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Angle of Friction In Reinforced Earth

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Abstract

The present work took care of the frictional resistance developed between the fill material and mats used as soil reinforcement which are made of locally natural materials. These natural materials are locally available plant organs, which are cheap and abundant, and is expected to result in lower construction cost.
The angle of friction is 0.77Φ between these plant mats and the sand, where Φ is the angle of internal friction of sand. The asphalt bitumen used as a protection coat against moisture and destructive organs, was found to result also in increasing the angle of friction between these mats and the sand to 0.88Φ .

قياس زاوية الاحتكاك للتربة المسلحة

الخلاصة

يتناول هذا البحث قياس مقاومة الاحتكاك المتولدة بين تربة الأملائيات و حصيرة التسليح المصنوعة من الأعضاء النباتية المحلية ، و التي تمتاز بتوفرها و انخفاض كلفتها مما يؤدي إلى تقليل كلف الإنشاء . تشير النتائج المستحصلة إلى أن زاوية الاحتكاك بين التربة الرملية المستخدمة للإملائيات و الحصائر النباتية δ هي0.77Φ
حيث Φ هي زاوية الاحتكاك الداخلي للتربة الرملية . كما تم التوصل إلى انه في حالة استخدام الطلاء الإسفلتي
لحماية هذه الحصائر من تأثير الرطوبة و الأحياء المجهرية الضارة يؤدي إلى زيادة زاوية الاحتكاك بين التربة والحصيرة δ لتصل إلى Φ 0.88 .

Introduction

The principle of reinforced earth is based on the development of friction between the fill material and the reinforcement materials. As there is a trend to expand the use of the reinforced earth concept through using locally available materials. A new direction is appearing towards using some natural plant organs as reinforcement (palm leaves, reed mats and pomegranate

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sticks) . This paper illustrates the mobilization of frictional resistance of some natural materials intended to be used as soil reinforcement, and to consider the parameters affecting friction development in such cases.

Testing Program

a. Materials:

The test program includes the use of three types of natural materials as soil reinforcement (date palm leaves, reed mats and pomegranate sticks), each material was considered in two conditions; either asphalt coated or uncoated.

For palm leaves and reed: test specimens were prepared by cutting 59*59 mm squares from the standard produced mats, while for the pomegranate the specimens were prepared by splitting the sticks into halves and weaving them with an aperture of 0.4 m to obtain a final small square specimen mat of 59*59mm . For reed specimens, two positions were considered, one for each side of the mat (i.e. face and back) to take into account the difference in surface texture for the two sides.

Two sets of specimens were prepared; the first was without any asphalt coat, and the second was coated with a thin layer of asphalt and through immersing the obtained specimens in a molten asphalt. The asphalt used for coating was of grade (40-50).

The moisture contents for the specimens of each material at room temperature as follows:

date- palm leaves mat	7.9%
Reed mat	4.3%
Pomegranate sticks mat	6.2%

The soil considered throughout this work was sand and in its three different states: dense, medium and loose. The sand was brought from Dijlah river bank and has the grain size distribution shown in Fig. (1)

b. Tests:

The coefficient of friction between the reinforcement material and sand was determined through using the direct shear testing machine at a rate of 0.6 mm/min as shown in Fig.(2) . A modification for the shear box was required to accomplish this work . The lower part of the shear box was packed with a wooden square block (59* 59 mm) which replaced the sand and the reinforcement material was glued on the top of this wooden block which then makes the upper face of the lower part at the predetermined shear plane. The upper part of the box is filled with sand at the various anticipated densities

Results:

The results obtained are illustrated in tables (1 and2) and in Figure(3)and(4) which express the relationship between the angle of friction of the different reinforcement materials and the angle of internal friction of the soil .There , Φ: is the angle of internal friction of the soil , δ: is the angle of internal friction between sand and the different reinforcement materials , and Ef: relative efficiency of material which is defined by :tan δ / tan Φ. The angle (Φ) is found to be directly related to the relative density and so is complying with Das(1983) .

Conclusions:

1-The angle of friction developed between reinforcement mats made of natural materials and the adjacent sand is directly related to the angle of frictional resistance of the sand itself.

2-The frictional resistance between the sand and the bitumen coated reinforcement materials is larger than that for the uncoated reinforcement materials and this can be attributed to the adhesion of sand particles on the bitumen coated surface and by so transferring the shear plane from sand- reinforcement interface to be within the sand itself.

3-The relative efficiency values for uncoated reinforcement materials ranged from 0.51 to 0.79 while for coated reinforcement ranged from 0.7 to 0.97.

4-Increasing soil- density increased frictional resistance between soil and reinforcement and this is attributed to the increased contact points and soil

1- dilation .

5-The relationship between the angle of friction of sand – reinforcement interface (δ) and that for sand (Φ) depends on the reinforcement surface texture . For reed mat , the results show that a higher value of angle of friction for the soil-reinforcement for mat on the back side than those on the smooth face side .

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Notations:

Ef: relative efficiency of material ($\tan\delta/\tan\Phi$).

δ : angle of frictional resistance between soil and reinforcement.

Φ: angle of frictional resistance of sand.

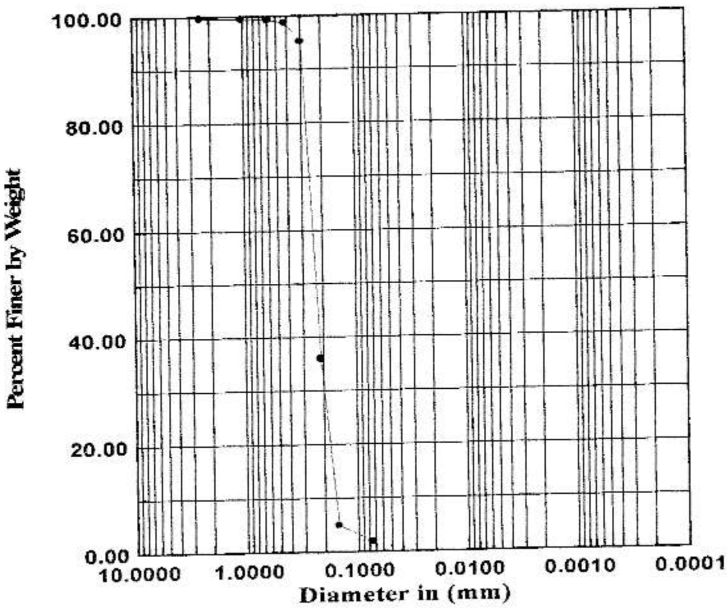


Fig.(1) Grain Size Distribution of The Soil Used

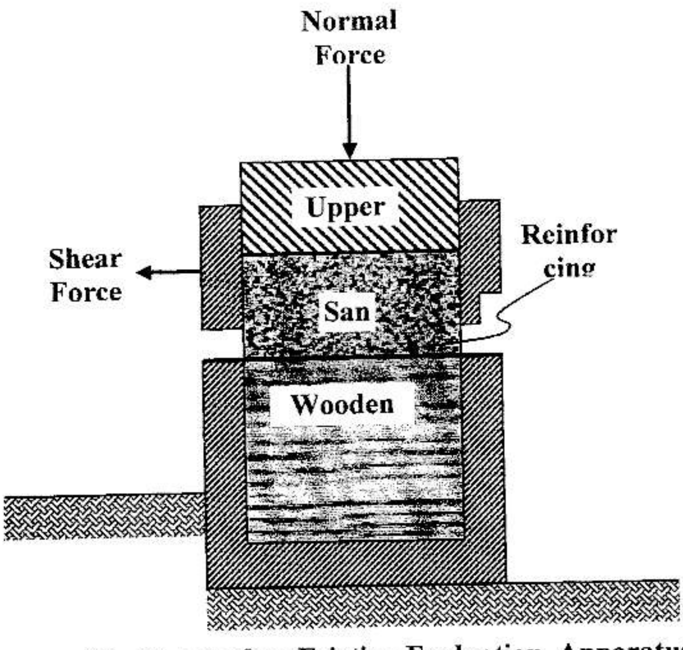


Fig.(2) Interface Friction Evaluation Apparatus

Table(1) Summary of angle of friction for soil- reinforcement interfaces

Reinforcement Type			Soil		
			Dense $\Phi=47°$	Medium $\Phi=44°$	Loose $\Phi=37°$
Uncoated Palm – Leaves mat		δ Ef	39° 0.76	36° 0.75	21° 0.51
Uncoated Reed mat	Face	δ Ef	36° 0.68	30° 0.73	28° 0.71
	Back	δ Ef	38° 0.73	35° 0.72	28° 0.71
Uncoated Pomegranate sticks		δ Ef	40° 0.78	37.5° 0.79	26.5° 0.66
Coated Palm – Leaves mat		δ Ef	44° 0.9	43° 0.966	33° 0.86
Coated Reed mat	Face	δ Ef	40° 0.78	34° 0.70	30° 0.77
	Back	δ Ef	43° 0.87	39° 0.84	29° 0.74
Coated Pomegranate sticks		δ Ef	44° 0.90	39° 0.84	34° 0.895

Table(2) The relationship between angle of friction of different reinforcement materials

Reinforcement materials		Uncoated	Coated
Palm leaves mat		$\delta = 0.76\Phi$	$\delta = 0.94\Phi$
Reed mat	Face	$\delta = 0.73\Phi$	$\delta = 0.81\Phi$
	Back	$\delta = 0.79\Phi$	$\delta = 0.87\Phi$
Pomegranate sticks mat		$\delta = 0.82\Phi$	$\delta = 0.9\ \Phi$

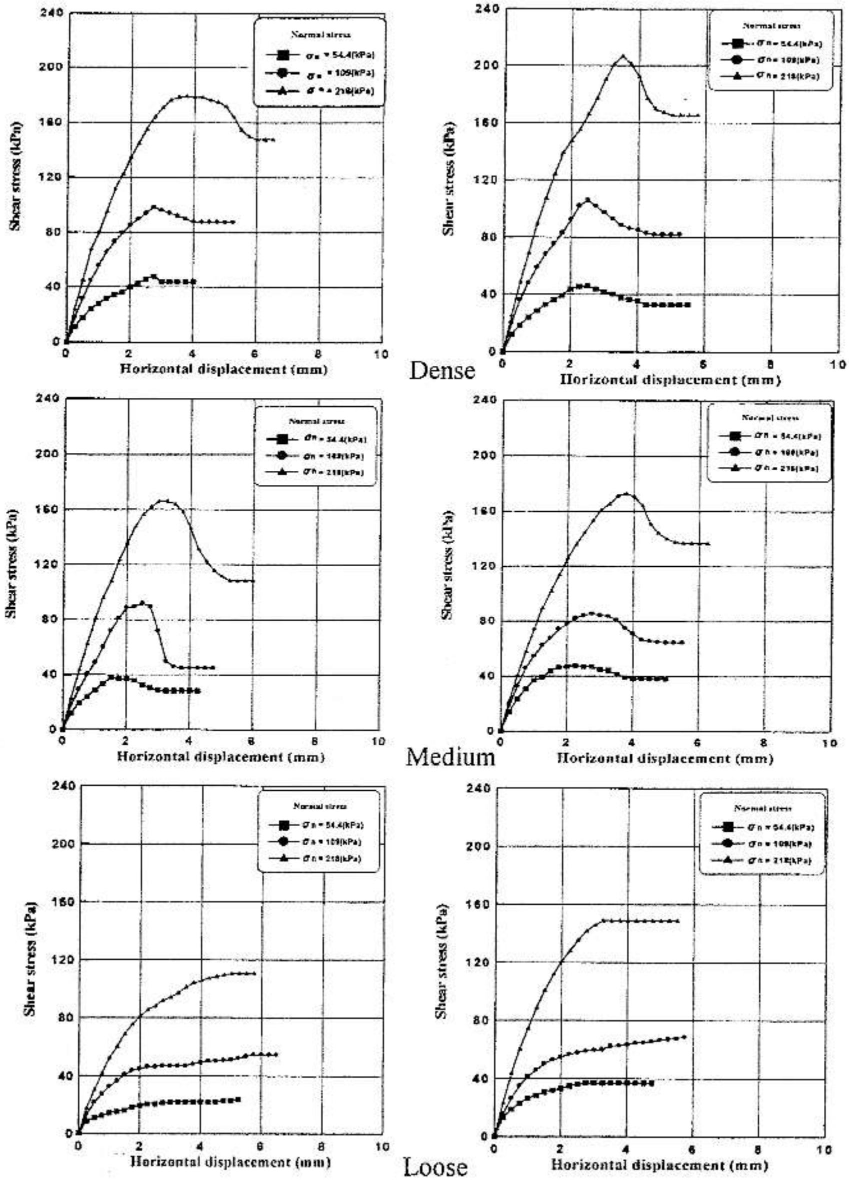
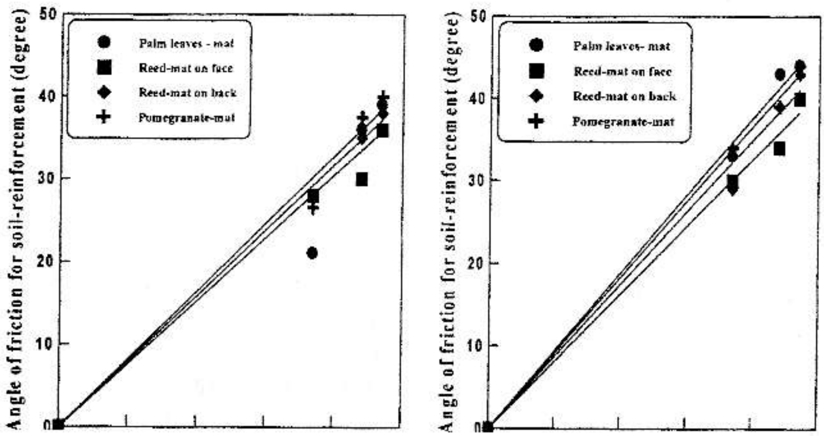


Fig.(3) Direct shear test results for pomegranate sticks mat



uncoat   coat

Fig.(4) Relationship between angle of internal friction for soil-soil and soil-reinforcement