The Effect of Bitumen Stabilized Subgrade on Cost of the Flexible Pavement

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Abstract— *In countries where freight transportation is mostly done by highway, the increasing load carrying capacity of heavy vehicles creates the need for strengthening the road pavements. In this study, the effects of stabilized subgrade with asphalt emulsion on flexible pavement thickness and pavement cost were determined. Consequently, the optimum emulsion content and the CBR value has been determined. As a result, it was seen that the thickness of the asphalt pavement and thus the cost of pavement decreased.*

Keywords— ***Bitumen Emulsion***, ***Stabilization, CBR, Flexible pavement, AASHTO 86.***

I. INTRODUCTION

Increased traffic volume, environmental and external factors, and flaws incurring during construction phase cause early deterioration of the road pavement [1,2,3,4]. Subgrade stability in road pavements significantly affects the superstructure. Because the subgrade should be able to resist the stresses caused by the traffic loads [5]. Soil improvement can be done by many different methods. One of these methods is to ensure the soil stabilization by adding additives. Cement, lime, fly ash, bitumen etc. Additives such as stabilizers are the most preferred stabilization methods to provide soil stabilization. In the literature, there were many studies on the effects of different materials on the California Bearing Ratio (CBR) or superstructure for different soil types. [6-10].

Kök et al. [6] investigated the relationship between the cost of flexible pavements and the cost of stabilization to be built on soils with cement stabilization. As a result, for the low, medium and high traffic values, the cost of the pavement decreased to 15% CBR, then gradually decreased and the stabilization cost increased with the increase in CBR amount.

Kolias et al. [7] investigated the effectiveness of stabilization with high calcium-containing fly ash and cement on clayey soils.

Çalışıcı et al. [8] have investigated the effects of CBR on the infrastructure on bitumen reinforced soil and found that there is a significant decrease in the superstructure thickness.

Şenol el al. [9] have investigated the effects of high volatility of carbon as well as fly ash containing CaO and carbon from different plants on the stabilization of soft soils. They found that CBR value and compressive strength increased significantly compared to the soil types with the increase in the ash content, and the highest increase was in the CL class in the fly ash content.

Eren and Filiz [10] In their study, they examined the CBR values of cement and lime added soil in different ratios. In the study, it was determined that the lime ratio could increase the CBR value up to a certain value, but also found that the lime added soil was more resistant to swelling.

II. MATERIAL AND METHODS

In this study, the soil is stabilized by bitumen emulsion and the bearing capacity is increased. The effects on the flexible pavement are determined by using the 2015 traffic data for Adana – Mersin highway using the AASHTO 86 pavement design method. The viscosity of the emulsion used in stabilization was 46 sec and the specific gravity was 1.0125 gr / cm3.

Soil sample used in stabilization was prepared to meet Turkish State Highway Specification and AASHTO specification limits. (Table 1).

Table.1: Sample gradation before and after oven

Sieve No	Specification Limits % passing	Before oven % passing	After oven % passing
4	50-100	85.00	89.50
40	35-100	55.00	56.90
200	10-50	20	21.50

Modified Proctor Tests was performed on the soil sample and maximum dry unit weight and optimum water content values were found in Figure 1.

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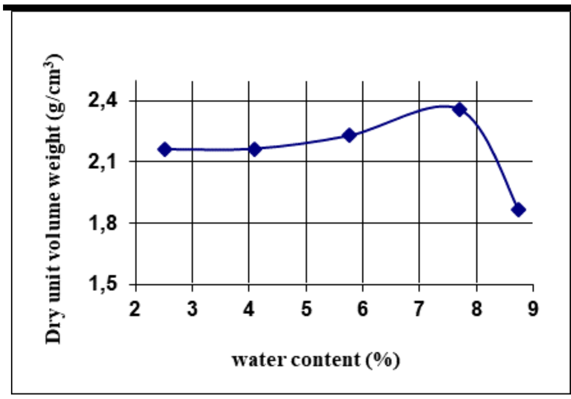

Fig. 1: Dry unit volume weight - water content relationship of soil

The sample prepared in optimum water content was mixed with bitumen emulsion at 1,2,3,4% and 5% by weight and subjected to Marshall Stability Test. As a result of the Marshall stability test, the optimum bitumen emulsion ratio for stabilization was 4% (Fig. 2)

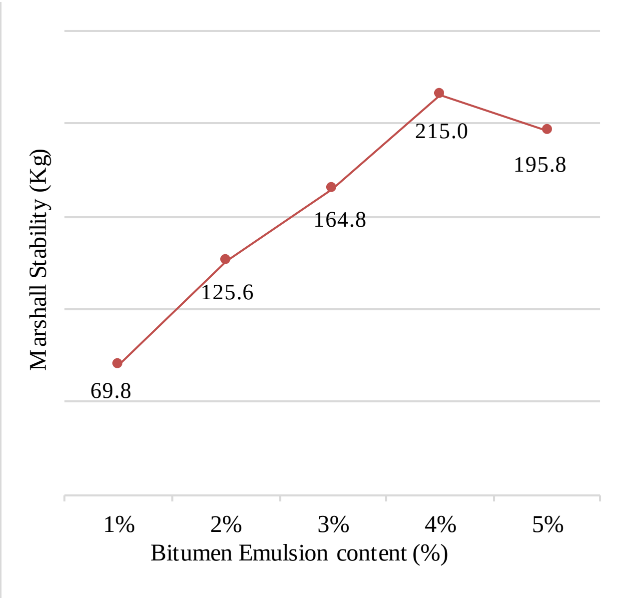

Fig. 2: The Marshall Stability Test Results

As a result of the CBR test performed before stabilization to the soil, the CBR value was found to be 18.09, the CBR of the sample stabilized with 4% bitumen emulsion was 24.05. According to this result, stabilization with bitumen emulsion resulted in an increase of 33% in the soil bearing strength.

III. RESULTS AND DISCUSSION

The CBR value obtained at the end of the experimental studies was selected as 24. Considering AASHTO 86 flexible pavement design criteria, Mersin and Adana state highway traffic data and environmental data values in Turkey were used the pavement design. The traffic data used in the design is presented in Table 2.

Table.2: Adana - Mersin highway annual average daily traffic data for 2015 [11].

Vehicle Type	Annual Average Daily Traffic	Annual increase rate (%)
Truck	3555	3
Trailer	3920	
Bus	450	5
Car	26000	

The M_R value used in the design can be calculated with the equation in Equation 1 depending on the CBR [12].

$$M_R = 1500 \times CBR \quad (1)$$

The planned route between Adana and Mersin is 4 lanes, the pavement width is 13 m and the base width is 20 m. Stabilization of the soil was adopted at a thickness of 10 cm. Service capability of road (Pt) = 2.6 and Area factor R = 1.0

IV. CONCLUSION

In this study, the effects of soil stabilization on the thickness of asphalt pavement were investigated. In addition, the cost reduction to be obtained by decreasing the pavement thickness is calculated. The layer thicknesses calculated before and after stabilization are given in Table 3 and Table 4.

Table.3: Pavement thickness before stabilization

5 cm	Surface Course	79 cm
8 cm	Binder Course	
66 cm	Base Course	
	Subgrade (CBR %18)	

Table.4: Pavement thickness after stabilization

5 cm	Surface Course	65 cm
8 cm	Binder Course	
52 cm	Base Course	
10 cm	Stabilized Subgrade (CBR %24)	
	Subgrade (CBR %18)	

Table 3 and Table 4 showed that the base course after stabilization decreased by 14 cm. With the increasing CBR after stabilization of the soil, the decrease in the base layer is an expected result. It can be calculated that the layer thickness of the base course is reduced by about 21.2%.

Although the base layer has been reduced in the

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calculated pavement for the stabilized subgrade, the economic gain should be calculated by taking into account the 10 cm stabilized subgrade cost. The distance between the cities of Adana and Mersin is 86 km. After the cost calculations, it was calculated that the road construction cost per kilometer has decreased by 5.3 % after stabilization.

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