Seminar on Sustainability of Pavement in Highway Design, Construction & Maintenance,
Malaysian Highway Authority,
Feb. 21, 2012, Auditorium LLM, Selangor, Malaysia

Sustainable Pavement Construction/Maintenance by Green Approaches of In-Situ Stabilization & Rehabilitation

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Chemilink Technologies Group, Singapore

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ZERO WASTE ENGINEERING

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1. Introduction

1-1. Background of Chemical Soil Stabilization

- Most untreated in-situ soil cannot commonly meet the latest requirements. Stronger pavements with stronger materials have to be used for heavier loadings with higher frequency.
- Those unsuitable in-situ soils are replaced by quarry materials. Apart from environmental impact, this is also difficult and expensive in some areas lacking of quarry materials. Disposal of in-situ soil is another problem.
- Mixing proper chemicals with in-situ soils to improve/strengthen the soil properties through chemical reactions. In-situ chemical soil stabilization is an proven solution especially in tropic regions.
- Similarly, solid construction wastes can be stabilized and recycled.

1. Introduction

1-1. Background of Chemical Soil Stabilization

Difficulties of Pavement Construction in Tropical Region:

- Swampy & soft ground, and lower land.
- Reverse climate conditions like rich rainfall and high water table.
- Poor geotechnical properties of in-situ soils, such as peaty and problematic soils.
- Lack of suitable construction sites and quarry materials.

Conventional Methods

- Engaging a large quantity of quarry materials.
- Lower technical performances and durability.
- Eco & environmental issues and higher CO_2 emission.

1. Introduction

1-2. Process of Chemical Stabilization Application

Mechanical Spreading

Mixing by Stabilizer

Compaction 1

Photo. 1. In-situ Mixing

Photo. 2. Central Mixing Plant and Road Surface after Compaction

1. Introduction

1-3. Chemical Stabilizing Agents

- Soil stabilization: "To mix proper chemical or bio-chemical admixture (or called Stabilizing Agent) with soils or solid construction wastes so as to significantly improve and increase the geotechnical properties of the stabilized materials in shallow base foundations".

- Conventional stabilizing agents, such as cement, lime, fly-ashes and bituminous materials, have various limitations in tropical region in aspects of:
  * Technical performances
  * Application workability
  * Environmental pollutions

- Commonly used stabilizing agents, Chemilink SS-108/111 sub-series systems & products, have been applied in South East Asia for past 20 years; and

Wish to contribute to Malaysian Highway and Infrastructure construction.

1. Introduction

1-3. Design for Stabilization and Rehabilitation

Typical Achievable Results **---**

- CBR (California Bearing Ratio, %) : 30 ~ 200 or more (7-day)
- UCS (Unconfined Compressive Strength, MPa) : 0.75 ~ 6.00 (7-day)
- MR (Resilient Modulus, MPa) : 1,000 ~ 10,000 (7- to 28-day)

2. Chemilink Soil/Stone Stabilization – A Green Solution

Chemilink Stabilizing Series Products

- Polymer modified chemical or binding agent, incorporating with such as bio-chemical and recycled materials, in fine powder form.
- Designed for soil stabilization especially for sandy and clayey soils under tropical conditions and environment; for in-situ material rehabilitation and for solid waste recycling.
- The systematic solutions have been verified and widely applied in South East Asia Countries and other countries such as China and India since 1994.

Chemilink Systematic Green Solutions for Pavements

- Designs, incorporated with project R&D if needed.
- Materials.
- Application methodologies.

2. Chemilink Soil/Stone Stabilization – A Green Solution

Total Green Concept

- ***Green Product:*** Various materials are recycled and utilized, such as agricultural bio-mass, in the fabrication of the product.
- ***Green Process***: The application of the stabilizing agents is green as the process reuse in-situ soil, thus minimize the demand on raw granite materials and reduce the removal of the soil as a waste. Besides, with faster construction speed, disturbance to environment and public will be less.
- ***Green End-Result***: The stabilized soil is physically and chemically stable under the specified usage and therefore creates no environmental problem.

3. Advantages of Chemical Soil Stabilization

3-1. Better Technical Performances

- Higher strengths and other parameters
- Can be adjusted to meet different design requirements.
- Structural Number (AASHTO)
- Equivalency Factor (United State FAA)

3. Advantages of Chemical Soil Stabilization

3-2. Reduce Demands on Raw Quarry Materials

- Physical and mechanical properties of in-situ soil can be improved to meet the requirements.
- Less raw quarry materials are required.
- Direct Benefits:

  - Environmental and Ecological friendly;

  - Commercially efficient when lacking of raw quarry materials;

  - Energy conservation; and

  -Time saving

3. Advantages of Chemical Soil Stabilization

3-3. Minimize Creation of Construction Wastes

- Various or unsuitable in-situ soils can be reused, instead of removed as construction wastes.
- More solid construction wastes can be recycled and re-used.
- Saving in dumping costs and eliminating illegal dumping

  (For example: Changi Airport Runways Widening with a total 21,000t of in-situ soil to be disposed if using conventional methods).
- Recycling and rehabilitation activities have produced much lower CO_2 emission (80~90%), if comparing with conventional methods.

3. Advantages of Chemical Soil Stabilization

3-4. Faster Construction and Less Disturbance to Environment and Public

- Less excavation of in-situ soil and replacement
- 3-5 times faster or more than conventional replacement method
- Reduce disruption to public
- Less environmental pollution such as air, noise and dirt deposit

3. Advantages of Chemical Soil Stabilization

3-5. Overall Cost Effectiveness

Short Term Direct Cost Saving:

- Reduction of raw granite usage
- Easier and faster construction
- Less manpower and machineries required

Long Term Cost Effectiveness

- Much less maintenances
- Longer durability and service life

4. Case Studies of Chemilink Stabilization/Recycling

4-1. Jalan Tutong Widening, Phases II&III (Brunei, 97&99)

Photo. 3. Jalan Tutong Widening, Phase II (after more than 4 yrs)

4. Case Studies of Chemilink Stabilization/Recycling

Additional Information about Phase I



Photo. 4. Typical Defects Found in Jalan Tutong Phase I

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4. Case Studies of Chemilink Stabilization/Recycling

4-1. Jalan Tutong Widening, Phases II&III (Brunei, 97&99)

a) Opened Road Cross Section

b) Road after 10-year completion

Photo. 5. Jalan Tutong Widening, Phase III

4. Case Studies of Chemilink Stabilization/Recycling

4-2. Expressway Quick Maintenance

a) Road Partially Closed for Maintenance

b) Road Opened for Use in the Next Day Morning

c) Cored Samples stabilized Recycled Materials

Photo. 6. Expressway Quick Maintenance

4. Case Studies of Chemilink Stabilization/Recycling

4-3. Singapore Changi International Airport (2005)

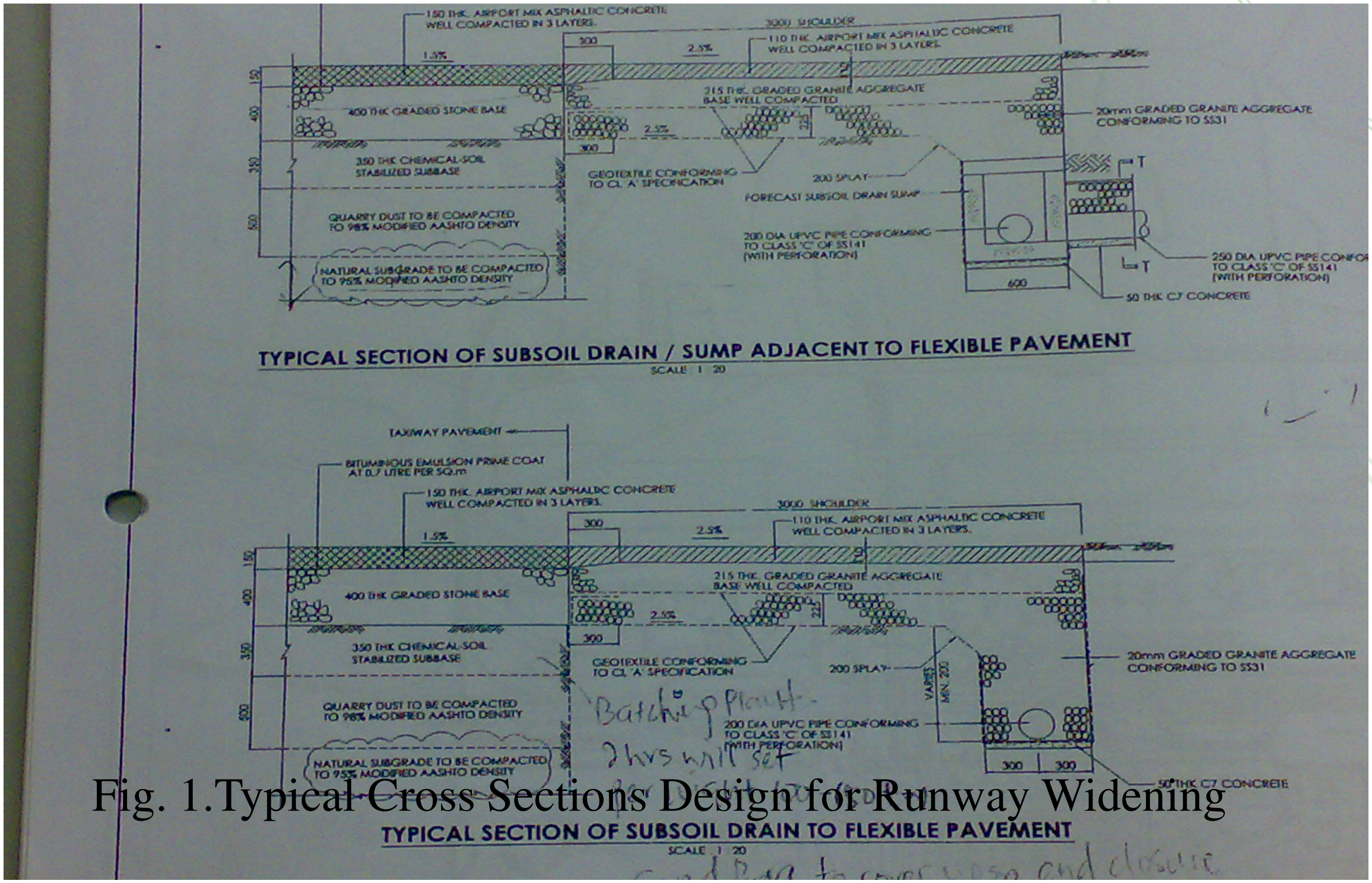
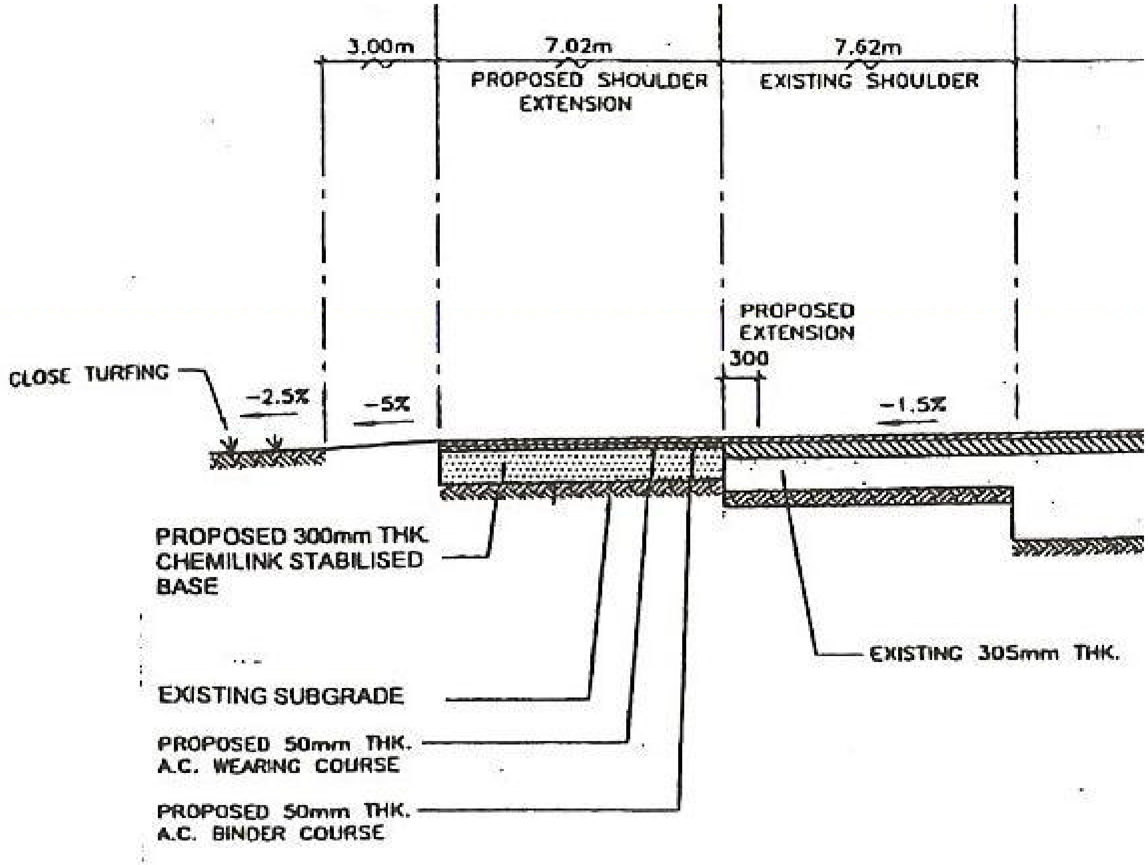


Fig. 1.Typical Cross Sections Design for Runway Widening

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



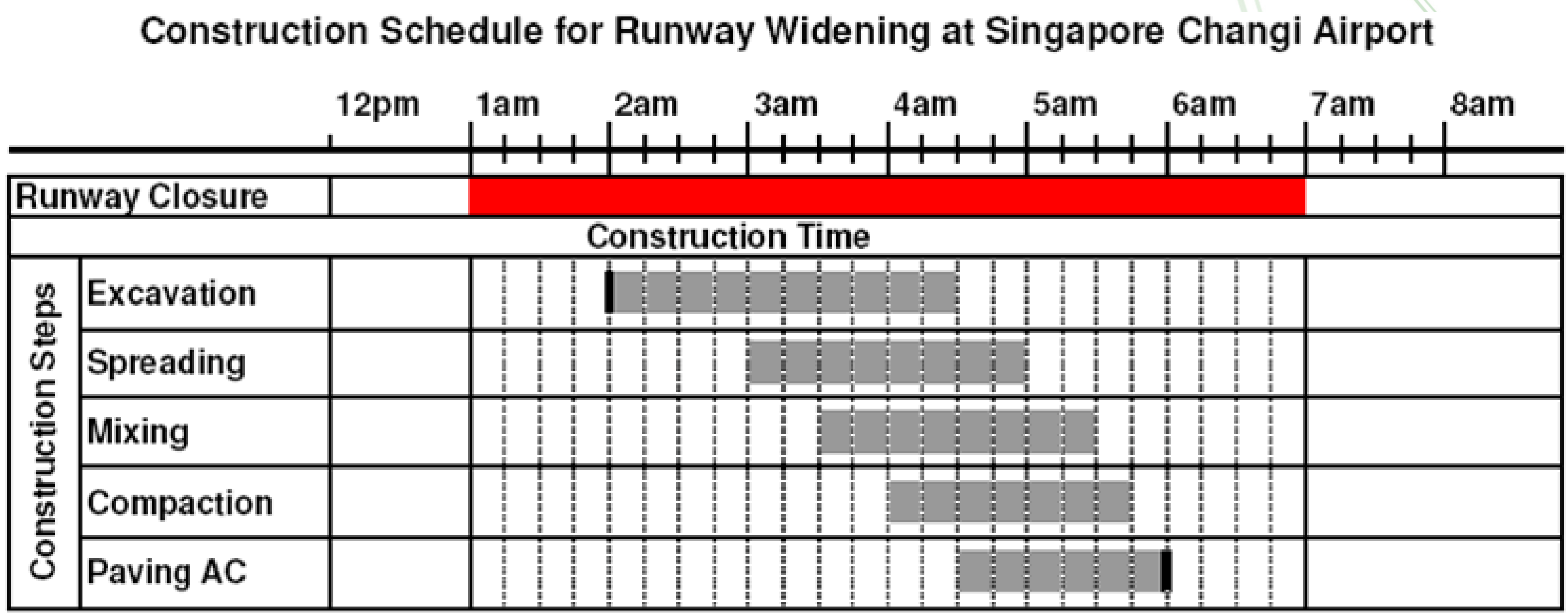
A polymer modified cementitious chemical stabilizing agent be used for base course topped by asphalt concrete

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

4-3. 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. 2: Typical Daily Construction Schedule

4. Case Studies of Chemilink Stabilization/Recycling

4-3. 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

4-3. Singapore Changi International Airport (2005)

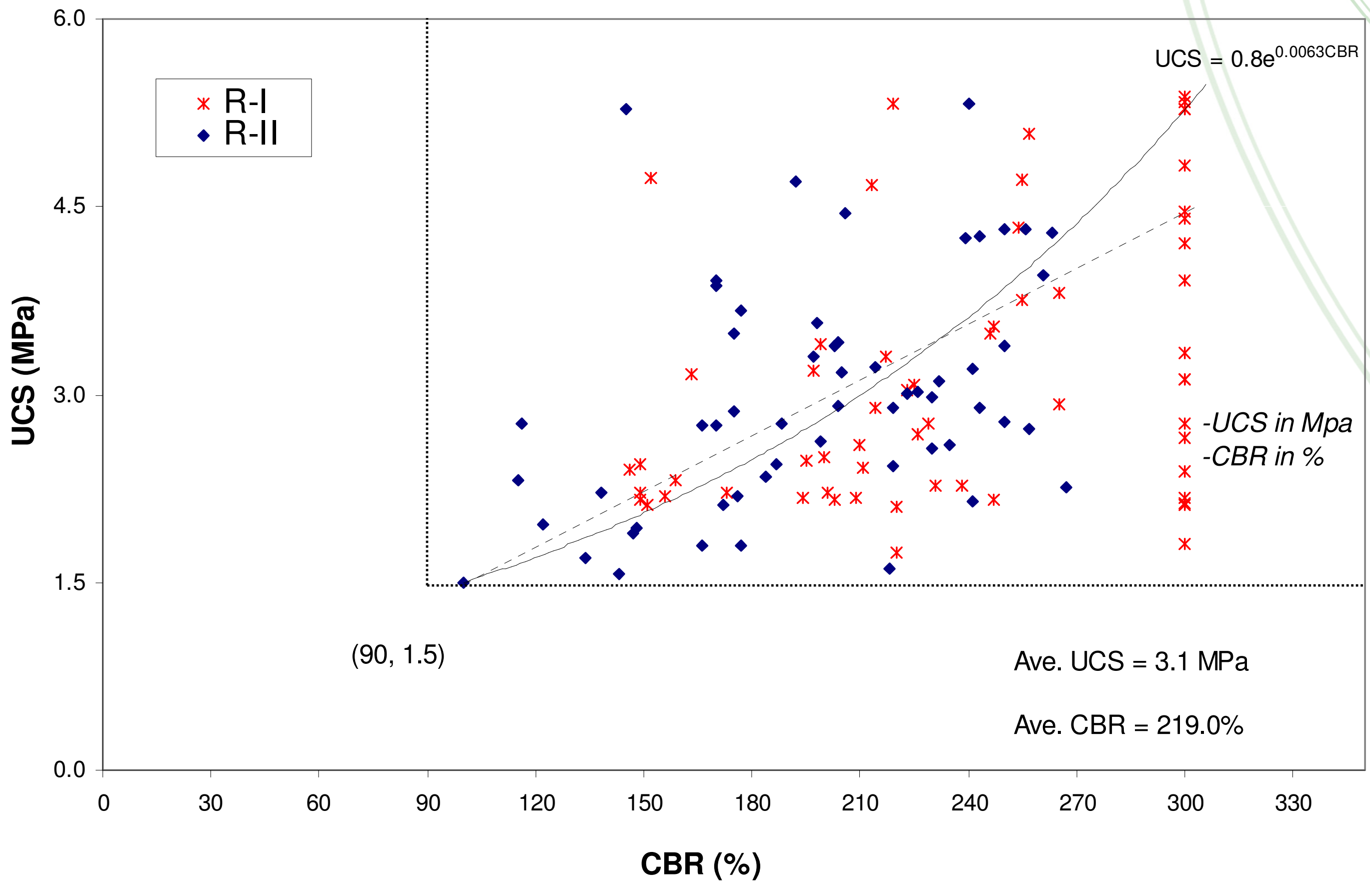


Fig. 3. UCS and CBR Testing Results for Runway-I and Runway-II

4. Case Studies of Chemilink Stabilization/Recycling

4-3. Singapore Changi International Airport (2005)

a) Runway I

b) Runway II

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

4. Case Studies of Chemilink Stabilization/Recycling

4-3. Singapore Changi International Airport (2005)

Snapshot taken from Discovery Channel "Man Made Marvels" Program (11/2008)

4. Case Studies of Chemilink Stabilization/Recycling

4-3. Singapore Changi International Airport (2005)

CHANGI
airport group

Date 28 October 2011

RECEIVED 021111

Chemilink Technologies Group Pte Ltd
20 Kranji Road
Singapore 739462.

Attention: Dr Wu Dong Qing

Dear Sir/Mdm,

RE: LETTER OF CONFIRMATION

We are pleased to confirm that the Chemilink Soil Stabilization Product/Technology was adopted at Changi Airport for the Runway Shoulder Widening project in 2005. The technology was applied to treat the soil next to the runway so that the runway paved shoulders could be extended by 4.5m to accommodate the Airbus A380 aircraft operations safely.

Since the completion of project, the performance of Chemilink Soil Stabilization Product/Technology is satisfactory. The technology has helped Changi Airport to provide new runway paved shoulders in a safe, cost-effective and expeditious manner.

Thank you

Yours faithfully,

Koh Ming Sue
Senior Vice President
Engineering & Master Planning Division

Changi Airport Group (Singapore) Pte Ltd
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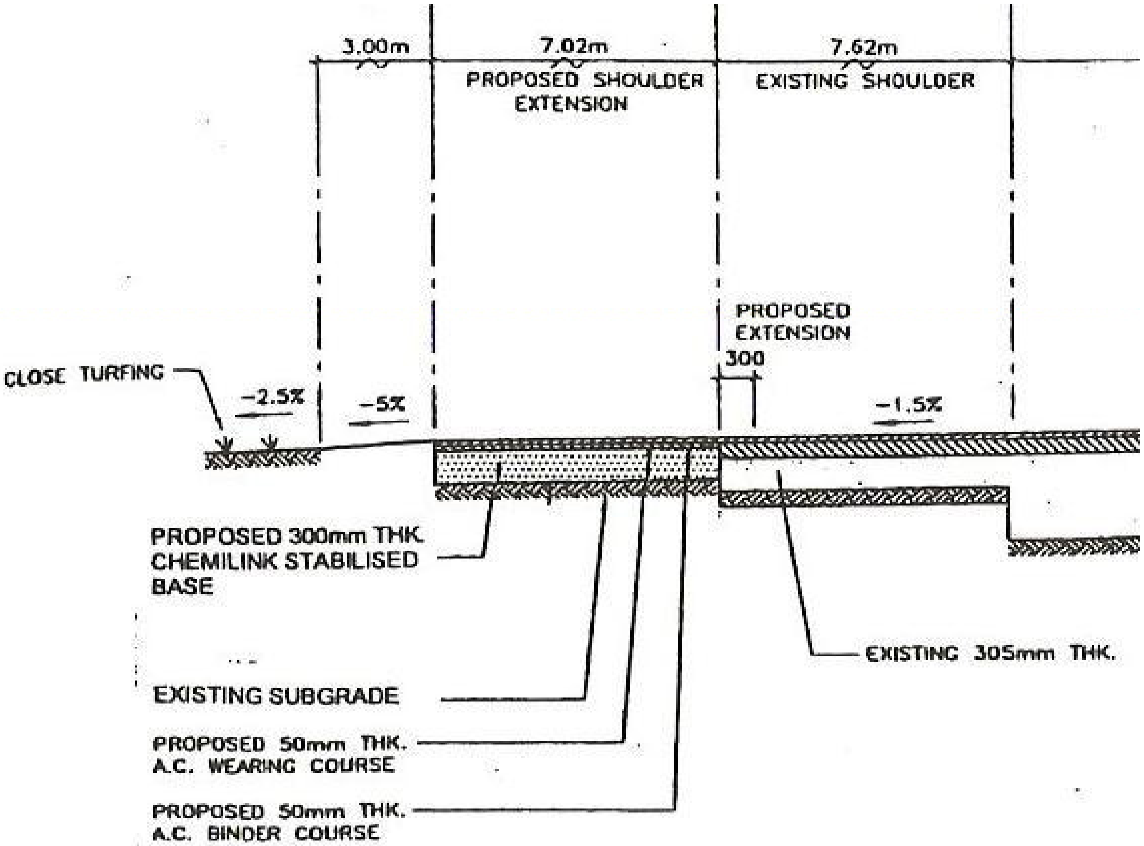
www.changiairportgroup.com
Registration No. 200910817N

Connecting Lives

4. Case Studies of Chemilink Stabilization/Recycling

4-4. 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

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

a) Spreading

b) In-Situ Mixing

c) Compaction

Photo. 9. Stabilization Work in Sultan Ismail International Airport

4. Case Studies of Chemilink Stabilization/Recycling

4-4. 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

4. Case Studies of Chemilink Stabilization/Recycling

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

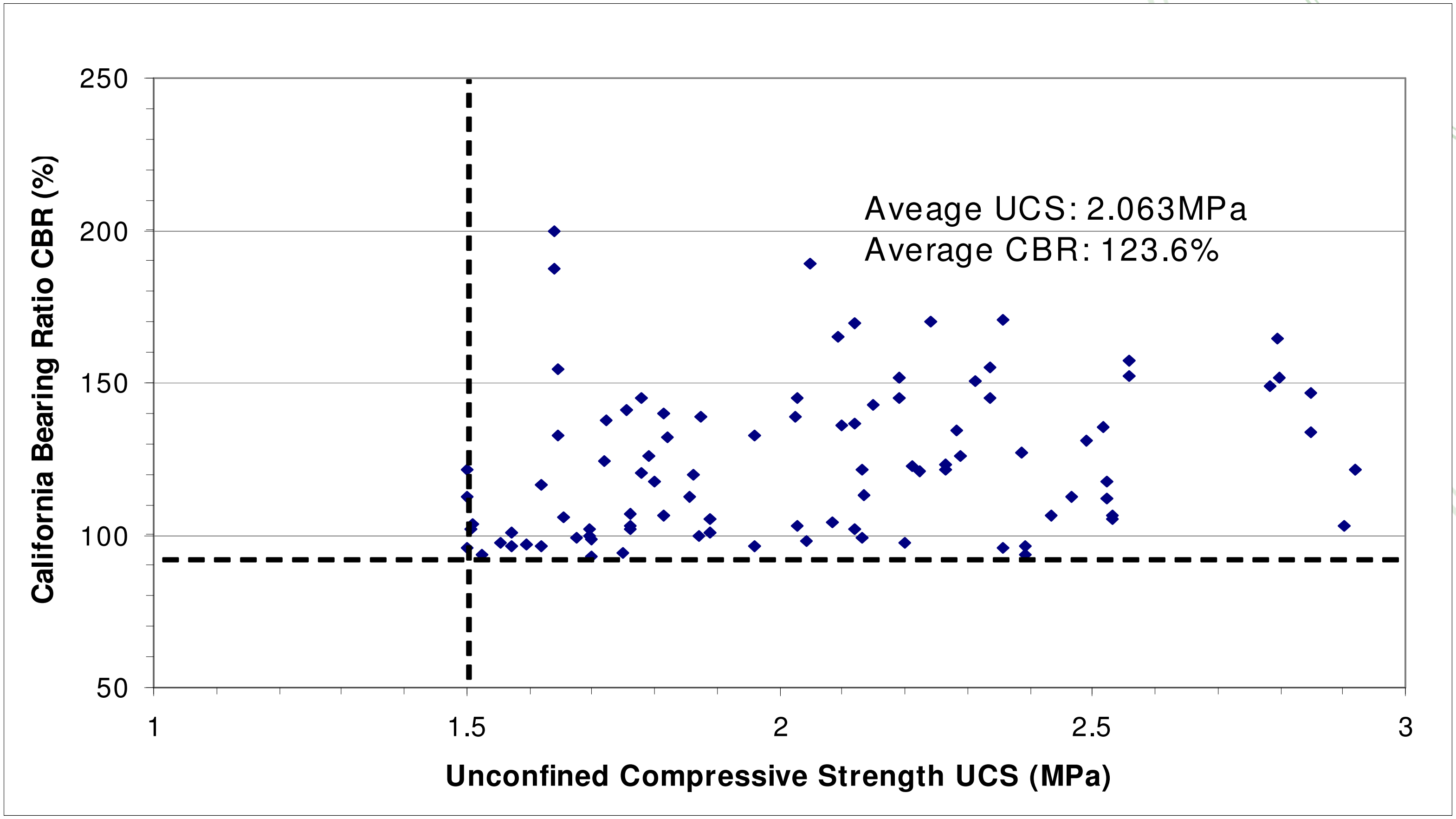


Fig. 5. UCS and CBR Testing Results

4. Case Studies of Chemilink Stabilization/Recycling

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

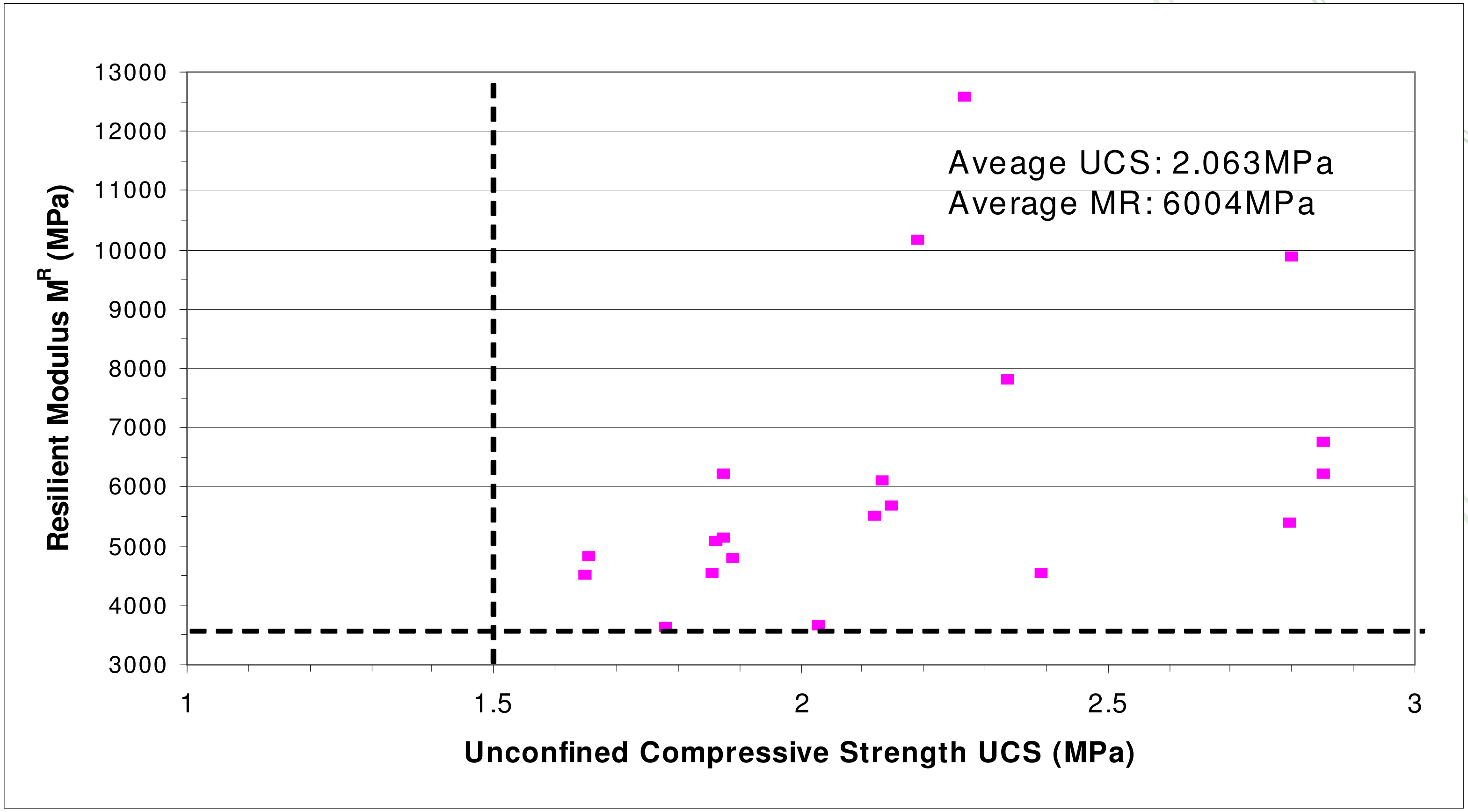


Fig. 6. UCS and Resilient Modulus Testing Results

4. Case Studies of Chemilink Stabilization/Recycling

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

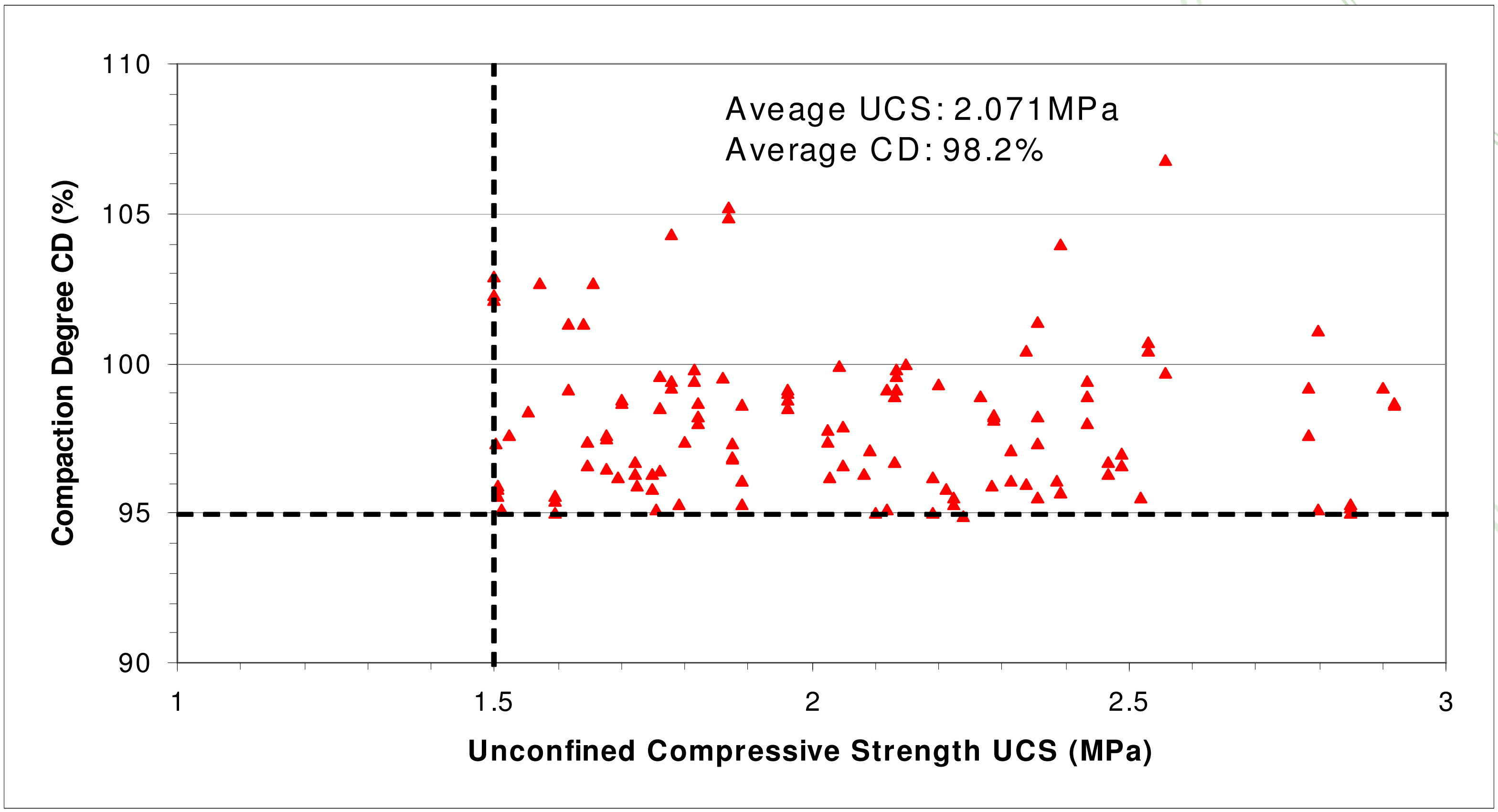


Fig. 7. UCS and Compaction Degree Testing Results

4. Case Studies of Chemilink Stabilization/Recycling

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

Photo 10. Completion of Runway Widening in Senai Airport

4. Case Studies of Chemilink Stabilization/Recycling

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

Senai Airport Terminal Services Sdn. Bhd (242383-M)

SenaiAirport

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Date : 20th September 2011

Chemilink Technologies Group Pte Ltd
20 Kranji Road
Singapore 739462.

Dear Sir,

Project Title: DESIGN AND BUILD DEVELOPMENT OF AIRSIDE INFRASTRUCTURE AT THE SULTAN ISMAIL INTERNATIONAL AIRPORT, JOHOR BAHRU, JOHOR (LTS)

Subject: Letter of Confirmation

Hereby, it is confirmed that **Chemilink Soil Stabilization** product and technology was adopted in Senai International Airport Runway and Taxiway Widening Projects. The said projects were completed in year 2007 and 2008 respectively. Projects performances up-to-date are still satisfactory.

Thank you.

Yours sincerely,
SENAI AIRPORT TERMINAL SERVICES SDN.BHD

SHAUN A KUMAR
Project Director's Representative

4. Case Studies of Chemilink Stabilization/Recycling

4-5. Northport Container Terminal Maintenance (Malaysia, 2010)

4. Case Studies of Chemilink Stabilization/Recycling

4-5. Northport Container Terminal Maintenance (Malaysia, 2010)

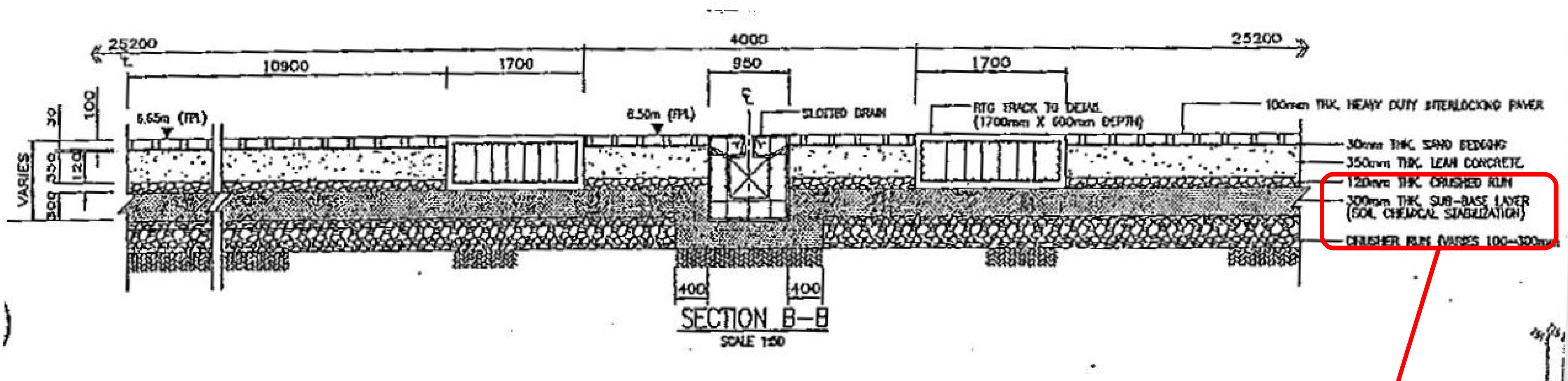
- Design for 6 tiers of laden container over soft ground
- Site Condition prior to maintenance:

  Serious Differential Settlement, Water Ponding, Potholes

Photo 11. Conditions before Rehabilitation

4. Case Studies of Chemilink Stabilization/Recycling

4-5. Northport Container Terminal Maintenance (Malaysia, 2010)



300mm THK SUB-BASE LAYER (SOIL-CHEMICAL STABILAZATION

Typical Cross-Sectional Design


Completed Area in Use
Area After Chemilink Stabilization
Area Before Chemilink Stabilization
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QC Testing Results:

Ave UCS (7-d) = 2.9MPa (spec > 2.0MPa)
Ave CBR (7-d) = 141.5% (spec > 120%)

After In-Situ Stabilization

First Phase in Operation

9 months after Completion and in Use

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5. Conclusions

1) In-situ stabilization as well as rehabilitation with appropriate stabilizing agents of chemical or bio-chemical admixtures, incorporated with proper designs and applicable methodologies, is a green and effective approach for pavement construction in our region.

2) The stabilization with green product, green process and green result, can maximize the usage of in-situ or local soils and solid construction wastes so as to significantly minimize the impacts to natural environment and greatly reduce the CO_2 emission, and therefore it is a sustainable way to built various pavements.

3) Based the comprehensive case studies, the systematic solution of the in-situ stabilization and rehabilitation has been proven for past 20 years to deliver higher technical parameters and performances with fast construction and thus to provide longer pavement lifespan and overall cost effectiveness.

4) This well-proven system has presented premier, innovative and leading models especially in "floating" semi-rigid platform over swampy ground; anti-cracking quality for high-grade pavements; and excellent workability and performances under heavy operational airport or road activities.

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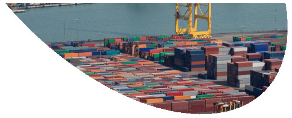


Thank You for Your Attention!