The 9th Malaysian Road Conference 2014
November 10-12, 2014, The Sunway Pyramid Convention Center, Kuala Lumpur, Malaysia

A Quick Repair Approach to Damaged Roads in West Malaysia.

By
Toh Paduka Setia Dato' Ir. Dr. Safry Kamal bin Hj. Ahmad (Director of Public Works, MALAYSIA) [1].
Shazali bin Mat Arof (GB Kuari Sdn Bhd, MALAYSIA) [2].
Francis Huang, Romy Tjuar, Dr Wu Dong Qing (Chemilink, SINGAPORE) [3].

[1] PERAK PWD, Jalan Panglima Bukit Gantang Wahab, 30000 Ipoh Perak, Malaysia, Email: administration @jkrperak.gov.my

[2] G. B. Kuari Sdn Bhd, 158 Jalan Gopeng 31350 Ipoh, Malaysia, Email: shazali@gbkuari.com.my

[3] Chemilink Technologies Group Pte Ltd, 20 Kranji Road, Singapore 739462, Email: hq@chemilink.com

ABSTRACT:

Truck overloading is the main cause of road damages in this region. Overloading is rampant; with 90% of the trucks plying our roads being overloaded to two (2) times or more, than the permissible loads. As a matter of fact, our roads get damaged faster than we can ever repair them; ever mindful of the relation between road damages (by overloaded vehicle axles) to the legal and permissible vehicle axle loads is to the power of four. Besides overloading, the bearing capacities in the sub-grade/road foundation build in soft grounds deteriorates with changes in moisture content, especially in peat swamps environments, coastal marine clays and even on high grounds with sedimentary pockets of fines of high organic content, silt and kaolin clays. With commercial exploit by truckers to overload zealously on the one hand, and a deterioration of sub-grade due to changes in water table/moisture content as a result of climate change, ferocious land clearing for development and flash floods, the road structure is subjected to enormous fatigue stresses, resulting in extensive pavement cracking. Aggravating the damage further is the subsequent and incessant rainfall infiltration into the road base and sub-grade below, thus reducing the road life span to immediate major road maintenance within the first three (3) years of operation. This paper illustrates a quick road repair technique of strengthening damaged road structure by in-situ recycling with chemical binders, creating a bound, semi-rigid 'floating' raft in soft ground environments; delivering quality pavements, eliminating bumpy rides due to undulating profiles along longitudinal road profiles, even under long-term constant soaking conditions. It is green, costs effective, environmental friendly, and with proven performance and durability for the past 20 years. Four (4) highly successful and completed major road repairs in the Public Works Department, Perak, Malaysia are hereby tabled.

Keywords: Quick Repairing, Pavements, In-situ Rehabilitation, Chemical Stabilization, Sustainable, Green and Eco-Friendly, Cost Effective.

TABLE OF CONTENTS

1. Introduction

2. Case studies
    a. Jalan Alor Pongsu, Kerian, Perak PWD – 2013, 2014
    b. Jalan Trans Perak, Perak PWD – 2013, 2014
    c. Jalan Sungai Tiang, Teluk Intan, Perak PWD - 2012
    d. Jalan Tanjong Piandang, Parit Buntar, Perak PWD – 2012

3. QA/QC procedures

4. Conclusions

5. References

6. Acknowledgement

INTRODUCTION

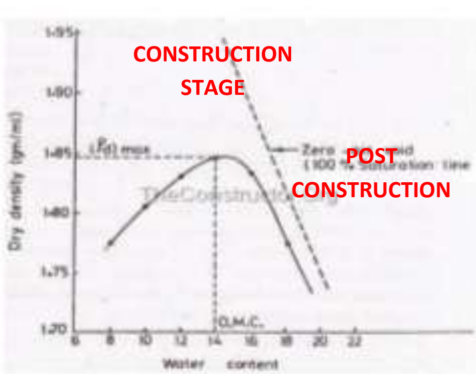
In order to build good roads, we need a good foundation/sub-grade to build on. The best way to build is to avoid areas with soft grounds. Hence, it is very difficult and almost impossible to build good roads in soft grounds such as

1. In the coastal marine clays
2. In peat swamps
3. In reclaimed land along shore lines
4. In pond fillings
5. In rice granaries where flooding for planting is common place
6. And even on cut grounds that are lined with sedimentary deposits of fine clay/silt.

Roads that are built in soft grounds, which are under constant soaking conditions, deteriorate very fast due to loss in bearing capacities in the sub-grade. Coupled with the uncontrolled overloading of trucks plying on such roads, yearly road maintenance is not only a very costly affair, the safety and comfort ride of road user is severely compromised.

Roads under constant soaking conditions

Flooding is common place in the granaries



Loss in bearing capacities
With moisture content changes

Under-ground streams beneath the road base

INTRODUCTION


Peat Swamp Environment


2 m over burden as temporary access


Crocodile cracks


Permanent rutting


'Koalin' clay formation


Vertical deformation in cut ground


Soil subsidence and lateral movements


V-shape cracks due to horizontal tensile strain

INTRODUCTION

Ground treatment using vertical drains/overburden surcharge, the removal and replacement with compacted suitable materials, grouting, geo-synthetics reinforcements has been employed but with limited success. Pavement cracking under heavily laden trucks, regular pot-holes patching, bumpy rides, and costly vehicle wear and tear are common with such road building techniques.

A **quick repair approach** for damaged roads in soft grounds using cold in-situ chemical soil stabilization re-cycling process is used successfully in Perak PWD, Malaysia. The damaged road surface is 'milled' so as to expose the underlying road base material to be strengthened. Spreading (2%-3% dosage) of a polymer modified cementitious chemical binder in powder form unto the exposed road base and using a stabilizing machine to mix the chemical admixture homogenously into the road base, and compact to 95% maximum dry density. A 300 mm thick stabilized road base is immediately protected (within one day) with a layer of asphaltic concrete binder course, and the road opened to traffic. Production achievable is 1 km x 3.5m width lane per day per stabilizer machine. There is no disruption to on-going traffic on busy roads during construction, with one lane closed for construction, and contra traffic flow on the open lane. Traffic management, safety cones and sign boards to caution public road users were deployed. The 7-day in-situ California Bearing Ratio testing achievable is 80% <CBR < 250%.

Distribution of chemical binders

Spreading binders in powder form.

Compaction

Mixing with a stabilizer machine

INTRODUCTION

The purpose of chemical soil stabilization is to add and mix chemical admixtures homogenously into the soil to bind up the fines into 'granular' so as to improve and maintain its material strength/bearing capacities, even under long term soaking conditions.

And by applying compaction onto the formation and transforming it into a layer of bound, semi-rigid platform or raft, 'floating' over underlying soft grounds.

A layer of bound, semi-rigid road base (platform) over eroded embankment

CASE STUDY No 1: Jalan Alor Pongsu, Kerian, Perak, Malaysia

This is a newly completed road in December, 2012 measuring 7km (L) x 8m (W) with over-laden trucks carrying earth and aggregates from Bukit Merah to nearby construction sites.

One lane is closed for construction, while contra traffic flow is channeled into the other lane with no disruption to on-going traffic flow. The construction process involved 1. Milling off existing damaged road tarmac to expose underlying crusher run road base. 2. Spread and mix chemical binders homogeneous into existing 300 mm thick road base to be strengthened. 3. Compact and grade to finish levels. 4. Lay a layer of asphaltic binder course and open road to traffic.

Despite the immense traffic plying this road (ADT: 70 truck trips per hour one way), road base strengthening/stabilization works was completed in two (2) working days for 650mL x 8mW (Phase 1 - July 2013) and also in two (2) working days for 600mL x 8mW (Phase II - June 2014)

Existing road conditions

Milling off road tarmac on day (1)

Contra traffic flow during construction

Soil stabilization on day (2) and day (3)

Binder course on day (4)

7d-CBR: 176%, 175%, 183%, 217%

CASE STUDY No 2: Jalan Trans Perak, Perak, Malaysia

The road was built in the 80's and up-graded and widened in the 90's. The road is located in the granaries, with constant flooding for rice cultivation. Differential settlement occurred between 'old and new' road sections, and the road is undulating along the longitudinal profile due to soil subsidence as a result of high traffic volume of heavy laden trucks plying their trades carrying grains and oil palm produce. Road base strengthening in the 'new' road section was completed in two (2) working days in November 2013 (Phase I - 1200mL x 4.5mW) and also in two (2) working days in June 2014 (Phase II - 2200mL x 3.5mW), by recycling the exposed underlying 300 mm thick crusher run.

Heavily over laden truck

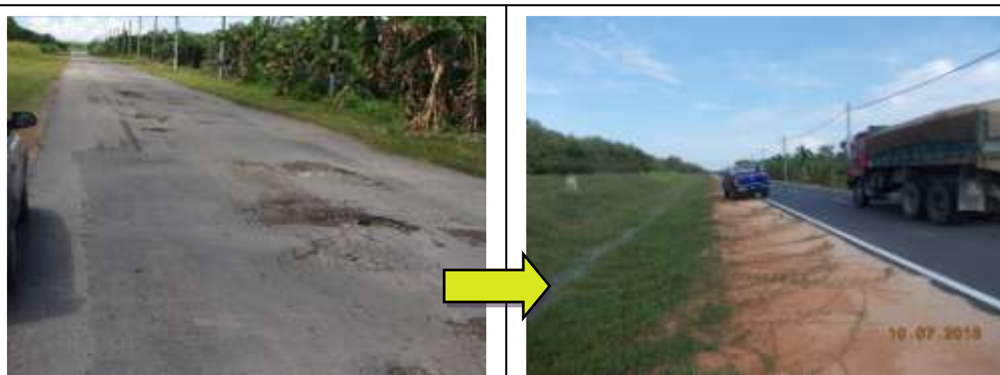
Milling off damaged road tarmac

Vehicle sinking in 'soft' road shoulder

7d-CBR: 155%, 156%, 160%, 163%

CASE STUDY No 3: Jalan Sungai Tiang (A123), Teluk Intan, Perak, Malaysia

Due to climate change and rising tidal levels, the road formation is located below the sea level; and water is stagnant in the roadside drains all year round. A new layer of 300 mm thick crusher run was placed on top of the damaged road over stretch of road measuring 400mL x 8mW.
Road base strengthening was completed on two (2) working days on 21st and 22nd December 2012.



Before | Soaking conditions:7d-CBR: 149%, 168%

CASE STUDY No 4: Jalan Tanjong Piandang, (A104), Parit Buntar, Perak, Malaysia

This is a busy road located in the granaries, with irrigation canals running on each side. Road base strengthening on 300 mm thick crusher run was carried out over a stretch of road measuring 400mL x 8mW, and completed in November 2012, with no disruption to traffic during construction.

Before | Soaking conditions: 7d-CBR: 111% (avg)

QA/QC PROCEDURES

Due consideration on the following 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

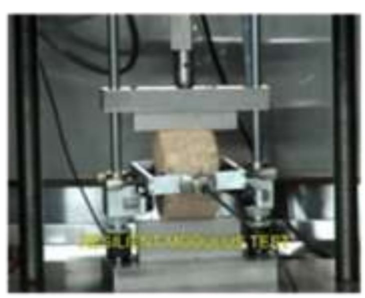
Spreading Rate Check

Preparation of Specimens

UCS Test

CBR Test

Nuclear Density Test



Resilient Modulus Test

QA/QC PROCEDURES

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

CONCLUSIONS

A quick repair approach on damaged roads has been successfully implemented in Public Works department, Perak, Malaysia.

1. The underlying road base materials in a damaged road can be re-cycled, re-use and strengthened with chemical soil stabilization, thus reducing construction waste.
2. The fine materials within the road base structure is bind up into ‘granular’, and with compaction, the bearing capacities is improved and maintained, even under long term soaking conditions.
3. Differential settlement due to soil subsidence, as well as rutting along wheel paths, can be eliminated, by way of a bound, semi-rigid raft ‘floating’ over soft grounds, thereby eliminating public complaints on bumpy rides, and vehicles wear and tear.
4. Using soil stabilizer machines, 1km x 3.5m width lane per day can be strengthened.
5. With one lane closed for construction works, no-disruption to the on-going heavy traffic is managed via contra traffic flow on the open lane under utmost traffic management.
6. The road is opened to traffic immediately upon completion of soil stabilization works.

REFERNECE

1. Kamal, A. Safry, Francis Huang, Wu, D.Q. "Over-Coming Differential Settlement in Soft Grounds Using 'Floating Semi-Rigid Pavement', 14th REAAA Conference 2013, March 26-28, 2013, Kuala Lumpur, Malaysia, pp. 445-452."
2. GS 07:1999. General Specification for Pavement Stabilization, Construction Planning and Research Unit, Ministry of Development, 1st Edition, Brunei Darussalam.
3. Mitchell, J.K. and Katti, R.K. (1981). Soil Improvement – State-of-the-Art-Report, Proc. Of the 10th Inter. Conf. On SMFE, Vol. 1, pp. 261-317.
4. Suhaimi, H.G. and Wu, D.Q. (2003), Review of Chemical Stabilization Technologies and Applications for Public Roads in Brunei Darussalam, REAAA Journal (The Journal of Road Engineering Association of Asia & Australia), Vol. 10, No. 1, PP7021/8/2003, pp. 42-53.
5. Wu, D.Q. (2012), Sustainable Pavement Construction/Maintenance by Green Approaches of In-Situ & Rehabilitation, Malaysian Highway Authority, Feb 21, 2012, Auditorium LLM, Selangor, Malaysia (Invited Key Speaker).

ACKNOWLEDGEMENT

The authors wish to thank the invaluable insight and contributions from the staff of Public Works Department, Perak and GB Kuari Sdn Bhd.