SOIL STABILIZATION – AN INNOVATIVE MEASURES TO UNPAVED ROAD

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ABSTRACT

There is a wide range of soil stabilizations technique available in the market nowadays. The most widely technique used in soil stabilizations are divided into 3 main areas mainly known as the water based (liquid based), cement based and lime based.

This paper will mainly describe the usage of water based (liquid based) soil stabilization method used for the road project in the rural area of the interior part of Malaysia. Various example of project were carried out, supervised and examined the field testing as required in the specification.

Apart from all the technical finding from the project, this paper will also discuss the outcome of the project in the aspect economic returned that can be achieved in the area of construction cost and maintenance cost of the project life cycles. The economic return is important and will be described in detail in this paper.

1. INTRODUCTION

Malaysia as a developing country has committed to Vision 2020 to become a fully developed nation as shown in *Figure 1*. With all the planning and the progress made as a developing country, the current rate of growth, our nation is in danger of losing our competitiveness falling short of our economic and social ambitions.

Figure 1 – Malaysian vision 2020

To meet the challenges in achieving of the Vision 2020, the Government of Malaysia has taken a big step in committing the "Government Transportation Programme – known as GTP with the main principles of ***1Malaysia, Peoples First, Performance Now***. In doing so, the government has developed a road map by detailing the objective, outcomes and

the action to be carried out in achieving it. Summary of the major program of rural basic infrastructure is illustrated as in *Figure 2*.

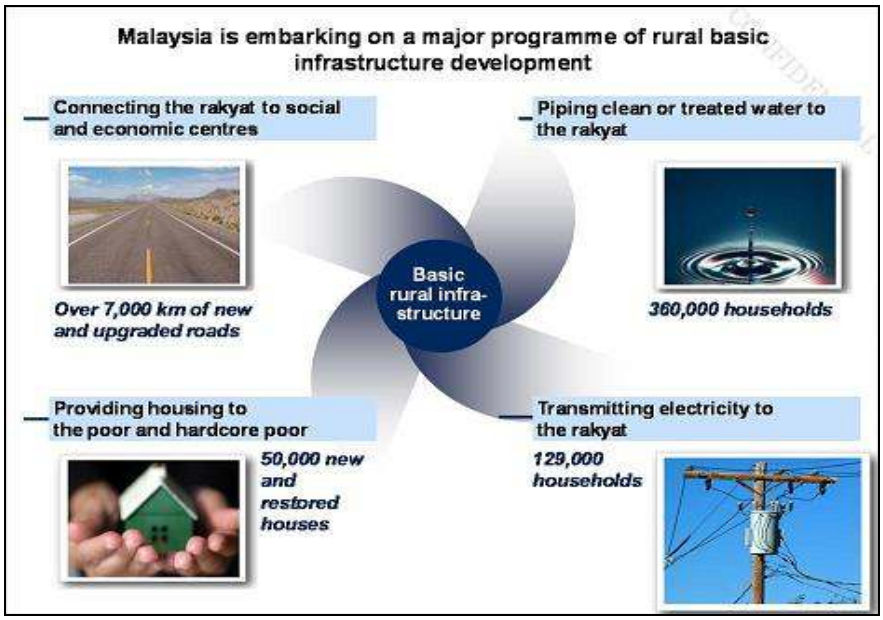

Figure 2 – GTP Program

One of the main agenda of the government to achieve Vision 2020, the rural basic infrastructure (RBI) in road network is required to be carried out. A total of 7,000 km of new and upgraded roads project will be carried by the end of the year 2012. Out of this total length of roads, 1,900 km will be in Sabah and Sarawak. The idea is to provide a road which will connect the peoples who lives within 5 km from a paved road. By providing the road, the peoples will then be connected to the outside world and thus the economic factor will be automatically arising from the local activities and product. As for the past years, the existence of none proper road infrastructure to connect to the interior area contribute to a less or none economic growth to the interior area.

This key issue of providing a road infrastructure connecting the rural area will definitely affected the financial resources and site constraint of the affected rural area. In doing so and with very limited financial funds, the government decides to go for alternative technology in constructing a road infrastructure. The type of road infrastructure that the government decided to implement is the implementation of **UNPAVED ROAD**.

Majority of the rural road in Malaysia especially in Sabah and Sarawak are of **UNPAVED ROAD**. The roads were designed and constructed based on the low traffic volume but sometime it will do subjected to heavy load. Beside that environmental issues of generated fugitive dust can be seen during the dry season. For the rainy season then the unpaved road will be expose to water and it will definitely damage the road and a high maintenance cost incur as in *Figure 3.*

Figure 3 – Overview of the Rural Road

To overcome this problems for the damage **UNPAVED ROAD**, the government thro *MALAYSIA PUBLIC WORKS DEPARTMENTS* together with *MINISTRY OF RURAL AND REGIONAL DEVELOPMENT* has decide to use the method of soil stabilization in the unpaved road construction for the rural area. One of the methods of soil stabilization that we consider to study and presented it out in this paper is the **LIQUID BASED SOIL STABILIZATION METHOD**.

2. BACKGROUND OF STUDY

The study was carried out applied the technology of unpaved road technology which utilizes the existing local materials by adding soil stabilizer and a layer of waterproof sealant to form a dust free and mud free environment friendly unpaved road has been adopted in a pilot project of constructing the access road, approximately 1km to a remote village, Pasir Salam Village which located in the state of Johor, Malaysia. Site investigation including 5 nos. of insitu CBR test, 10 nos. of mackintosh probes as well as 10 nos. of hand auger was conducted at the designated location to determine the existing soil profile and its bearing capacity meanwhile soil classification tests have been carried out in laboratory in order to obtain the soil properties. Generally, the existing ground consists of yellowish sandy clay about 1.2m. Natural moisture content of the insitu soil is within the range of 12.59% – 25.13% while the plastic index of the soil is between 12% - 34%. The condition of existing ground is as shown in *Figure 4*. After construction, California Bearing Ratio test based on BS 1377: Part 9: 1990, was conducted periodically on the determined samples at project site in order to measure the improved strength of the unpaved road which has been stabilized using the above technology. It is hoped that by utilizing this method, construction and maintenance of unpaved roads in developing countries will be more durable and easier in of creating a safer and better environmental user friendly road.

Figure 4 – Existing road condition

2.1 Principal Of Soil Stabilization Technology

Technology of soil stabilization is an alternative to the unpaved road in and that have been applied to this project. Soil stabilizing agent will added and mixed into the soil subgrade or existing earth. There are three (3) procedures to transform soil road into all season road which stabilized the road, sealing the stabilize soil surface and maintenance.

Through the soil stabilization agent the treatment process is soil particles are being coated with the chemical agent to reduce the Plastic Index of the soil. The purpose is to make the treated soil adsorb less water. Then , by compaction process, the water , air voids and empty spaces will reduced and bring soil particles tighter together to increase the density of soil and also to achieves soil maximum dry density and maximized the CBR strength. The soils particles are pack close together thus permeability of the soil also reduces. It controls the water absorption and also prevents the water seep in. Then, the water-proof sealant is applied in order to dust control and prevent the road surface from erosion. Maximum load the road can be carried is about 30tonne. Road structure is as in *Figure 5*.

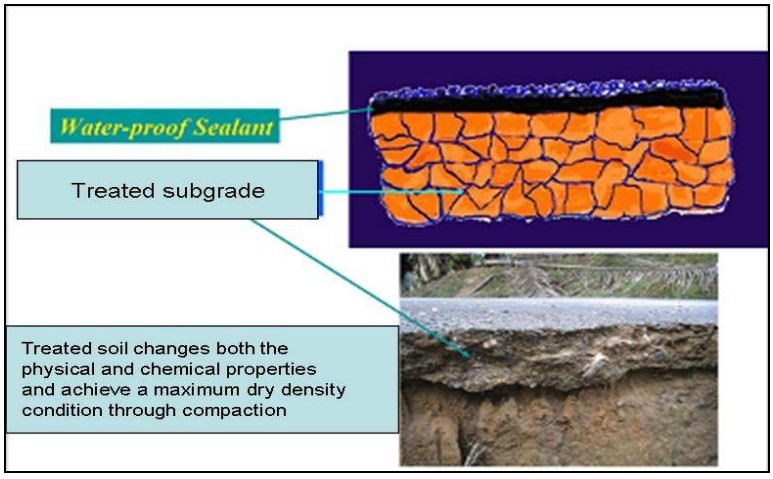

Figure 5 – Soil stabilization road structure

2.2 Installation process

Figure 6 – Loosening existing soil

Figure 6 shows the construction procedure of the road. The existing soil is loose by scarifier mounted to the grader to a depth required about 6 inches before the soil stabilization agent is sprayed into the soil. The purpose of this process is to ensure the stabilization agent can properly mix together the soil and works to achieve its function beside to form the side drains.

Figure 7 – Spraying the soil stabilization agent

Then, the soil stabilization agent plus water is sprayed by using water tanker through out the road before compaction work is done as in *Figure 7*. This process is done by thoroughly mixing the solution with the soil using the rotovator attached to the tractor or using a motor grader. Material needs to be wet slightly to achieve the optimum moisture content for well compacted.

Figure 8 – Compaction work using roller compacted 10tonne

A first run compaction (without vibrating) is a process is the process to obtain the uniformity of the respective layer, thus the reserved material is used to fill up any low spots or holes. Refer *Figure 8*. Compacting process is continued with full vibration until the material is well compacted .The road base is compact in order to ensure it stable and achieved the required strength. Then, treated area vibratarily compacted again for an adequate an hour and leave the road to cure.

Figure 9- spraying the waterproof sealant on the road surface

Then, sealant is applied as shown in *Figure 9* to prevent seepage of water into the road surface and to prevent it from the erosion. Road surface sprayed with the waterproof sealant to provide extra strength and protection on the treated road. This surface can also act as wearing surface for the road. The job can be done by using Bitumen emulsion or just manually spray pump or bitumen distributor truck.

Figure 10 – Spreading the chipping stone

In order to increase the road durability and tyre grip on the road surface, chipping stones are spread at 15kg/m^2 through the road surface. Finally, the road surface is compacted without vibrating to spread stone shipping. This process will provide more traction on road surface as shown in *Figure 10*.

2.3 Testing and Results

After Construction, In-Situ California Bearing Ratio Test Based on Bs 1377: Part 9: 1990, was conducted periodically in order to measure the improved strength of the unpaved road which has been stabilized using the above technology. The result of CBR Test is tabulated in *Table 1*.

California bearing ratio (CBR) is a test for evaluation of the road subgrades strength for ground where the road will built over. In normal conventional road procedures, the higher CBR value is required and demanding for save cost of project by less thick road structure

designing and constructing. The subgrade must be able to support loads transmitted from the pavement structure.

Table 1 : CBR test result (before and after treatment)

No.	Location	CBR %		
		Before Treatment	After Treatment	% Increase
1	Point 1	36.6	66.2	80.9
2	Point 2	38.9	77.0	98.0
3	Point 3	46.1	91.0	97.0
4	Point 4	30.2	58.9	95.0
5	Point 5	60.3	102.4	69.8

From this result, it shows that by mixing the soil stabilizing agent added with the soil at the subgrade layers, the soil will stabilized and increase the strength. As a result, CBR value for the existing subgrades condition will increases slightly. The table shows the value of CBR that increase before treatment to after treatment range from 60% to 98%.

3. BENEFITS AND IMPACT OF ECONOMY TO THE GOVERNMENT AND COMMODITI AGENCY

3.1 Construction Cost

The application of this technology in rural road will benefit the government in term of construction cost. This method is easier and cheaper than the other method. This essence of this technology is fully utilised the existing soil and earth on site compared to conventional method which consist of crusher run and sand as a road base. The construction cost of soil stabilization is about RM 32.00/m^2 for double layer of sealant while for flexible pavement road is about RM 60/ m^2. Less cost of construction will contribute to the planning of government fund in the most efficient manner. The saving is about 40% compare to the conventional pavement method. The saving can use to cover longer and more roads in rural area. This benefit is tie to the government intends to provide road and basic infrastructure for people and rural area.

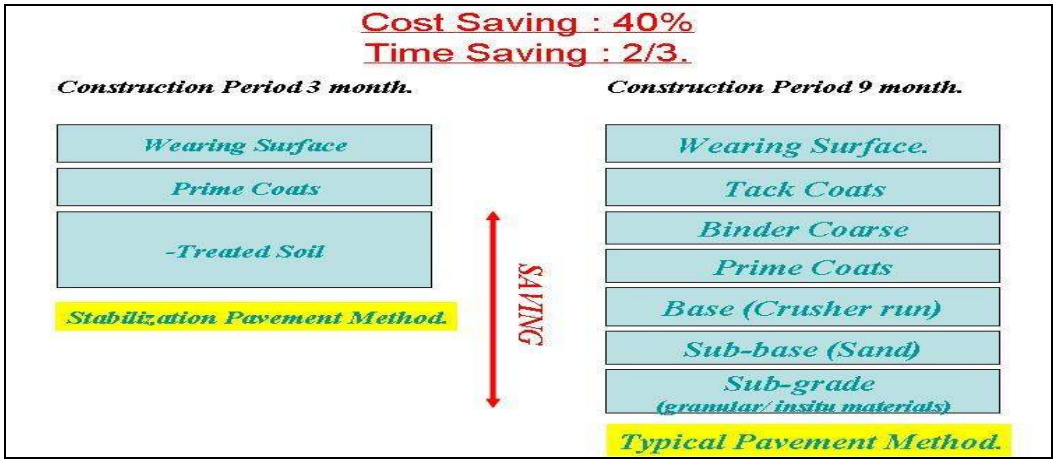

Figure 11 – Comparison of road structure between conventional method and soil stabilization road.

Based on *Figure 11* it clearly shows the comparison of different layer and material for typical conventional pavement method and stabilization pavement method. The construction period shortened about 2/3 period from the conventional pavement construction due to the less work and materials involved. It benefits the government in term of economy by saving the money for management expenditure to other future project.

3.2 Cost of Maintenance

Majority of the road in Malaysia will be exposed to rain water and worst is the road being soaked in water during heavy downpour. For any type or road, upon completion, maintenance of the road is required to prolong the life span of the road. As for this type of road which has been stabilized the maintenance is easy as we need only to use the soil stabilizer agent mix with the roadside soil and then seal it with the water proof sealant as shown in *Figure 12* and *Figure 13*.

The normal conventional maintenance do requires transporting of expensive materials, heavy machinery and time consuming as shown in *Figure 14*. All this factors will contribute to the increase in cost for the road maintenance. Usually the road is located at a very remote area which is far away from the nearest material source. By using this soil stabilization method the cost of maintenance will be subsequently be reduced and the saving can be used for some other purpose.

Figure 12 – Mixing soil with soil stabilizer agent

Figure 13 – Applied the sealant on the road surface

Figure 14 – Patching works using stone for conventional method

The advantages of this method of maintenance are:-

i) Requirement of minimal and less skill workers.
ii) Minimal machinery required. Heavy machineries not required.
iii) Can generate income for the local people in the area to carry out the maintenance of the road.

Comparison of maintenance cost between soil stabilization road, conventional pavement road and gravel road is as per tabulated in *Table 2*.

Table 2 – Cost comparison

Item	Soil stabilization Road	Conventional Road	Gravel Road
Cost / km for maintenance	RM 11, 200.00	RM 300,000.00	RM 23,300.00

The *Table 2* shows that the cost of maintenance for soil stabilization road is the lowest as compared to the conventional road and gravel road.

3.3 Maintenance Team

The maintenance team consist of a minimal 3 workers with 1 ton lorry and it can cover for at least 40km up to 60km length of road to be maintenance per 30 working days (i.e. about 1 to 2 km/day) as shown in *Figure 15*. Usually once the road has been treated with this method of soil stabilization, the cycle of regular maintenance will be once every three months or as when required. For the problematic area or potholes area, it is required to patch the treated soil and sealed it with water-proof sealant.

The team can come from the existing village people who can be trained for this maintenance job and thus with this system, it can generate income for the local peoples and they can becomes entrepreneurs.

The maintenance concept of the unpaved road also will contribute to the increment of local economy at rural area. By using a small vehicle and equipment, local people can get involved to set up a maintenance team and implemented it by themselves. This situation will create job and business opportunity. Therefore, it will benefit the local population by increasing their income and they can become entrepreneurs.

Figure 15 – Maintenance team

The maintenance cycle can also be considered in term of number of years plus the warranty and it should be renewable after 3 years. This method will bring benefit to both parties as the life span of the road will be longer after maintenance being carried out. Most of these practices of maintenance contract were carried out in plantation area as majority of the road were sometime being exposed to bad condition and it will affect the transportation of agricultural product out to the factory. When this happens the economical rate of return of any business will be affected.

4. ADVANTAGES OF THE TECHNOLOGY APPLICATION

4.1 Advantages

Application of this technology will benefit to the economy. It also benefits to the government in all perspectives such as for road safety and satisfaction of road user. Among the advantages are as follow:

- Better Environment due to dust and mud free (all season road)
- Less Vehicle Maintenance
- Better Road Access
- Easy Maintenance
- Quality Fruits when road have free movement and fruits can be transport out without any difficulties
- More trips per day will benefits the lorry driver due road condition in good term
- Zero downtime
- Social responsibility
- No hilly problem, not slippery will increase the safety of the road user
- Better working environment
- Less operation cost due to less of vehicle maintenance
- Higher productivity with good road access
- Less erosion by water and traffic
- Maintain soil/gravel road strength even during rainy season
- Can be easily upgraded to Asphalt Road with laying of ACWC on top of the existing treated road.

4.2 Disadvantages

This road technology still has a limitation as follows:

- Prolong exposed to water reduced strength
- Immediate maintenance required
- Will not get a smooth riding effect

5. FUTURE ACTION AND PLANNING

After about 5 years or whenever it is necessary the road can RE-SURFACE by applying 2 liter/sq. meter of sealant and dressing and then top up with 15 kg/sq. meter of chipped stones to protect the stabilized surface from erosion and free from dust.

In future, through this technology it is easy to upgrade the road pavement into a asphaltic road by paving 50 – 75 mm ACWC. This exercise is carried out after the 3 rd year of the project life cycles.

It is presumed that after the 3rd year, there is allocation available for the road upgrading work, a full design of pavement structure can be adopted from ACWC and ACBC. Usually at this moment of time the road base and structure are already fully stabilized.

6. CONCLUSIONS & RECOMMENDATIONS

Based on all the studies, on site results, research and experience on the finished project on site, it is highly recommended that this technology of LIQUID BASED SOIL STABILIZATION to be used for rural road or agricultural road. This is due to the fact that the usage of this technology will contribute saving the government.

Productivity will increase as more agricultural product can be transported out which will the generate income to the country. With a better road condition, it will help to generate the social implication of the agricultural land use of the dedicated area.

The quality of life will be much better to the surrounding area as the flow of traffic in and out of the area will bring more income to the local people. Business will increase and the perception of education will rise up.

In the rural area, the aspect of environment should not be neglected. Positive action need to be considered and thus the using of this technology will help to preserve a friendly and clean environment to the area. The chemical used was tested and meet the environmental requirement.

Furthermore, this technology has a minimal impact to the environment. For pavement area with the CBR value is more than 30%, it will only required to stabilize the existing soil layer as a road base. As for the conventional pavement method, the requirements of raw material from natural sources need to be provided. This will create a negative impact to the environment.

The most advantage factor of choosing this LIQUID BASED SOIL STABILIZATION is due to the fact that this technology does generate economic growth in the area. The economic factors include the material usage for the pavement structure, material usage and the creation of job and business opportunity in that area. Local peoples will get the benefit to this growth in economical factor.

Lastly if we can achieve all this, then the country will feel the healthy and the happiness of the peoples in it due to the good track performance of soil stabilization road as in *Figure 16.* A good nation that is on the development track to become a strong nation do really need a good road infrastructure in the whole country. Is it strongly recommended that the rural road and agricultural road in a nation need to be provided together with the usage of this soil stabilization concept so that the nation do get a good road infrastructure but at the same time do have saving to be use in other area of development.

Figure 16 – The performance of soil stabilization road

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