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STABILIZATION OF DUNE SAND WITH WASTE PLASTIC BOTTLE SQUARE PIECES AS ADMIXTURE

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Abstract— **Rajasthan is area wise the largest state of India. Western part of Rajasthan is covered by windblown sand, popularly known as Fine sand or Dune sand. As per Indian Standards Classification system of soil, fine sand with no cohesion and no resistance to deformation under loading and low strength property. Dune sand can be stabilized by mechanical means economically changing its gradation. Earlier attempts have been made for fine sand stabilization with molasses, lime, cement and marble powder etc. Present work has been taken by addition of 5mmx5mm square size of waste plastic bottle. Varying percentage 0.05, 0.06, 0.7, 0.8, 0.9, 1 and 5mmx5mm square size of waste plastic bottle were mixed with sand. Density, California Bearing Ratio Values and Permeability properties of sand with composite material were observed experimentally. On the Basis of these experiments, conclusions have been drawn on strength characteristics of stabilized sand, CBR values of composite material for use in sub base layer flexible pavement.CBR, Direct shear test values increases with increase in plastic strips mix composition with increase in percentage mixed to sand and Permeability decreases.**

Keywords— **California Bearing Ratio, Maximum Dry Density, Unsoaked**

I. INTRODUCTION

Soil Stabilization is a combination of process like compaction, preconsolidation, drainage etc which alters the soil material itself for the improvement of its properties. It is required when the foundation soil available for construction is not suitable for the intended purpose. The principles of soil stabilization are used for controlling the grading of soils and aggregates in the construction of bases and sub bases of the highways and airfields.

II. SCOPE OF PRESENT WORK:

The main aim of present work is to develop a mix composition which can be economically used for stabilization of dune sand in any type of drying environment and sub base layer of flexible pavement. The investigation presents the findings of laboratory studies in stabilization of dune sand using square pieces of waste water bottles, composite mix with varying percentage of pieces that is 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1% by weight of sand were prepared. Varying percentages by weight of these pieces were mixed with dune sand in decreasing order. Dry bulk density of dune sand with varying of percentage water added 2%, 4%, 8%, 10%, 12%, 14%, 16%, 18% and 20% were observed by Procter Test.
Various curve were plotted between maximum dry density and water content to work out optimum moisture content as 1.66gm/cm the percentage of moisture content added to each sample 1.66gm/cc, 5kg of sand, 12.5 gm of plastic bottle square pieces and 900ml of water was thoroughly mixed initially. Composite mix thus prepared was placed in mould and was compacted in three layers. C.B.R values of specimen thus prepared were observed for Unsoaked and soaked for 24 hours condition. Similar samples were prepared by varying percentage of plastic bottle square pieces of size 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1%.Test programme conducted as above & results have been tabulated and represented graphically also. On the bases of above experimental results & curves it has been observed that loose dune sand transform after stabilization into a strength rigid mass. Various Conclusions based on above analysis of test results has been drawn.

III. SCOPE AND OBJECTIVE:

It is proposed to evaluate stabilizing effect and use in flexible pavements of waste plastic bottle square pieces with dune sand. The present study has been undertaken with following objectives.

1. To study the changes in CBR Values of dune sand by mixing plastic bottle square pieces of varying percentage in different proportions in soaked and Unsoaked conditions.
2. To study the changes in permeability of dune sand by mixing with plastic bottle square pieces of varying percentage in different proportions.
3. To study the changes in shear stress of dune sand mixing with plastic bottle square pieces of varying percentage in different proportions.

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A. Material And Their Properties:

The soil used in present study was dune sand taken from village Osian. It is fine grained, uniform clean as per unified soil classification system. Particle size ranges between 75µ to 4.75mm. Dune sand has very little to nil plasticity that is cohessionless and drainage fair good with coefficient of permeability ranging between 10-4 mm/sec to 10-2 mm/sec. The admixture used in present study was Polyethylene terephthalate,

B. Test Programme:

The test programme included the preliminary tests for dune sand and mix composition of dune sand with plastic bottle square pieces. Following tests were carried out:

1. Light compaction test (Standard Procter Test) for determining maximum dry density and optimum moisture content.
2. Permeability by variable head test of dune sand and mix composition with plastic bottle square pieces.
3. CBR tests to determine CBR Values for dune sand and mix composition with plastic bottle square pieces.
4. Direct shear test to determine shear stress of dune sand and mix composition with plastic bottle square pieces.

Variables investigated and mix compositions used have been given in following table

S.No	Effect of	Variables	Range Investigated
1.	Curing environment C.B.R value.	Type of curing	Soaked/Unsoaked
2.	Plastic bottle square pieces on different properties of sand	Strip Size	5mmx5mm
3.	Mix plastic bottle square pieces by Wt of sand	Proportion Percentage	0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1%
4.	MDD and proctor density	Water Content	6.32%, 10.68%, 12.55%

IV. RESULTS AND DISCUSSIONS:

The tests were performed to investigate the behavior of waste plastic bottle square pieces with varying percentages mixed with dune sand in terms of Proctor's density, California Bearing Ratio, Coefficient of Permeability and Shear Strength Parameters.

A. Standard Proctor Test:

Standard Proctor Test as per IS: 2720 (part VII) performed on dune sand, in varying percentage have shown that with the addition of water. The maximum dry density is at water added 18% is 1.67gm/cc. For the tests procedure we use three dry density respectively 1.67gm/cc, 1.61gm/cc and 1.55gm/cc at varying percentage of waste plastic bottle square pieces.

Dry Density Variation with Water Content

S.No	% Water Added (By Weight)	Water Content (%)	Dry Density (gm/cc)
1.	2%	2.52	1.565
2.	4%	4.15	1.544
3.	6%	6.32	1.547
4.	8%	7.87	1.589
5.	10%	8.59	1.597
6.	12%	9.63	1.606
7.	14%	10.68	1.610
8.	16%	11.66	1.658
9.	18%	12.55	1.670
10.	20%	13.04	1.642

B. California Bearing Ratio (C.B.R) Test:

Variation in C.B.R values have been graphically represented for soaked and unsoaked conditions. On the graph, at abscissa (x-axis) waste plastic percentage of sand varying from 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1% at interval of 0.25% has been marked and on ordinate (y-axis). C.B.R values have been plotted for mix composition of waste plastic bottle square pieces.

Table: C.B.R for 0.05 admixture at MDD 1.67gm/cc Unsoaked (CA1)

S.No	Penetration (mm)	Dial Reading	Actual Load (Kg)	C.B.R Value
1	0	0	0	
2	0.5	2	9.8	
3	1.0	4	19.6	
4	1.5	7	34.3	
5	2.0	10	49	
6	2.5	12	58.8	4.29
7	3.0	15	73.5	
8	3.5	17	83.3	
9	4.0	19	93.1	
10	4.5	22	107.8	
11	5.0	23	112.7	5.48
12	6.0	23	112.7	
13	7.0	22	107.8	

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Test result obtained for Soaked and Unsoaked condition have been tabulated and plotted on variation curve show that C.B.R value at 0.05% mix composition for density 1.67gm/cc is 5.48 and for the same 0.05% mix composition for density 1.61gm/cc C.B.R value obtained is 5.09 and for the same 0.05% mix composition for density 1.55gm/cc C.B.R value obtained is 4.46. This show that with increase in water content for various density 1.55gm/cc, 1.61gm/cc and 1.67gm/cc. C.B.R value varying increase at same percentage of all mix composition from 0.05%,0.06%, 0.7%,0.8%,0.9% and 1%.

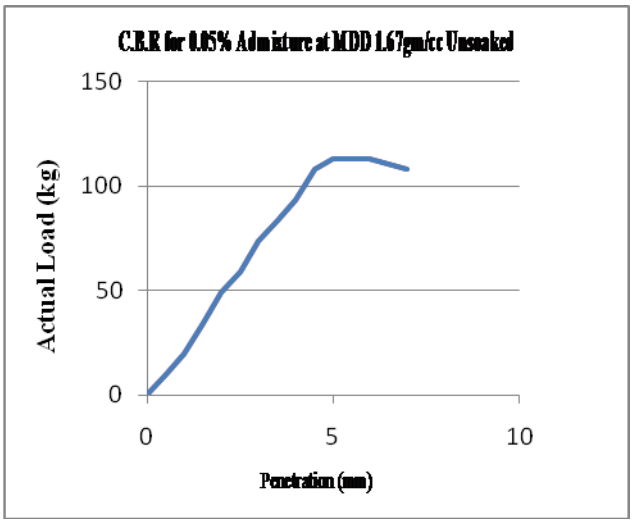

Figure shows 0.05% admixture by wt that is 2.5gm + dune sand 5kg at MDD 1.67gm/cc Unsoaked (CA1)

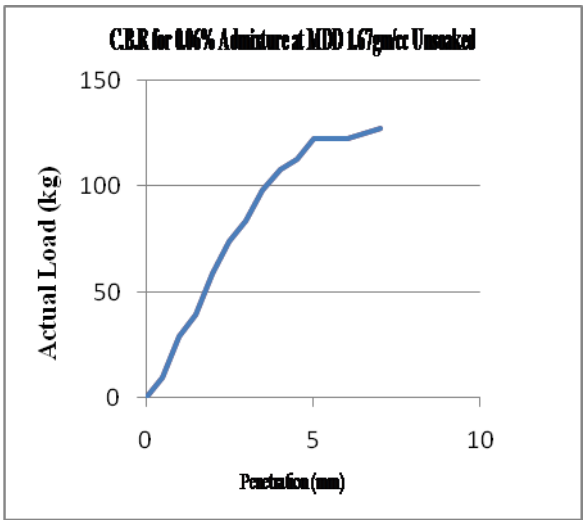

Figure shows 0.06% admixture by wt that is 3 gm + Dune sand 5kg at MDD 1.67gm/cc Unsoaked (CA2)

Similarly various tables and graphs have been plotted

Table: C.B.R for 0.05 admixture at MDD 1.67gm/cc Soaked (CD1)

S.No	Penetration (mm)	Dial Reading	Actual Load (Kg)	C.B.R Value
1	0	0	0	
2	0.5	2	4.9	
3	1.0	4	14.7	
4	1.5	7	34.8	
5	2.0	10	44.9	
6	2.5	12	58.6	4.75
7	3.0	15	68.7	
8	3.5	17	73.4	
9	4.0	19	83.5	
10	4.5	22	88.9	
11	5.0	23	93.3	4.78
12	6.0	23	93.4	
13	7.0	22	98	

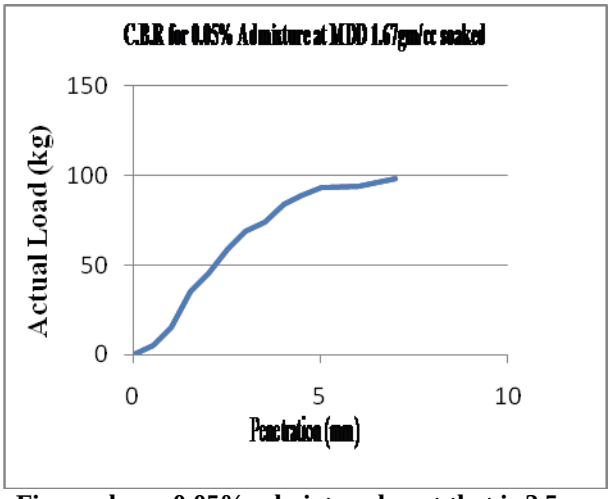

Figure shows 0.05% admixture by wt that is 2.5gm + Dune sand 5kg at MDD 1.67gm/cc soaked (CD1)

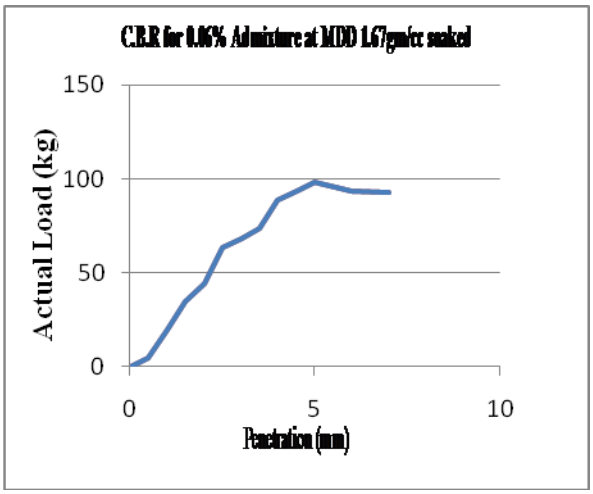

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Figure shows 0.06% admixture by wt that is 3 gm + Dune sand 5kg at MDD 1.67gm/cc soaked (CD2)

Similarly various tables and graphs have been plotted

Variation in % C.B.R with Mixture of Dune Sand and % of Waste Plastic Bottle square pieces in Unsoaked Condition

S.No	Mix Composition	% C.B.R
1.	CA1	5.48
2.	CA2	5.75
3.	CA3	5.32
4.	CA4	5.13
5.	CA5	4.68
6.	CA6	4.12
7.	CB1	5.09
8.	CB2	5.35
9.	CB3	4.89
10.	CB4	4.09
11.	CB5	4.38
12.	CB6	3.75
13.	CC1	4.46
14.	CC2	5.05
15.	CC3	4.45
16.	CC4	4.09
17.	CC5	3.97
18.	CC6	3.75

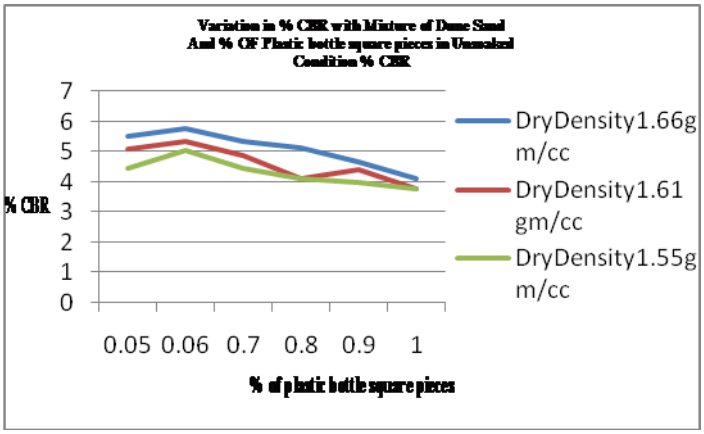

Figure shows variation in % CBR with mix of dune sand and % of plastic bottle square pieces in Unsoaked condition

Similarly variation in C.B.R values for soaked conditions with percentage mix composition as obtained from test result has been graphically presented in following figure and tabulated in following table. The results obtained show that C.B.R value increase with increase in waste plastic bottle square pieces percentage. Also CBR values for same percentage waste plastic bottle square pieces mix composition increase with increase in dry density of sand.

Variation in % C.B.R with Mixture of Dune Sand and % of Waste Plastic Bottle square pieces in soaked Condition

S.No	Mix Composition	% C.B.R
1.	CD1	4.78
2.	CD2	4.78
3.	CD3	4.34
4.	CD4	4.04
5.	CD5	3.78
6.	CD6	3.07
7.	CE1	4.46
8.	CE2	4.46
9.	CE3	3.78
10.	CE4	3.98
11.	CE5	3.45
12.	CE6	2.78
13.	CF1	3.66
14.	CF2	4.45
15.	CF3	3.45
16.	CF4	3.22
17.	CF5	2.72
18.	CF6	2.46

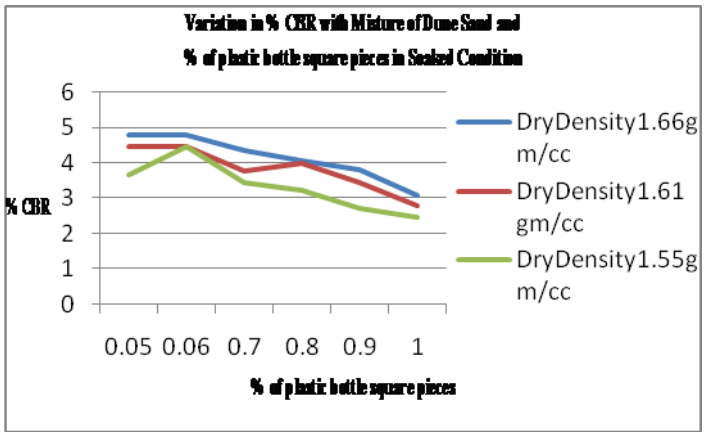

Figure shows variation in % CBR with mix of dune sand and % of plastic bottle square pieces in soaked condition

C. Variable Head Permeability Test:

Various tests were performed on variable head permeameter as per IS 2720 (Part XVII).Mix composition on waste plastic bottle in varying percentage 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1% of sand were tested. Results obtained have been graphically presented in following figure and tabulated in following table.

Mix Composition for Variable Head Permeability Test

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PA1 to PA6 represents **0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1%** plastic bottle square pieces by weight corresponding to **1.5gm, 1.8gm, 21gm, 24gm, 27gm, 30 gm** by Weight plus dune sand 3 kg.

Variation of Coefficient of Permeability with Mix Composition

S.No	Mix Composition	Coefficient of Permeability(k) cm/sec
1.	PA1	2.46 x 10-3
2.	PA2	3.12 x 10-3
3.	PA3	2.41 x 10-3
4.	PA4	2.21 x 10-3
5.	PA5	1.89 x 10-3
6.	PA6	1.79 x 10-3

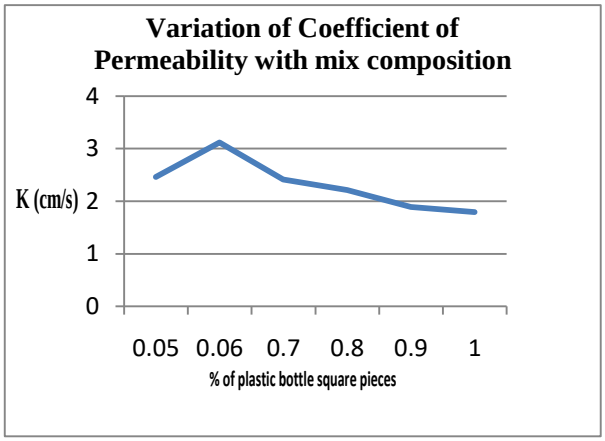

Figure Shows Variation of Coefficient of Permeability with Mix Composition

From results obtained, it can be concluded that coefficient of permeability decreases with increases in percentage of plastic bottle square pieces in mix composition.

D. DIRECT SHEAR TEST:

Variation of failure stress and angle of internal friction Φ of 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1% admixture has been graphically represented in following figure and tabulated in following table.

Shear Stress for 0.05% Admixture at MDD 1.67gm/cc (SA1)

S.No	Norma Load (kg)	Normal Stress (kg/cm2)	Shear Force at Failure		Failure Stress (kg/cm2)	Φ (Degree)
			Division	Force(kg)		
1	5	0.5	55	18.15	0.509	
2	10	1.0	103	33.99	0.944	4303'21"
3	15	1.5	150	49.5	1.376	

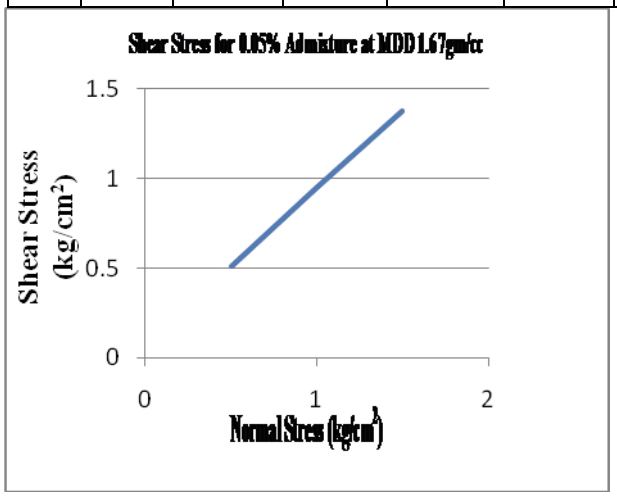

Figure shows 0.05% Admixture by wt that is 0.25gm+ dune sand 500gm at MDD 1.67gm/cc (SA1)

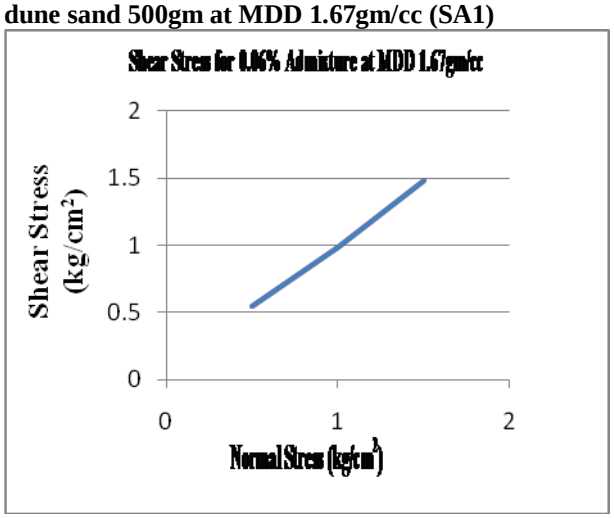

Figure shows 0.06% Admixture by wt that 0.3gm + Dune sand 500gm at MDD 1.67gm/cc (SA2)

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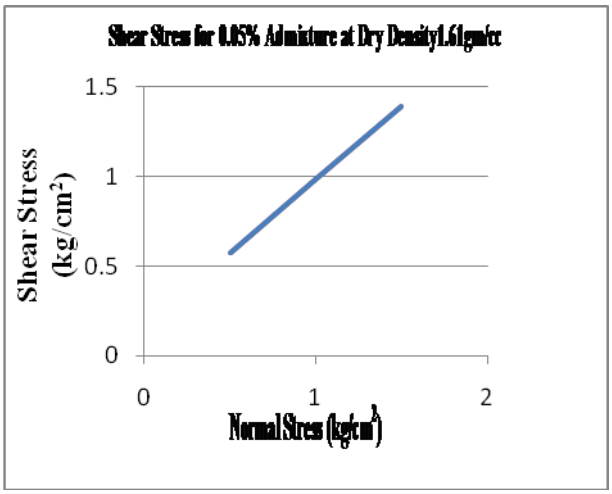

Figure shows 0.05% Admixture by wt that is0.25gm + Dune sand 500gm at DD 1.61gm/cc (SB1)

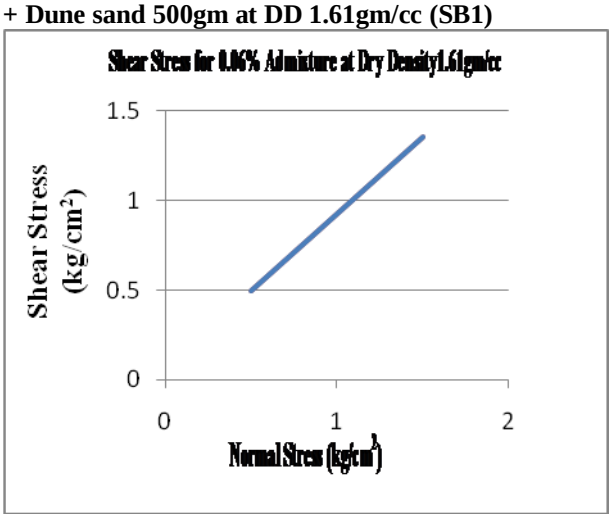

Figure shows 0.06% Admixture by wt that0.3gm + Dune sand 500gm at DD 1.61gm/cc (SB2)

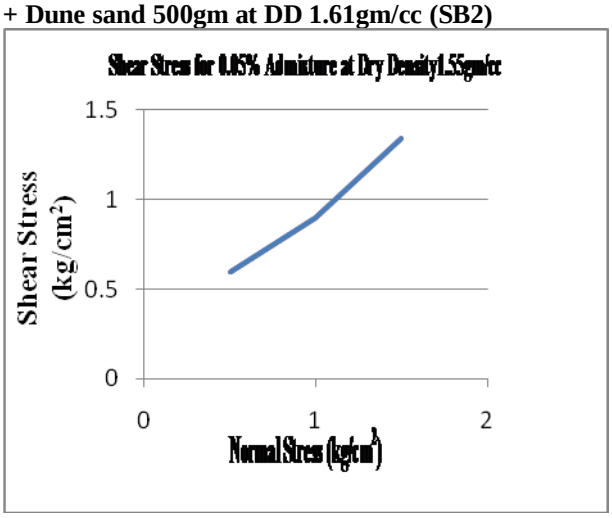

Figure shows 0.05% Admixture by wt that is0.25gm + Dune sand 500gm at DD 1.55gm/cc (SC1)

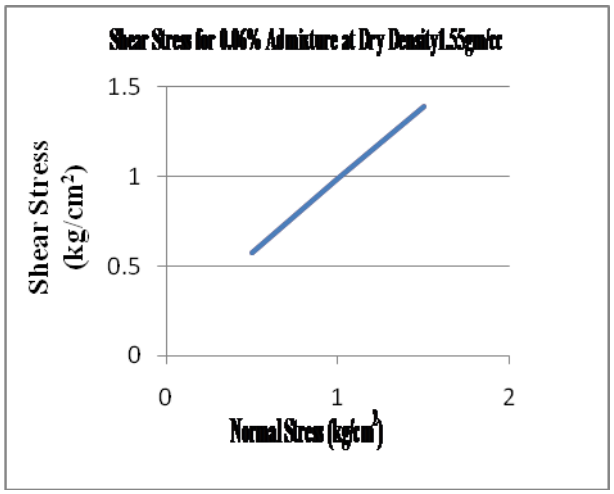

Figure shows 0.06% Admixture by wt that 0.3gm + Dune sand 500gm at DD 1.55gm/cc (SC2)

Similarly various tables and graphs have been plotted

Variation of Shear Stress for Admixture SA1 to SA6 at MDD 1.67 gm/cc

Normal Stress (kg/cm2)	Mix Composition					
	SA1	SA2	SA3	SA4	SA5	SA6
0.5	0.509	0.542	0.525	0.550	0.517	0.555
1.0	0.944	0.983	0.966	1.038	1.002	0.966
1.5	1.376	1.48	1.464	1.526	1.516	1.468

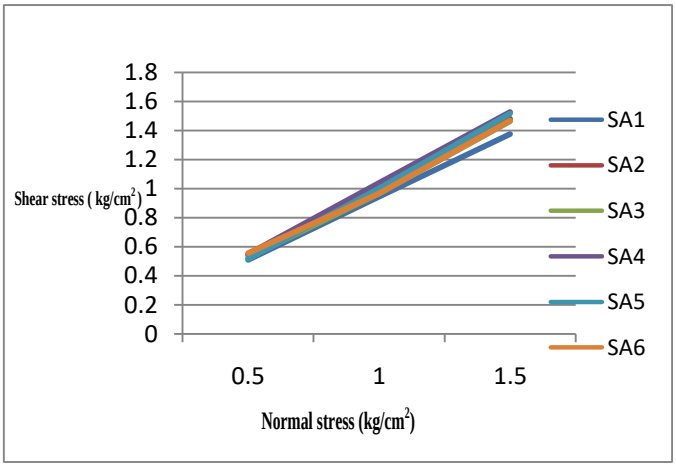

Figure (Graph) Shows Variation of Shear Stress for Admixture SA1 to SA6 at MDD 1.67 gm/cc

Variation of Shear Stress for Admixture SB1 to SB6 at Dry Density 1.61 gm/cc

Normal Stress (kg/cm2)	Mix Composition					
	SB1	SB2	SB3	SB4	SB5	SB6

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0.5	**0.578**	**0.497**	**0.618**	**0.508**	**0.768**	**0.558**
1.0	**0.989**	**0.928**	**1.109**	**0.979**	**0.999**	**1.017**
1.5	**1.394**	**1.353**	**1.510**	**1.434**	**1.478**	**1.476**

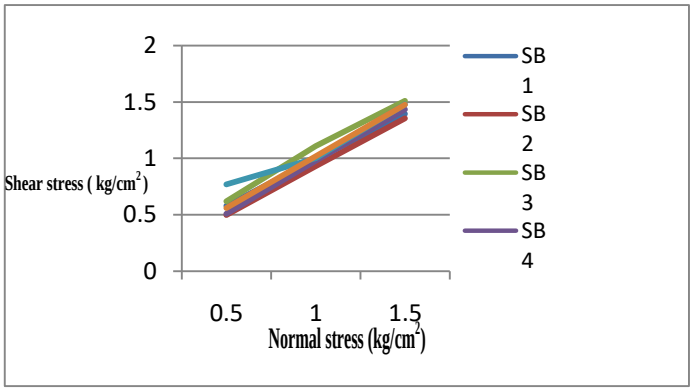

Figure (Graph) Shows Variation of Shear Stress for Admixture SB1 to SB6 at Dry Density 1.61 gm/cc
Variation of Shear Stress for Admixture SC1 to SC6 at Dry Density 1.55 gm/cc

Normal Stress (kg/cm2)	**Mix Composition**					
	SC1	**SC2**	**SC3**	**SC4**	**SC5**	**SC6**
0.5	**0.598**	**0.578**	**0.534**	**0.507**	**0.569**	**0.508**
1.0	**0.900**	**0.989**	**0.955**	**0.965**	**0.985**	**0.943**
1.5	**1.344**	**1.391**	**1.386**	**1.450**	**1.404**	**1.397**

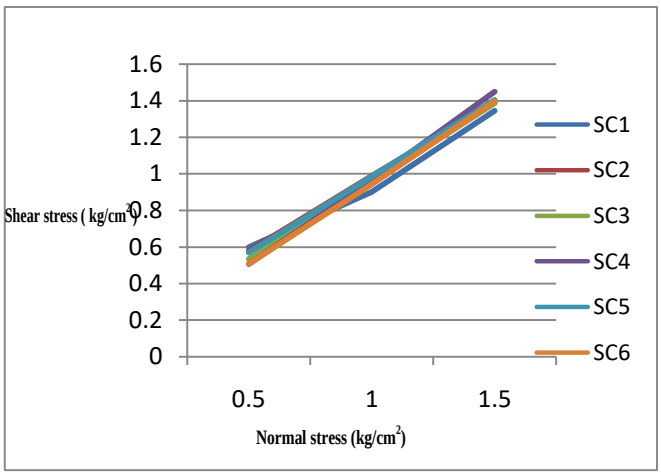

Figure (Graph) Shows Variation of Shear Stress for Admixture SC1 to SC6 at Dry Density 1.55 gm/cc

From the results obtained it can be concluded that angle of internal friction Φ varies with increase in waste plastic bottle square pieces with composition. Also for the same percentage of water added in mix composition, angle of internal friction Φ increases.

Another comparative graphs has been plotted to show the trend of variation of angle of shearing resistance (internal friction Φ in Degree) with percentage admixture of plastic bottle square pieces of 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1% at density 1.67gm/cc, 1.61gm/cc, 1.55gm/cc tabulated in following table. In the graphical presentation on the x-axis 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1% admixture and on y - axis angle of internal friction Φ in degree has been plotted for different percentage of plastic bottle square pieces.

Variation of Φ with % of Plastic bottle square pieces with Dune Sand

S.No.	**Mix Composition**	**Φ (Degree)**
1	**SA1**	**43003'21"**
2	**SA2**	**44040'17"**
3	**SA3**	**43026'59"**
4	**SA4**	**44019'25"**
5	**SA5**	**44018'16"**
6	**SA6**	**43044'18"**
7	**SB1**	**38058'45"**
8	**SB2**	**41043'42"**
9	**SB3**	**43048'58"**
10	**SB4**	**42044'33"**
11	**SB5**	**44037'17"**
12	**SB6**	**43024'38"**
13	**SC1**	**37022'24"**
14	**SC2**	**38032'52"**
15	**SC3**	**41027'51"**
16	**SC4**	**43047'58"**
17	**SC5**	**43036'14"**
18	**SC6**	**42038'03"**

From the above, it can be concluded that angle of internal friction Φ increases with increase in admixture composition.

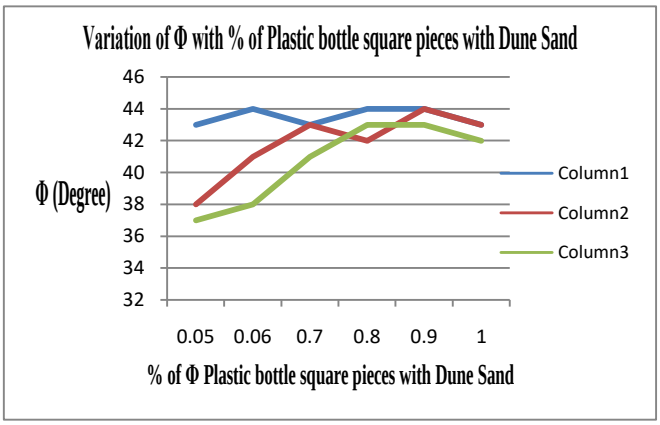

Figure (Graph) Shows Variation of Φ with % of Plastic bottle square pieces with Dune Sand

V. CONCLUSIONS

The results tabulated in various tables & graphs of various tests suggest that waste plastic bottle square pieces of size

5mmx5mm square that may prove useful as stabilizing agent for dune sand.

Following main conclusions are drawn from present investigations

1. CBR values of mix compositions, sand with waste plastic bottle square pieces of varying percentage 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1% at different Density 1.67 gm/cc, 1.61gm/cc and 1.55gm/cc indicate linear increase for both soaked and unsoaked conditions. In unsoaked condition, C.B.R values for CA1 is 5.48 whereas at CB1 it is at 5.09, thus there is an increase with increase in water content. For soaked condition, increase in CBR values is comparatively less than that for unsoaked condition. Value at CD1 in soaked condition is 4.46 whereas for CA1 in unsoaked condition the value is 5.48.With the increase in percentage of plastic bottle square pieces 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1% CBR values gradually increase. For unsoaked condition, CBR values are greater than for soaked condition.
2. Coefficient of Permeability K (cm/sec) decreases with increase in percentage of plastic bottle square pieces mixed to sand that is ,at P1 'K' is 2.46 x 10-3 cm/sec whereas at P5 'K' is 1.79x10-3 cm/sec. Permeability tests were performed for 0.05%, 0.06%, 0.7%, 0.8%, 0.9% and 1% mix compositions. Greater the percentage of plastic bottle square pieces more was the mix composition permeable. Also for the permeability decrease with in crease in percentage of plastic bottle square pieces to sand.
3. Shear tests was performed for mix composition 0.05%, 0.06%, 0.7%. 0.8%, 0.9% and 1% plastic bottle square pieces to that of sand in each sample for density 1.67 gm/cc, 1.61gm/cc and 1.55gm/cc. Angle of internal friction (shearing resistance) Φ increases with increase in density of plastic bottle square pieces and sand in mix composition that is 1% at density 1.55gm/cc admixture 42038'3", gradually increases to 43044'18" at 1% density 1.67 gm/cc admixture. CBR, Direct shear test values increases with increase in plastic strips mix composition with increase in percentage mixed to sand and Permeability decreases.

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