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THE EFFECTS OF ADDING RECLAIMED ASPHALT PAVEMENT (RAP) AND CEMENT ON THE PROPERTIES OF PAVEMENT BASE COURSE

Farag Khodary
Civil Engineering Department, Qena Faculty of Engineering, South Valley University, Qena, Egypt
Khodary@svu.edu.eg

ABSTRACT

Reclaimed Asphalt pavement (RAP) is removed using a milling machine which grinds the asphalt into small pieces and it is a useful alternative to virgin materials because it reduces the use of virgin aggregate. Base course is a layer that comes under the surface layer of asphalt pavement and consists of gravel materials with lower specifications than the surface layer. The main aim of this research is to evaluate using reclaimed asphalt pavement and Portland cement as stabilizer to the base course materials. Different amount from RAP materials were added to the base course soil by weight. The RAP percentage added are 5%, 10%, 15%, 20% and 25% with fixed amount of cementing 2% for all mixtures. Different tests were conducted sieve analysis, Los Angelos Abrasion, Modified Proctor and California bearing ratio. The results showed that adding recycled asphalt to the base soil improved all mixtures properties with different rate. After adding recycled asphalt and cement, the sieve size analysis of the mixtures with different proportions of components still falls within the limits of the Egyptian standard. There is a noticeable improvement in the wear value for the mixture, 20% recycled asphalt and 2% cement, with a value of about 15%, and this value is good for improving the wear resistance of the mixture. The dry density value increase by 10% for the mixture, contain 20% recycled asphalt and 2% cement. California bearing ratio test result indicate that adding recycled asphalt to the soil improve the bearing capacity of soil that can be used as base course of pavement. The whole results of the research give good indication for pavement full depth recycling and reuse it as anew base course layer.

Keywords: Asphalt Pavement, Base course, Reclaimed Asphalt pavement, California bearing ratio, Dry density

INTRODUCTION

Population growth and economic development have resulted in an extensive network of asphalt paved roadways. Many thousands of miles (kilometres) were constructed to meet the demands of increased traffic. When the roadway network was rapidly expanding, the initial construction cost was the most importance, with little or no attention being paid to the maintenance costs. However, as the roadway network has expanded, as the traffic volume and gross vehicle weights have increased. In Egypt, there are about 4 million tons per year of reclaimed asphalt materials are not used [1]. Recycled asphalt can be used in different asphalt layers, where it can be inserted with the asphalt mixture or with the base layer in different proportions according to the layer in which it will be used. The use of recycled asphalt is considered a form of optimizing the utilization of resources and supporting sustainable development. Reclaimed asphalt pavement (RAP) saves virgin materials because it reduces the need to use virgin aggregate; it also reduces the amount of costly new asphalt binder required in the production of asphalt paving mixtures [2]. Among the advantages of recycled materials is that it saves the use of new materials as well as saves the energy spent to extract these materials and may result in behaviour almost equal to the behaviour of new materials [3]. Most recycling methods are often less expensive than extracting new materials. The use of recycled asphalt in the asphalt mix saves the use of new bitumen [4]. During the maintenance process, the surface layer needs to be removed, and there are large quantities of recycled asphalt. There are many studies to find out the suitability of using the recycled asphalt materials, whether in asphalt mixtures or the base course layer layers for roads [5].Various materials can be used to improve the properties of the base course layer for asphalt roads, and one of these materials is silica fume, which has proven efficient in improving the bearing capacity of soil [6].

MATERIALS

The soil used in this research is from quarry which is located at Qena Governorate. Many tests were done to evaluate the properties of the soil used and compare them with the standard specifications. Recycled asphalt was obtained as a result of milling a street in the city of Qena Governorate. Recycled asphalt was added in different proportions from the total weight of the sample used and 2% from commercially available Ordinary Portland Cement. The required tests were performed to compare the soil properties before and after the addition of Reclaimed Asphalt. Figure (1) present the materials used in this research

RAP Cement Soil

Figure 1: materials types' soil, RAP and Cement

EXPERIMENTAL LABORATORY PROGRAM

In this research, four tests were done at qena Faculty of Engineering labs. The tests were conducted on the sample taken from the quarry as well as the tests were carried out on the samples after adding recycled asphalt and cement. The sample was prepared by adding different percentages of recycled asphalt, which are 5%, 10%, 15%, 20% and 25%, with the addition of a fixed percentage of cement, which is 2% of the sample weight, for all previous samples according to the following table.

Table 1: percentage of RAP and cement added to the mixtures

Sample	% of (RAP) by weight	% cement by weight
untreated sample	0%	0%
1	5%	2%
2	10%	2%
3	15%	2%
4	20%	2%
5	25%	2%

TESTS TYPE

- Sieve analysis test (AASHTO T 27) is used to classify the soil by its Sieve Analysis using sieves with apertures ranging from 100 mm (4 in) to 0.075 mm (Sieve No. 200). The aim of the Sieve analysis test is determination of the gradient of granulation of aggregates as well as determines the validity of the aggregates and its conformity with the standard specifications [7].
- Los Angelos Abrasion (AASHTO T 96) is to calculate the Abrasion ratio of gravel materials and to measure of aggregate toughness and abrasion resistance. Where it is possible to determine the suitability of aggregates for any type of construction process, and the lower the percentage, the better the aggregate and vice versa [8].

- Modified Proctor Test (AASHTO T99) Soil compaction represents one of the most important requirements in projects related to soil work, the most important of which are roads, earth dams and foundations. Soil compaction is known as the mechanical energy that increases it by expelling the air between its particles. The aim of the test, finding the maximum dry density and optimum moisture content of the soil after it has been affected by the compaction process according to the Proctor method. As well as determining the energy that the soil is exposed to in the compaction in the laboratory to represent it on nature using various compaction tools and equipment. The pressure theory test is based on evaluating the water content and the dry density relationship of the soil for a specific compressive stress. The mechanical process of condensation by reducing the air voids in the soil mass is called compaction. The amount of mechanical energy applied to a soil mass is the compressed stress [9].

- California bearing ratio (AASHTO T193-99) this method is used to assess the inherent resistance of foundation materials including materials used in pavements and airports. The CBR value extracted in this way is an integral part of many approaches to designing flexible pavements. It is the measurement of the load required to insert a needle of a specific diameter and at a certain speed in the soil sample at specific values of water content and density, and calculating the ratio of this load (pressure) to the standard load (pressure) at needle stitches of (0.1 inch) and (0.2 Inch) and gives the test provides information on the extent of soil swelling and the loss of strength of the soil when the soil is saturated with water, and the tolerance ratio for California gives an idea of the behavior of the soil under the asphalt (base materials) [10].

TEST RESULT

- The sieve analysis test was performed on the untreated sample, as well as the samples to which recycled asphalt and cement were added. The results show that the untreated sample falls within the upper and lower limits of the standard Egyptian specifications for the base layers. Figure 2 present Sieve analysis test result for untreated sample and mixtures

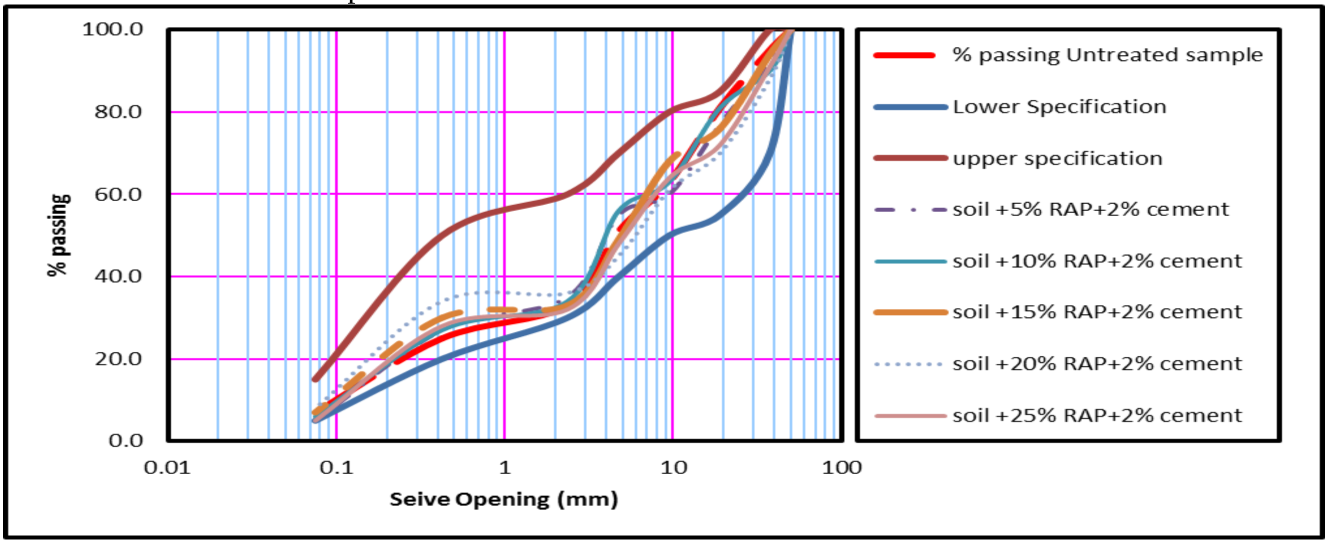

Figure 2 Sieve analysis test result for untreated sample and mixtures

- The Los Angeles Abrasion test is widely used and gives a strong indication of aggregate quality. There is an improvement in the mixture's resistance to Abrasion (soil + 20% RAP + 2% cement) by 15%. These results were acceptable and thus increased the soil resistance to abrasion. Table 2 present the Los Angelos Abrasion test result for untreated sample and mixtures

Table 2 Los Angelos Abrasion test result for untreated sample and mixtures

Sample	Los Angelos Abrasion After 100 revolutions	Los Angelos Abrasion After 500 revolutions
Untreated sample	9.7	39.3
soil +5% RAP+2% cement	8.9	39.0
soil +10% RAP+2% cement	8.6	38.7
soil +15% RAP+2% cement	8.3	36.4
soil +20% RAP+2% cement	8.2	36.2
soil +25% RAP+2% cement	8.2	36.1

- Modified Proctor Test result: The result of the standard proctor test indicated that there is a marked improvement in the dry density value. The resistance of aggregate to the abrasive is considered one of the signs indicating the quality of the aggregate and since the recycled aggregate from asphalt mixtures is originally the product of crushing crushers. Therefore, the higher percentage in the mixture is the higher the dry density value .The dry density of the mixture increased by 20% recycled asphalt and 2% cement to a value of 10%. Therefore, this ratio is considered good for improving the density value of the soil. Figure 3 present Modified Proctor test result and table 3 proctor test result for untreated sample and mixtures.

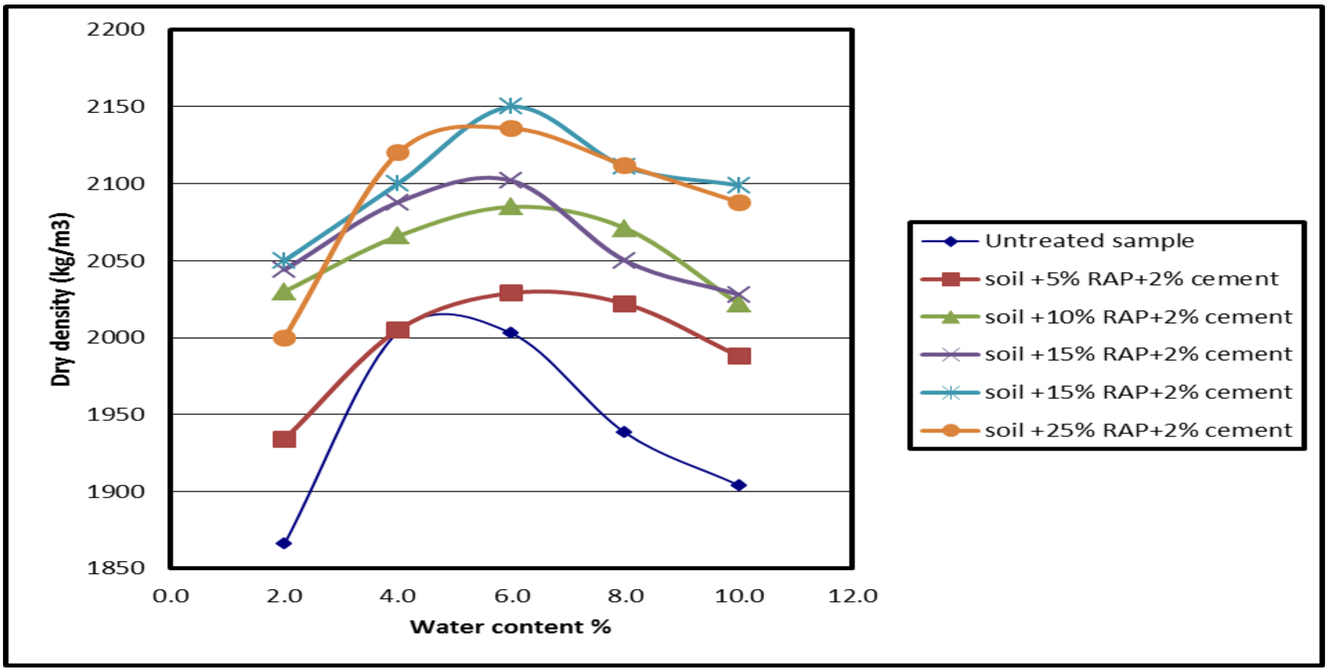

Figure 3 Proctor Compaction Curve for untreated sample and mixtures

Table 3 proctor test result for untreated sample and mixtures.

sample	Maximum Dry density (Kg/m^3)	Optimum water content
Untreated sample	2003	4.5
soil +5% RAP+2% cement	2029	6.0
soil +10% RAP+2% cement	2085	6.1
soil +15% RAP+2% cement	2102	5.8
soil +20% RAP+2% cement	2150	5.0
soil +25% RAP+2% cement	2136	6.1

- California bearing ratio test is considered one of the most important tests in the field of highway, as it determines the soil bearing capacity, and design theories take California bearing ratio as one of the factors involved in the structural design of roads. In this research it was made clear that the addition of recycled asphalt with a percentage of cement to the soil used in the base layers of the roads increased the bearing capacity of the soil to the loads load bearing capacity of the soil by a value of up to 37% for the soil modified with 20% Reclaimed Asphalt pavement and 2% cement.
- The improvement of the CBR value is an indication of the possibility of using recycled asphalt and a percentage of cement in stabilizing and improving the properties of the soil used in the base course layer in asphalt pavement construction. Figure 4 California bearing ratio test result for untreated sample and mixtures and table 4 present the calculated of CBR for untreated sample and mixtures

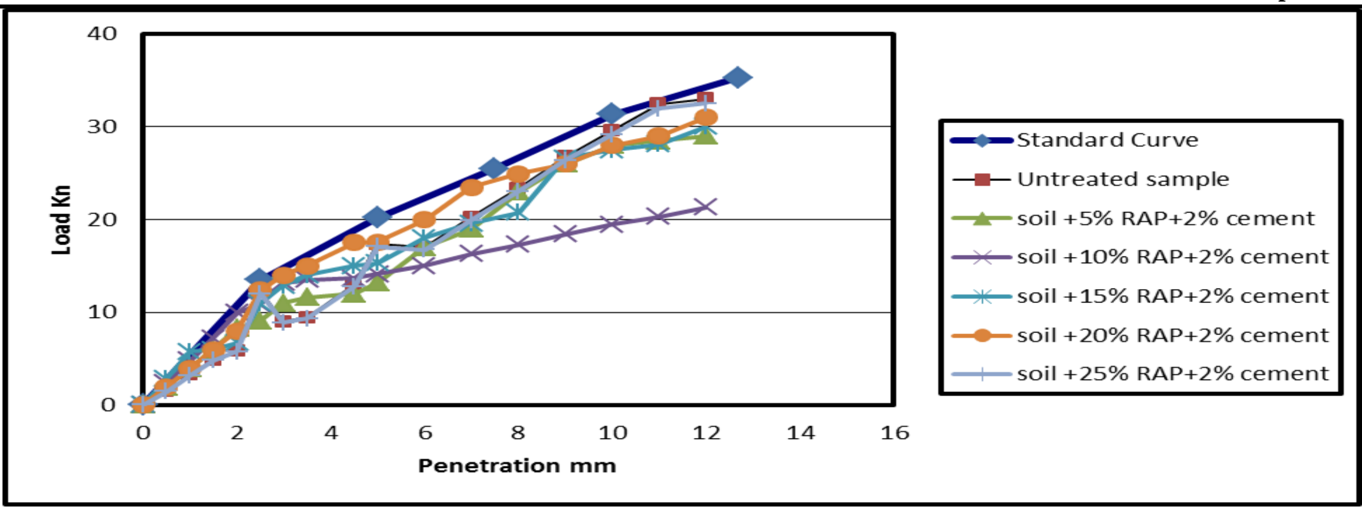

Figure 4 California bearing ratio test result for untreated sample and mixtures

Table 4 shows the calculated CBR results and that this table contains the value of CBR at penetration of 25 mm and also at a penetration value of 50 mm. Also, the table shows the percentage of improvement in the CBR value for the mixtures and there is a variation in the values according to the strength of the interlacing between the soil and Reclaimed Asphalt.

Table 4 calculated of CBR for untreated sample and mixtures.

sample	California bearing ratio (CBR)		Final Result CBR %	% of improvements in CBR ratio
	Penetration 2.5 mm	Penetration 5.0 mm		
Untreated sample	66.7	64.9	66.7	0%
soil +5% RAP+2% cement	67.3	65.4	67.3	0.9%
soil +10% RAP+2% cement	80.7	69.8	80.7	20%
soil +15% RAP+2% cement	81.3	75.8	81.3	21%
soil +20% RAP+2% cement	91.7	87.2	91.7	37%
soil +25% RAP+2% cement	90.3	85.9	90.3	35%

CONCLOSION

From the results of the tests used in this research, there are many points that can be summarized as follows:

- The use of recycled materials saves energy and preserves the natural resources of the materials used in the construction of asphalt roads
- Improved properties of soils containing recycled asphalt and a percentage of cement are evidence of the possibility of using these materials with base course layer for asphalt roads.
- The results promise the possibility of expanding the process of recycling full depth of the roads surface layers, base layer, and using them after their recycling and compacting as a new base layer for asphalt roads in what is known as the technology full depth recycling (FDR).

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