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Recycling of Unsuitable In-situ Soils and Construction Wastes by Chemical Soil Stabilization

Dr Wu Dong Qing **Tan Poi Cheong**

Chemilink Technologies Group, Singapore

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1. Introduction

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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 regions lacking of quarry materials, such as Singapore. 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, construction waste can be stabilized and recycled.

1. Introduction

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1-2. Process of Chemical Stablization 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. Commonly Used Chemical Stabilizing Agents

Common Chemical Reaction involved:

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

Commonly Used Chemical Stabilizing Agents:

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

2. Chemilink Soil/Stone Stabilization – A Green Solution

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Chemilink Stabilizing Series Products

- polymer modified cementitious chemical agent, incorporating with bio-chemical and recycled materials, 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

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. Chemilink Soil/Stone Stabilization – A Green Solution

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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

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3-1. Better Technical Performances

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

3. Advantages of Chemical Soil Stabilization

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3-2. Reduce Demands on Raw Backfilling Materials

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

  Environmental and Ecological friendly;

  Commercially efficient when lacking of raw quarry materials;

  Energy conservation.

3. Advantages of Chemical Soil Stabilization

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3-3. Minimize Creation of Construction Waste

- Unsuitable in-situ soil can be reused, instead of removed as a construction waste.
- Saving in dumping cost and eliminate illegal dumping.
- Eg: Changi Airport Runway Widening

  Total 21,000 ton of soil to be disposed if using conventional method

  Saving in dumping cost = S$200,000

3. Advantages of Chemical Soil Stabilization

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

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

3. Advantages of Chemical Soil Stabilization

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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 In-direct Cost Effectiveness

❖Much less maintenances

❖Longer durability and service life

4. Case Studies of Chemilink Stabilization/Recycling

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4-1. Jalan Tutong Widening, Phase II & III (Brunei, 1998)

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

4. Case Studies of Chemilink Stabilization/Recycling

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

4. Case Studies of Chemilink Stabilization/Recycling

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4-1. Jalan Tutong Widening, Phase III (Brunei, 1998)

a) Opened Road Cross Section

b) Road after 2-year completion

Photo. 5. Jalan Tutong Widening, Phase III

4. Case Studies of Chemilink Stabilization/Recycling

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4-2. City Road Maintenance

a) Road Partially Closed for Maintenance

b) Road Opened for Use on the Next Day

c) Cored Samples stabilized Recycled Materials

Photo. 6. City Road Maintenance

4. Case Studies of Chemilink Stabilization/Recycling

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4-3. Singapore Changi International Airport (2005)

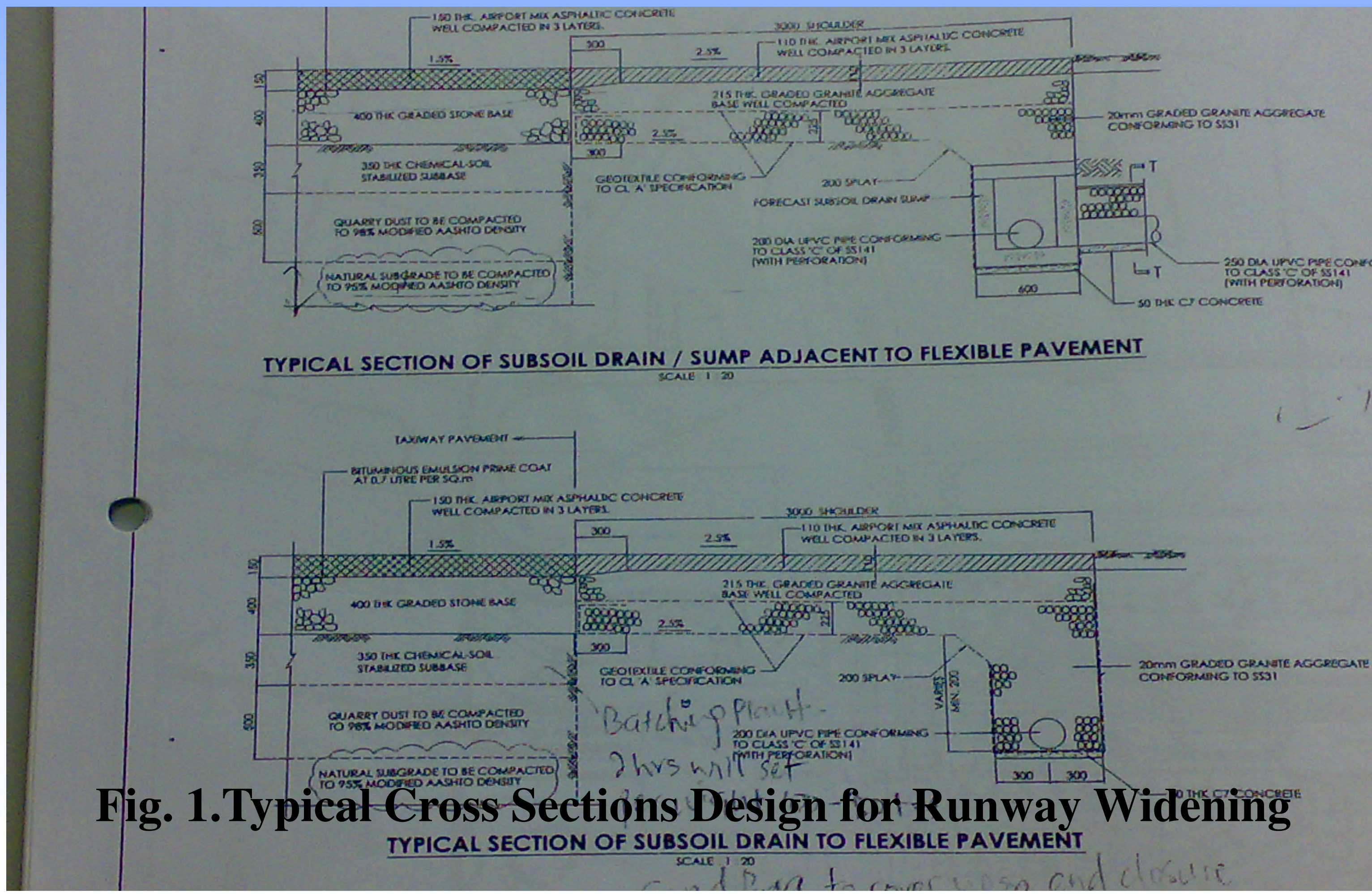

Fig. 1.Typical Cross Sections Design for Runway Widening

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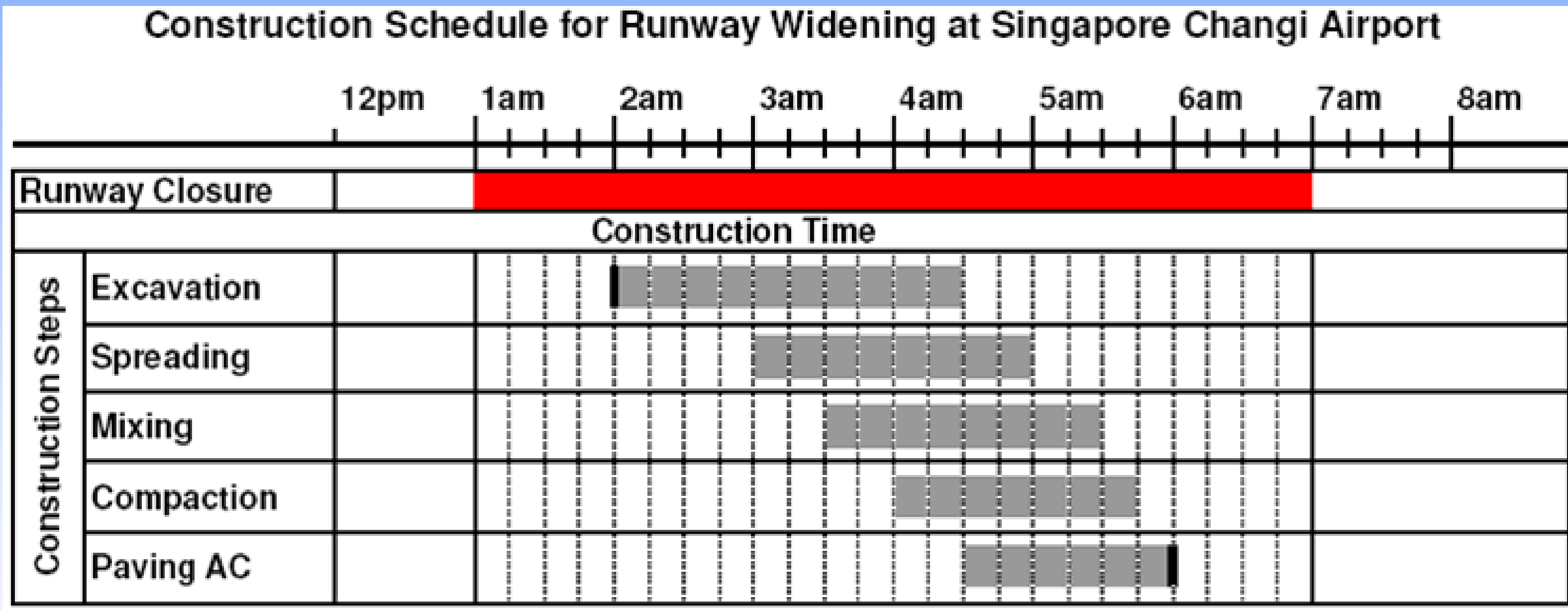
4-3. Singapore Changi International Airport (2005)



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

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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

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4-3. Singapore Changi International Airport (2005)

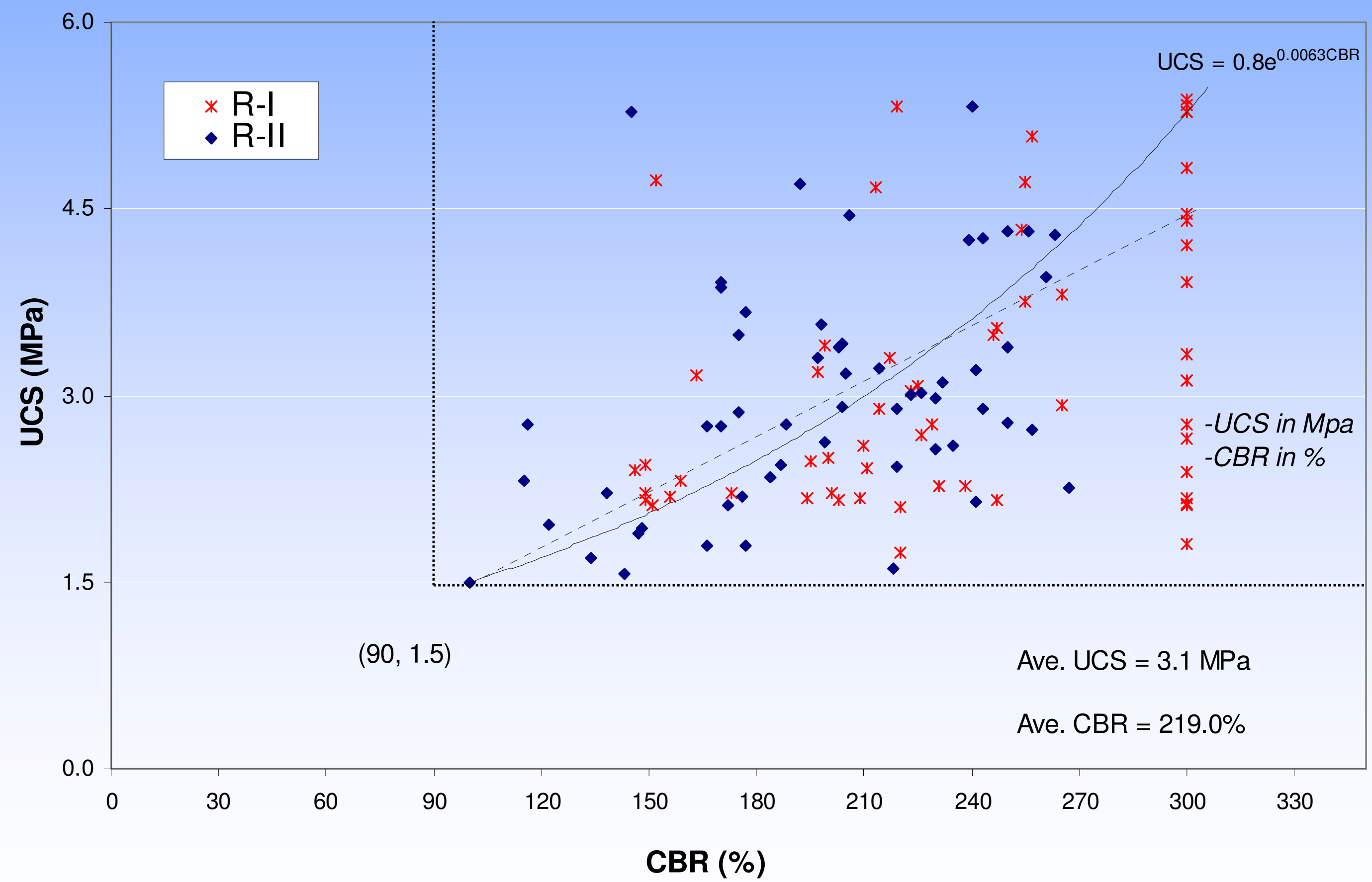

Fig. 3. UCS and CBR Testing Results for Runway-I and Runway-II

4. Case Studies of Chemilink Stabilization/Recycling

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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)

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4-3. Singapore Changi International Airport (2005)

Snapshot taken from Discovery Channel "Man Made Marvels" Program

4. Case Studies of Chemilink Stabilization/Recycling

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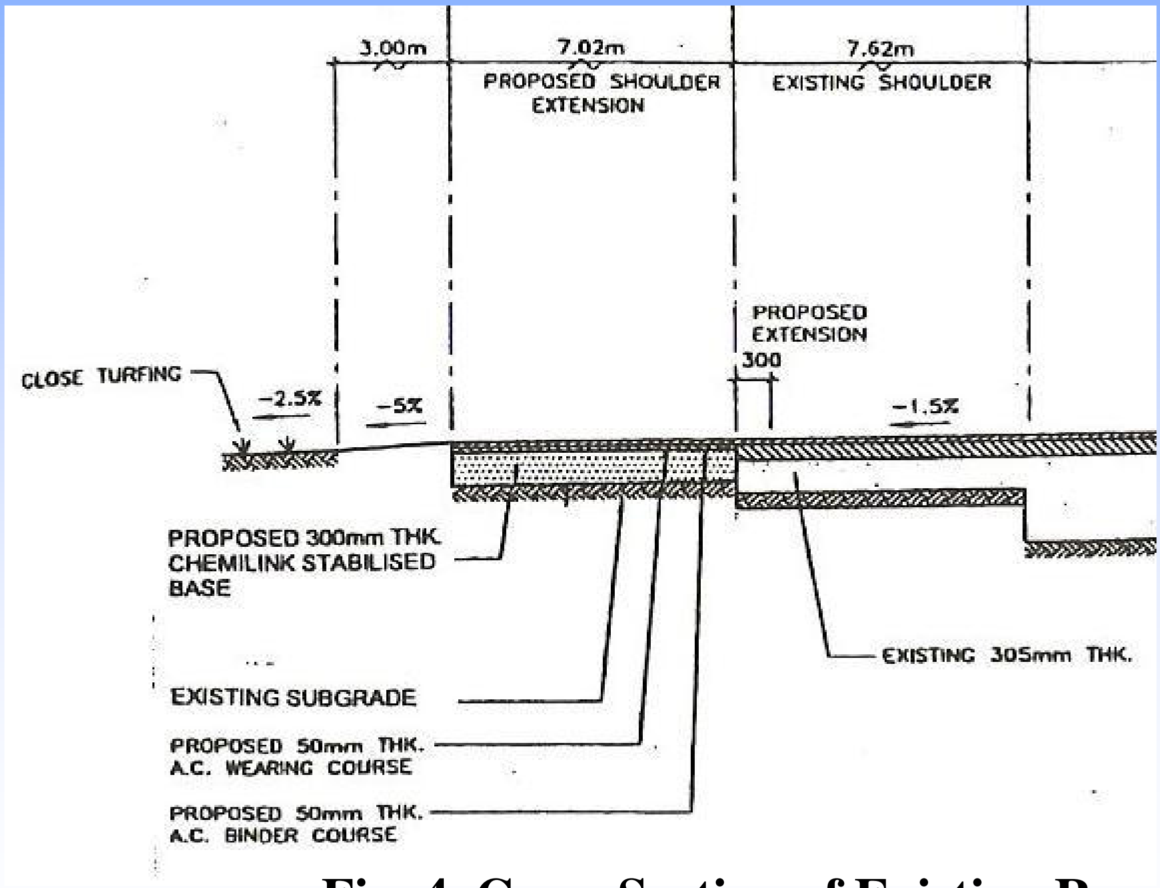
4-4. Sultan Ismail International Airport (Malaysia, 2007)



- ❖ 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

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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

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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**

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

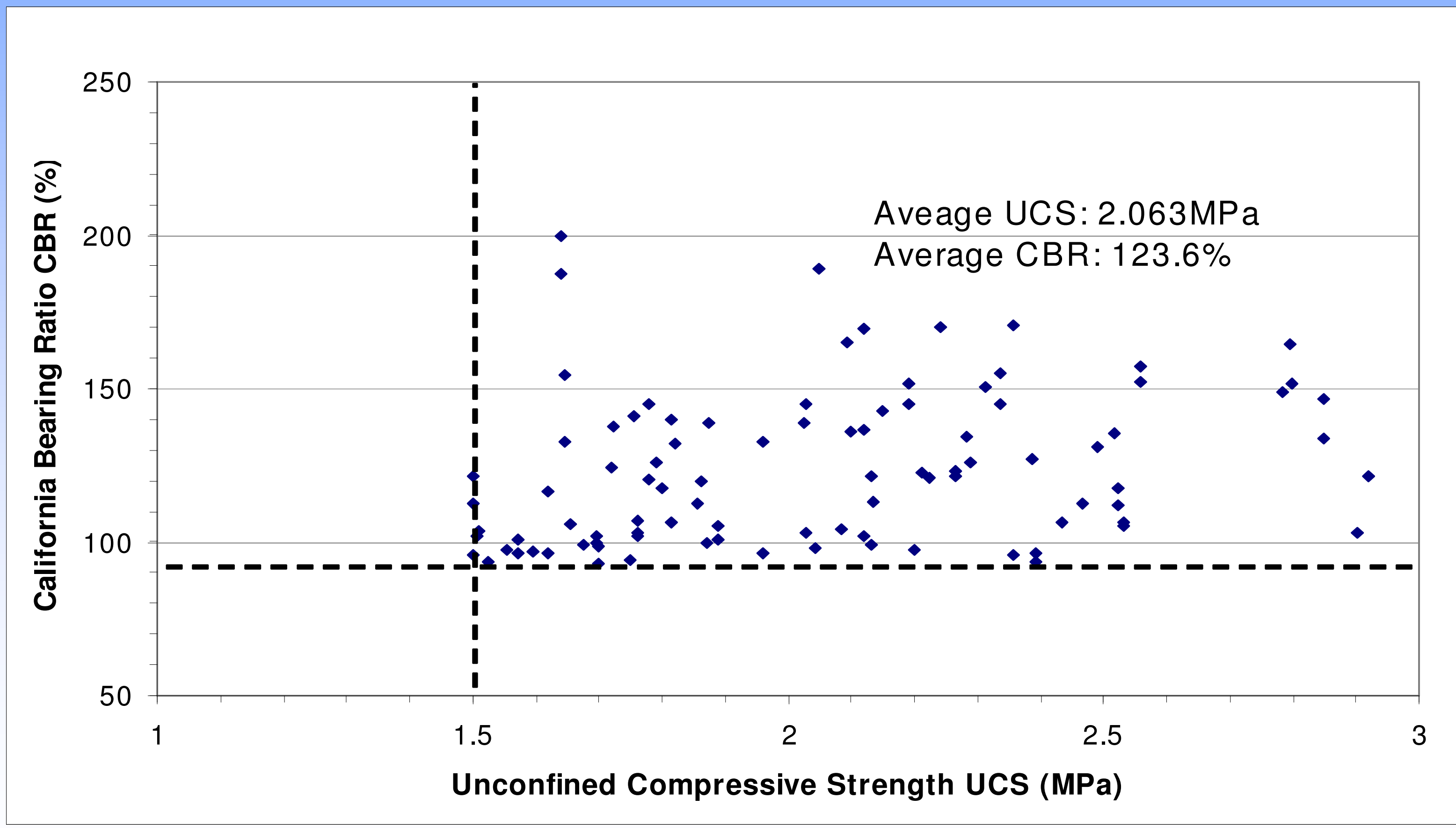

Fig. 5. UCS and CBR Testing Results

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

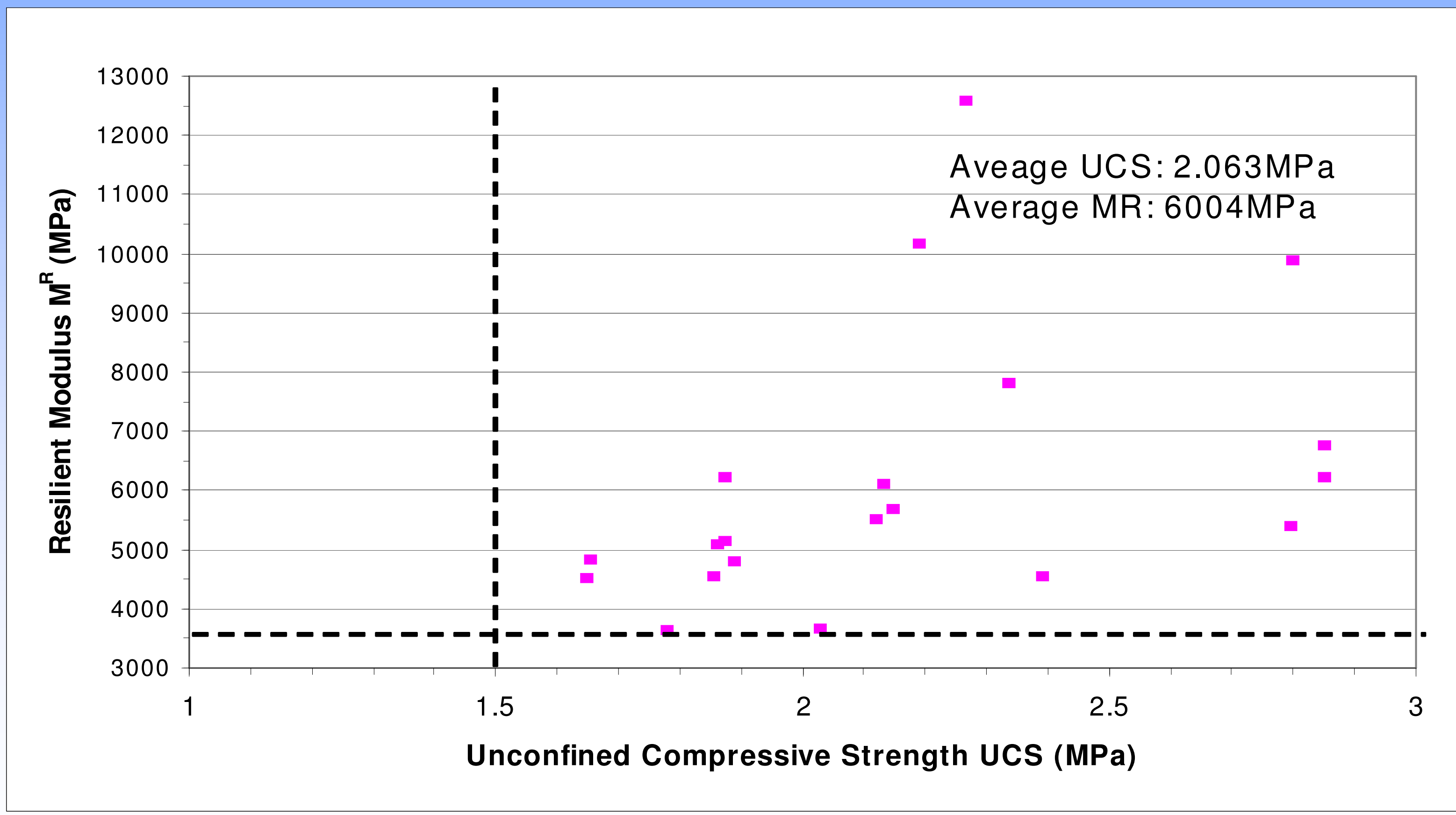

Fig. 6. UCS and Resilient Modulus Testing Results

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

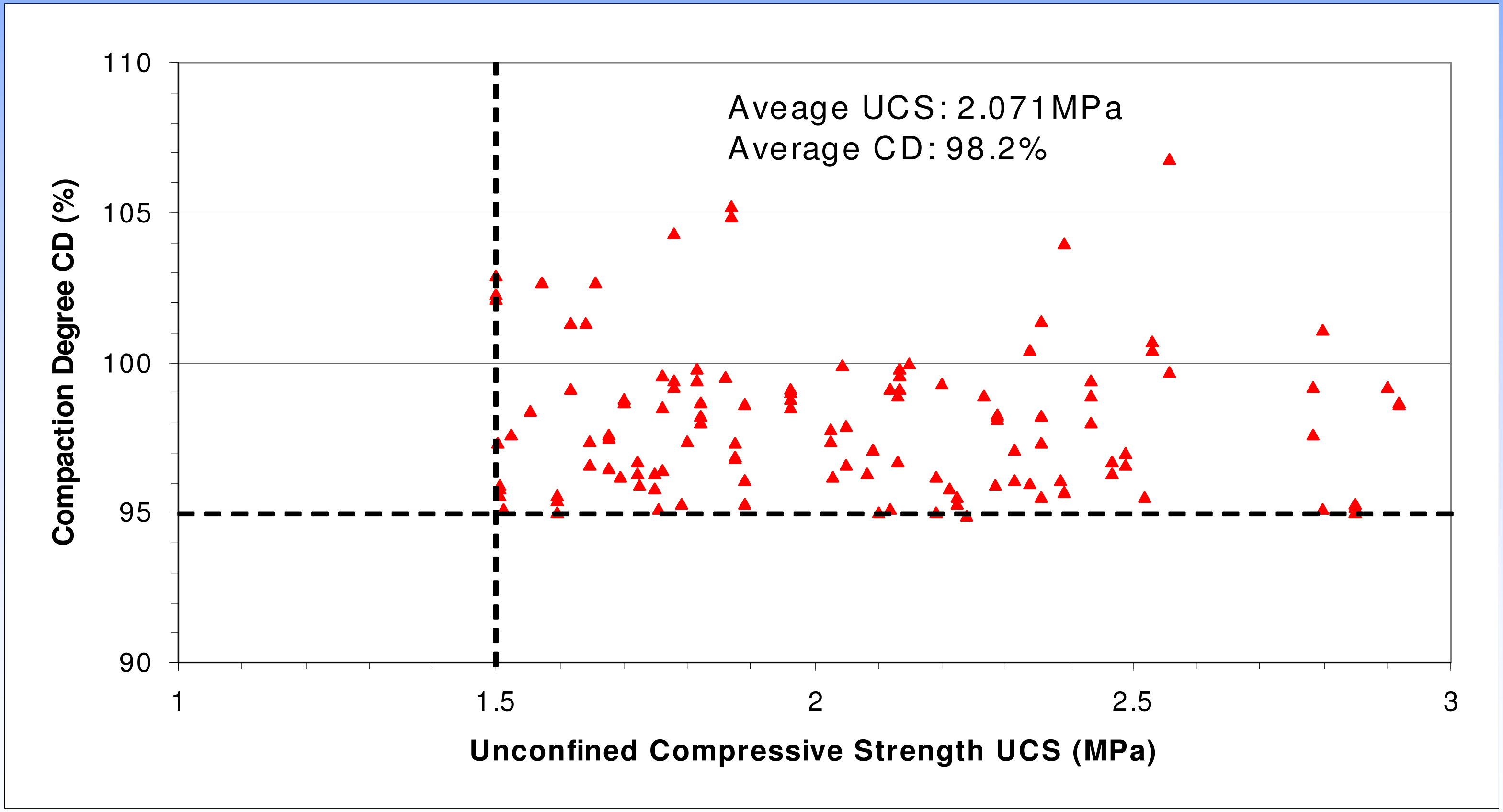

Fig. 7. UCS and Compaction Degree Testing Results

4. Case Studies of Chemilink Stabilization/Recycling

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

Photo 10. Completion of Runway Widening in Senai Airport

5. Conclusions

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- **Chemical stabilization of unsuitable in-situ soil and construction waste is an effective approach for civil engineering.**
- **More attention has been paid on the chemical/bio-chemical modified cementitious base stabilizing agents, such as Chemilink Soil/Stone Stabilization because of the effectiveness and durability.**
- **Chemical stabilization method has solved many technical difficulties, especially the total and differential settlements, at clayey, swampy or low-lying land areas with peaty soils.**
- **Chemical Soil Stabilization is a "green" approach to infrastructure construction.**

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Thank You for Your Attention!