

In-Situ Rehabilitation for Taxiway Strengthening in Operational Airport



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References

1. Introduction

- More and more airfield pavements repair and upgrading are frequently required over soft ground and swampy areas in tropical region.
- The ISR (In-Situ Rehabilitation) method is significantly effective for strengthening or stabilizing in-situ materials as sub-grade, sub-base and base courses, while it is also remarkably green and sustainable.
- The key successful factor of ISR method is to incorporate with the appropriate chemical binding agents so as to form the **ISR Solution**.
- The **ISR Solution** with Chemilink series systems has been proven in this region for past 20 over years in faster construction, superior technical performances, much longer durability and cost effectiveness, while it has exceptional advantages and benefits to airfield construction under heavy operational restrictions.
- Two successful applications of such **ISR Solution** are selected below.

1. Introduction

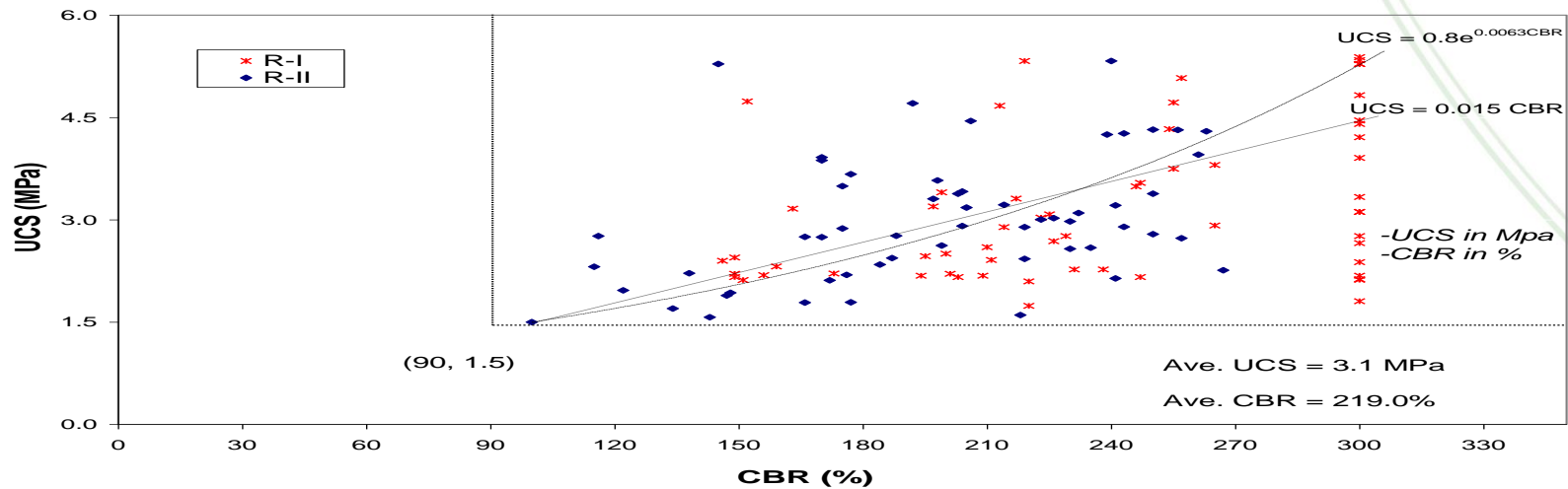
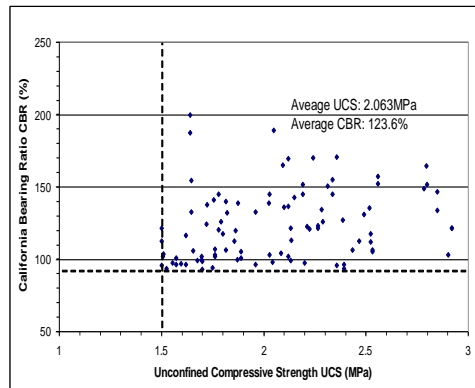
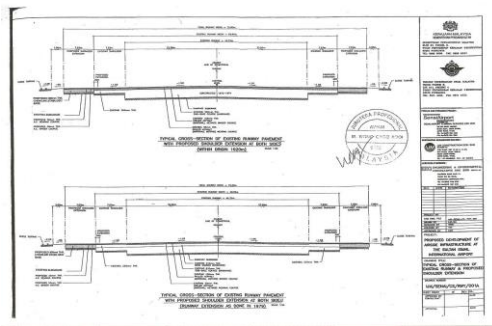
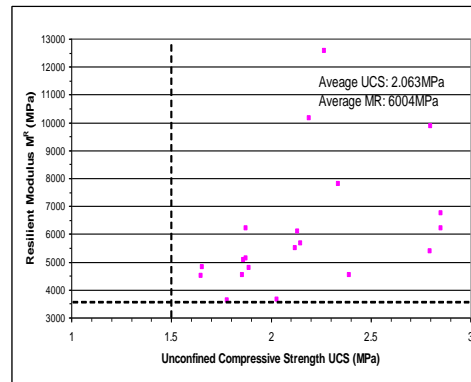


Fig. 1 UCS and CBR Testing Results for Singapore Airport Runways Widening
 (at 7-day in laboratory, after Koh et al., 2005)

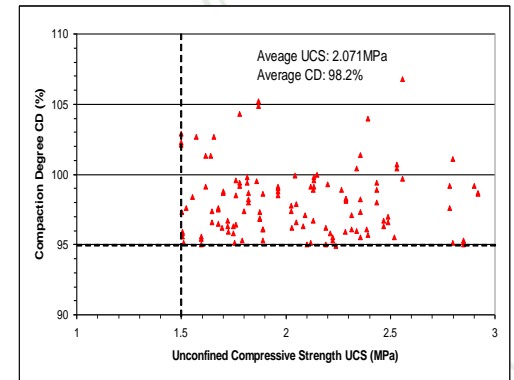
1. Introduction



a) UCS vs. CBR



b) UCS vs. M_R



c) UCS vs. CD

Fig. 2 Testing Results in Malaysia Senai International Airport
(after Wu et al., 2008)

2. Site Investigations

- A full investigation using airport pavement management system was conducted in Penang International Airport, which is one of the biggest and busiest international airports in Malaysia.
- The original pavement design before rehabilitation is generally as follows:
 - 500-600mm CR;
 - 450mm CTB or CR
 - 120mm Bituminous Macadam
 - 100-150mm AC
- Examples of Stiffness Moduli of Base by Heavy Weight Deflectometer Test
 - Section Runway 04-22 - 233-475MPa
 - Sections Taxiways A-J & Taxi-lane - 33-683MPa
- Therefore, it is very necessary to strengthen the damaged or weakened bases, where the average modulus of new Asphalt Concrete surface suppose to be 3,000MPa.

2. Site Investigations

Visual Investigation

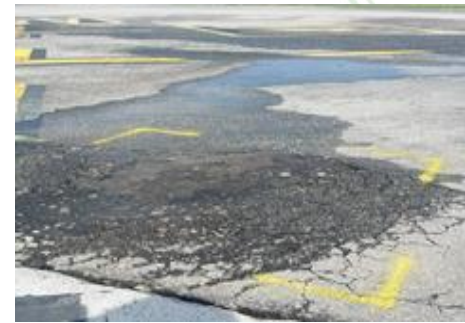
- Visual investigations were conducted immediately before the strengthening project started.
- The observations tally with the full investigation report and thus the strengthening designs were quickly adjusted and **ISR Solution** were engaged.



a) Section 1



b) Section 2



c) Section 3

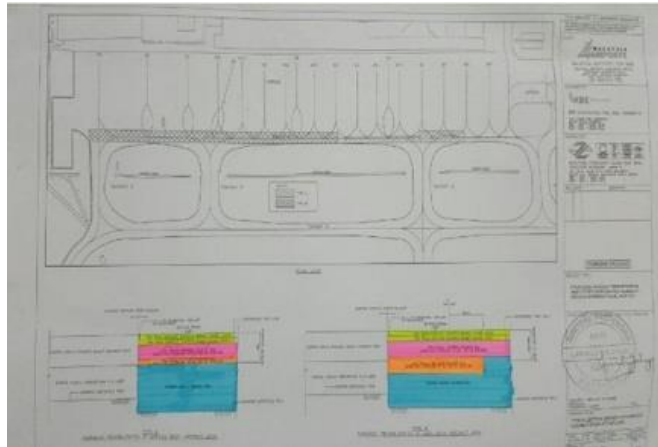
Fig. 3 Selected Damaged Sections of Taxiways

3. Rehabilitation Designs and New QC Criteria

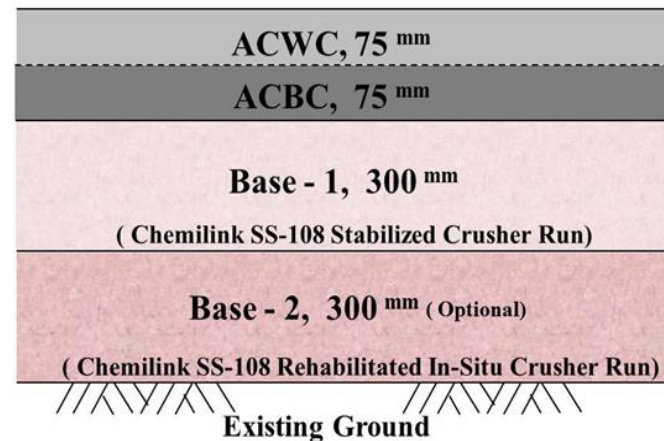
Case 1. Both Base-2 and Base-1, when $\text{CBR} \geq 30\%$ -60% on the original top of Base-2 after excavation.

Case 2. Base-1 only

(also prepared for some sections of Runway Strengthening in Pahse-2)



a) Typical Section Details



b) Cross Section Design

Fig. 4 Typical Cross Section Designs of Pavement Rehabilitation at Taxiways

3. Rehabilitation Designs and New QC Criteria

- A major traditional local measurement in strengths for roads is the In-Situ CBR test
- International and local traditional standard for CBR is at 7-day, occasionally soaked CBR at 4-day
- Such CBR at 7-day can not promptly reflect or represent the quality within short time before the pavement is in use

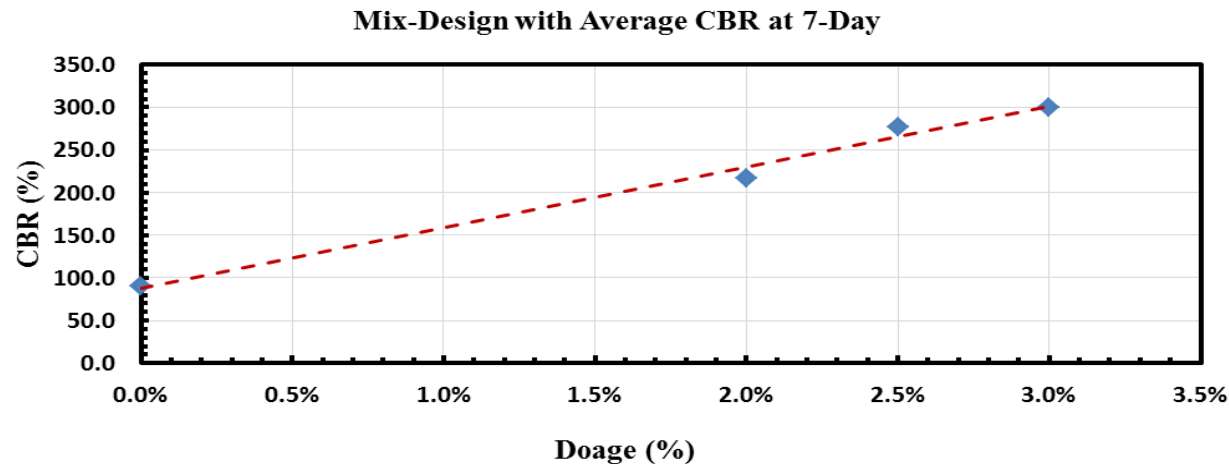
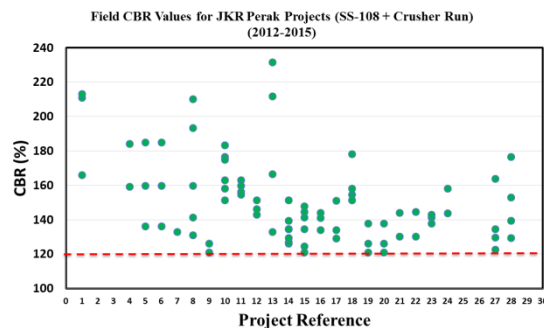


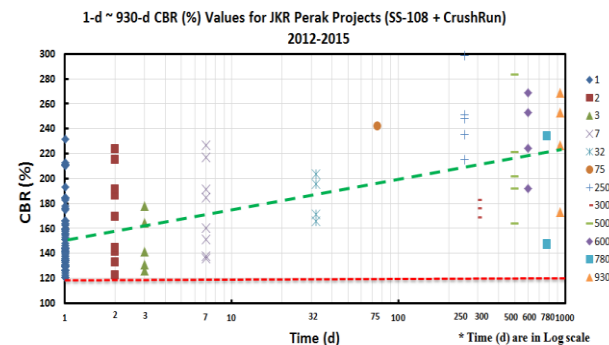
Fig. 5 Mix-Design of Rehabilitated Crusher Run (CR) at 7-Day

3. Rehabilitation Designs and New QC Criteria

- In order to promptly monitor CBR before the pavement in use so as to assure the quality of rehabilitation, CBR within 24-hour before laying AC surface has been exercised in PWD road repair and maintenance works since 2012.
- All in-situ CBR testing results over the years with the **ISR Solution** have well meet the requirement of $\geq 120\%$ within 24-hour, where as a reference, CBR value for well compacted pure CR or graded stones is about 90%.
- Further studies on long-term CBR up to 930-day on the same roads were conducted and the CBR development trend is steadily increasing.



a) At 1-Day



b) At 1- to 930-Day

Fig. 6 In-Situ CBR Values of Rehabilitated Base from 28 Public Roads

3. Rehabilitation Designs and New QC Criteria

- Based on such revolutionary innovation in QC criteria of CBR within 24-hour and its successful implementations for past years in public roads, a site trial in a selected Taxiway section with more than 3,000m² was conducted.
- The both site and lab. testing results within 24-hour are all above 120%, which tally with the current practice in roads.
- After comprehensive studies and considerations, the authority and its consultant specified the new criteria for the rehabilitated or stabilized materials Mix-Design and QC in this airfield project as

$\text{CBR} \geq 120\%$ within 24-hour

4. Construction Procedure

Major Construction Procure, Steps 1 to 7

Step-1. Excavation and Site CBR Tests

Step-2. Rehabilitation for Base-2

Step-3. Backfill of CR Materials for Base-1
(Original In-situ CR + Imported CR)

Step 4. Rehabilitation/Stabilization for Base-1

Step-5. In-Situ CBR Tests on Base-1

Step-6. Laying of Asphalt Concrete Layers and Others

4. Construction Procedure

Step-2 and Step 4. Rehabilitation

- 3 Key rehabilitation processes
 - **Spreading**
 - **Mixing**
 - **Compaction**



a) Spreading



b) Mixing



c) Compaction

Fig. 7 Rehabilitation in Process

4. Construction Procedure

Step-7. Immediate Re-Opening to Airport Operations



a) Passenger Aircraft Taxiing



b) Cargo B747 Arriving



c) Aircrafts to Be Taking-off

Fig. 8 Immediate Opening to Airport Operations

5. QC Results and Discussions

All CBR Data Library

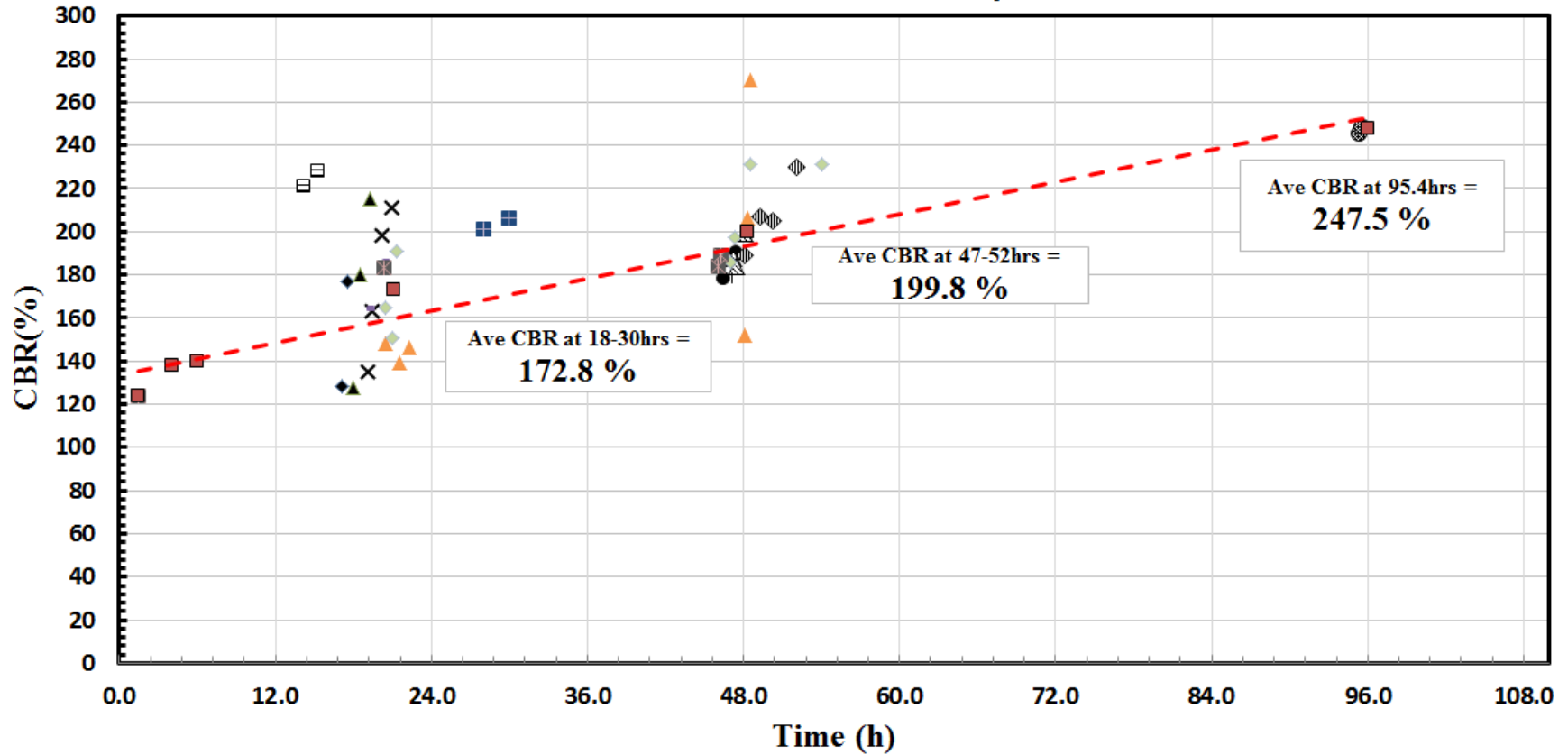
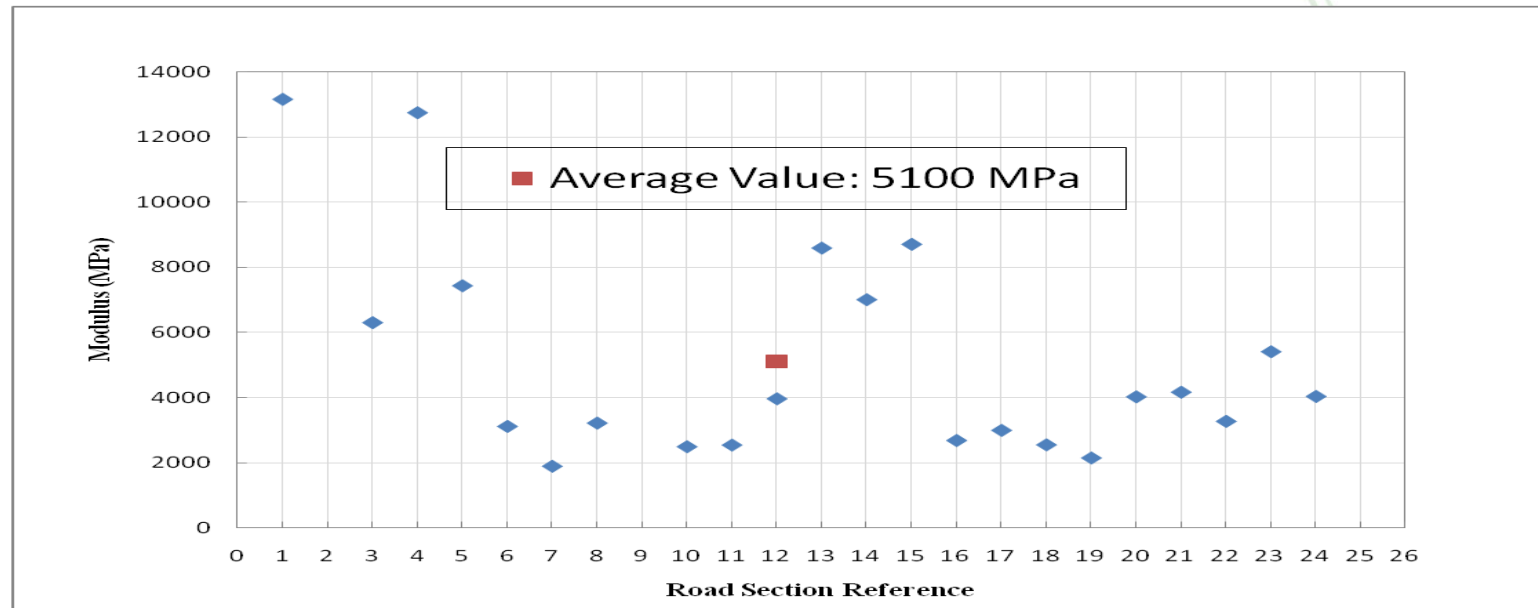


Fig. 9 In-Situ CBR Test Results for ISR of Taxiways

5. QC Results and Discussions

- Malaysia Federal PWD conducted HWD tests (2016) on 24 public road sections used for past years (2012-2015) to investigate the stiffness moduli of the rehabilitated bases over soft ground or swampy areas similar to the airport
- The average value of Stiffness Moduli is **5,100MPa**



**Fig. 10 Stiffness Moduli of Chemilink Rehabilitated Base
in Malaysia Public Roads**

5. QC Results and Discussions

- The stiffness modulus indicates overall performances in strengths & deformation
- The 24 investigated public roads are weaker in design than airport pavements, but under the similar soft ground conditions with higher water table.
- The Stiffness Moduli of those road bases vary from **2,000 to 13,000MPa**, and their average value of is **5,100MPa**
- The stiffness moduli of **Old Taxiway Base** vary from **33MPa to 683MPa**; the stiffness moduli of a current **Runway Section** vary from **233 to 475MPa**
- The modulus archived by rehabilitation is averagely 10 times higher than those old pavement bases formed by either Cement Treated Base or well compacted CR
- Therefore, the better overall performances and longer durability of rehabilitated pavements are definitely expected.

5. QC Results and Discussions

* After completion in about 18 months, AS layers in a section of 32m by 8m were completely removed and the surface of rehabilitated layers was carefully investigated. No any defects like cracking, deforming, softing and etc. had been found at all.



Fig. 12 Investigation on the Rehabilitation Quality after 18 months

5. QC Results and Discussions

* For past 10-18 months, **no defects** have been found and Penang International Airport is in **smooth operations**.



Fig. 11 Airport in Smooth Operations after Strengthening with Rehabilitation

6. Conclusions

- The in-situ rehabilitation (ISR) method has been applied in **strengthening of the Taxiway base course under operational conditions** in Malaysia Penang International Airport and the entire process of the application has been introduced and discussed in this paper.
- An innovative design and QC criteria of **the in-situ CBR \geq 120% within 24-hour** for chemically rehabilitated materials in quick repairing and maintenance works is proposed to promptly ensure the quality and reliability of pavement construction. The workability of this revolutionary change has been proven to be effective in this large-scale airport project and thus unnecessary disruptions to airport operations and other risks related to the construction have been minimized or eliminated.
- Specific advantages and benefits using the ISR method with the appropriate chemical binder for higher-grade pavements under airport operational restrictions have been concluded and discussed, which indicate the adaptation, practicability and reliability of this **ISR Solution** not only in technical performances but also in commercial/operational aspects.
- Technical performances of the rehabilitated base course of the Taxiways to-date are satisfactory and **no defects** are found as well.

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