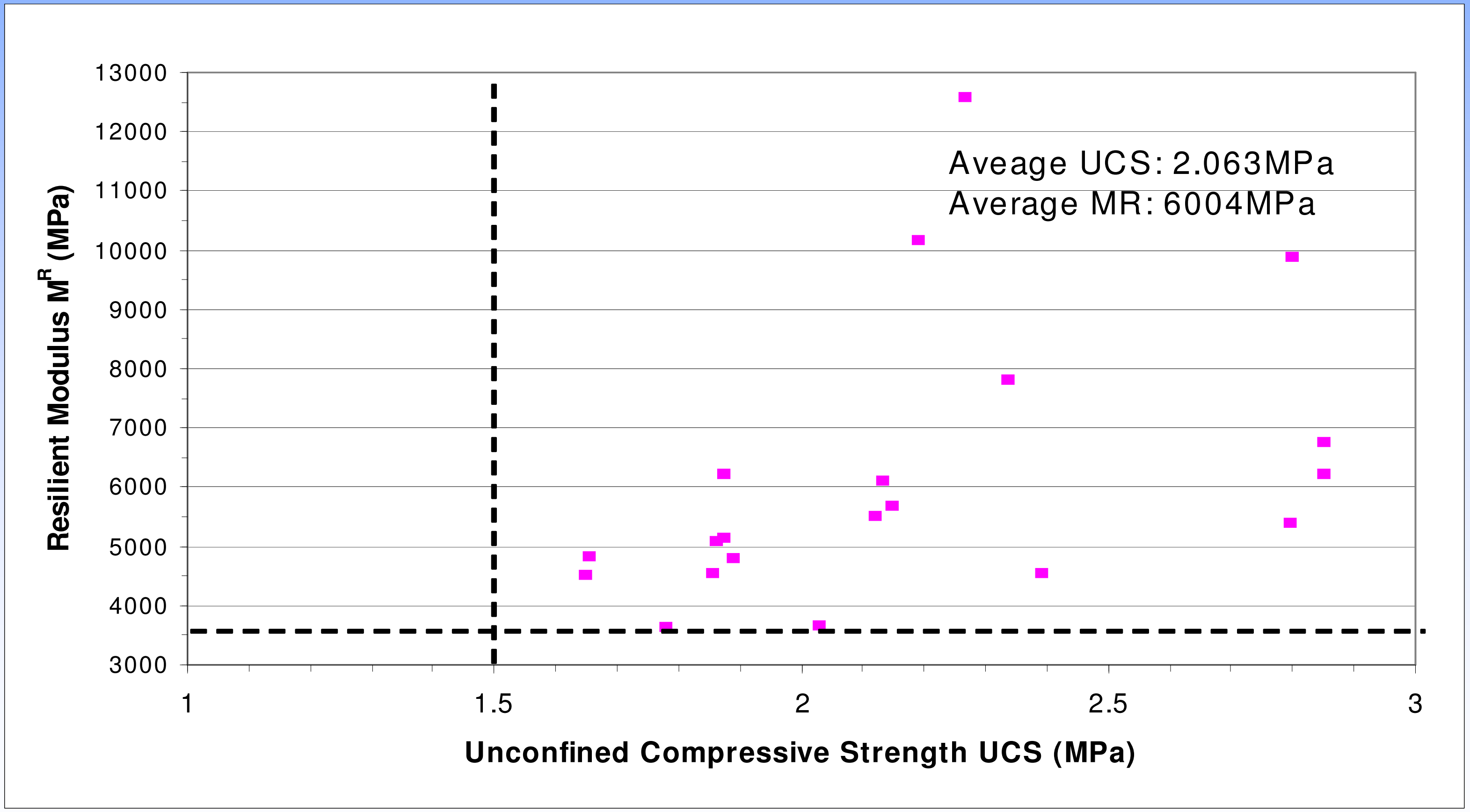

Fig. 7. UCS and Resilient Modulus Testing Results

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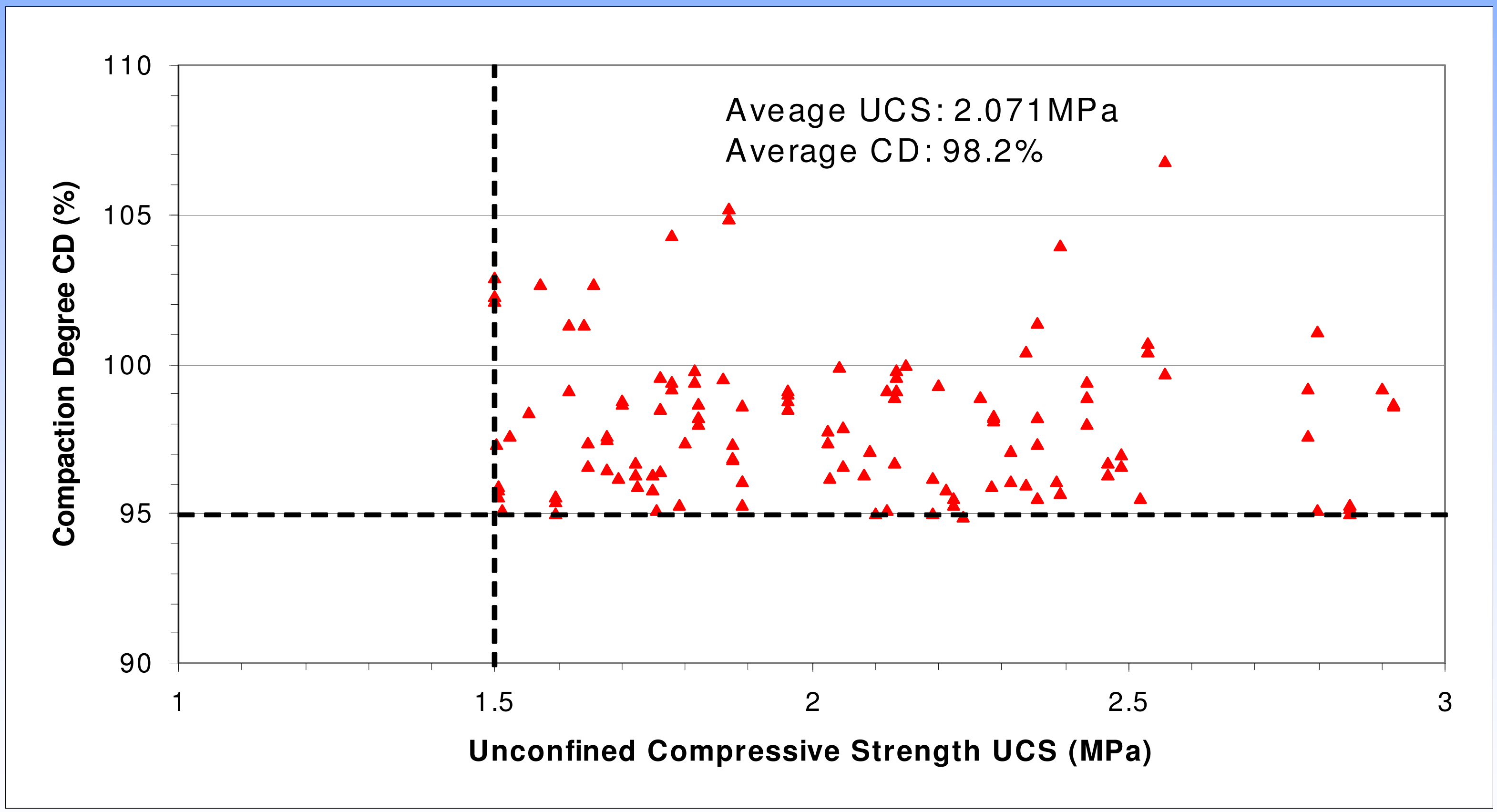

Fig. 8. UCS and Compaction Degree Testing Results

4. Case Studies of Chemilink Stabilization/Recycling

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4-11. Sultan Ismail International Airport (Malaysia, 2007)

Benefits of Chemical–Soil Stabilization in the Airport Environment

Comparison Item (Daily basis and for base course only)	Conventional Replacement Method	Chemical-Soil Stabilization
Construction Rate (by 7.5m)	< 50m	Average: 121m
Transportation (in & out, 10t truck)	100 trips	< 20 trips

- ❖ Chemical-Soil Stabilization
  - ❑Manpower: < 50 workheads
  - ❑Machinery/ Vehicles: < 20 units
  - ❑Re-opening time: 30 minutes
- ❖1.5 month ahead of the 4 months schedule

4. Case Studies of Chemilink Stabilization/Recycling

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4-11. Sultan Ismail International Airport (Malaysia, 2007)

Photo 11. Completion of Runway Widening in Senai Airport

5. Quality Assurance and Quality Control

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Including following aspects and elements

1) Preparations

- ❖ Properties of in-situ/imported materials to be stabilized
- ❖ Chemical stabilizing agents to be used

2) Construction

- ❖ Spreading quality
- ❖ Mixing depths and widths
- ❖ In-situ moisture control
- ❖ Compaction Controls

3) Finishing

- ❖ Level controls
- ❖ Surface finishing tolerances

4) Technical Results

- ❖ UCS, CBR, Resilient Modulus and etc

5. Quality Assurance and Quality Control

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Photo 12. Spreading Rate Check

Photo 13. Preparations of Specimens

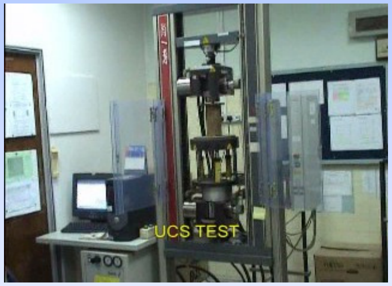

Photo 14. UCS Test

Photo 15. CBR Test

Photo 16. Nuclear Density Test

Photo 17. Resilient Modulus Test

6. Conclusions

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1) Soil stabilization and recycling with chemical admixtures is an effective approach for civil engineering. Chemical stabilization, with proper stabilizing agents and with advanced construction machinery and method, could be one of the best satisfactory construction methods for roads and shallow base foundations under tropical conditions in this region.

❖ Many projects with chemical stabilization have been carried out in this region and the performances of the completed projects are generally satisfactory. With chemical stabilization method, many technical difficulties, especially the total and differential settlements, at clayey, swampy or low-lying land areas with peaty soils have successfully been resolved. The benefits and advantages derived from chemical stabilized roads are far more superior to those of roads constructed by conventional methods.

6. Conclusions

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- The commonly used chemical stabilizing agents are reviewed and discussed in the paper. The major criterion of selecting the agents has been proposed that the right agent must be able to overcome the both general engineering difficulties and localized construction troubles. It is recommended to pay more attention on the modified cementitious base and/or polymer base stabilizing agents because of the effectiveness and durability.
- Chemilink Soil Stabilization has technically and commercially been proven to be the effective and durable method especially for road and airfield construction in this region, based on the performance and durability of numerous projects with Chemilink Technologies and Products. Since Chemilink has successfully been applied a lot of high-difficulty projects for both roads and airfield for past many years, it has been recognized to be a leading technology in soil stabilization industry internationally.
- It is necessary and vital to comply with the quality control requirements in order to achieve successful stabilization works.

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