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Chemical-Clay Stabilization for Runway Widening at Sultan Ismail International Airport, Malaysia

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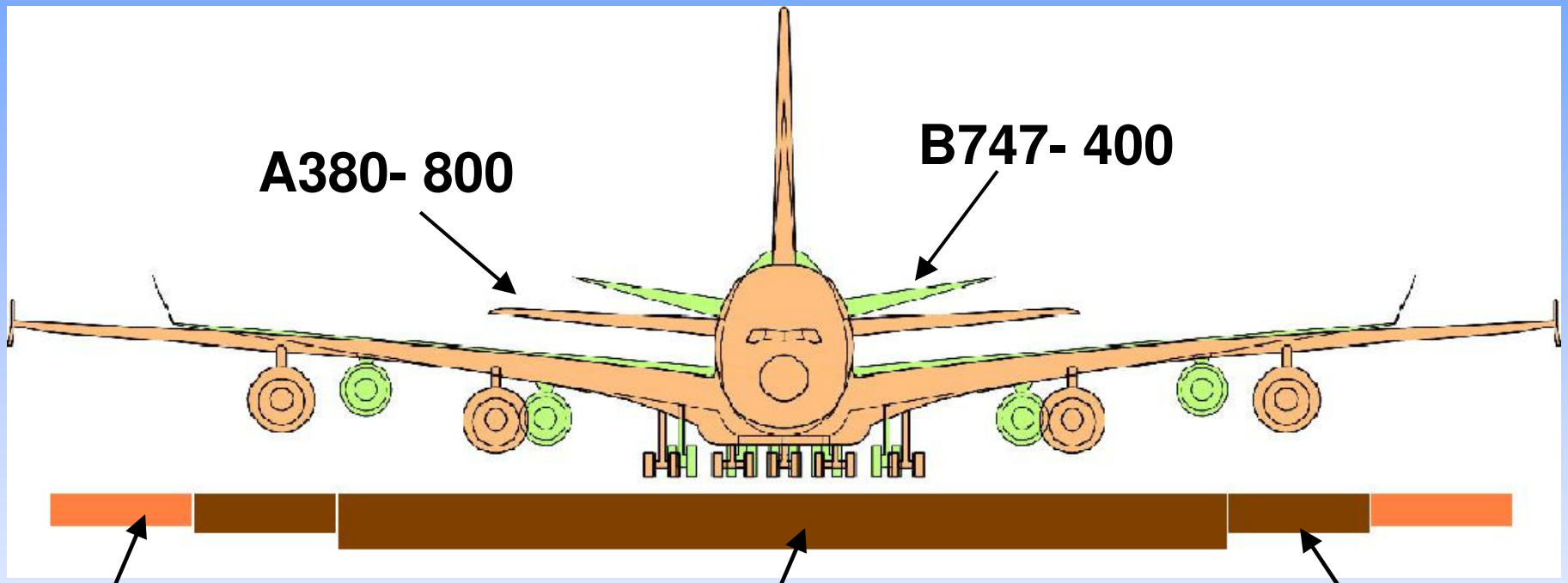
1. Introduction

* **Airbus A380 is the largest commercial aircraft built to date.**
* **The runway shoulders have to be widened to support A380 operations for following reasons:**

  (a) Provide a safe area that can withstand occasional runway excursion by aircraft;
  (b) support ground emergency response vehicles
  (c) resist jet wash and prevent Foreign Object Damage (FOD) hazard

* **Senai Airport runway shoulder was widened for airport new development and services, such as training centre for SIA Airbus A380.**

1. Introduction



* Existing runway width: 60m (45m runway + 15m shoulder)
* Widened runway width: 75m (45m runway + 30m shoulder)
* How to do widening without affecting airport daily operation?

2. Evaluation Criteria

* **Senai Airport Authority evaluated various technical proposals with following major considerations:**

2-1 Ability to Meet Airport Operational Restrictions

2-2 Construction Speed and Timing

2-3 Reliability Structural Design

2-4 Environmental Impact

2-5 Cost Effectiveness

2-6 Similar Project Record in Other International Airport

2-1 Ability to Meet Airport Operational Restrictions

- Limited runway closure time from 12:00 am to 6:00 am
- Effective construction time is only about 4.5 hours
- Runways re-opening within 1 hour

2-2 Construction Speed

- Higher construction unit rate
- Shorter project duration
- Safer construction activities

2-3 Structural Design

- ICAO requirements
- Latest recommendation from Airbus
- Sub-grade conditions – high clay contain with high moisture content
- Proven technology and product in tropical region with a long history

2-4 Environmental Impact

- Less excavation and backfilling
- Less ground movements caused by vehicles, machines and manpower
- Less airport control and coordination works
- Environment friendly

2-5 Cost Effectiveness

❖ **Overall Costs**

- ❑ **Construction cost & related costs**
- ❑ **Long-term maintenance costs and related costs**

2-6 Similar Project Record in Other International Airport

- In 2005 Soil Stabilization Method was used in Singapore Changi International Airport Runway Widening
- Till date, no defects (such as cracking and settlement) were detected and the overall performances were satisfactory

2. Evaluation Criteria

* **Final Decision**

Non-replacement method – In-situ chemical-soil stabilization

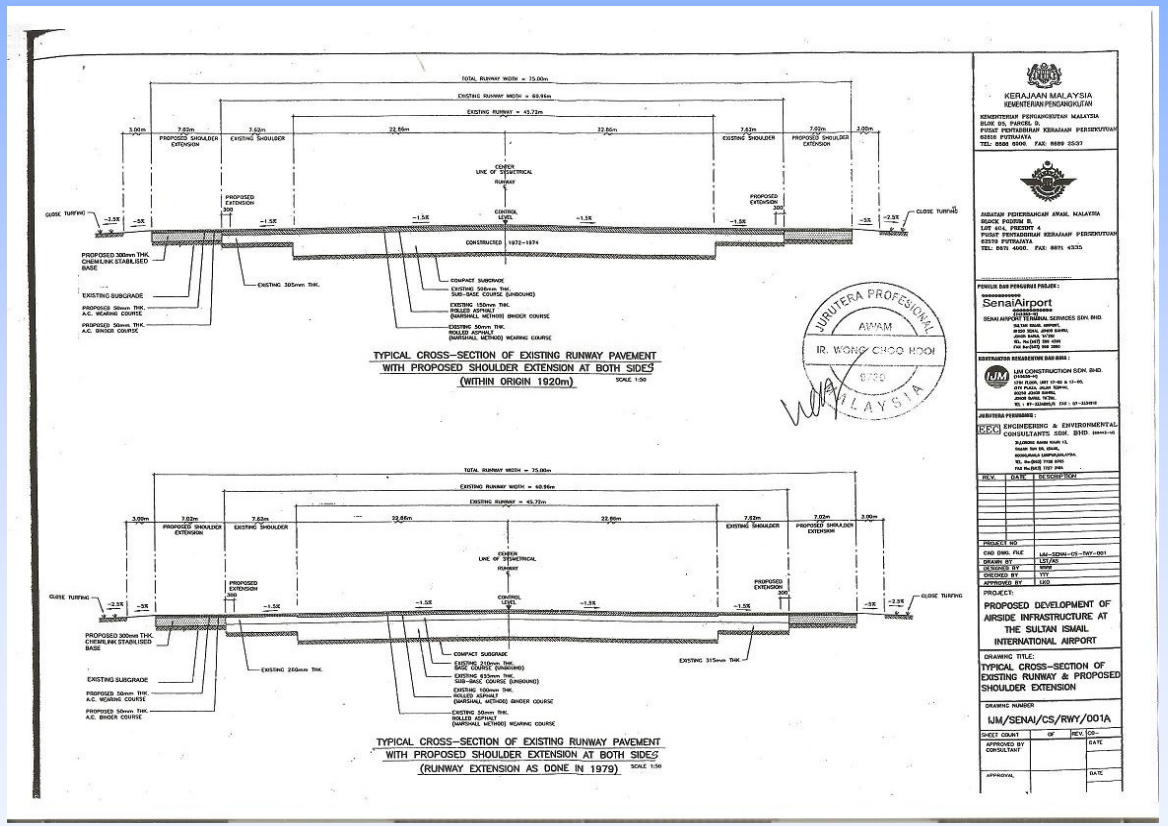
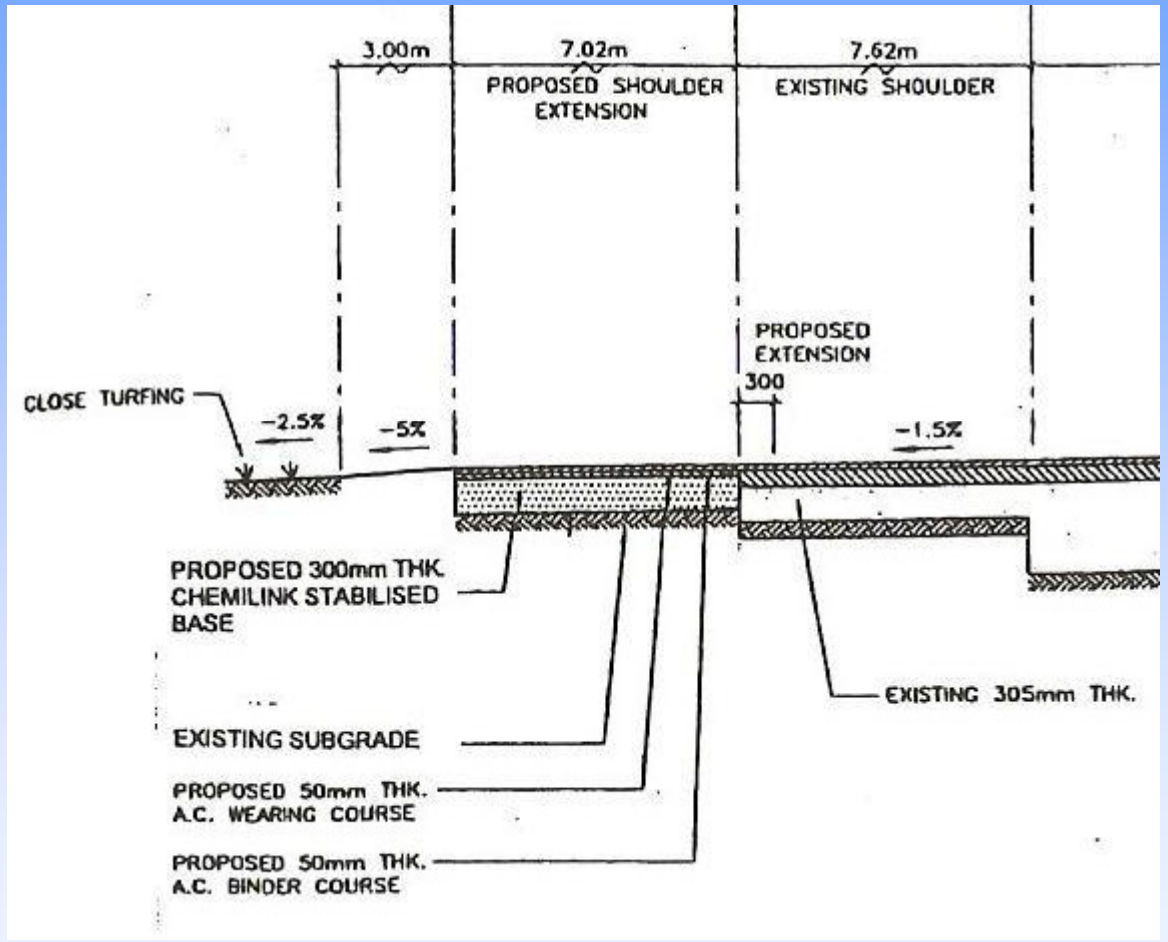


Fig. 2. Cross Section of Existing Runway Shoulders vs. Widened Section by Chemical Stabilization

2. Evaluation Criteria



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

Fig. 3. Cross Section of Existing Runway Shoulders vs. Widened Section by Chemical Stabilization

3. Chemical–Soil Stabilization

* **Definition:**

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

* **The selected chemical stabilizing agent has successfully been applied in Asia, especially in South-East Asia region for more than 10 years.**

* **A series of specially designed version of chemical agent has been used for over 10 years more to stabilize:**

  - ❑ **Clayey soils**
  - ❑ **Sandy soils**
  - ❑ **Crushed stones**
  - ❑ **Their mixtures**

3. Chemical–Soil Stabilization

* **Design requirements:**
  - ❑ UCS ≥ 1.5 ~2.0 MPa (7-d)
  - ❑ CBR ≥ 90% (7-d)
  - ❑ M_R ≥ 3,500 MPa (28-d)
  - ❑ Compaction Degree ≥ 95%

* **Chemical Dosage : 3.7% for all widened base course**

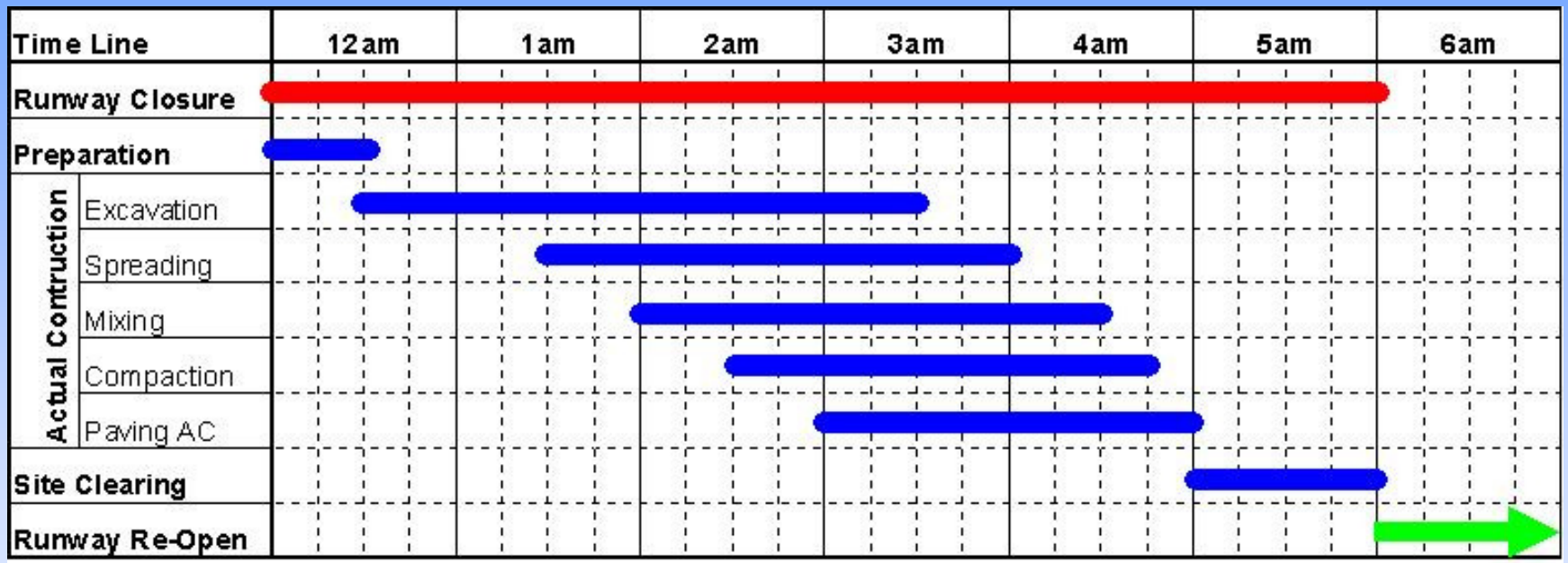
* **Major Stabilization Process**

  1st step: Spreading

  2nd step: Mixing

  3rd step: Compaction

4. Runway Shoulder Widening Process



Remarks:

1. Runway closure time: 12am to 6am
2. Closure time is subjected to schedule of last arrival/departure flight
3. Effective contruction hour: 1230am to 5am (4.5hours/day)

Fig. 4. Typical Construction Procedure of New Shoulders

4. Runway Shoulder Widening Process

Photo 1. Excavation

Photo 2. Spreading

4. Runway Shoulder Widening Process

Photo 3. In-Situ Mixing

Photo 4. Compaction

4. Runway Shoulder Widening Process

Photo 5. Paving Asphalt Concrete

Photo 6. Completion of Widening

4. Runway Shoulder Widening Process

Table 1. Comparison of Planned and Actual Construction Period for Runway Shoulders Construction using Chemical Soil Stabilization Method

Planned Construction Period	Actual Construction Period	Effective Working Days	Remarks
120 days	(04/09/07~10/11/07) 68 days	48 days	Ave. 121 m/day = 858 m^2/day

5. Technical Performances

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							
1	P1	350	23.76	11.50	1.80	79	40	64.80	34.70	0.50
2	P2	350	25.18	11.50	1.80	81	41	55.50	41.30	3.20
3	P3	350	21.04	11.30	1.80	55	22	64.70	35.00	0.30
4	P4	350	21.10	15.50	1.71	66	29	61.60	35.10	3.30
5	P5	350	30.70	18.00	1.79	76	28	62.90	36.60	0.50
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
9	P9	350	23.52	13.50	1.68	63	25	54.30	31.60	14.10
10	P10	350	22.66	14.00	1.72	59	23	60.90	38.60	0.50
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
14	P14	350	24.47	15.00	1.73	70	37	57.80	41.10	1.10
15	P15	350	21.04	11.50	1.76	67	31	58.70	40.10	1.20
16	P16	350	17.86	14.50	1.80	67	29	51.50	43.30	5.20
17	P17	350	25.48	16.00	1.49	56	23	40.10	34.10	25.80
18	P18	350	18.31	18.00	1.69	70	37	61.50	36.60	1.90
19	P19	350	23.57	12.00	1.60	67	31	50.10	46.60	3.30

Table 1. Soil Investigation Summary

5. Technical Performances

SENAI AIRPORT RUNWAY SHOULDER WIDENING
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Challenges:

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

5. Technical Performances

Photo 7. Spreading Rate Check

Photo 8. Preparations of Specimens

Photo 9. UCS Test

Photo 10. CBR Test

Photo 11. Nuclear Density Test

Photo 12. Resilient Modulus Test

5. Technical Performances

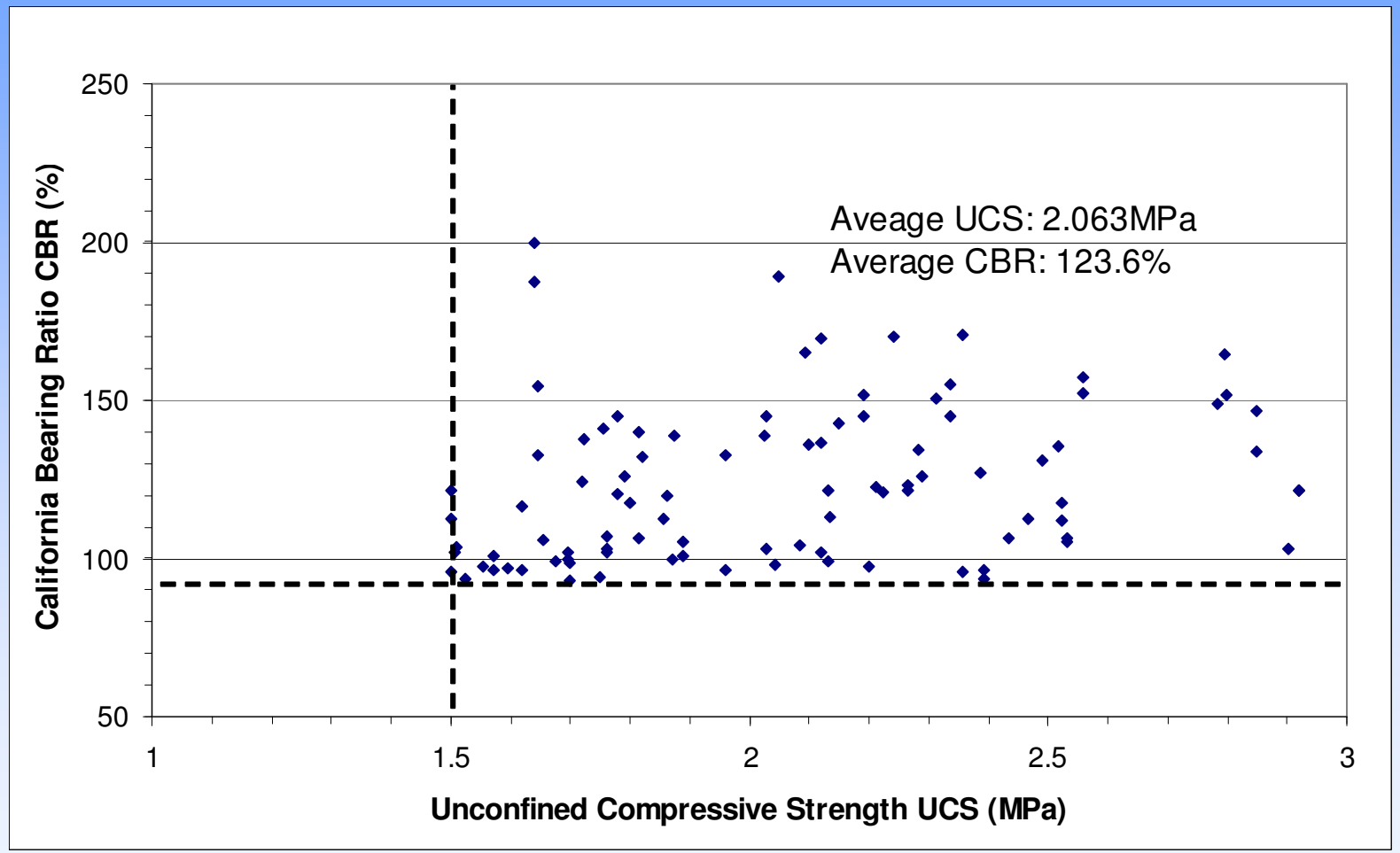


Fig. 5. UCS and CBR Testing Results

5. Technical Performances

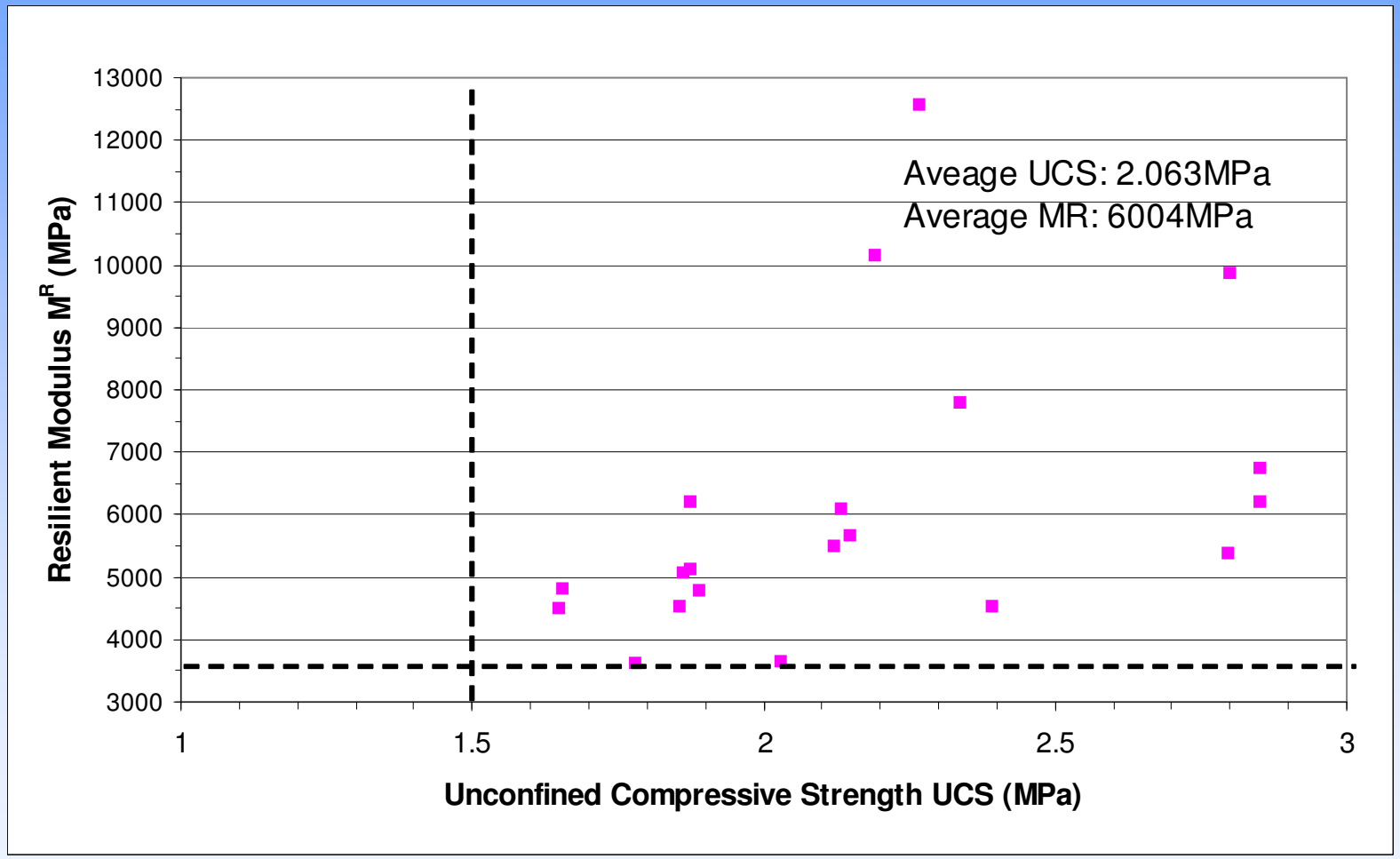


Fig. 6. UCS Resilient Modulus Results

5. Technical Performances

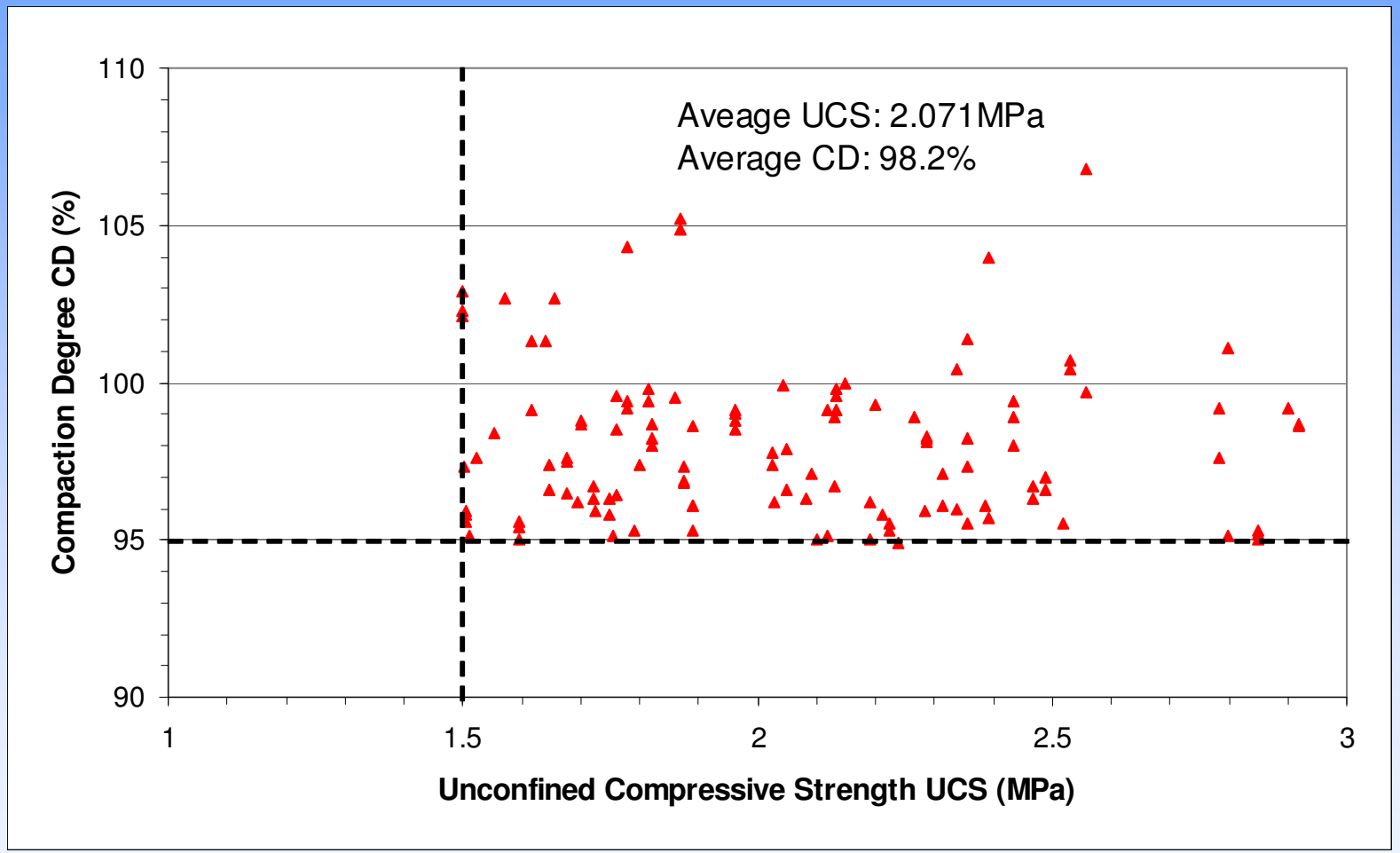


Fig. 7. UCS and Compaction Degree Testing Results


New Widened Shoulder
After 4 months,
No any defect was detected, such as
• Cracks
• Settlement

6. Benefits of Chemical–Soil Stabilization in the Airport Environment

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

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

6. Benefits of Chemical–Soil Stabilization in the Airport Environment

- Better Environment Protection
- Limited Disturbances to Airport Operations
- Higher Airport Safety Assurances
- Simple and Faster Construction and Less Materials Transportation
- Better Technical Performances
- Cost Saving and Overall Cost Effectiveness

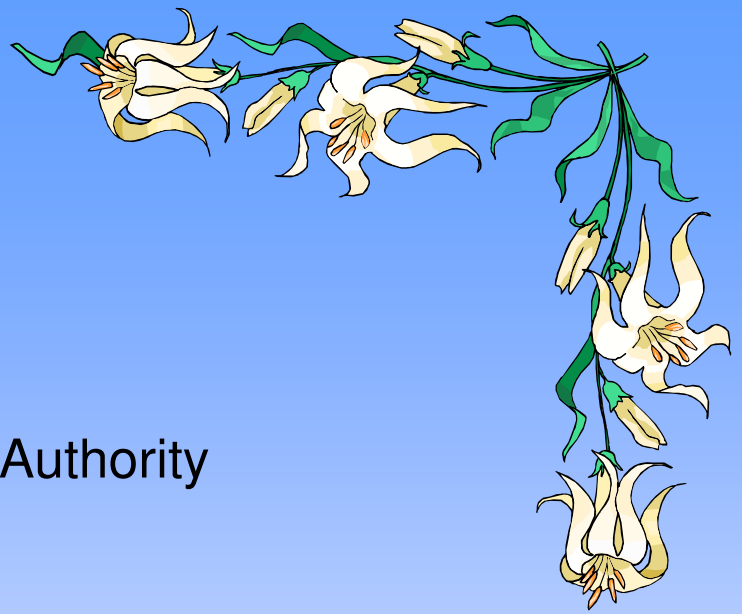
7. Conclusions

1) Widening has successfully been completed for Sultan Ismail International Airport ready for A380

2) Comprehensive project planning and methodology evaluation are critical for the smooth and on-time project completion.

3) The Chemical-Soil Stabilization Method is applicable with significant advantages and benefits

4) Technical performance to-date is satisfactory



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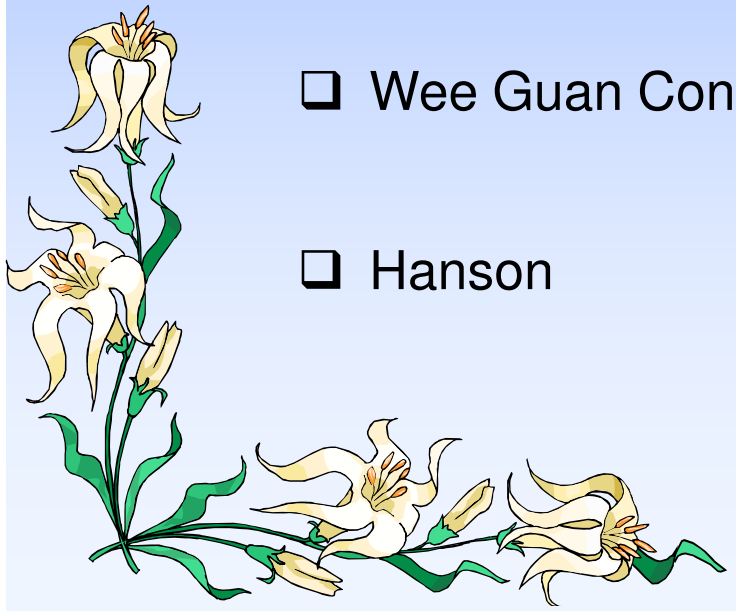

Thanks for Your Attention!