Over-coming differential settlement in soft grounds using **'Floating Semi-Rigid Pavement'**

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Objectives

- Sustainable road construction
  - Building durable roads with proven performance in soft grounds
- Improved bearing capacities
  - By maintaining the soaking strength against possible damages due to swelling, shrinkage and seepage.
- Minimize differential settlement
  - Creating a platform effect to reduce total settlement and minimize differential settlement, even under long term soaking conditions.

Peat: Water-logging and acidic conditions

Road on piled foundation in peaty soils

Coastal towns and high tides

Roads under constant soaking conditions

Differential settlement

Perennial flooding for planting in the granaries

Sea Port Container Yard

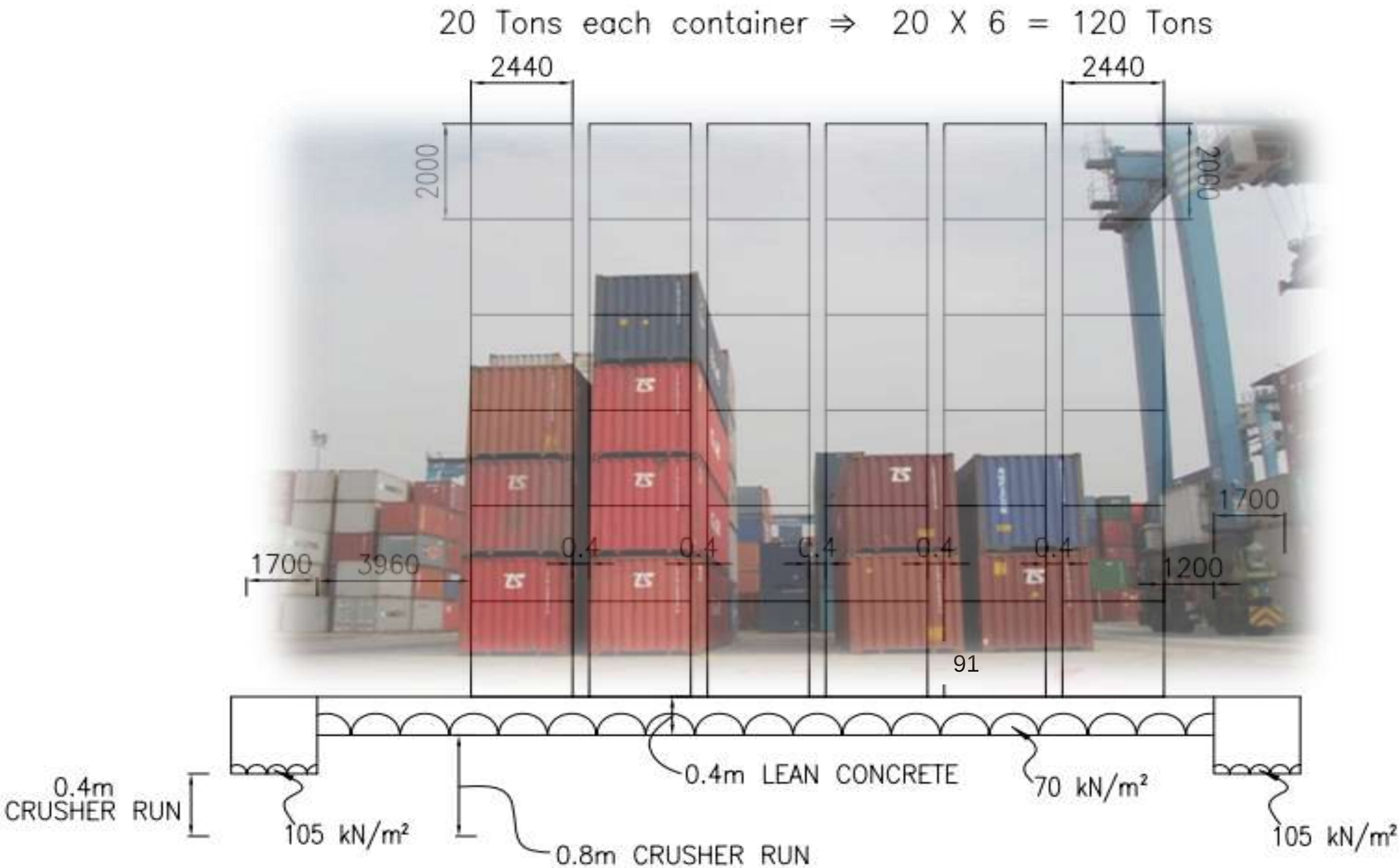
Background

Deep marine clay.
High tidal levels.
Serious settlement.
Operation capacity
far below designed.

Key Technical Merits

Pavement rehabilitation
By re-cycling
in-situ crusher run
below existing pavement
to form a Semi-Rigid Platform
to eliminate
differential settlement
and upgrade
container stacking capacity.

Typical Container Yard



Bounded (stabilized) structure vs Unbounded

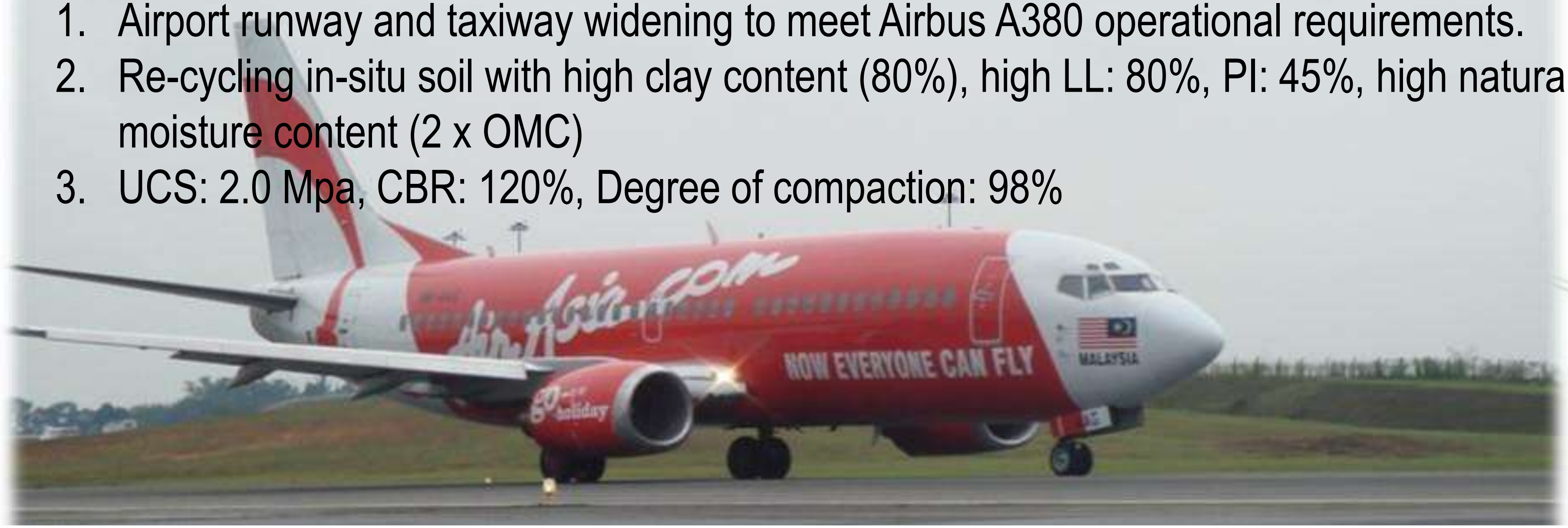
Pavement Structure	100 mm heavy duty inter-locking pavers	
	400 mm thick Grade 15 concrete slab	350 mm thick Grade 15 concrete slab
	800 mm compacted crusher run (semi-rigid sub-base)	400 mm stabilized crusher run CBR = 120%, UCS =2.0MPa
Sub - grade	Reclaimed land (loose marine sand) In deep marine clays-50m	

In service 9 months after construction (Phase I, 2011)

Senai I'ntl Airport Runway(2007) & Taxiway (2008) Widening

Background

1. Airport runway and taxiway widening to meet Airbus A380 operational requirements.
2. Re-cycling in-situ soil with high clay content (80%), high LL: 80%, PI: 45%, high natural moisture content (2 x OMC)
3. UCS: 2.0 Mpa, CBR: 120%, Degree of compaction: 98%



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

200 mm thick access – Caltex Petroleum, Indonesia, 2002

Subgrade Condition

200 mm thick stabilized road floating over peat and in use after 3 months construction

Jalan Lamunin, JKR Brunei, 2002

Platform on eroded embankment

Soil stabilization using chemical binders

A polymer modified cementitious chemical binder in fine powder form

1. To Improve/maintain soaking strength of soils through chemical binding of soil particles.
2. To decrease compressibility and permeability of soils, and to provide anti-cracking effect, thereby eliminate potential damages due to swelling, shrinkage and seepage.
3. To improve long term performance of soils.
4. To create 'platform-effect' to reduce total settlement and minimize differential settlement.

Specially designed to stabilize

- ❑ **Clayey soils**
- ❑ **Silty and sandy soils**
- ❑ **Crusher run**
- ❑ **Their mixtures**

Stabilization process

- ❑ **Spreading**
- ❑ **Mixing**
- ❑ **Compaction**

Road repairs: 300mm stabilized road base


1. Pot holes on existing road


2. Ensure chemical agent are delivered, stacked and properly covered on site


3. Lay 300 mm crusher run road base on existing pavement


4. Setting out road center line and road edge lines

Road repairs: 300mm stabilized road base

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5. 1 ton jumbo bags distributed

6. Spreading chemical on road base

7. Even out spreading using labor

8. Stabilizer machine for mixing

Road repairs: 300mm stabilized road base

9. Dry mixing for 1st run.

10. 2nd mixing in opposite direction, add water if required.

11. Check moisture content.

12. Lightly compact, level and grade before final compaction.

Road repairs: 300mm stabilized road base

13. Final compaction; 8 runs

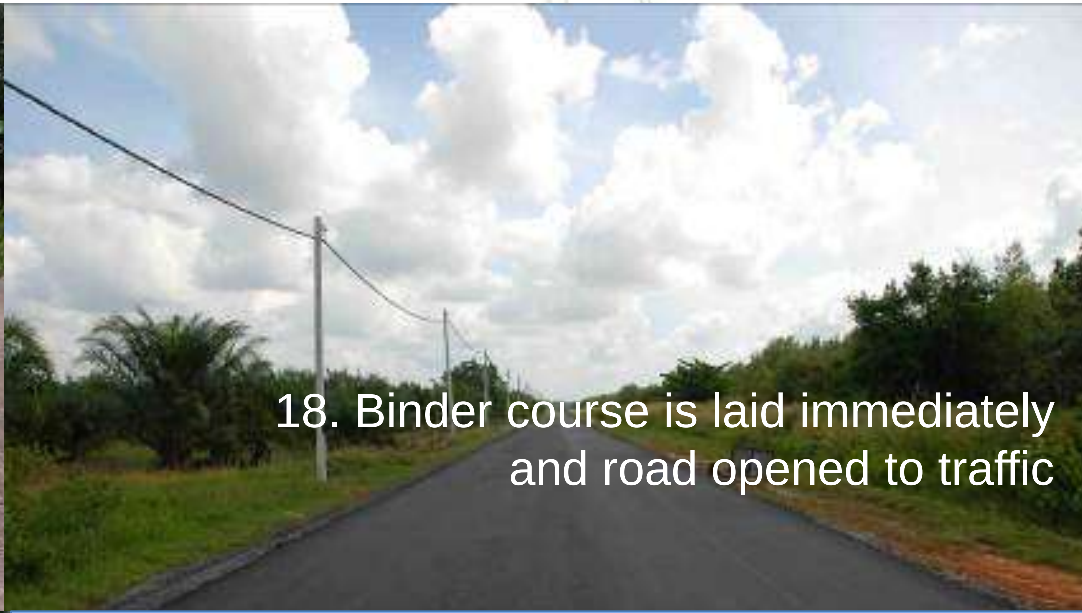
14. Completed lane opened to traffic, and chemical spread on other lane.

15. Dry mixing on the other lane

16. Minimum 300mm construction joint lapping between old and new works

Road repairs: 300mm stabilized road base

17. Road base stabilization process repeated till completion



18. Binder course is laid immediately and road opened to traffic

19. In-situ C.B.R. testing

CBR RESULTS (B.S. 1377: Part 9: 1990- 4.3)

Jalan A123, KM 20, Bagan Datoh, Perak

1. C.B.R. value: 168 % (7 day)
2. C.B.R. value : 146 % (7 day)

Jalan A104, KM 6, Tanjong Piandang, Perak

1. C.B.R. value: 103 % (7 day)
2. C.B.R. value : 111 % (7 day)
3. C.B.R. value: 111 % (7 day)

Quality Assurance and Quality Control

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

3) Finishing
   Level controls ❖ Surface finishing tolerances

4) Technical Results
   UCS, CBR, Resilient Modulus and etc

Quality Assurance and Quality Control

Spreading Rate Check

Preparation of Specimens

UCS Test

CBR Test

Nuclear Density Test

Resilient Modulus Test

JKR Brunei: GS 7: 1999

General Specifications for Pavement Stabilization

Table 5

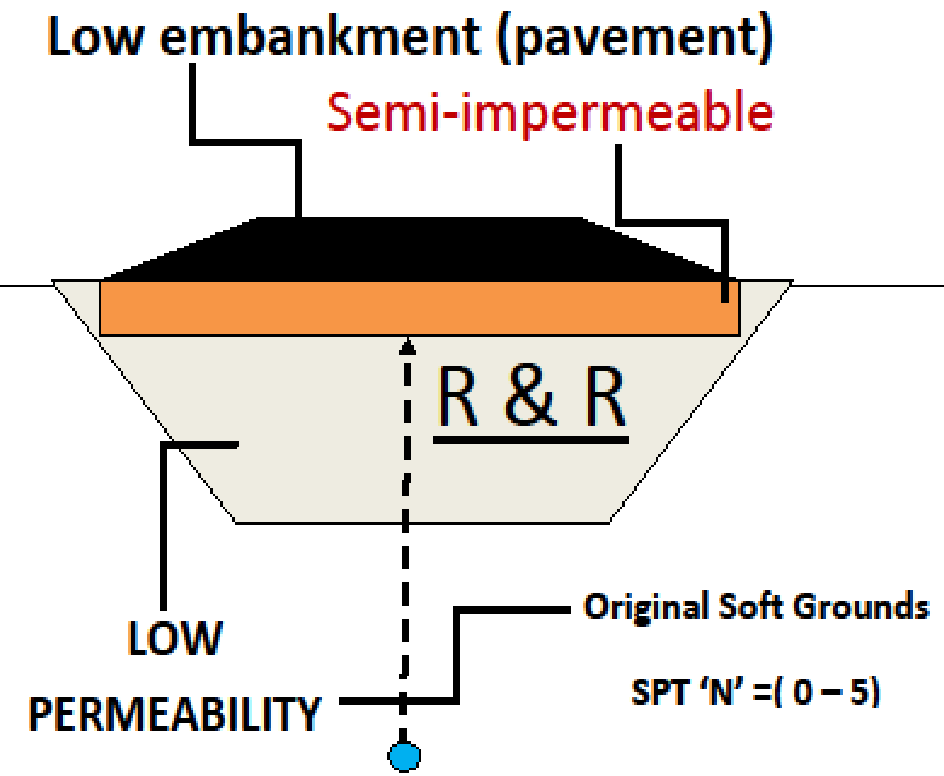
Quality Control Requirements for Chemical Stabilisation of Sub-Grade

Element	Test Method	Target	Minimum Frequency	Record
Suitability of using existing material	CBR tests to BS 1377	5%	as required with change in soil conditions	Test Report
Depth of stabilisation	Measurement	1.4 times designated thickness	every 50 meters	Daily Report
Dosage and spreading	Weighing and visual inspection	Not less than specified value	every 40 meters	Daily Report
Overlapping - Minimum Lengths	Measurement	Long : 0.3m Lateral : 1.0m	every 50 meters	Daily Report
Resultant strength	CBR and 28-Day UCS tests according to BS 1377	> 30% and 0.7-2.5 MPa	every 50 meters or a determined by RE	Test Report

Settlement with time

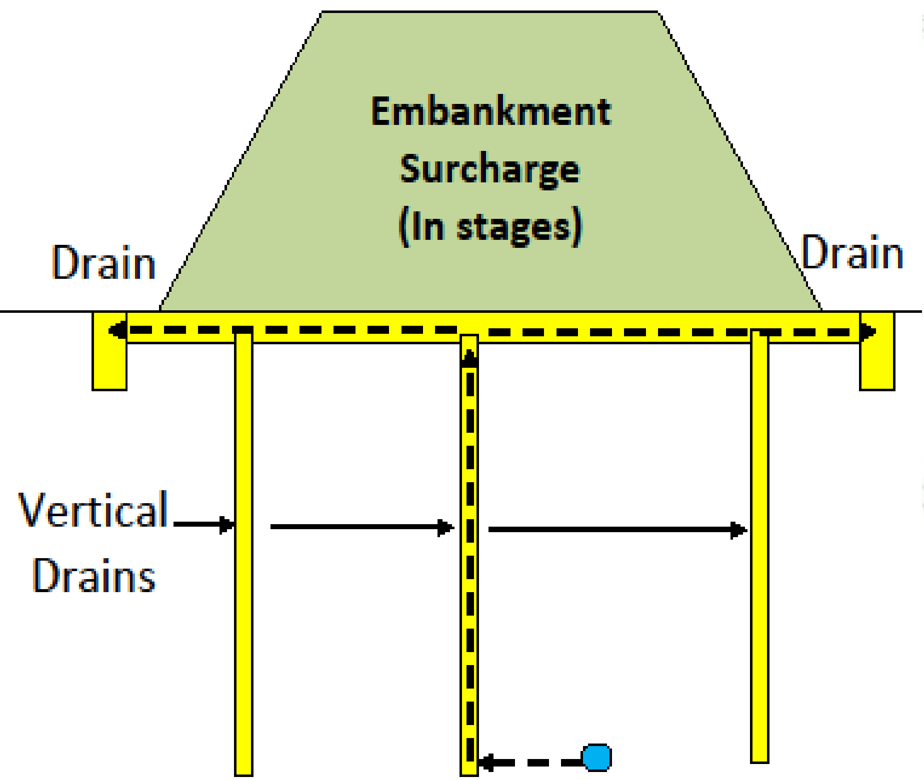
‘FLOATING’ semi-rigid pavement

- 1-dimentional consolidation
- With longer drainage path
- Under poor drainage conditions
- Very slow consolidation process

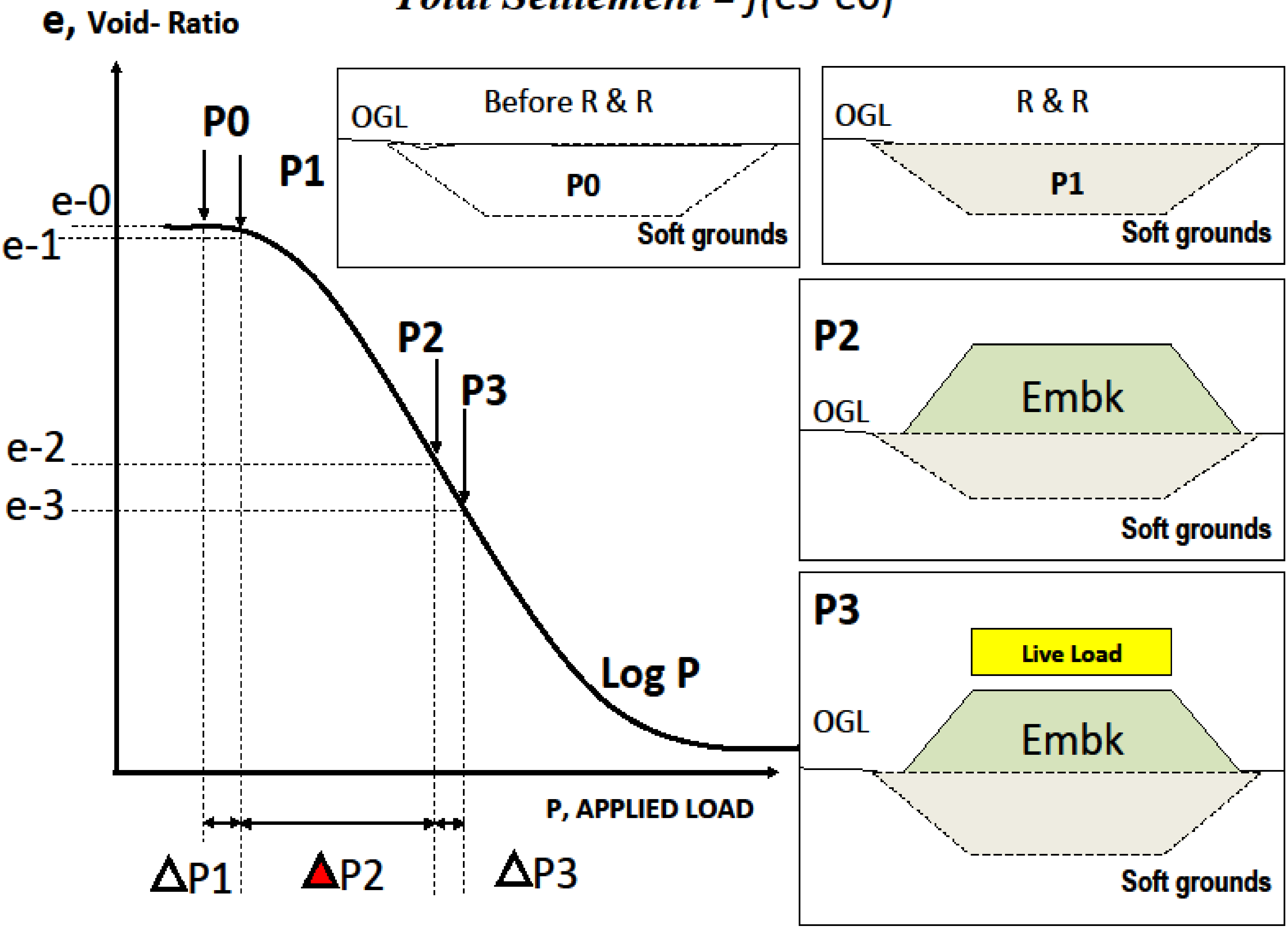


Conventional Preloading

- PVDs with 3-dimentional consolidation
- Shorter drainage path
- Good drainage conditions
- Faster consolidation process



Total Settlement = f(e3-e0)



Conclusion and recommendations

- In soft grounds with high water table, seepage and subsequent loss in bearing capacities is the major cause for pavement failures.
- Various contemplations to strengthen the pavement structure using cement, lime, soil stabilizers in liquid form and geo-synthetics reinforcement are always unsatisfactory.
- Polymer modified cementitious chemicals soil stabilization system is green, sustainable and cost-effective to improve and maintain the soaking strength of pavement structures against possible damages due to swelling, shrinkage and seepage.
- It has certain tensile strength and anti-cracking properties to create a platform effect even under a long-term soaking condition to reduce total settlement and minimize differential settlement.
- With numerous engineering applications in airfields, seaports and roads, the performances and durability are proven since 1994, with no major repairs up to date.