IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 07, Issue 10 (October. 2017), ||V2|| PP 11-19

Design of Slope for Road Embankment withthe Help of Geo Studio for Fine Sand with Plastic Cement Bags Strips

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ABSTRACT: Fine sand is not readily suitable for construction of road embankments but when stabilised with appropriate materials, it is very useful for construction purposes. Large quantity of plastic cement bags strip is available annually widespread in Rajasthan, India and bulk utilization of this waste produced is possible in geotechnical engineering applications like construction of road embankments etc. This research paper includes the design of slope for road embankment with the help of software by utilization for fine sand with plastic cement bags strips. Different laboratory experiments were performed on fine sand with direct mixing of fine sand of different dry densities 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc (M.D.D.) with different percentage 0%, 0.05%, 0.10% and 0.25% by weight of polybags having square strips of size 5 mm. A geo-technical software was used for calculating the factor of safety for road embankments of various heights 6.0 m, 7.5 m and 9.0 m. The rate analysis was done manually according to B.S.R. 2016, P.W.D., Rajasthan, India and the cost reduction ratios were also calculated. The reduction in cross-section area of the road embankment was tremendous and it`s cost of construction also reduced to an appreciable extent.

KEYWORDS: Direct shear test, road embankment, factor of safety, plastic cement bags strip, slope stability analysis, geo-technical software.

Date of Submission: 18-10-2017 Date of acceptance: 31-10-2017

I. INTRODUCTION

Soil is the basic construction material which is used for the construction of road embankments. Stabilization of soil is carried out for a variety of civil engineering works, the most common application being in the construction of flexible pavements and airfield pavements, where the main objective is to increase the strength, reduce the erosion of soil and lessen the construction cost by making best use of locally available materials.

In the Western Rajasthan (India), fine sand is found in abundance. Fine sand is scarcely suitable for construction of embankments for roads due to poor bearing capacity and higher compressibility thus necessitating either improving available fine sand or importing good quality admixture. Soil stabilization in a broad sense incorporates the various methods employed for modifying the properties of a soil to improve its engineering performance.

The problem of the disposal of plastic cement bags strips can also be overcome by using it for stabilization of fine sand. The best method to handle plastic cement bags strips wastage is to utilize it for engineering application after shredding in order to conserve the natural valuable resource like sand. Utilization of plastic cement bags strips waste for improvement of soil properties is a sustainable and cost-effective technique.

The basic aim for engineers nowadays is the optimization of cost of construction of the road embankments by stabilizing the soil with proper admixtures along with ensuring the safety of the slope they use for the road embankments by maintaining the recommended factor of safety. This can be achieved by using the proper stability analysis of embankments constructed on stabilised fine sand. A geotechnical software which is based on the limit equilibrium method has been used in simulating and stability analysis and estimation of embankments of various heights constructed on fine sand of different properties having laboratory determined different dry densities. Bishop’s method has been used in this analysis.

II. MATERIALS USED FOR PRESENT STUDY

2.1 FINE SAND

Fine sand is fine grained, uniform clean sand as per unified soil classification system. Particle size ranges between 75µ to 4.75mm that is, fine to coarse sand, round to angular in particle shape as per Indian Standard Classification system. Fine sand has very little to nil plasticity that is, cohessionless, and drainage fairly good with coefficient of permeability ranging between 10^{-4} mm/sec to 10^{-2} mm/sec. Fine sand is found in abundance in Western Rajasthan. The soil used in present study was fine sand located between Dangiyawas and Banar villages, at about 30 – 35 km away from Jodhpur on Jodhpur – Jaipur road. Table 1 shows the different geotechnical properties of fine sand.

2.2 POLYETHYLENE

The admixture used in present study is plastic cement bags strips (Figure 1) also known as polyethylene or polythene. Plastic cement bags are easily and widely available at construction sites and in industries as wastage material. It is also known as a polymer, produced by the polymerization of ethylene gas, a derivative of the petroleum industry. The polymer consists essentially of long chain molecules of very high molecular weight, made up of many thousands of the $-CH_2-$ repeating unit (Figure 2).

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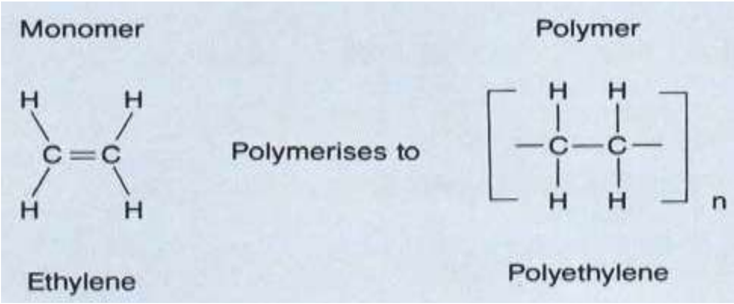

Figure 1: Polymerization of Ethylene to Polyethylene

Figure 2: Plastic strips used in present study

In this study, waste plastic high density polyethylene has been used, density of which ranges from 0.93 gm/cc to 0.97 gm/cc. Although the density of high density polyethylene is only marginally higher than that of low density polyethylene, high density polyethylene has little branching, giving it stronger intermolecular forces and tensile strength than low density polyethylene. The difference in strength exceeds the difference in density, giving high density polyethylene a higher specific strength. It is also harder and more opaque and can with stand some what higher temperatures (120°c for short periods, 110°c continuously).

III. INVESTIGATION PLAN

This research paper includes laboratory experimental work, stability analysis using software, as well as cost estimation. In the laboratory experiments, standard proctor test was performed to determine the three dry densities of fine sand i.e. 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc for further investigations. Direct shear tests were then conducted for determination of shear stress and angle of internal friction for fine sand of 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc dry densities mixed with different percentage 0%, 0.05%, 0.10% and 0.25% by weight of plastic cement bags strips having size of 5.0 mm x 5.0 mm. Further, slope stability analysis and calculation of cost reduction ratio were carried out for different heights of road embankment i.e. 6.0 m, 7.5 m and 9.0 m for above stated mixed compositions of fine sand.

IV. INVESTIGATION RESULTS

4.1 LIGHT COMPACTION TEST (STANDARD PROCTOR TEST)

The Proctor's Compaction Test was performed in accordance with IS 2720 (Part VII) on fine sand and mix proportions. The test was carried out to determine the optimum moisture content and maximum dry density of fine sand and also for mix proportions. Compaction of soil is a mechanical process by which the soil particles are constrained to be packed more closely together by reducing the air voids.

4.2 DIRECT SHEAR TEST

Direct shear test is used to determine the shear strength parameters of a sandy soil. It was performed on dry fine sand with a strain controlled shear apparatus at a rate of strain of 1.25 mm/min. in accordance with IS 2720 (Part XIII). Direct shear tests were carried out to determine the angle of internal friction (ϕ) of different mix compositions of fine sand of 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc dry density mixed with different percentage viz. 0%, 0.05%, 0.10%, and 0.25% by weight of plastic cement bags strips material. The results of direct shear tests are given in Table 2.

Table 1: Variation of Friction Angle (ϕ) for Different Mix Compositions of Fine Sand Mixed with Different Percentage by Weight of Polybags

Dry Density (gm/cc)	Angle of Internal Friction ϕ (Degree)			
	Percentage mix composition of plastic cement bags strips			
	0%	0.05%	0.10%	0.25%
1.51	30.17°	36.08°	38.45°	36.03°
1.54	32.25°	38.43°	42.76°	40.67°
1.58	33.92°	40.65°	46.59°	44.79°

4.3 SLOPE STABILITY ANALYSIS

Slope stability analysis is performed to assess the safe design of man-made or natural slopes (e.g. embankments, open-pit mining, road cuts, landfills, excavations etc.) and the equilibrium conditions. In the present investigation, a modern geotechnical software program which is based on the limit equilibrium analysis is used to compute the factor of safety. Factor of safety is calculated by Bishop's method. The Bishop's method assumes that the vertical inter slice shear force does not exist and the resultant inter slice force is therefore horizontal (Bishop, 1955). It satisfies the equilibrium of moment but not the equilibrium of forces. According to IRC 75:1979, the recommended factor of safety for the design of low embankments is 1.25. Investigation is done for two lane road embankments of width 8 m (taking allowance for shoulders) and heights 6.0 m, 7.5 m, and 9.0 m by steeping of the side slope to the maximum extent such that the factor of safety of the critical slip surface remains within the recommended limit of 1.25 as stated by IRC. Figure 3 shows all the valid critical slip surfaces and Figure 3 shows a typical critical slip surface for a particular condition.

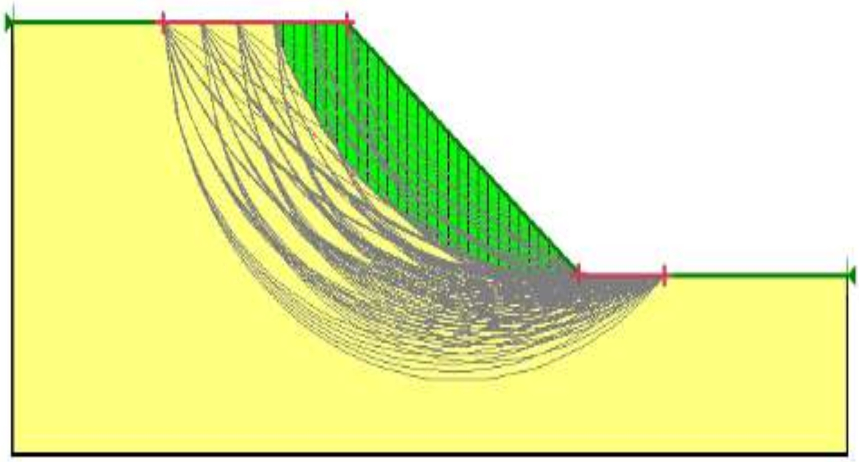

Figure 3: All Valid Critical Slip Surfaces

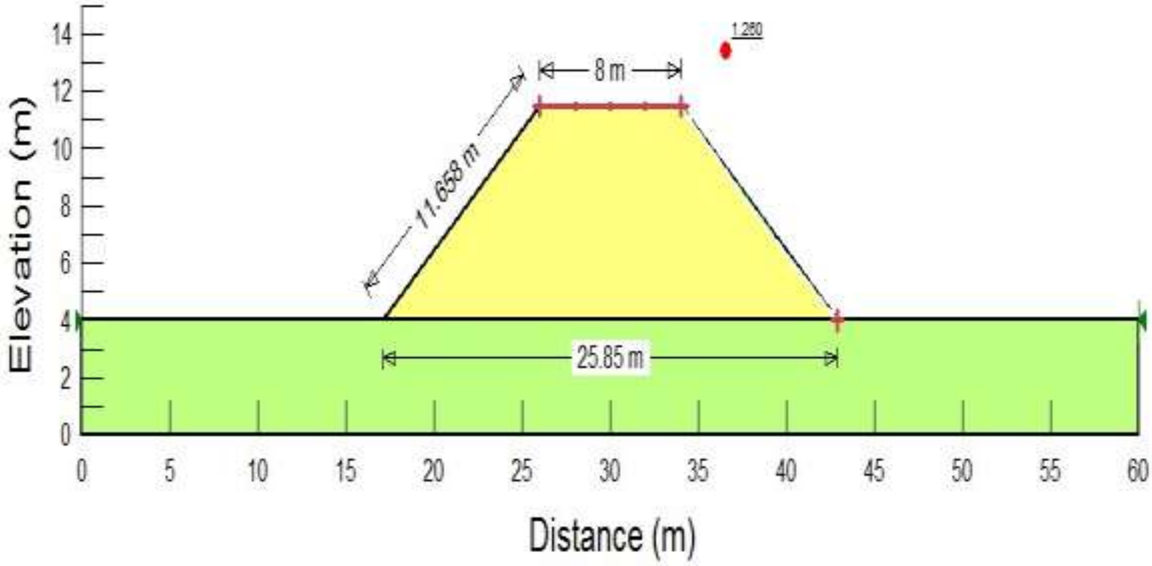

Figure4: Critical Slip Surface, when ht. = 7.5 m, density = 1.58 gm /cc, and % of plastic cement bags strips = 0.10%

Tables 2, 3, and 4 tabulates the results of slope stability analysis for different heights of embankment viz. 6.0 m, 7.5 m and 9.0 m for different mix compositions of fine sand of different dry densities 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc mixed with different percentage 0%, 0.05%, 0.10% and 0.25% by weight of admixture. The steepest slope of the embankment is found when fine sand of different dry densities is mixed with 0.10% by weight of admixture.

Table 2: Results of Slope Stability Analysis performed by GEO STUDIO software at 1.51 gm/cc density and various % by weight of admixture plastic cement bags strips

S. No.	Height of Embankment (m)	Admixture (%)	Angle of Internal Friction (ϕ)	Slope (H:V)	Factor of Safety
1.	6.0	0	30.17	2.15:1	1.252
2.	6.0	0.05	36.08	1.72:1	1.256
3.	6.0	0.1	38.45	1.58:1	1.257
4.	6.0	0.25	36.03	1.72:1	1.253
6.	7.5	0	30.17	2.15:1	1.252
7.	7.5	0.05	36.08	1.72:1	1.256
8.	7.5	0.1	38.45	1.58:1	1.257
9.	7.5	0.25	36.03	1.72:1	1.253
11.	9.0	0	30.17	2.15:1	1.252
12.	9.0	0.05	36.08	1.72:1	1.256
13.	9.0	0.1	38.45	1.58:1	1.257
14.	9.0	0.25	36.03	1.72:1	1.253

Table 3:Results of Slope Stability Analysis performed by GEO STUDIO software at 1.54 gm/cc density and various % by weight of admixture plastic cement bags strips

S. No.	Height of Embankment (m)	Admixture (%)	Angle of Internal Friction (ϕ)	Slope (H:V)	Factor of Safety
1.	6.0	0	32.25	1.98:1	1.252
2.	6.0	0.05	38.43	1.58:1	1.256
3.	6.0	0.1	42.76	1.35:1	1.251
4.	6.0	0.25	40.67	1.46:1	1.257
6.	7.5	0	32.25	1.98:1	1.252

7.	7.5	0.05	38.43	1.58:1	1.256
8.	7.5	0.1	42.76	1.35:1	1.251
9.	7.5	0.25	40.67	1.46:1	1.257
11.	9.0	0	32.25	1.98:1	1.252
12.	9.0	0.05	38.43	1.58:1	1.256
13.	9.0	0.1	42.76	1.35:1	1.251
14.	9.0	0.25	40.67	1.46:1	1.257

Table 4: Results of Slope Stability Analysis performed by GEO STUDIO software at 1.58 gm/cc density and various % by weight of admixture plastic cement bags strips

S. No.	Height of Embankment (m)	Admixture (%)	Angle of Internal Friction (ϕ)	Slope (H:V)	Factor of Safety
1.	6	0	33.92	1.86:1	1.253
2.	6	0.05	40.65	1.46:1	1.256
3.	6	0.1	46.59	1.19:1	1.260
4.	6	0.25	44.79	1.26:1	1.253
6.	7.5	0	33.92	1.86:1	1.253
7.	7.5	0.05	40.65	1.46:1	1.256
8.	7.5	0.1	46.59	1.19:1	1.260
9.	7.5	0.25	44.79	1.26:1	1.253
11.	9	0	33.92	1.86:1	1.253
12.	9	0.05	40.65	1.46:1	1.256
13.	9	0.1	46.59	1.19:1	1.260
14.	9	0.25	44.79	1.26:1	1.253

4.4 RATE ANALYSIS AND COST REDUCTION RATIOS

Construction of Embankment with Material Obtained from Roadway Cutting.
Item: Construction of embankment with approved materials deposited at site obtained from roadway cutting and excavation from drain and foundation or other structures graded and compacted to meet requirement - Rs. 34 per m^3 (As per Unified P.W.D. B.S.R. Rajasthan June 2014)
Add lump sum 5.0% extra for transportation, reaping, mixing of plastic cement bags strips.
Cost of Earthwork, stabilized with reaped plastic cement bags strips = 34+.05 x 34 = Rs. 35.70 per m^3.
Tables 5, 6 and 7 tabulates the saving in the quantity of earthwork, cost of earthwork and cost reduction ratio of fine sand of dry densities 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc mixed with 0%, 0.05%, 0.10% and 0.25% by weight of admixture for different heights of road embankment 6.0 m, 7.5 m and 9.0 m for 1 km long two lane road.

Table 5: Saving of Earthwork Quantity and Cost Reduction Ratio for Road Embankment of Different Heights for Fine Sand of Dry Density 1.51 gm/cc using Different % by Weight of Admixture for 1 km Long Two Lane Road

S. No.	Height of Embankment (m)	Percentage of Admixture(%)	Widthof Pavement (m)	Area (m^2)	Quantity of Earthwork (m^3)	Saving of Quantity of Earthwork (m^3)	PWD BSR Rate per m^3	Cost of Road Embankment (Rs)	Saving of Cost (Rs)	Cost Reduction Ratio
1.	6.0	0	8	125.40	125400.00	-	34	4263600	-	1.00
2.	6.0	0.05	8	109.92	109920.00	15480.00	35.7	3924144	552636	0.92
3.	6.0	0.1	8	104.88	104880.00	20520.00	35.7	3744216	732564	0.88
4.	6.0	0.25	8	109.92	109920.00	15480.00	35.7	3924144	552636	0.92
6.	7.5	0	8	180.94	180937.50	-	34	6151875	-	1.00
7.	7.5	0.05	8	156.75	156750.00	24187.50	35.7	5595975	863493.75	0.91
8.	7.5	0.1	8	148.88	148875.00	32062.50	35.7	5314837.5	1144631.3	0.86
9.	7.5	0.25	8	156.75	156750.00	24187.50	35.7	5595975	863493.75	0.91
11.	9.0	0	8	246.15	246150.00	-	34	8369100	-	1.00
12.	9.0	0.05	8	211.32	211320.00	34830.00	35.7	7544124	1243431	0.90
13.	9.0	0.1	8	199.98	199980.00	46170.00	35.7	7139286	1648269	0.85
14.	9.0	0.25	8	211.32	211320.00	34830.00	35.7	7544124	1243431	0.90

Table 5 shows that the max cost reduction ratio for the road embankment of height 9 m is 0.85 when the density of the fine sand is 1.51 gm/cc at 0.10% by weight of admixture. Thus, the approximate maximum saving in the cost of road embankment construction of height 9 m is 15%.

Table 6: Saving of Earthwork Quantity and Cost Reduction Ratio for Road Embankment of Different Heights for Fine Sand of Dry Density 1.54 gm/cc using Different % by Weight of Admixture for 1 km Long Two Lane Road

S. No.	Height of Embankment (m)	Percentage of Admixture (%)	Width of Pavement (m)	Area (m^2)	Quantity of Earthwork (m^3)	Saving of Quantity of Earthwork (m^3)	PWD BSR Rate per m^3	Cost of Road Embankment (Rs)	Saving of Cost (Rs)	Cost Reduction Ratio
1.	6.0	0	8	119.28	119280.00	-	34	4055520	-	1.00
2.	6.0	0.05	8	104.88	104880.00	14400.00	35.7	3744216	514080	0.92
3.	6.0	0.1	8	96.60	96600.00	22680.00	35.7	3448620	809676	0.85
4.	6.0	0.25	8	100.56	100560.00	18720.00	35.7	3589992	668304	0.89
6.	7.5	0	8	171.38	171375.00	-	34	5826750	-	1.00
7.	7.5	0.05	8	148.88	148875.00	22500.00	35.7	5314837.5	803250	0.91
8.	7.5	0.1	8	135.94	135937.50	35437.50	35.7	4852968.8	1265118.8	0.83
9.	7.5	0.25	8	142.13	142125.00	29250.00	35.7	5073862.5	1044225	0.87
11.	9.0	0	8	232.38	232380.00	-	34	7900920	-	1.00
12.	9.0	0.05	8	199.98	199980.00	32400.00	35.7	7139286	1156680	0.90
13.	9.0	0.1	8	181.35	181350.00	51030.00	35.7	6474195	1821771	0.82
14.	9.0	0.25	8	190.26	190260.00	42120.00	35.7	6792282	1503684	0.86

Table 6 shows that the max cost reduction ratio for the road embankment of height 9 m is 0.82 when the density of the fine sand is 1.54 gm/cc at 0.10% by weight of admixture. Thus, the approximate maximum saving in the cost of road embankment construction of height 9 m is 18%.

Table 7: Saving of Earthwork Quantity and Cost Reduction Ratio for Road Embankment of Different Heights for Fine Sand of Dry Density 1.58 gm/cc using Different % by Weight of Admixture for 1 km Long Two Lane Road

S. No.	Height of Embankment (m)	Percentage of Admixture (%)	Width of Pavement (m)	Area (m^2)	Quantity of Earthwork (m^3)	Saving of quantity of earthwork (m^3)	PWD BSR Rate per m^3	Cost of Road Embankment (Rs)	Saving of Cost (Rs)	Cost Reduction Ratio
1.	6.0	0	8	114.96	114960.00	-	34	3908640	-	1.00
2.	6.0	0.05	8	100.56	100560.00	14400.00	35.7	3589992	514080	0.92
3.	6.0	0.1	8	90.84	90840.00	24120.00	35.7	3242988	861084	0.83
4.	6.0	0.25	8	93.36	93360.00	21600.00	35.7	3332952	771120	0.85
6.	7.5	0	8	164.63	164625.00	-	34	5597250	-	1.00
7.	7.5	0.05	8	142.13	142125.00	22500.00	35.7	5073862.5	803250	0.91
8.	7.5	0.1	8	126.94	126937.50	37687.50	35.7	4531668.8	1345443.8	0.81
9.	7.5	0.25	8	130.88	130875.00	33750.00	35.7	4672237.5	1204875	0.83
11.	9.0	0	8	222.66	222660.00	-	34	7570440	-	1.00
12.	9.0	0.05	8	190.26	190260.00	32400.00	35.7	6792282	1156680	0.90
13.	9.0	0.1	8	168.39	168390.00	54270.00	35.7	6011523	1937439	0.79
14.	9.0	0.25	8	174.06	174060.00	48600.00	35.7	6213942	1735020	0.82

Table 7 shows that the max cost reduction ratio for the road embankment of height 9 m is 0.79 when the density of the fine sand is 1.58 gm/cc at 0.10% by weight of admixture. Thus, the approximate maximum saving in the cost of road embankment construction of height 9 m is 21%.

It can be concluded from Tables 5 to 7, that maximum saving in the cost of construction of road embankment of any height is when we mix 0.10% by weight of plastic cement bags strips.

5.5 COMPARATIVE STUDY

The graphs have been plotted between the dry density of the fine sand and the cross-section area of the embankment for different percentages by weight of plastic cement bags strips mixed with the fine sand.The graphs (Figure 5 to Figure 7) show that the cross-section area is reduced most when the percentage of plastic cement bags strips by weight mixed with the fine sand is 0.10% irrespective of the height of the embankment. The graphs shown are for different percentages of plastic cement bags strips by weight mixed with the fine sand.

The graphs clearly indicate that when percentage of plastic cement bags strips by weight mixed with the fine sand increases from 0.0% to 0.10%, the cross section area is reduced to the maximum extent i.e. the slope is the steepest irrespective of the height of the embankment and when percentage of plastic cement bags strips by weight mixed with the fine sand increases from 0.10% to 0.25%, the cross section area is increased though it is lesser than what it is at pure fine sand with no plastic cement bags strips. In scope of our study it is also concluded that the slope is the steepest for the maximum dry density of the fine sand i.e. 1.58 gm/cc at 0.10 % of plastic cement bags strips by weight mixed with the fine sand.

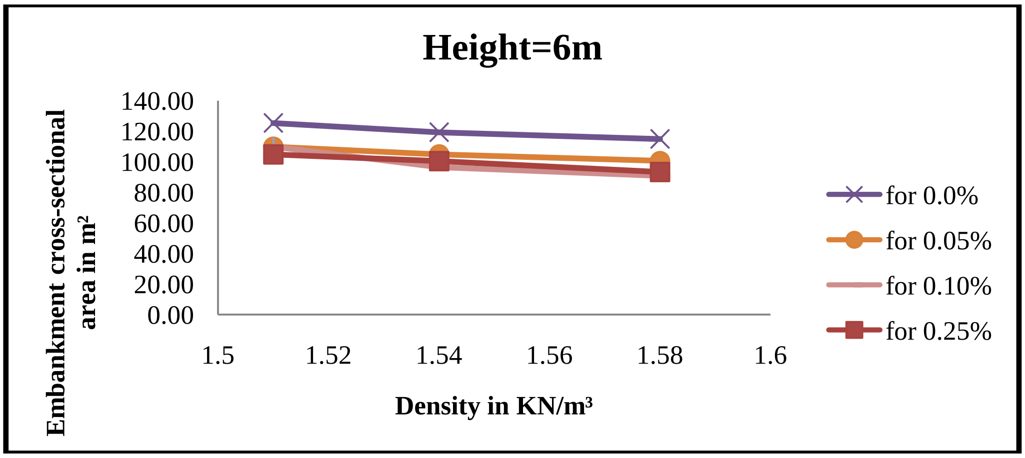

Figure 5: Variation in cross-section area of the embankment having height of 6 m with the dry density of fine sand for different percentages of plastic cement bags strips by weight mixed with the fine sand

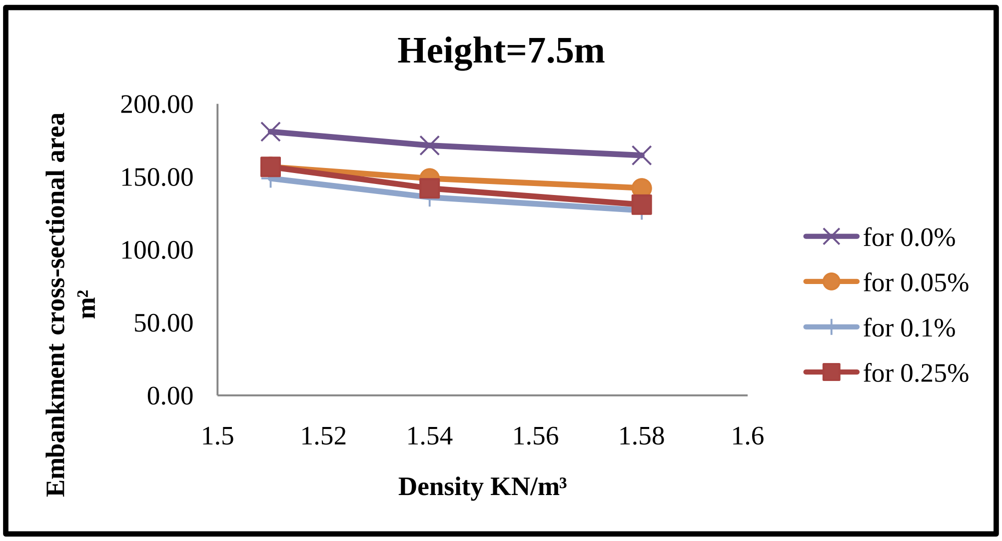

Figure 6: Variation in cross-section area of the embankment having height of 7.5 m with the dry density of fine sand for different percentages of plastic cement bags strips by weight mixed with the fine sand

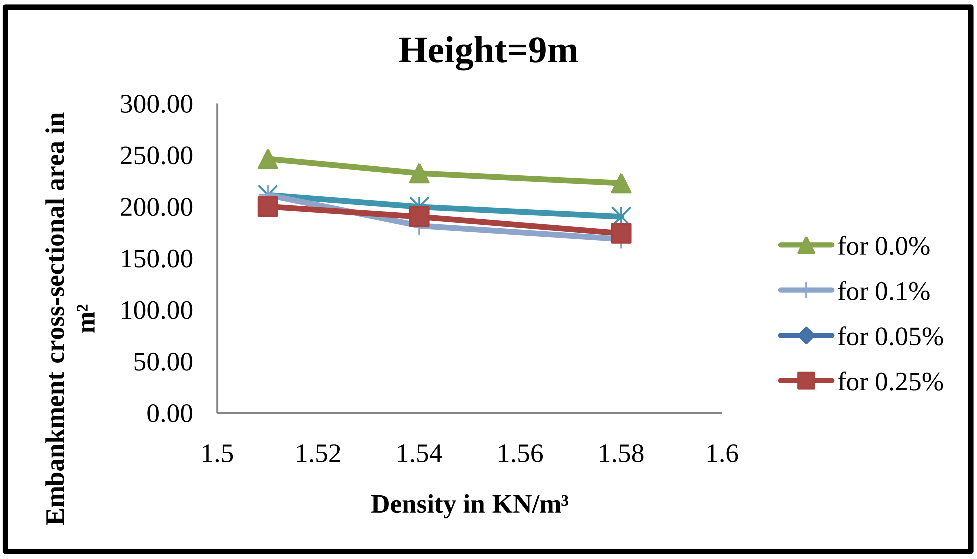

Figure 7: Variation in cross-section area of the embankment having height of 9 m with the dry density of fine sand for different percentages of plastic cement bags strips by weight mixed with the fine sand

V. CONCLUSIONS

The results of the slope stability analysis have been described in detail in the present research work with suitable tables and graphs. The following conclusions are drawn from this present work:

1. When the percentage of plastic cement bags strips by weight mixed with fine sand is increased from 0.0% to 0.10%, irrespective of the height of the road embankment, its slope is steepened from 2.15:1 to 1.58:1, 1.98:1 to 1.35:1 and 1.86:1 to 1.19:1 for density 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc respectively. The slope at 0.10% is the steepest slope of the embankment irrespective of its height.
2. As the percentage of plastic cement bags strips by weight mixed with fine sand is increased from 0.10% to 0.25%, the slope turns gentler from 1.58:1 to 1.72:1, 1.35:1 to 1.46:1 and 1.19:1 to 1.26:1 for density 1.51 gm/cc, 1.54 gm/cc and 1.58 gm/cc respectively, although the slope in all these cases is steeper than what it is at 0.0% (i.e. pure sand).
3. Among the four fine sand samples taken in this work, the steepest slope of the road embankment is found when the dry density and the friction angle of the soil is maximum irrespective of the height of the embankment. To put in figures the steepest slope of the road embankment evaluated is 1.19:1 which is found when the maximum dry density obtained is 1.58 gm/cc, the maximum friction angle of the soil evaluated is 46.59° which is obtained when the percentage of plastic cement bags strips by weight mixed with fine sand is 0.10% irrespective of the height of the embankment.
4. The graphs (Figure 5 to Figure 57) plotted between the dry density of the dune sand and the cross-section area of the embankment for different percentages of plastic cement bags strips by weight mixed with the fine sand are also more or less linear thus, signifying the parellism in the variation of dry density and cross section area with the different percentage content of plastic cement bags strips.
5. The maximum cost reduction ratio for the road embankment of height 6 m varies from 0.83 to 0.88 when the density of the fine sand varies from 1.51 gm/cc to 1.58 gm/cc. Thus, the approximate saving in the cost of road embankment construction of height 6 m varies between 12-17%.
6. The maximum cost reduction ratio for the road embankment of height 7.5 m varies from 0.81 to 0.86 when the density of the fine sand varies from 1.51 gm/cc to 1.58 gm/cc. Thus, the approximate saving in the cost of road embankment construction of height 7.5 m varies between 14-19%.
7. The maximum cost reduction ratio for the road embankment of height 9 m varies from 0.79 to 0.85 when the density of the fine sand varies from 1.51 gm/cc to 1.58 gm/cc. Thus, the approximate saving in the cost of road embankment construction of height 9 m varies between 15-21%.
8. The slope stability analysis conducted by the software SLOPE/W provides results in a very short time and thus can be used for the design of slope of road embankments.
9. The objective of this work which is to find the steepest slope of embankment till the recommended factor of safety so that there is no failure caused to the slope stability is being achieved. With the help of this work, road construction works will be eco-friendly as well as economical due to steepening of slope of the road embankment.
10. The slope stability analysis conducted by the software provides reliable results in short time and thus can be used for the design of slope for road embankments.

REFERENCES

[1] Ameta N.K., Wayal A.S., Puneet Hiranandani, "Stabilization of Dune Sand with Ceramic Tile Waste as Admixture". A.J.E.R., Vol. 02, Issue-09, 2013.
[2] Bishop, A.W., "The Use of the Slip Circle in the Stability Analysis of Slopes", Geotechnique, Vol. 5, pp. 7–17, 1955.
[3] Dutta R.K., Venkatappa Rao G., "Ground Improvement with Waste Plastic". Indian Institute of Technology, New Delhi, India.
[4] E Spencer, "A Method of Analysis of the Stability of Embankments Assuming Parallel Inter-Slice Forces",Geotechnique, 17(1), pp. 11-26, 1967.
[5] Gopal R., Singh Y. P., Bhati O. P., Singh Jeevan, Bhati J., Singh Inder, Ghosh P. K., Parihar M. S. and Das Ghanshyam, "Chemical Stabilisation of Sand : Part* II Construction and Studies of 50m x 4m Road". Defence Laboratory, Jodhpur-342001, 1980.
[6] Geo slope international 2012, Geostudio (student version 8.0.10.6504)computer software.
[7] Hammouri, N.A., Husein Malkawi, A.I. & Yamin, M.M.A. 2008, 'Stability analysis of slopes using the finite element method and limiting equilibrium approach' Bulletin of Engineering Geology and the Environment, vol. 67.
[8] IRC: 75-1979 guidelines for the design of high embankment.
[9] Lee W., Thomas S., Sunil S., and Glenn M., "Slope Stability and Stabilization Methods", 2nd Edition, New York, John Wiley & Sons, ISBN 0-471-384933, 2002.

[10] Pal Shish, Kumar Vinod Sonthwal, Rattan Jasvir S, “Review on Stabilisation of Soil Using Polypropylene as Waste Fibre Material”. International Journal of Innovative Research in Science, Engineering and Technology, Nov 2015.
[11] Patel Vatsal, Popli Snehal, Bhatt Drashti, “Utilization of Plastic Waste in Construction of Roads”. International Journal of Scientific Research, 2014.
[12] Stability Modelling with SLOPE/W: An Engineering Methodology July 2012 Edition – GEO-SLOPE INTERNATIONAL LTD.
[13] Whitman, R., & Bailey, W. (1967). Use of Computers for Slope Stability Analysis. Journal of the Soil Mechanics and Foundation Division, Vol. (Placeholder 3).

Sumitra Choudhary Design of Slope for Road Embankment with the Help of Geo Studio for Fine Sand with Plastic Cement Bags Strips.” IOSR Journal of Engineering (IOSRJEN) , vol. 7, no. 10, 2017, pp. 11-19.