Military Technical College
Kobry El-Kobbah,
Cairo, Egypt

8th International Conference on Civil and Architecture Engineering
ICCAE-8-2010

EVALUATION OF SAND BITUMEN AS A BASE LAYER FOR DESERT ROADS

By

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ABSTRACT

In Libya, the cost of gravel and crushed stone rises as existing sources become exhausted and suitable supplies have been overly exploited. Sand in Libya is the most prevailing available material for constructions. It is suggested that economic benefit could be derived from the rational use of stabilized sand in road construction. A main desert highway was constructed in Libya using in-place sand mix base. The main objective of this paper is to document and characterize the sand bitumen mix which was successfully used in this road. The work completed in this paper included field investigation, laboratory work and analysis of results. The field investigation was conducted to evaluate the pavement surface condition of the existing road in Libya. Core samples were obtained through this phase of study and tested for aggregates gradation and optimum MCO%. Results of work conducted in this research showed that sand bitumen mix could be used successfully as a base layer in desert roads. The average MCO content was found to be 2.82%. Future work should be conducted to check the response of sand bitumen mix under repeated traffic loads and to establish sand mix design criteria.

key words:

Desert road, pavement condition index (PCI) and sand bitumen, Libya.

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1. INTRODUCTION

In recent years, considerable research has been conducted in the construction of pavement layers incorporating cutback asphalt. Development of improved stabilizing techniques has enabled both effective and economical stabilization of marginal quality pavement materials. Ajdabiya-Jalo road was constructed in Libya about 30 years ago using MCO-in place sand mix base. The resulting pavement had varying performance. This paper explores the pavement surface condition in terms of pavement condition index (PCI) for the current situation, analysis of the used mix and the subgrade conditions. This should help document success and failure in employing the concept of using sand mix.

DISCRIBTION OF THE AJDABYA-JALO ROAD

Ajdabiya- Jalo Road is of a total length of 252 km. It is the key part of the road between the coastal highway and the Sahara desert, which is the southern part of Great Socialist People's Libyan Arab Jamahiriya (G.S.P.L.A.J) as shown in figure (1).

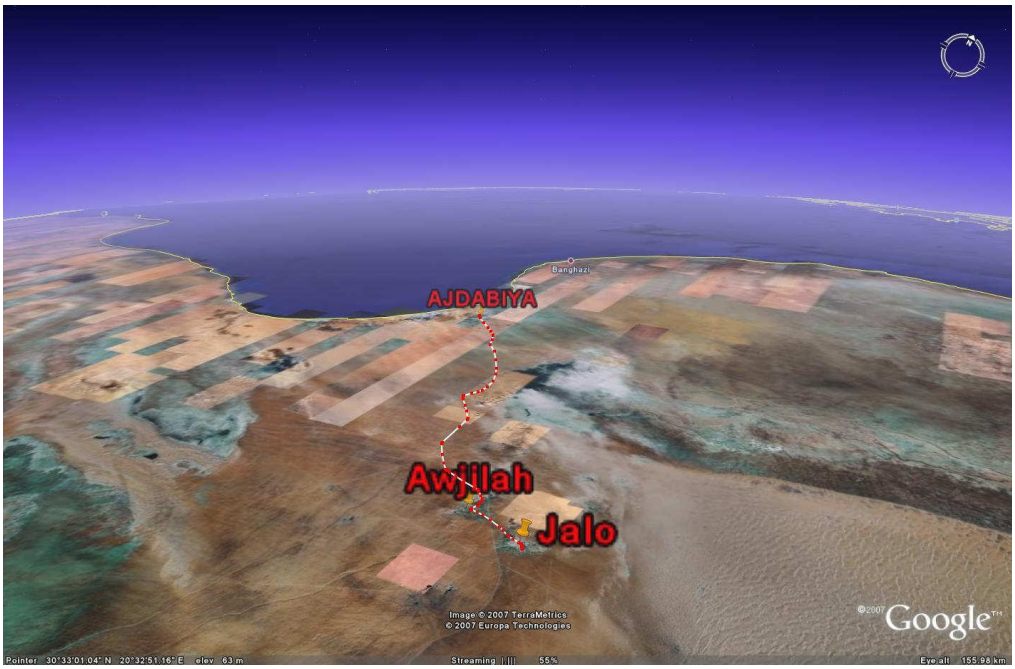

Figure (1): Ajdabiya- Jalo road

As a typical road it was planned to serve for 20 years. Having served for over 30 years, good portions of the road is in "good" condition especially those sections which have

sand subgrades. Some parts of the road, however, are stressed considerably especially from KM 85 to KM130 where sebkha is the predominant soils for subgrade foundations.

Sabkha is an expression that has long been used for arid, saline flat deposites that are underlain by sand, silt, or clay; and are often encrusted with salt. It is one of the many types of evaporate regimes that exist around the globe, particularly within tropical zones. It exists in many parts of the world including the Middle East, North and Southern Africa, India, North America, and Australia, [1].

LAYERS THICKNESS FOR AJDABIYA-JALO ROAD

The road x-section is shown in figure (2) where pavement layers are composed of 3 cm wearing surface, 7 cm binder course, 10 cm cold sand mix and subgrade soil.

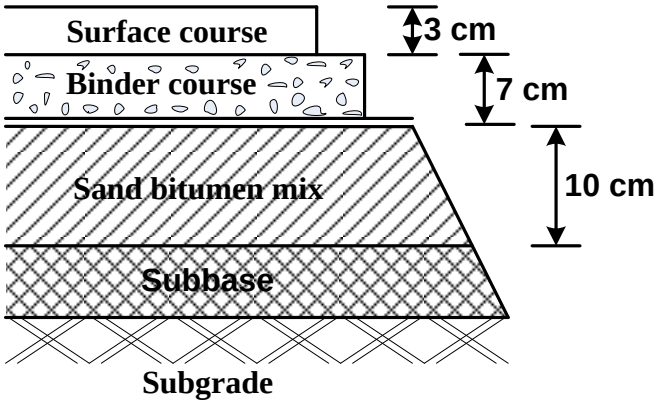

Figure (2): The Ajdabiya- Jalo road x-section

2. PAVEMENT CONDITION INDEX (PCI) METHOD

The PCI is numerical indicator based on a scale of 0 to 100 and is determined by measuring pavement surface distress that reflects the surface condition of the pavement. Pavement condition ratings (from excellent to failed) are assigned to different levels of numerical PCI values, these ratings and their respective PCI value definitions are shown in Figure (3), [2]. Each road section to be evaluated for pavement surface condition is divided into a number of sample units. The length of each sample unit is chosen to be 900m ± 100m. The condition survey provides estimated density and severity of each distress type from which the PCI can be determined.

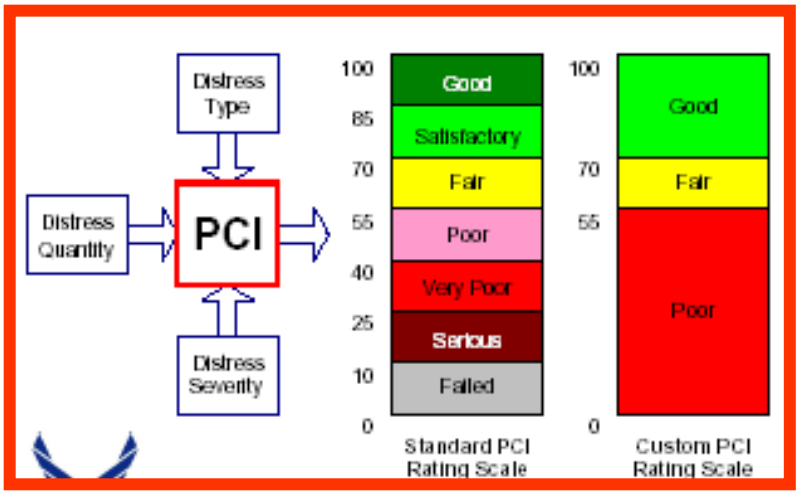

Figure (3): PCI scale and condition rating, [2].

There are sixteen types of pavement distresses considered in the PCI method. The distresses vary in measuring units and in identifying the related cause (load, climate/durability, other). Load-related distresses occur where the pavement has been over-stressed by heavy traffic. Climate/durability-related distresses arise due to exposure to climatic condition. Other distresses are caused by action not related to load or climate, such as oil spillage.

3. FIELD INVESTIGATION

The road profile was divided into two main portions; 45 km in subkha subgrade and 135 km in sand subgrade. Evaluation of pavement surface conditions included visual inspection of 45 km in subkha subgrade and 45 km in sand subgrade selected to represent the surface condition of the 135 km of road built in sand subgrade.

The first phase of evaluation of pavement surface conditions included training of 4-teams each of 3-persons for one week to know how to conduct pavement surface evaluation using PCI method. This phase included recognizing different pavement distresses, identifying density of each distress and measuring its severity, figure (4). Then deduct value was calculated and PCI could be obtained for each road sample unit. Each road section to be evaluated for pavement surface condition was divided into a number of sample units. The length of each sample unit was chosen to be 1000 m. Thirteen sample units represented the pavements on sebkha subgrade and another 13 sample units represented pavements with sand subgrade as shown in tables (1) and (2).

Figure (4): Identifying density of each distress and measure its severity

The average pavement condition index (PCI) value of pavement constructed on sabkha subgrade was calculated to be 37. Based on this value, the rating of pavement surface was found to be poor. On the other hand, the average PCI value of pavement constructed on sand subgrade was calculated to be 65. Consequently, the rating of pavement surface was evaluated to be good.

Table (1): Summary of PCI calculations for Ajdabya-Jalo road on sabkha subgrade

Sample unit	PCI	Rating	Average PCI
1	32	Poor	39 (POOR)
2	20	Very poor	
3	27	Poor	
4	22	Very poor	
5	50	Fair	
6	25	Very poor	
7	41	Fair	
8	27	Poor	
9	38	Poor	
10	39	Poor	
11	52	Fair	
12	70	Good	
13	60	good	

Table (2): Summary of PCI calculations for Ajdabya-Jalo road on sand subgrade

Sample unit	PCI	Rating	Average PCI
14	69	Good	65 (GOOD)
15	55	Fair	
16	71	Good	
17	61	Good	
18	65	Good	
19	76	Very good	
20	70	Very good	
21	69	Good	
22	71	Very good	
23	53	Fair	
24	71	Very good	
25	55	Fair	
26	65	Good	

4. FIELD SAMPLING AND TESTING.

Eight core samples were brought from test points of road on Km85, Km103, Km120 Km130, Km145, Km160, Km186 and Km 225, figure (5). Binder extraction test was carried out on eight core specimens; four cores were extracted from the part of the road constructed

Figure (5): Field core samples from different test points

on sand subgrade and the other four cores were obtained from the part of the road constructed on sabkha subgrade. Those core samples were inspected and tested for extraction to get the binder content and sieve analysis as seen in figure (6). Then by statistical analysis of the 8 core samples we get the representative sand gradational and average of MCO.

Figure (6): Extraction test

Table (3) presents a summary of the extraction test results.

Table (3) Extraction Test Results

Sample No.	Subgrade	Location (Km)	Bitumen Content (%)	Average MCO (%)	Overall Average MCO (%)
1	Sabkha	85+000	3.92	3.0	2.82
2		97+000	2.19		
3		103+000	3.17		
4		122+000	2.30		
5	Sand	130+000	2.85	2.64	
6		145+000	2.18		
7		155+000	3.26		
8		167+000	2.28		

Table (3) shows that the bitumen content values ranged between 2.18% to 3.92%. The average bitumen content for sand bitumen mix on sabkha subgrade was found to be 3.0%, while that on sand subgrade was found to be 2.64%. For all tested cores the average bitumen content was calculated to be 2.82%. The calculations and results of sieve analysis test on sand in sand bitumen mix are shows in figures (7) and (8) which illustrate the results of sieve analysis of the part of the road constructed on sand subgrade. Figures (7) and (8) show that the sand used in sand bitumen mix is well graded. In addition there is no significant difference between sand used for both parts of the roads.

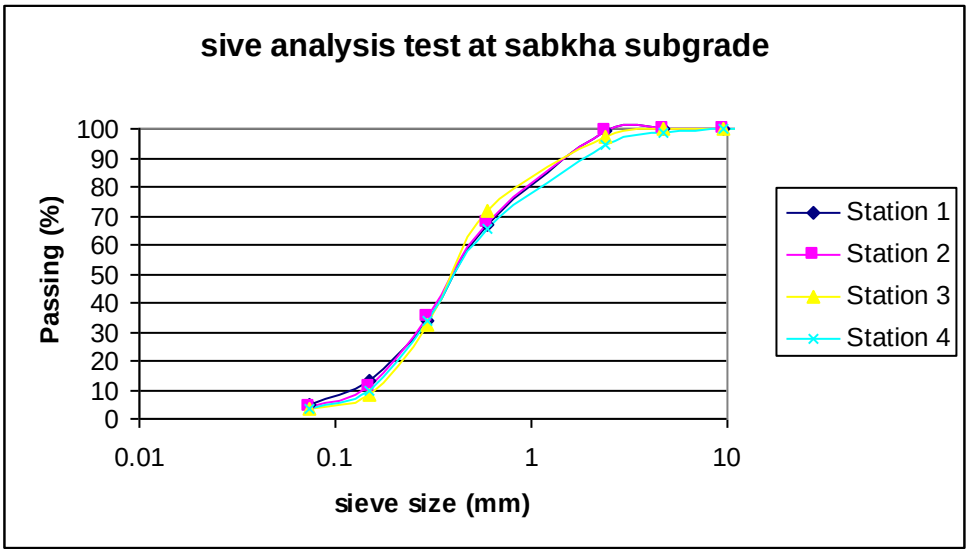

Figure (7): Sieve analysis of sand in sand mix on sabkha subgrade

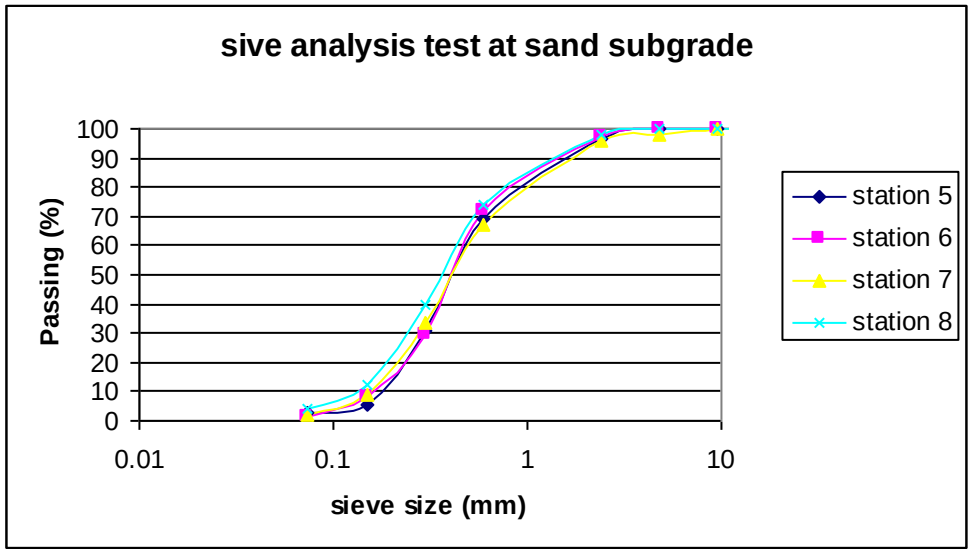

Figure (8): Sieve analysis sand in sand mix on sand subgrade

Statistical analysis for the results of the gradation analysis lead to the normalized gradational size distribution as shown in Table (4). This normalized distribution presents the particle size for sand available in Great Socialist People's Libyan Arab Jamahiriya (G.S.P.L.A.J). It can be used in sand bitumen mix to act as a base layer for desert roads.

Table (4): Statistical analysis result for sieve analysis tests

Sieve analysis extraction	Passing (%)
#4	99.63
#8	97.59
#30	69.59
#50	42.06
#100	19.45
#200	4.27

Soils under sand bitumen layer at sabkha subgrade and sand subgrade were brought from test points of the road to measure the CBR as shown in Figure (9). As described before, eight subgrade soil samples were obtained from the field. These samples were tested for their CBR values. Table (5) presents a summary of CBR test results.

Figure (9): CBR procedure test.

Table (5): CBR test results

Sample No.	Subgrade	Location (Km)	CBR (%)	Average CBR (%)
1	Sabkha	85+000	6.0	7.75
2		97+000	9.0	
3		110+000	6.5	
4		122+000	9.5	
5	Sand	130+000	26.5	27.63
6		145+000	29.5	
7		155+000	27.5	
8		167+000	27.0	

Table (5) shows a summary of CBR test for part of the road constructed on sabkha subgrade and sand subgrade. The table shows that the CBR values ranged between 6%

and 29.5%. The average CBR for sabkha subgrade was found to be 7.75%, while for sand subgrade it was found to be 27.63%.

Reviewing the results of the PCI values, presented in this paper which were 39 at the part of the road constructed on sabkha subgrade and 65 at the part of the road constructed on sand subgrade, suggests that the low value of PCI noticed for the part of the road constructed on sabkha subgrade could be caused by the poor properties of sabkha subgrade indicated by the average CBR value of 7.75%. In other words, the CBR value of subgrade soils could be responsible for the differential values of PCI of pavement surfaces.

5. Conclusions

Based on the work presented in this paper the following could be concluded:

1. Using sand bitumen as a base layer in desert roads is a viable solution where other construction materials are of short or expensive supply.

2. Documented field experience showed that sand bitumen mix base performed will over 36 years of road in service especially for roads constructed on sand subgrade of CBR value of 27%.

3. Low-quality subgrade of low CBR values might cause severe pavement distresses.

4. An MCO content of 2.8% was found to have worked well for the bitumen-sand mix.

5. It is recommended to check the response of sand bitumen mixes under repeated traffic loads and to evaluate their rutting resistance.

6. It is recommended to develop design criteria for sand mix base used in desert roads in pertinent climatic conditions.

7. It may be recommended to study the possible use of sand mix as a surface layer for low-volume desert roads.

6. REFERENCES

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