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Cawangan Jalan

Bulletin on:
EXPERIENCES OF USING SOIL STABILISATION TECHNIQUE FOR LOW VOLUME ROADS CONSTRUCTIONS IN JKR PROJECT

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SOIL STABILISATION TECHNIQUE FOR LOW VOLUME ROADS CONSTRUCTIONS

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EXPERIENCES OF USING SOIL STABILISATION TECHNIQUE FOR LOW VOLUME ROADS CONSTRUCTIONS IN JKR PROJECT

1. Introduction

There are about total of 216,837 kilometer of roads length in Malaysia including federal and state roads. From this total length of road, there are 52,801 kilometer of unpaved roads that consist of earth and gravel roads. Majority of the roads are falling into the low volume roads category and usually surrounded with rural development as it promotes access to economic and social services, generating agricultural income and productive employment. Long term performance of pavement structure is significantly effected by the stability of the underlying soil usually refer to insitu subgrade that often not achieve the require level of performance under traffic loading and enviromental demands. Soil stabilisation can be used to treat the several inches of soil depth, aggregate surface or other properties of the in-place soil that not achieves the require level of anticipated traffic. Soil stabilisation method also helps to reduce the construction cost by reducing the hauling and tranportation of import materials on site due to recycling of the existing materials. The construction of soil stabilisation also required the minimum type of construction machine so that the acessing of the machine to the construction site especially at the remote area will be ease.

Basically, soil stabilisation is the alteration of any inherent property of a soil to improve its engineering performance. Its is the treatment of natural soil to improve the engineering strength and properties. The most commonly used stabiliser in road construction have been traditionally cement, lime or asphalt products but due to the improvement and innovation of the product by the industry, the non-traditional stabiliser product was developed such as chloride, resins, sulfonated oil, synthetic polymer and various biological enzymes.
Currently, the application of soil stabilisation in road construction in Malaysia was limited to the certain purpose or issues due to the deficiency of the contractor's competency, uncertain about the effectiveness of the technique for the large scale of project and also lack of the suitable machinery for the purpose of soil stabilisation works. Application of soil stabilisation method in Malaysia is very common for construction of plantation roads, rural roads but not in major roads.

Due to the benefits of having stabilisation technique to increase the existing subgrade strength with economical cost, the government of Malaysia through Public Works Departments together with Ministry of Rural and Regional Development were decided to use this method for rural road construction. The construction of the road using soil stabilisation technique was studied and monitored to identify the suitability of the method, the effectiveness of application and the performance compare to conventional method. The study also managed to observe and record all the activities included during planning, designing, procurement and construction.

2. Background of the project

The Project of Menaiktaraf Jalan di Pos Sinderut, Dun Jelai, Cameron Highland, Pahang was one of the projects in the 10th Malaysian Plan under the provisions of the Ministry of Rural and Regional Development. The Public Works Department has been appointed as an implementor for the project. The scope of the project was comprised the upgrading of 35 kilometers of an existing roads according to JKR R1 Standard. An existing road conditions was earth roads without proper drainage and it was resulted to the severe damage on road surface condition and has poor driving quality. This existing route is used by indigenous people as a medium of communication and transportation which is only suitable for pedestrians, motorcycles or four-wheel drive vehicles. Figure 1 below showed the existing road conditions at the project site before the construction.

Figure 1: Condition of existing road before construction.

The project site is located in Kuala Lipis District, Pahang Darul Makmur as shown in Figure 2. Through the result of in situ California Bearing Ratio (CBR) that had been conducted on the existing subgrade before start the construction works, it was identified 12 locations of soil stabilisation as showed in Table 1 and Figure 3.

Figure 2: Location of the project

The selected sections of soil stabilisation are represented as the lowest subgrade value of CBR strength. Site investigation including mackintosh probes and hand auger tests was conducted to determine the existing soil profiles and its bearing capacity meanwhile soil clasification test have been carried out in laboratory in order to obtain the soil properties. Generally, the existing ground soil consists of yellowish brown sandy clay with little gravel. The average of insitu California Bearing Ratio (CBR) test base on BS1377 for the soil stabilised sections are ranges between 8 – 20% when tested using Dynamic Cone Penetrometer (DCP).

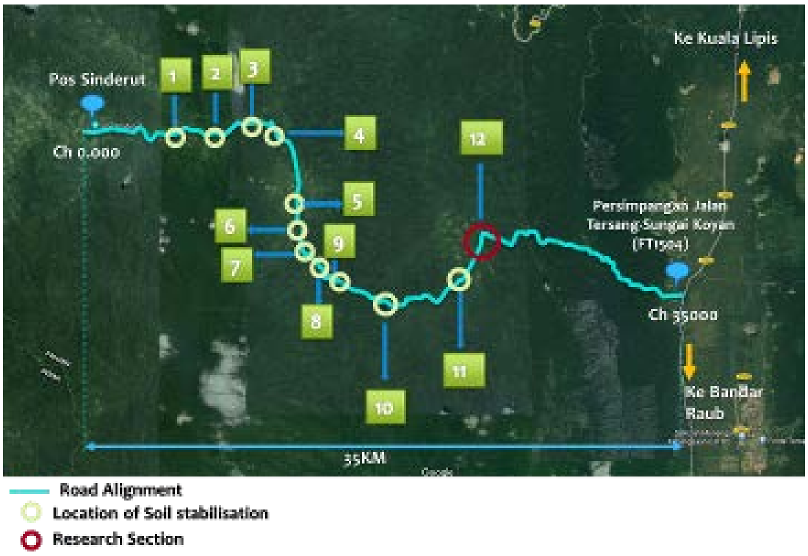

Figure 3: Location of soil stabilisation and research section

Table 1: Location of soil stabilisation section

Section	Start CH	Finish CH	Length (m)
1	5875	6285	410
2	6650	7850	1200
3	8650	8950	300
4	9651	9951	300
5	11950	12350	400
6	13170	13904	734
7	14150	14950	800
8	15350	15550	200
9	16744	17044	300
10	19419	20127	708
11	21724	23074	1350
12	**23816 (research section)**	**25416**	**1600**
Total Length			**8302**

Refer to Table 1 and Figure 4, the research section (Section 12) was divided into four (4) segment which is each segment was stabilised with different percentage of stabiliser. Initially, there are four (4) types of soil stabiliser was selected to be incorporated with an existing soil material on site for this study. The soil stabiliser namely Portland Cement, Bitumen Emulsion, Hydrated Lime and cement/fly ash blended were initially selected as the soil stabiliser to be used in this project. From the test report and analysis, it was found that the used of bitumen emulsion and lime was not suitable with the existing soil and not shows any significant improvement on the strength of the soil.

The mix design report showed the used of four percent (4%) cement in the soil mix comply with the minimum requirement of the stabilised layer strength as required in Design Guide for Alternative Pavement Structures Low Volume Roads. Therefore, 4% cement was applied in this project on the 11 sections of soil stabilisation except for research section. For study purposes, the research section was divided into four segments and each segment was applying 3%, 4%, 5% and 6% of cement as showed in the Figure 4.

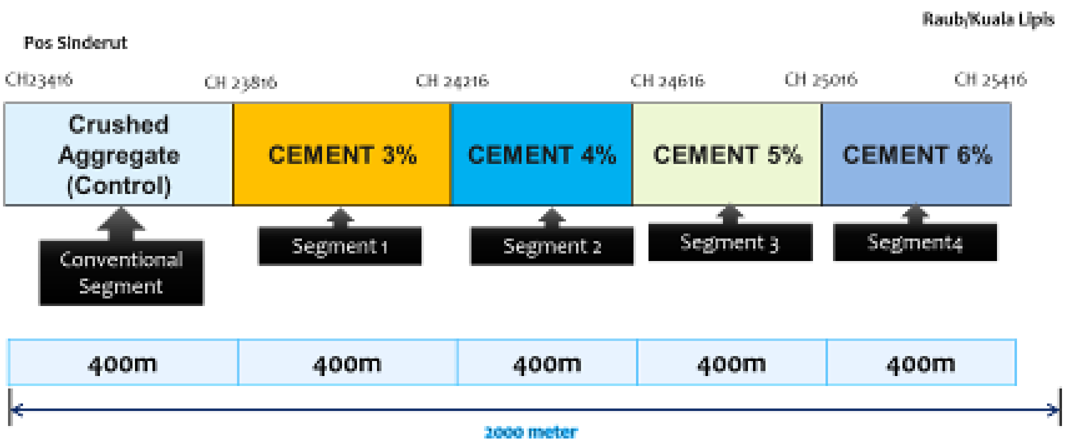

Figure 4: Segmentation of soil stabilisation research section

3. Structural design

The pavement structure was designed according to Arahan Teknik Jalan 5/85 (Pindaan 2013) and Design Guide for Alternative Pavement Structure Low Volume Roads. It was designed base on the requirement of local traffic loading which is in the range of low traffic volume. There are two types of structural designs which are conventional design using crusher run as road base material and stabilised an existing subgrade soil to become road base as showed in Figure 5 and 6 below. Pavement surface structures were overlay with double surface dressing layer throughout the length.

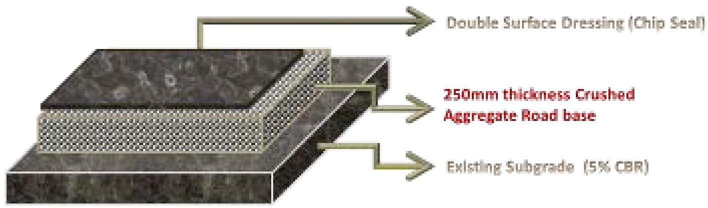

Figure 5 : Conventional structure design

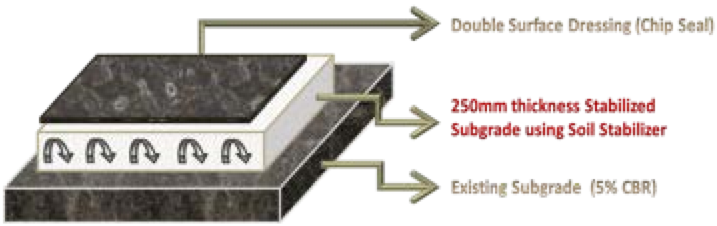

Figure 6 : Soil stabilisation structure design

4. Construction

The construction of soil stabilisation project using cement as stabilising agent in this project was successfully completed by early 2016. The construction of soil stabilisation section was start from site preparation to ensure that the soil surface is free from any foreign material such as grass, sticks, and rubbish. The prepared stretch should be compacted and free from boulders rocks or any other hard material to the designed depth and accessible by the stabilisation machinery. The stabilisation work was including spreading of the binding agent, mixing, compacting, shaping, testing and curing. Supply of cement in bulk or bags will transferred into the purposed built spreader. After stabilisation areas have been prepared, the required quantity of cement was spread over the area. To achieve uniform spreading in line with the design mix requirement, the cement was spread in areas using a mechanical spreader. During the mixing process, the stabiliser machine was used to mix the existing soil materials with cement and water to the design thickness. The purposes of this mixing process however is to incorporate moisture so that the required chemical reaction can take place so that the uniform strength can be achieved. The optimum moisture content was achieved by connected water truck with the stabiliser machine.

The motor grader was used to grade and form the desired cross fall as well as achieving finished surface level after the mixing process. Finally, the vibratory compactor was used to compact the stabilised layer in a way to achieve the desired density. The stabilised layer need to be curing before it was paved with double surface dressing.
The application of surface dressing started with spraying the polymer modified emulsion on the stabilised layer surfacing and then the single size of stone chipping precoated with adhesion agent was spreading through the road surface in two layers. The construction process was showed in the Figure 7 below.

Figure 7 : Soil stabilisation process

5. Laboratory and Field Testing

Laboratory and field testing were carried out before and after construction. Laboratory testing consisted of material testing to identify the characteristic of the soil and mix design to identify the most suitable stabiliser, stabiliser content and the optimum moisture content. The result from the initial mix design test showed that the existing soil material on site was compatible stabilised using cement compared to other types of stabiliser such as lime and bitumen emulsion. The result of mix design was showed in the Figure 8 and 9 below. The mix design samples were tested for Unconfined Compressive Strength (UCS) and California Bearing Ratio test in laboratory. Sample 1, Sample 2 and Sample 3 were represented the different locations of sample taken from the construction site. An existing material from site was stabilised with 4%, 6% and 8% by mass of Ordinary Portland Cement. The Unconfined Compressive Strength (UCS) was carried out after cube moulds cured for 7 days according to B.S. 1881. California Bearing Ratio (CBR) according to ASTM D 1883-07 test procedure also was carried out to identify the optimum stabiliser content in the mix.

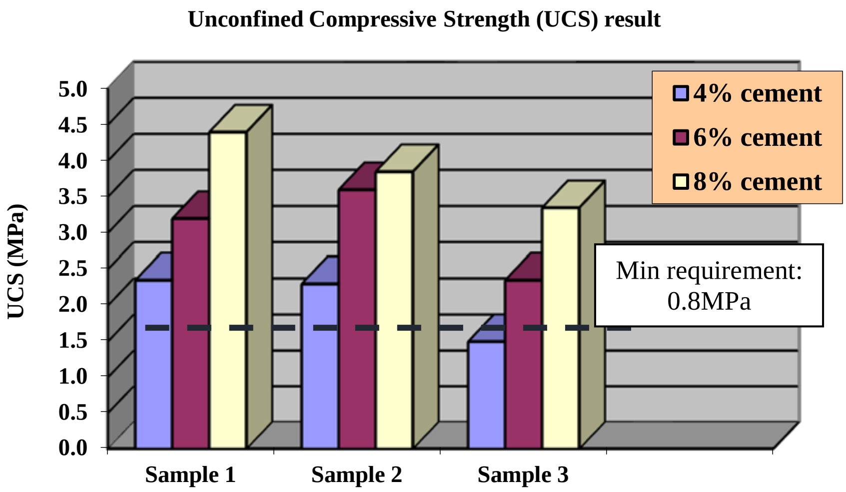

Figure 8: Unconfined Compressive Strength (UCS) result

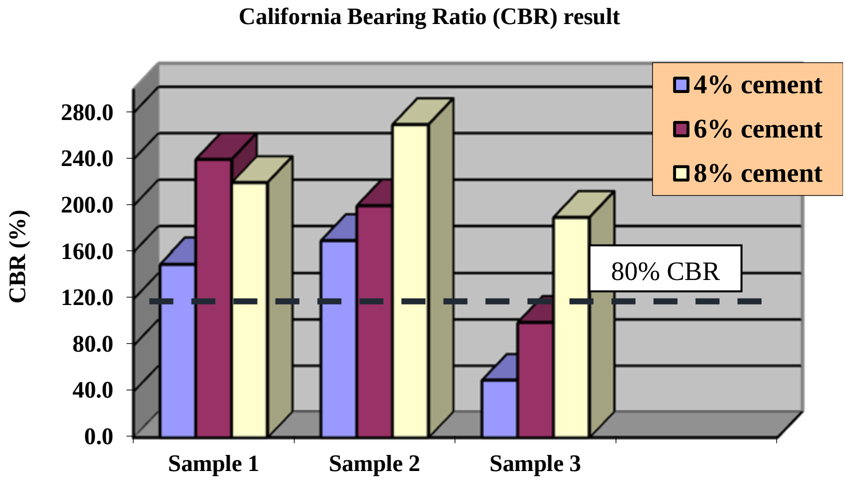

Figure 9: California Bearing Ratio test result (CBR)

It was reported that most of the samples were comply the minimum requirement of UCS and CBR values as stated in the specification which are respectively 0.8MPa and 80%. All CBR results comply with the specification except for Sample no 3 with 4% cement was suspected having error during sample handling. From the result, it was concluded that all the test for the mix design was achieved the minimum requirement of soil stabilised strength at 4% cement content. Therefore, 4% of cement content by dry mass was applied for soil stabilisation workst at this project site.

Field testing was carried out to identify the performance of the stabilised pavement structure before and after construction. The performance of soil stabilised pavement structure was monitored before and after construction by conducting the field testing to identify the strength of the stabilised layer using Clegg Hammer and Lightweight Deflectometer.

The result in Figure 10 and 11 obviously showed that the used of cement increase the CBR value and the modulus of the existing subgrade material. The value of subgrade CBR was increased up to 400% after one months stabilised while the E-Modulus was increased up to 200% after one month.

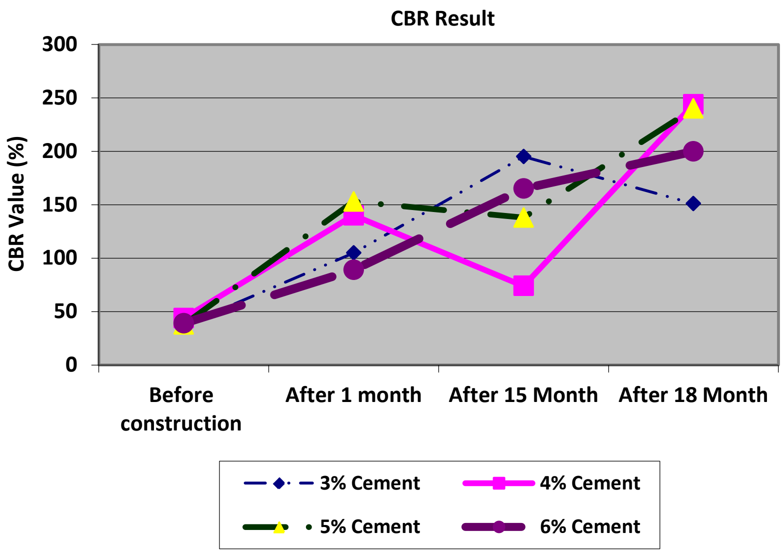

Figure 10: California Bearing Ratio test result (CBR)

From the result showed in Figure 11, the value of subgrade was increased for all section after 15 months stabilised except for section of 4% and 5% cement. This is was suspected that the decreasing of CBR value at these particular sections may due to the effect of the slope failure that occurred during construction caused by high water table along this section. However, the CBR values at stabilised section are more that the required value state in the specification after 18 months construction.

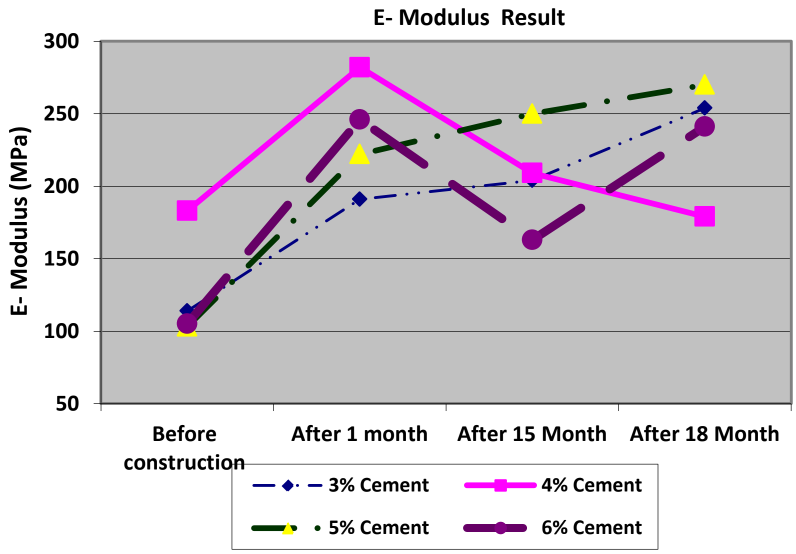

Figure 11: E-Modulus Result

Field testing at Control Section was carried out after 12-month construction and it showed that the Modulus strength value was 162MPa when tested using Lightweight Deflectometer. This result showed the increasing of Modulus value which is about 120% compared to the Modulus value of subgrade before construction.

From the survey on the surface condition that had been carried out randomly at site, it showed that the most of the stabililised area section are still in good condition compared to the conventional section. The Figure 13 showed the condition of site at stabilised section and conventional section after 18-month construction. The surface pavement was overlay with double surface dressing as the final surfacing throughout the length. Figure 12 showed that the surface dressing of both sections were peel off and exposed the lower layer. This is may be due to the poor construction quality and quality control during construction of surface dressing itself. Therefore, the stabilised layer which is unbound layer was exposed to the water penetration became breakable to the high surface loading due to the poor condition of surface dressing.

Conventional Section **Stabilised Section**

Figure 12: The condition at site after 18 months

6. Conclusion

Based on the findings, result, analysis and observation on the implementation of soil stabilisation technique in this project, it can be concluded as followed:

i. To ensure that a uniform and homogenous stabilised mix was achieved, it is very important to use the proper machine but the condition of the remote construction site area may cause the difficulty on bringing the machine inside. Therefore, it is suggested to allow the use of any simple machine or purpose-built machine as long as it can provide the homogenous stabilised mixture.

ii. The soil stabilisation mix design should be always to be carry out at every project due to the different of soil properties required different types and content of stabiliser agent.

iii. Soil stabilisation using cement increase the existing subgred after construction complete and performed well compared to the conventional method.

iv. It was suggested to have a particular Malaysian design manual and specification in soil stabilisation to assist the engineer and construction industry to have a better design and quality control regarding soil stabilisation.

v. The implementation of soil stabilisation technique should be extended to the higher hierarchy standard of the road such as federal or state road.

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