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USING THE MATS OF PALM FRONDS IN REINFORCEMENT PAVEMENT LAYERS

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Abstract

Pavement distresses are among the major problems that affects to a decisive extent on the using (operational capacity) the roads and reducing their service life. Therefore, its require to limitation this distresses and knowing the reasons that lead to appearing this distresses and give the correction during the construction of roads. The major distresses is the rutting which increases at intersections and the check points when the vehicle is stopping. The reinforcement pavement layer became an important step of design and the reconstruction of pavement layers which is control of almost distress, reduce the maintenance cost, and provide long service life of roads. In this study will study using the mats of palm fronds in reinforcement pavement layers instead industrial materials due to existence the palms with large quantity in Iraq. The result display the using the mats of palms fronds reduce the rutting percent 96.7, 88.3, 83.3 at 40, 50, 60 ºC respectively at surface course according the test by wheel track machine.

Keywords:

Reinforced;
Rutting depth;
Improvement ratio;
Flexible pavement.

1 Introduction

Pavement distresses are among the major problem that affects effectively on the using the roads and reduce the service life of roads. Therefore, its require to limitation this distresses and knowing the reasons that lead to appearing this distresses and give the correction during the construction of roads. Poor materials, high temperatures, high traffic load, stopping vehicles and the construction methods lead to these stresses. The major distresses is the rutting depth which define as the bulges that occur in surface layers of road and appear as long channel at vehicle track. The rutting depth is increases at intersections and the check points when the vehicle is stopping. The major reason of rutting is tension force applied on the road by amount exceed the cohesive force. [1].

On the other hand, the rutting causes deterioration of pavement structure due to the penetration of water accumulated in the groove [2]. In order to long service life, decreasing common frustration, and perfection the pavement performance, the reinforcement pavement became a strong part of designing and maintenance of pavement layers [3].

Weather and traffic conditions including traffic densities, heavy loads, slow-moving traffic and high temperatures greatly affected on rutting depth [4]. The rutting can occur easily based on temperature and time superposition principles in highways with long and/or steep section [5].

Recent climate change in Iraq is a result of global warming caused by increased human activities to burn more fuel, which has led to an increased concentration of gases. This change caused a negative impact on the climate of Iraq, leading to...higher temperatures and less rainfall, as the temperature exceeded 52 degrees Celsius in the shade, while the surface temperature of the pavement exceeded 60 degrees Celsius in the month of July [6].

In Iraq roads, the rutting depth is appear at a short time after the construction, may be less than one year due to the high loads of loaded trucks, hot weather most days of the year, especially from the fifth month to the tenth month from every year [7]. The poor quality control can increase the rutting susceptibility [8], Fig. 1 shows the roads in Basra city that appearing the depth of rutting clearly.

Fig. 1: Rutting in intersection approach.

In Iraq, reinforcement pavement technology was not used due to the high cost of industrial materials and the environmental pollution therefor in this study, the principle aim that will study using the mats of palm fronds in reinforcement pavement layers.

2 Last studies

Saad [9] concluded that the steel mesh reinforcements will increase the life of road between (50-90) % and decrease the maximum lateral stress about 15%, due to the traffic load and 20% to change the temperature from 22 ºC to 51 ºC.

Cagliari University states the steel mesh reinforcements increase the service life of pavement by a factor with range (3-12), while Palermo University conclude the rutting depth decrease by 50% [10].

Jasim [11] studied the effect of using the steel grids in surface mixtures at different positions, he concluded the steel grid reduce the rutting depth and largest decrease that occur when steel mesh at bottom, but when increasing the test temperature, the cycle number of load reduce. Cycle number reduce to 67.3% when temperature change 30c to 45 while reduce 58.7% when temperature change 45º c to 60 ºC.

Sa'adi et al., [12] Tested seven of road sections with geotextile reinforcement at different positions and compared with unenforced section under cycle number 10000. they found the rutting depth is decreasing about 96% when using three geotextile (above subbase, base and binder), and 52% when using one geotextile (above binder).

Ahmed et al., [13] Used the reed mats in different positions, and stated the maximum improvement ratio occurs when using two mats which located at the middle and the bottom of the wearing layer.

Fayissa et al., [14] studied the effect of using sawdust ash as a filler in the asphalt mixture on permanent deformation by dynamic creep and static creep tests. They used different proportions of sawdust ash (3%, 6%, 9%, and 12%), they found that sawdust ash works to reduce permanent deformation, and that the best ratio is 12%, which covers the least amount of deformation.

Darling and Wolstencroft (2000) [15] evaluated the performance of glass grids of reducing reflective cracking by monitoring two test sites. Both evaluation Sites, which were originally built by flexible and composite full depth The piers showed severe transverse and longitudinal cracking.

Darling and Wolstencroft (2004) [16] reported that glass fibre mesh can be used for spot pavement repairs (reinforcement Concrete joints, crack repair) or to cover the full width of the entire sidewalk. They can be used in all climates (cold, temperate, and hot climates) and geographical areas regions, performance is equally good in desert conditions and in near-Arctic regions It is subject to extreme cold and seasonal temperature fluctuations.

Lee [17] in 2008 found that the open mesh structure of glass fibre reinforces through-hole Bearing capacity and allows more pressure to be transferred to the network through Interlocking aggregate for asphalt layers.

3 Materials

3.1 Asphalt cement

We brought the asphalt from Al- Basra refinery and Table 1 shows the physical properties for it.

Table 1: Physical properties of asphalt cement.

Test	Units	ASTM [10]	Test value	SCRB/ R9 Specification 2004 [4]
Penetration	1/10 mm	D-5	43	40-50
Softening Point	ºC	D-36	58	51-62
Specific Gravity	------	D-70	1.02	1.01-1.05
Ductility	cm	D-113	>100	>100
Flash Point	ºC	D-92	330	>232

3.2 Aggregate

Coarse aggregate, fine aggregate, river sand, and crashed sand, were brought from Dairet plant Table 2 shows the physical properties of these materials.

Table 2: Physical properties of aggregate.

No.	Test	ASTM [10]	Test value
Coarse aggregate			
1	Bulk Specific Gravity	C-127	2.54
2	Apparent Specific Gravity	C-127	2.60
3	Percent Water Absorption	C-127	0.7
Fine aggregate			
1	Bulk Specific Gravity	C-128	2.63
2	Apparent Specific Gravity	C-128	2.69
3	Percent Water Absorption	C-128	0.71

3.4 Aggregate gradation

Coarse and fine aggregates are screened and separated into different sizes. The trial and error method was used to find the ratios of aggregate and cement and calculate the mixing equation limits, as well as the mixture equation ratios for the surface course, as shown in Table 3, which conforms to the Iraqi specification limits (SCRB, R/9 2004) [18].

3.5 Optimum asphalt content

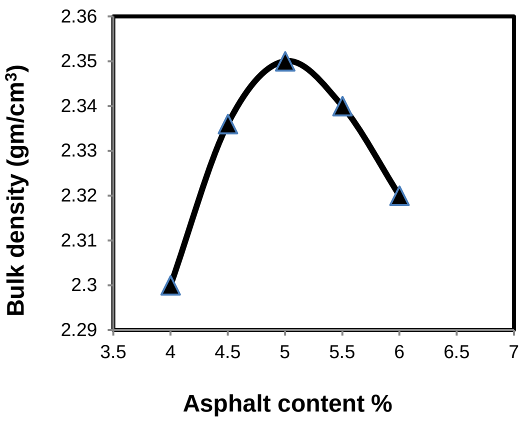
In order to determine the Optimum asphalt content has been used Marshall Test according to ASTM (D 1559) [19]. Table 4 shows the Marshall test, the optimum asphalt content equal 5% which satisfied the Iraq specification (SCRB, R/9 2004) See Fig. 2.

Table 3: Aggregate gradation.

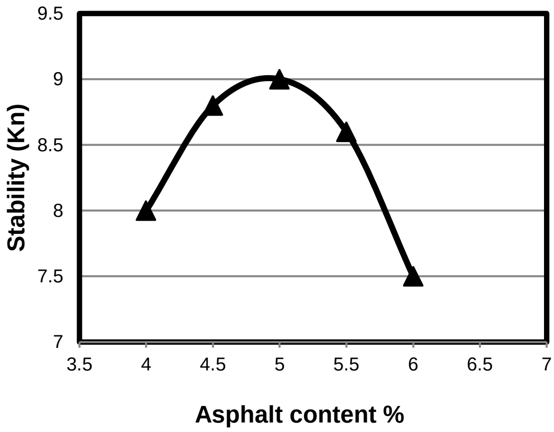
Sieve size (mm)	Course Aggregate %	Medium Aggregate %	Fine Aggregate %	Crushe dsand %	River Sand %	Cement %	The mixture Equation Ratios	The Mixture Equation Limits	Iraq Specific ation Limits
19	100	100	100	100	100	100	100	100	100
12.5	38	100	100	100	100	100	94	90-100	90-100
9.5	------	42	100	100	98	100	81	76-87	76-90
4.75	------	------	19	100	95	100	54	46-60	44-74
2.36	------	------	------	93	85	100	46	42-50	28-58
0.3	------	------	------	18	5	100	11	7-15	5-21
0.075	------	------	------	1	------	95	5	4-7	4-10
Mix ratio	10	15	25	30	15	5	------	------	-------

Table 4: The result of Marshall test.

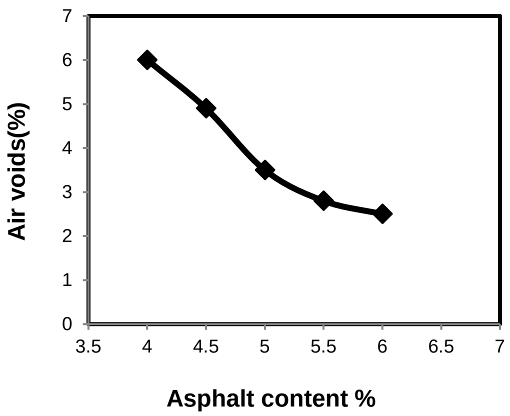
Asphalt %	Density gm/cm^3	Stability kN	Flow mm	Air voids%
4	2.30	8.0	1.5	6.0
4.5	2.335	8.7	2.2	5.0
5	2.35	9.0	2.8	3.0
5.5	2.34	8.5	3.5	2.5
6.0	2.315	7.5	5.0	2.0



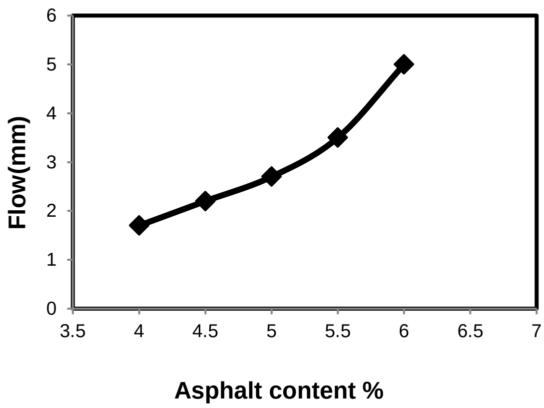
a) The relationship between asphalt content and bulk density.



b) The relationship between asphalt content and stability.



c) The relationship between asphalt content and air voids.



d) The relationship between asphalt content and flow.

Fig. 2: Marshal curves results.

3.3 Palm fronds netting reinforcement

Iraq is distinguished by its abundance of palm trees, with an estimated number of 22 million palm trees in 2023, according to statistics from the Iraqi Ministry of Agriculture [20]. Fig. 3 representing one of the palm groves in Iraq one of the parts of the palm tree is fronds, as each palm tree produces approximately ten fronds per year. The frond consists of leaves, thorns, and a stem. All parts of the frond are used in many handicrafts and woodworking, see Fig. 4.

The palm fronds are used in this study as reinforcement material, which manufactured as rectangle netting as shown as in Fig. 5. The physical properties of palm fronds netting and tension test can be seen in Table 5.

Fig. 3: One of the palm groves in Iraq.

Fig. 4 Frond of palm.

Fig. 5: Palm fronds mat netting.

Table 5: Palm fronds mat netting properties.

Property	Test method	Unit	Data
Dimensions	-------	mm*mm	290*390
Thickness	-------	mm	25
Mass per unit area	-----	gm/m^2	1350
Color	-----	-----	yallo
Tension Test (load-deformation)	Tensile Testing Machine	(kN – mm)	21-35

4 Experimental work

The steps can be summarized into:

Step one: According to optimum asphalt content (5%) which found in the Marshall test the asphalt mixes prepared.

Step two: The asphalt mixture was put in the steel mold manufactured with dimensions (30 cm width *40 cm length *8 height).

Step three: The hand wheel roller has been manufactured in a local workshop is designed to simulate steel roller which is usually used in the field of compaction, it consist of cylinder weigh 40 kg,180 diameter, and 200 mm length.

Step four: We prepared three unreinforced specimen for each temperature 40,50, and 60.: To reach the density same as Marshall density hand wheel roller has been passed over the specimen 100 times.

Step five: Palm fronds mat netting. Placed at the bottom of the steel mold, then asphalt mixture was put above it and hand wheel roller has been passed over the specimen 100 times (reinforced specimen). we prepared three reinforced specimen for each temperature 40,50, and 60.

Step six: The wheel tracking device was used to study the permanent deformation phenomena for both reinforced and unreinforced asphalt samples. A wheel tracking machine has been used because it has the ability to apply repeated loads in order to simulate the permanent deformation that occurs under the load of traffic The loaded wheel applies about 700 ± 10 N of load, passes repetitively over the sample for up to 10,000 cycles at contact points of sample. Fig. 6 shows the experimental work.

Fig. 6: Experimental work.

5 Results

Fig. 7 show the relationship between cycle load number and rutting depth at 40 ºC. it can seen the rutting depth increase with increasing in cycle load. But this increasing is decreasing at reinforced specimen largely and the improvement ratio at 10000 cycle load equal to 96.7%.

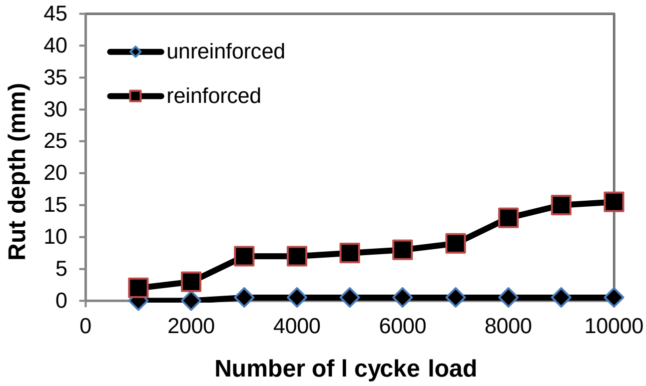


Fig. 7: The relationship between cycle load number and rutting depth at 40 ºC.

a) Unreinforced. b) Reinforced.

Fig. 8: Wheel tracking result for asphalt mix with and without additives at 40 °C.

At 50 ºC the rutting depth continue increasing with increasing cycle load largely in unreinforced specimen until reaching to 30 mm at 10000 cycle load, while in reinforced specimen this increasing is very small which reaching to 3.5 mm at 10000 cycle load and the improvement ratio equal to 88.3%. See Fig. 9.

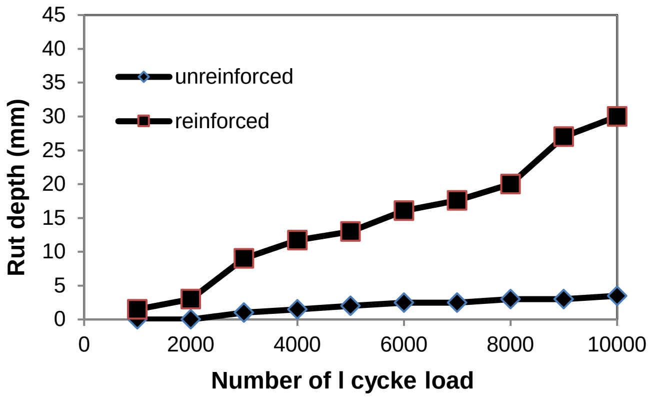


Fig. 9: The relationship between cycle load number and rutting depth at 50 ºC.

a) Unreinforced. b) Reinforced.

Fig. 10: Wheel tracking result of reinforced and unreinforced specimen at 50 ºC.

Reinforced specimen still control the rutting depth at 60 ºc, In spite of, the value is greater than at 40 ºC and 50 ºC which can be shown in Fig. 11. The improvement ratio equal to 83.3%.

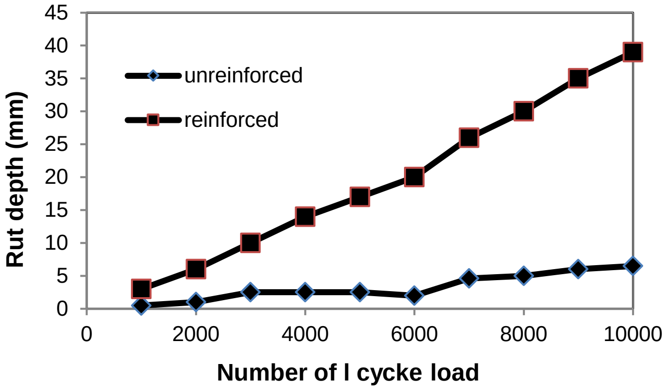


Fig. 11: The relationship between cycle load number and rutting depth at 60 ºC.

a) Unreinforced. b) Reinforced.

Fig. 12: Wheel tracking result of reinforced and unreinforced specimen at 60 ºC.

Table 6 showing the effect of temperature on rutting depth which indicate the rutting depth increasing with increasing temperature, but the reinforced with the mats of palm fronds control this increasing at small value.

Table 6: Rutting depth at different temperature.

Temperature test °C	Test method		Improvement ratio %
	Reinforced	Unreinforced	
40	15.5	0.5	96.7
50	30	3.5	88.3
60	39	6.5	83.3

6 Conclusion

We could be summarized the concluding in this study as the:

1) The stability, density, air void percent for the using asphalt mixture equal to 9 kN, 2.35 gm/cm^3, 3% respectively.

2) The using the mat of palm fronds is considered one of the best alternatives due to its low economic cost and being a renewable material.

3) The reinforce layer improved the performance of flexible pavement which result to control the rutting depth about 96.7%.

4) The rutting depth is greatly affected by increase the degree of temperatures which reach 39 mm at 60 ºC, however, this effect is reduced about 83.3 if a palm mat mash is used.

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