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Strength Improvement of Black Cotton Soil by using Different Materials

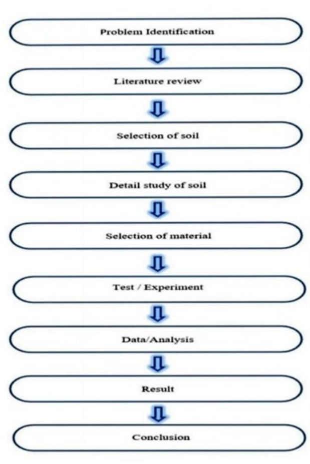
Mr. Alpesh K Sankhat[1], Shivani Joshi[2], Vijay Baraiya[3]
[1]Professor, Department of Civil Engineering, GMB Polytechnic-Rajula (GTU), India
[2, 3]Department of Civil Engineering, Gujarat Technological University

***Abstract:** This study examines the effect of geotextiles, plastic rings, plastic shavings and fibres on soil California bearing capacity (CBR). The experiment evaluates the effectiveness of these additions to improve the bearing capacity and reduce the sedimentation of the soil samples. Geotextiles are introduced to improve soil compaction and reduce lateral movement. Plastic rings and chips are added to create voids and improve drainage, which can reduce water content and improve strength. Polypropylene Fibres were added to study their effect on soil reinforcement and stress distribution improvement. CBR tests are performed on soil samples with hand without these additives to quantify the improvement in strength and deformation properties. The results of this study should provide valuable information on the potential benefits of using geotextiles, plastic rings, plastic chips and polypropylene fibres in pavement construction to improve soil CBR of soils in pavement applications*
***Keywords:** CBR Test , Geotextiles, plastic chips, plastic rings, polypropylene fibres,*

I. INTRODUCTION

1) Black Cotton Soil :Black cotton soil, also known as regur soil, is a type of soil found in the Deccan Plateau region of India. It is characterized by its brown-black color, high clay content, and high shrink-swell properties.
2) CBR Test : CBR (California Bearing Ratio) testing is performed primarily to provide information for pavement design. It was first developed by the California State Highway Department. It is a penetration or subsidence test under load, mainly used to evaluate the base strength of roads, pavements and foundations..
3) Geotextiles: Geotextiles are essentially strong fabrics used in construction projects. They are the most Versatile type of geosynthetic material, with a wide range of applications. Due to the variety of Geotextiles available, choosing the right one for a specific project is crucial.
4) Polypropylene Fibres: Experiments were conducted using different Percentages of polypropylene fibres mixed with compacted soil samples. The tests measured the Soil's strength, bearing capacity, and swelling behaviour. While the detailed results aren't provided. This research suggests that fibre reinforcement has promise for improving problematic soils.
5) Plastic bottle : The project involves mixing the soil with various percentages of these plastic strips. Tests like Compaction and California Bearing Ratio (CBR) will then be conducted to analyse the impact on Soil properties

II. METHODOLOGY



III. TESTS AND RESULTS

To determine the properties of soil tests we conducted on soil are:

1) Free Swell Index

FREE SWELL INDEX
(As per IS2720 part - 40)

Lab Job No.:	235	Date of Sampling:	25/02/24
Sample Description:	Black Cotton Soil	Date of Testing:	26/02/24
Source/Location:	180+700 LHS	Sampled By:	Jointly
Proposed Use:	Embankment/Subgrade	Tested By:	Jointly

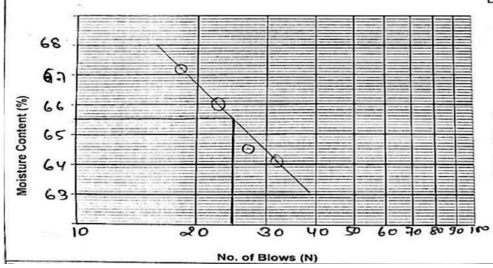
Sr. No	Determination		Test-1	Test-2	Average
1	Volume of Specimen in Graduated Cylinder Containing Distilled Water after 24 hrs = (ml)	Vd	20	21	/
2	Volume of Specimen in Graduated Cylinder Containing Kerosene after 24 hrs = (ml)	Vk	13	13	/
3	Difference of Volume in Water & Kerosene (ml)	Vd-Vk	7	8	/
4	Free Swelling Index, [%] =	[(Vd-Vk)/Vk] x 100	53.85	61.54	57.70

2) Liquid Limit And Plastic Limit Tests

ATTERBERG LIMITS
(As Per IS 2720 - Part 5)
(By Casagranda Apparatus)

Lab Job No.	235	Date of Sampling	25/02/24
Sample Description	Black Cotton Soil	Date of Testing	26/02/24
Source/Location	130+700 LHS	Sampled By	Jointly
Proposed Use	Emb/Sub.	Tested By	Jointly

Sr. No.	Determination		Liquid Limits				Plastic Limits	
			1	2	3	5	1	2
1	No. of Blows		32	27	22	18	—	—
2	Container Number		2	3	4	5	6	7
3	Weight of container (gm)	W1	18.62	19.02	17.25	16.83	18.65	18.78
4	Wt. of Cont.+Wet Sample (gm)	W2	46.83	49.32	49.49	48.25	28.08	30.40
5	Wt.of Cont.+ Oven dry Sample	W3	35.81	37.44	36.67	35.62	26.17	27.76
6	Wt. of Water	W4= W2-W3	11.02	11.88	12.82	12.63	1.91	2.64
7	Wt. of Dry Sample	W5 = W3-W1	17.19	18.42	19.42	18.79	7.52	8.98
8	% Moisture content	W4/W5X100	64.11	64.50	66.01	67.22	25.40	29.40
						Average	27.40	



LL: Moisture Content @ 25 Blows

RESULTS

Liquid Limit LL (%) = 65.50
Plastic Limit PL (%) = 27.40
Plasticity Index PI (%) = 38.10
(LL-PL)

3) Grain Size Analysis

GRAIN SIZE ANALYSIS
[As per IS 2720 (Part - 4)]

Lab Job No.	235	Date of Sampling	25/02/24
Sample Description	Black Cotton Soil	Date of Testing	26/02/24
Source/Location	130+700 LHS	Sampled By	Jointly
Proposed Use	Emb/Sub.	Tested By	Jointly
Wt. of Sample (gm)	1000 gms		

IS Sieve Size (mm)	Weight Retained (gm)	Cumulative Weight Retained (gm)	Cumulative Perentage Retained (%)	Cumulative Percentage Passing (%)	Remarks
100					
75					
19	0	0	0	100	
4.75	16	16	1.6	98.4	
2.0	9	25	2.50	97.5	
0.425	47	72	7.2	92.8	
0.075	53	125	12.5	87.5	
Pan					

DESCRIPTION OF PARTICLE		SIEVE SIZE (mm)	PERCENTAGE	
Gravel	Coarse	75 - 19	—	1.60
	Fine	19 - 4.75	1.60	
Sand	Coarse	4.75 - 2.00	0.90	10.9
	Medium	2.00 - 0.425	4.7	
	Fine	0.425 - 0.075	5.3	
Silt & Clay		Passing through 0.075		87.5

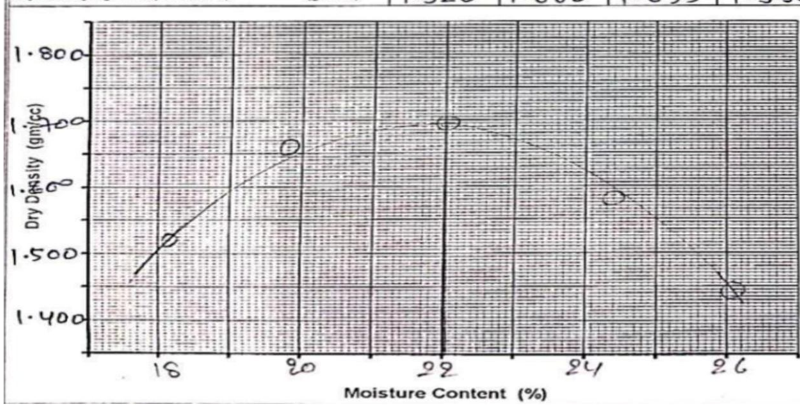
4) Modified Proctor Test

MODIFIED PROCTOR COMPACTION TEST
As Per IS 2720 [Part - 8]

Lab Job No.	235	Date of Sampling	25/02/24
Sample Description	Black Cotton Soil	Date of Testing	26/02/24
Source/Location	130+700 LHS	Sampled By	Jointly
Proposed Use	Emb/Sub.	Tested By	Jointly

Mould No — Wt. of Mould, W_1 (gm) 3990 — Volume of mould, V (cc) 1000

% of Water		18%	20%	22%	24%	26%
Wt. of Wet Sample + mould, W_2	(gm)	5786	5979	6058	5956	5871
Wt. of Wet Sample, $W_3=(W_2-W_1)$	(gm)	1796	1989	2068	1966	1881
Wet density, $Y_b = W_3/V$	(gm/cc)	1.796	1.989	2.068	1.966	1.881
Container No		56	57	58	59	60
Wt. of container, W_5	(gm)	40.30	46.4	47.57	48.25	48.15
Wt. of wet soil + cont., W_6	(gm)	146.99	161.89	166.61	170.47	171.92
Wt. of dry soil + cont., W_7	(gm)	130.60	142.80	145.14	146.5	146.3
Wt. of water, $W_8=(W_6-W_7)$	(gm)	16.39	19.09	21.47	23.97	25.62
Wt. of dry soil, $W_9=(W_7-W_5)$	(gm)	90.30	96.40	97.57	98.25	98.15
Moisture content $w = W_8/W_9 \times 100$	(%)	18.15	19.80	22.00	24.40	26.10
Dry density $Y_d = Yb/(1+ w/100)$	(gm/cc)	1.520	1.660	1.695	1.580	1.492



Test Results
MDD (gm/cc) = 1.695
OMC (%) = 22.00

5) California Bearing Ratio Test

a) CBR Test With Noramal Black Soil

Laboratory Job No.	235	Date of Sampling :	25/02/'24
Location/Source	130+700 LHS	Sampled by :	Jointly
Type of Material :	Normal Black soil	Tested by :	Jointly
Proposed use:		Date of Casting :	28/02/'24
Period of Soaking:	96 Hours	Date of Testing :	03/03/24

MOISTURE CONTENT AND UNIT WEIGHT OF TEST SAMPLES

	Mould No. 24		Mould No. 25		Mould No. 26	
No. of layers	5	5	5	5	5	5
No. of blows per layer	10	10	30	30	65	65
CONDITION OF SAMPLE	Before soaking	After soaking	Before soaking	After soaking	Before soaking	After soaking
Wt. of Mould, W	6995	6995	7960	7960	6885	6885
Wt. of Wet Sample + Mould, W_2 (gm)	11072	11122	12390	12424	11441	11493
Wt. of Wet Sample, $W_3=(W_2-W_1)$ (gm)	4077	4127	4430	4464	4556	4608
Volume of mould, V (cc)	2250	2250	2250	2250	2250	2250
Wet Density, $Y_b = W_3/V$ (gm/cc)	1.812	1.834	1.969	1.984	2.025	2.048
MOISTURE DETERMINATION	Before soaking	After soaking	Before soaking	After soaking	Before soaking	After soaking
Container No.	1	2	3	4	5	6
Wt. of container, W_5 (gm)	47.31	48.90	48.71	46.31	46.29	48.87
Wt. of Wet Sample +Cont., W_6 (gm)	341.15	345.55	348.35	350.34	353.45	312.33
Wt. of Dry Sample + Cont., W_7 (gm)	289.31	287.90	293.71	292.31	298.29	261.87
Wt. of water, $W_8=(W_6-W_7)$ (gm)	51.84	57.65	54.64	58.03	55.16	50.46
Wt. of Dry Sample, $W_9=(W_7-W_5)$ (gm)	242.0	239.0	245.0	246.0	252.0	213.0
Moisture content $W = W_8/W_9$ (%)	21.42	24.12	22.30	23.59	21.89	23.69
Dry Density $Y_d = Y_b/(1+ w/100)$ (gm/cc)	1.492	1.478	1.610	1.605	1.661	1.656

LOAD- PENETRATION TEST DATA :

Proving ring No.: **Proving Ring Calibration Factor :**

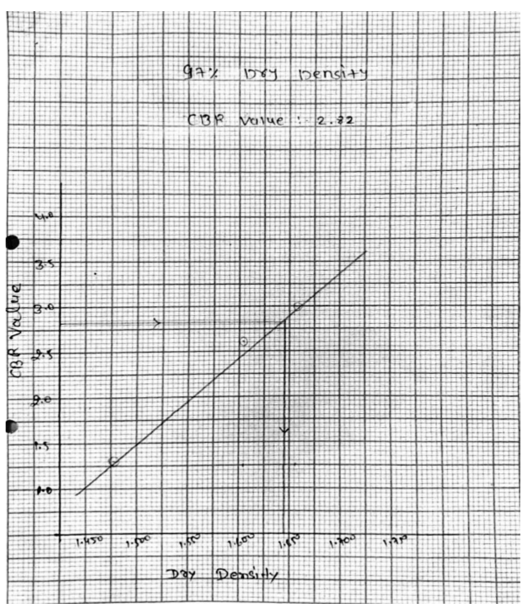
Sr.No.	Penetration (mm)	Mould No. 24 Proving ring Reading	Mould No. 24 Corrected load (Kg)	Mould No. 25 Proving ring Reading	Mould No. 25 Corrected load (Kg)	Mould No. 26 Proving ring Reading	Mould No. 26 Corrected load (Kg)
1	0.5	1	3.35	3	10.05	3	10.05
2	1.0	2	6.70	5	16.75	6	20.10
3	1.5	3	10.05	7	23.45	8	26.80
4	2.0	4	13.40	8	26.80	10	33.50
5	2.5	5	16.75	10	33.50	12	40.20
6	3.0	6	20.10	11	36.85	13	43.55
7	4.0	7	23.45	14	46.90	16	53.60
8	5.0	8	26.80	16	53.60	18	60.30
9	7.5	10	33.50	19	63.65	21	70.35
10	10.0	11	36.85	20	67.0	22	73.70
11	12.5	11	36.85	22	73.7	23	77.05

CBR CALCULATION

Mould No.	Corrected Unit Load in kgf (from graph) 2.5 mm	Corrected Unit Load in kgf (from graph) 5.0 mm	CBR% 2.5 mm	CBR% 5.0 mm	CBR % reported
24	16.75	26.80	1.22	1.30	2.82
25	33.50	53.60	2.45	2.61	
26	40.20	60.30	2.93	2.93	
Average					

Note:
1) Graph for load vs penetration attached
2) CBR = (corrected load/standard load) x 100
3) Standard unit load : @ 2.5mm Penetration = 1370 Kg
: @ 5.0 mm Penetration = 2055 Kg

CBR Value @ 97 % MDD 1.695 gm/cc = 2.200 %



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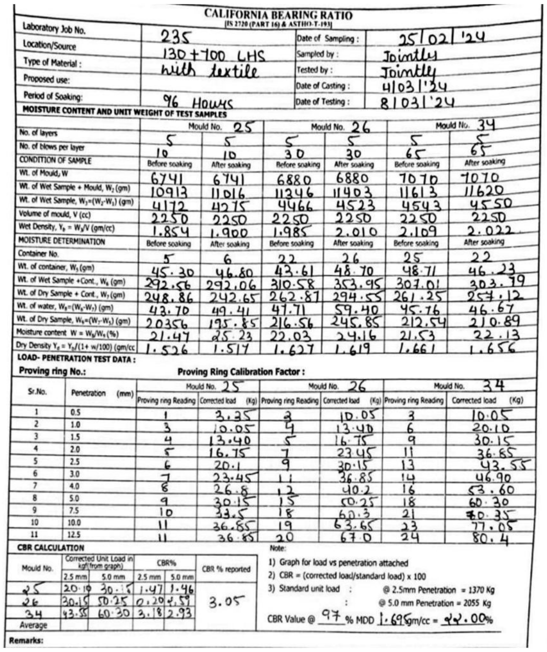
b) CBR Test with Geotextile



CALIFORNIA BEARING RATIO
[IS 2720 (PART 16) & ASTHO-T-193]

Laboratory Job No.	235	Date of Sampling :	25/02/'24
Location/Source	130+700 LHS	Sampled by :	Jointly
Type of Material :	with textile	Tested by :	Jointly
Proposed use:		Date of Casting :	4/03/'24
Period of Soaking:	96 Hours	Date of Testing :	8/03/'24

MOISTURE CONTENT AND UNIT WEIGHT OF TEST SAMPLES

	Mould No. 25		Mould No. 26		Mould No. 34	
No. of layers	5	5	5	5	5	5
No. of blows per layer	10	10	30	30	65	65
CONDITION OF SAMPLE	Before soaking	After soaking	Before soaking	After soaking	Before soaking	After soaking
Wt. of Mould, W	6741	6741	6880	6880	7070	7070
Wt. of Wet Sample + Mould, W_2 (gm)	10913	11016	11346	11403	11613	11620
Wt. of Wet Sample, $W_3=(W_2-W_1)$ (gm)	4172	4275	4466	4523	4543	4550
Volume of mould, V (cc)	2250	2250	2250	2250	2250	2250
Wet Density, $Y_b = W_3/V$ (gm/cc)	1.854	1.900	1.985	2.010	2.109	2.022
MOISTURE DETERMINATION	Before soaking	After soaking	Before soaking	After soaking	Before soaking	After soaking
Container No.	5	6	22	26	25	22
Wt. of container, W_5 (gm)	45.30	46.80	43.61	48.70	48.71	46.23
Wt. of Wet Sample + Cont., W_6 (gm)	292.56	292.06	310.58	353.95	307.01	303.79
Wt. of Dry Sample + Cont., W_7 (gm)	248.86	242.65	262.87	294.55	261.25	257.12
Wt. of water, $W_8=(W_6-W_7)$ (gm)	43.70	49.41	47.71	59.40	45.76	46.67
Wt. of Dry Sample, $W_9=(W_7-W_5)$ (gm)	20356	195.85	216.56	245.85	212.54	210.89
Moisture content $W = W_8/W_9$ (%)	21.47	25.23	22.03	24.16	21.53	22.13
Dry Density $Y_d = Y_b/(1+w/100)$ (gm/cc)	1.526	1.517	1.627	1.619	1.661	1.656

LOAD- PENETRATION TEST DATA :

Proving ring No.: **Proving Ring Calibration Factor :**

Sr.No.	Penetration (mm)	Mould No. 25		Mould No. 26		Mould No. 34	
		Proving ring Reading	Corrected load (Kg)	Proving ring Reading	Corrected load (Kg)	Proving ring Reading	Corrected load (Kg)
1	0.5	1	3.35	3	10.05	3	10.05
2	1.0	3	10.05	4	13.40	6	20.10
3	1.5	4	13.40	5	16.75	9	30.15
4	2.0	5	16.75	7	23.45	11	36.85
5	2.5	6	20.1	9	30.15	13	43.55
6	3.0	7	23.45	11	36.85	14	46.90
7	4.0	8	26.8	12	40.2	16	53.60
8	5.0	9	30.15	15	50.25	18	60.30
9	7.5	10	33.5	18	60.3	21	70.35
10	10.0	11	36.85	19	63.65	23	77.05
11	12.5	11	36.85	20	67.0	24	80.4

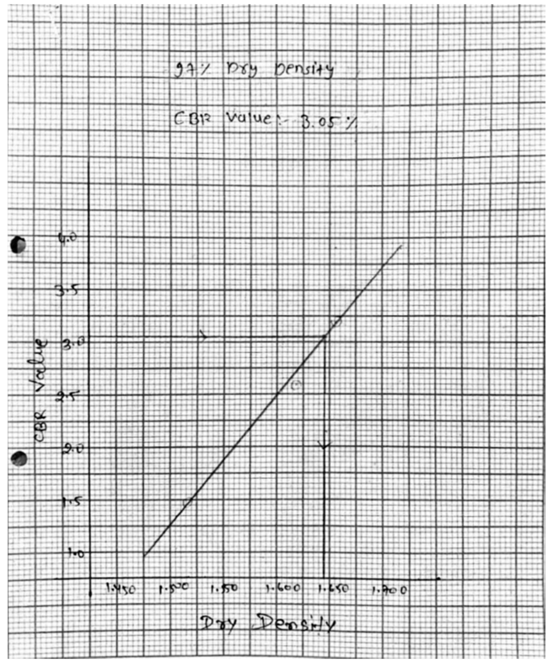
CBR CALCULATION

Mould No.	Corrected Unit Load in kgf (from graph)		CBR%		CBR % reported
	2.5 mm	5.0 mm	2.5 mm	5.0 mm	
25	20.10	30.15	1.47	1.46	3.05
26	30.15	50.25	2.20	2.59	
34	43.55	60.30	3.18	2.93	
Average					

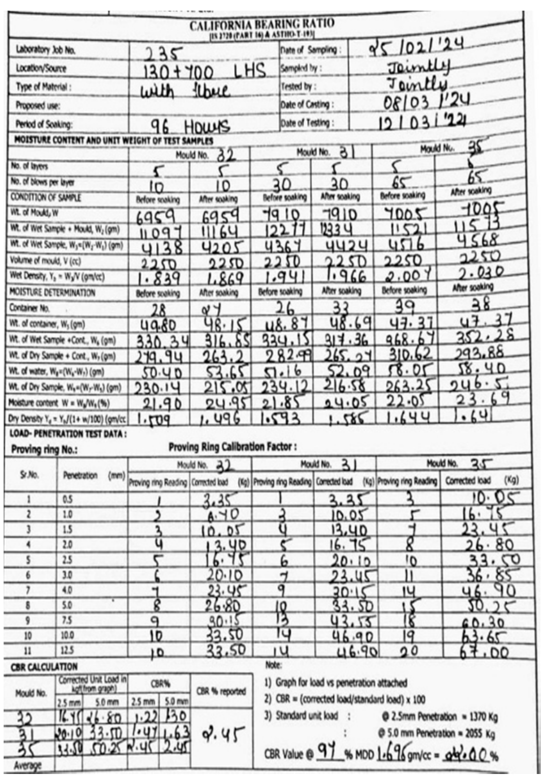
Note:
1) Graph for load vs penetration attached
2) CBR = (corrected load/standard load) x 100
3) Standard unit load : @ 2.5mm Penetration = 1370 Kg
: @ 5.0 mm Penetration = 2055 Kg

CBR Value @ 97 % MDD 1.695 gm/cc = 22.00 %

Remarks:



c) CBR Test with Fibre



CALIFORNIA BEARING RATIO
[IS 2720 (PART 16) & ASTHO-T-193]

Laboratory Job No.	235	Date of Sampling :	25/02/'24
Location/Source	130+700 LHS	Sampled by :	Jointly
Type of Material :	with fibre	Tested by :	Jointly
Proposed use:		Date of Casting :	08/03/'24
Period of Soaking:	96 Hours	Date of Testing :	12/03/'24

MOISTURE CONTENT AND UNIT WEIGHT OF TEST SAMPLES

	Mould No. 32		Mould No. 31		Mould No. 35	
No. of layers	5	5	5	5	5	5
No. of blows per layer	10	10	30	30	65	65
CONDITION OF SAMPLE	Before soaking	After soaking	Before soaking	After soaking	Before soaking	After soaking
Wt. of Mould, W	6959	6959	7910	7910	7005	7005
Wt. of Wet Sample + Mould, W_2 (gm)	11097	11164	12277	12334	11521	11573
Wt. of Wet Sample, $W_3=(W_2-W_1)$ (gm)	4138	4205	4367	4424	4516	4568
Volume of mould, V (cc)	2250	2250	2250	2250	2250	2250
Wet Density, $Y_b = W_3/V$ (gm/cc)	1.839	1.869	1.941	1.966	2.007	2.030
MOISTURE DETERMINATION	Before soaking	After soaking	Before soaking	After soaking	Before soaking	After soaking
Container No.	28	27	26	33	39	38
Wt. of container, W_5 (gm)	49.80	48.15	48.87	48.69	47.37	47.37
Wt. of Wet Sample + Cont., W_6 (gm)	330.34	316.85	334.15	317.36	368.67	352.28
Wt. of Dry Sample + Cont., W_7 (gm)	279.94	263.2	282.99	265.27	310.62	293.88
Wt. of water, $W_8=(W_6-W_7)$ (gm)	50.40	53.65	51.16	52.09	58.05	58.40
Wt. of Dry Sample, $W_9=(W_7-W_5)$ (gm)	230.14	215.05	234.12	216.58	263.25	246.5
Moisture content $W = W_8/W_9$ (%)	21.90	24.95	21.85	24.05	22.05	23.69
Dry Density $Y_d = Y_b/(1+w/100)$ (gm/cc)	1.509	1.496	1.593	1.585	1.644	1.64

LOAD- PENETRATION TEST DATA :

Proving ring No.: **Proving Ring Calibration Factor :**

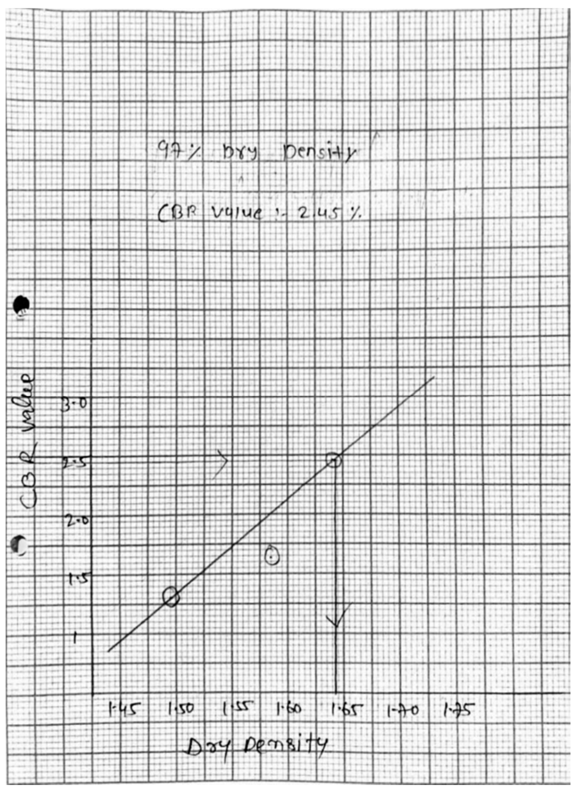
Sr.No.	Penetration (mm)	Mould No. 32		Mould No. 31		Mould No. 35	
		Proving ring Reading	Corrected load (Kg)	Proving ring Reading	Corrected load (Kg)	Proving ring Reading	Corrected load (Kg)
1	0.5	1	3.35	1	3.35	3	10.05
2	1.0	2	6.70	3	10.05	5	16.75
3	1.5	3	10.05	4	13.40	7	23.45
4	2.0	4	13.40	5	16.75	8	26.80
5	2.5	5	16.75	6	20.10	10	33.50
6	3.0	6	20.10	7	23.45	11	36.85
7	4.0	7	23.45	9	30.15	14	46.90
8	5.0	8	26.80	10	33.50	15	50.25
9	7.5	9	30.15	13	43.55	18	60.30
10	10.0	10	33.50	14	46.90	19	63.65
11	12.5	10	33.50	14	46.90	20	67.00

CBR CALCULATION

Mould No.	Corrected Unit Load in kgf (from graph)		CBR%		CBR % reported
	2.5 mm	5.0 mm	2.5 mm	5.0 mm	
32	16.75	26.80	1.22	1.30	2.45
31	20.10	33.50	1.47	1.63	
35	33.50	50.25	2.45	2.45	
Average					

Note:
1) Graph for load vs penetration attached
2) CBR = (corrected load/standard load) x 100
3) Standard unit load : @ 2.5mm Penetration = 1370 Kg
: @ 5.0 mm Penetration = 2055 Kg

CBR Value @ 97 % MDD 1.696 gm/cc = 24.00 %



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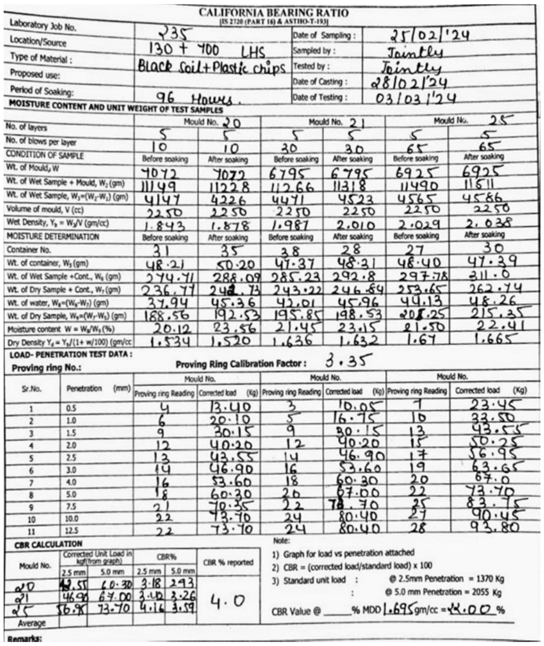
d) CBR Test Black with Plastic Bottle Chips



CALIFORNIA BEARING RATIO
[IS 2720 (PART 16) & ASTHO-T-193]

Laboratory Job No.	235	Date of Sampling :	25/02/'24
Location/Source	130 + 400 LHS	Sampled by :	Jointly
Type of Material :	Black Soil+Plastic chips	Tested by :	Jointly
Proposed use:		Date of Casting :	28/02/'24
Period of Soaking:	96 Hours.	Date of Testing :	03/03/'24

MOISTURE CONTENT AND UNIT WEIGHT OF TEST SAMPLES

	Mould No. 20		Mould No. 21		Mould No. 25	
No. of layers	5	5	5	5	5	5
No. of blows per layer	10	10	30	30	65	65
CONDITION OF SAMPLE	Before soaking	After soaking	Before soaking	After soaking	Before soaking	After soaking
Wt. of Mould, W	7072	7072	6795	6795	6925	6925
Wt. of Wet Sample + Mould, W_2 (gm)	11149	11228	11266	11318	11490	11511
Wt. of Wet Sample, $W_3=(W_2-W_1)$ (gm)	4147	4226	4471	4523	4565	4586
Volume of mould, V (cc)	2250	2250	2250	2250	2250	2250
Wet Density, $\gamma_b = W_3/V$ (gm/cc)	1.843	1.878	1.987	2.010	2.029	2.038
MOISTURE DETERMINATION	Before soaking	After soaking	Before soaking	After soaking	Before soaking	After soaking
Container No.	31	35	38	28	27	30
Wt. of container, W_5 (gm)	48.21	50.20	47.37	48.31	48.40	47.39
Wt. of Wet Sample +Cont., W_6 (gm)	274.71	288.09	285.23	292.8	297.78	311.0
Wt. of Dry Sample + Cont., W_7 (gm)	236.77	242.73	243.22	246.84	253.65	262.74
Wt. of water, $W_8=(W_6-W_7)$ (gm)	37.94	45.36	42.01	45.96	44.13	48.26
Wt. of Dry Sample, $W_9=(W_7-W_5)$ (gm)	188.56	192.53	195.85	198.53	205.25	215.35
Moisture content $W = W_8/W_9$ (%)	20.12	23.56	21.45	23.15	21.50	22.41
Dry Density $\gamma_d = \gamma_b/(1+w/100)$ (gm/cc)	1.534	1.520	1.636	1.632	1.67	1.665

LOAD- PENETRATION TEST DATA :
Proving ring No.: Proving Ring Calibration Factor : 3.35

Sr.No.	Penetration (mm)	Mould No. Proving ring Reading	Corrected load (Kg)	Mould No. Proving ring Reading	Corrected load (Kg)	Mould No. Proving ring Reading	Corrected load (Kg)
1	0.5	4	13.40	3	10.05	7	23.45
2	1.0	6	20.10	5	16.75	10	33.50
3	1.5	9	30.15	9	30.15	13	43.55
4	2.0	12	40.20	12	40.20	15	50.25
5	2.5	13	43.55	14	46.90	17	56.95
6	3.0	14	46.90	16	53.60	19	63.65
7	4.0	16	53.60	18	60.30	20	67.0
8	5.0	18	60.30	20	67.00	22	73.70
9	7.5	21	70.35	22	73.70	25	83.75
10	10.0	22	73.70	24	80.40	27	90.45
11	12.5	22	73.70	24	80.40	28	93.80

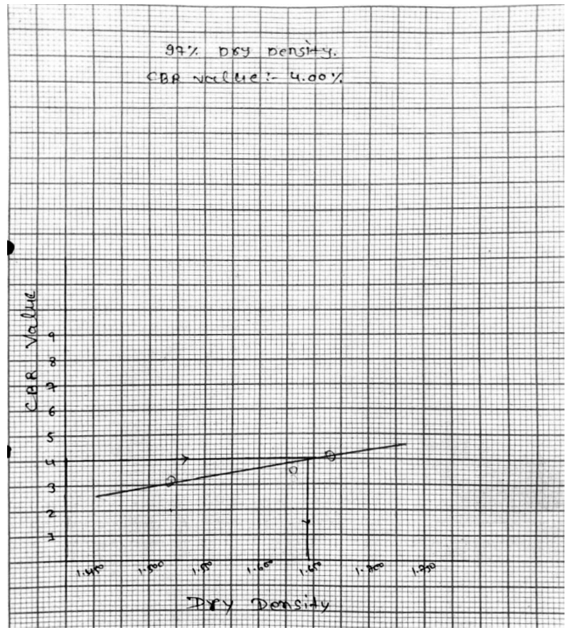
CBR CALCULATION

Mould No.	Corrected Unit Load in kgf(from graph) 2.5 mm	5.0 mm	CBR% 2.5 mm	5.0 mm	CBR % reported
20	43.55	60.30	3.18	2.93	4.0
21	46.90	67.00	3.42	3.26	
25	56.95	73.70	4.16	3.59	
Average					

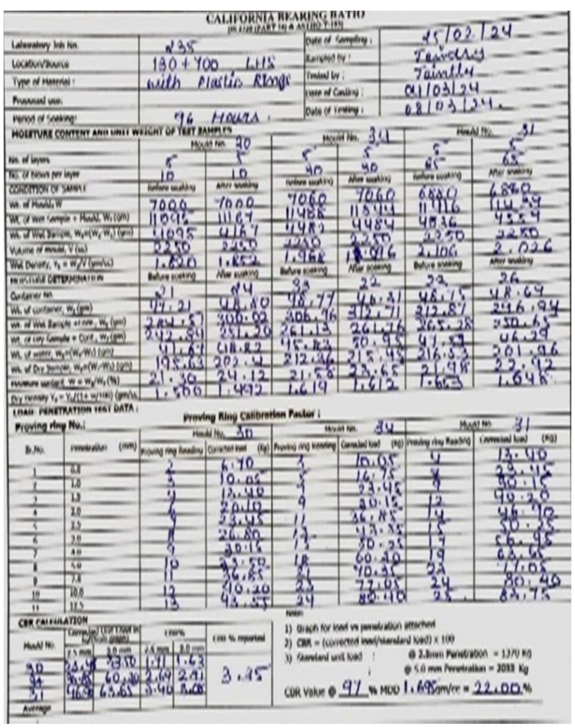
Note:
1) Graph for load vs penetration attached
2) CBR = (corrected load/standard load) x 100
3) Standard unit load : @ 2.5mm Penetration = 1370 Kg
: @ 5.0 mm Penetration = 2055 Kg

CBR Value @ ____% MDD 1.695 gm/cc = 4.00 %

Remarks:



e) CBR test with Plastic Bottle Ring



CALIFORNIA BEARING RATIO
[IS 2720 (PART 16) & ASTHO-T-193]

Laboratory Job No.	235	Date of Sampling :	25/02/24
Location/Source	130 + 400 LHS	Sampled by :	Jointly
Type of Material :	with Plastic Rings	Tested by :	Jointly
Proposed use:		Date of Casting :	01/03/24
Period of Soaking:	96 Hours.	Date of Testing :	08/03/24.

MOISTURE CONTENT AND UNIT WEIGHT OF TEST SAMPLES

	Mould No. 20		Mould No. 34		Mould No. 31	
No. of layers	5	5	5	5	5	5
No. of blows per layer	10	10	30	30	65	65
CONDITION OF SAMPLE	Before soaking	After soaking	Before soaking	After soaking	Before soaking	After soaking
Wt. of Mould, W	7000	7000	7060	7060	6880	6860
Wt. of Wet Sample + Mould, W_2 (gm)	11095	11167	11488	11544	11716	11459
Wt. of Wet Sample, $W_3=(W_2-W_1)$ (gm)	4095	4167	4483	4484	4836	4554
Volume of mould, V (cc)	2250	2250	2250	2250	2250	2250
Wet Density, $\gamma_b = W_3/V$ (gm/cc)	1.820	1.852	1.968	1.996	2.106	2.026
MOISTURE DETERMINATION	Before soaking	After soaking	Before soaking	After soaking	Before soaking	After soaking
Container No.	21	24	33	22	32	26
Wt. of container, W_5 (gm)	47.21	48.80	48.77	46.31	48.15	48.69
Wt. of Wet Sample +Cont., W_6 (gm)	284.57	300.02	306.96	312.71	312.87	296.94
Wt. of Dry Sample + Cont., W_7 (gm)	242.84	251.20	261.13	261.76	265.28	250.65
Wt. of water, $W_8=(W_6-W_7)$ (gm)	41.67	48.82	45.83	50.95	47.59	46.29
Wt. of Dry Sample, $W_9=(W_7-W_5)$ (gm)	195.63	202.4	212.36	215.45	216.53	201.96
Moisture content $W = W_8/W_9$ (%)	21.30	24.12	21.58	23.65	21.98	22.92
Dry Density $\gamma_d = \gamma_b/(1+w/100)$ (gm/cc)	1.500	1.492	1.619	1.612	1.663	1.648

LOAD- PENETRATION TEST DATA :
Proving ring No.: Proving Ring Calibration Factor :

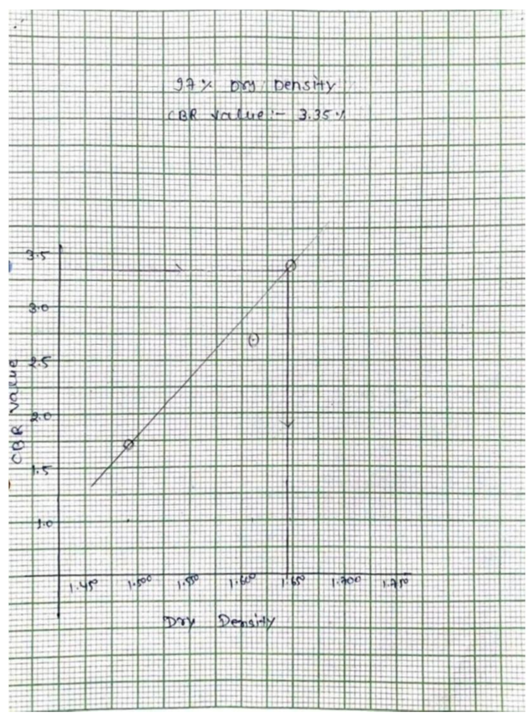
Sr.No.	Penetration (mm)	Mould No. 30 Proving ring Reading	Corrected load (Kg)	Mould No. 34 Proving ring Reading	Corrected load (Kg)	Mould No. 31 Proving ring Reading	Corrected load (Kg)
1	0.5	2	6.70	3	10.05	4	13.40
2	1.0	3	10.05	5	16.75	7	23.45
3	1.5	4	13.40	7	23.45	9	30.15
4	2.0	6	20.10	9	30.15	12	40.20
5	2.5	7	23.45	11	36.85	14	46.90
6	3.0	8	26.80	13	43.55	15	50.25
7	4.0	9	30.15	15	50.25	17	56.95
8	5.0	10	33.50	18	60.30	19	63.65
9	7.5	11	36.85	21	70.35	23	77.05
10	10.0	12	40.20	23	77.05	24	80.40
11	12.5	13	43.55	24	80.40	25	83.75

CBR CALCULATION

Mould No.	Corrected Unit Load in kgf(from graph) 2.5 mm	5.0 mm	CBR% 2.5 mm	5.0 mm	CBR % reported
30	23.45	33.50	1.71	1.63	3.35
34	36.85	60.30	2.69	2.93	
31	46.90	63.65	3.40	3.08	
Average					

Note:
1) Graph for load vs penetration attached
2) CBR = (corrected load/standard load) x 100
3) Standard unit load : @ 2.5mm Penetration = 1370 Kg
: @ 5.0 mm Penetration = 2055 Kg

CBR Value @ 97 % MDD 1.695 gm/cc = 22.00 %



IV. RESULT ANALYSIS

A. Free Swell Index Result Analysis

Here's an analysis of the Free Swell Index test results :

- Free Swell Index: The Free Swell Index of the soil sample is 57.70%. A free swell index greater than 30% indicates a high swelling potential
- Interpretation:

The high Free Swell Index suggests that the soil sample has a high potential to swell when saturated with water. This can cause problems with foundations and other structures built on this soil, as the swelling soil can cause cracking and movement.

B. Liquid Limit Result Analysis

Atterberg Limits

- Liquid Limit (LL): The Liquid Limit is 65.50%. This is the moisture content at which the soil changes from a liquid state to a plastic state
- Plastic Limit (PL): The Plastic Limit is 27.40%. This is the moisture content at which the Soil changes from a plastic state to a brittle state .
- Plasticity Index (PI): The Plasticity Index (PI) is calculated as the difference between the
- Liquid Limit (LL) and the Plastic Limit (PL). In this case, the PI is 65.50% - 27.40% = 38.10%. A higher PI value indicates a more plastic soil.

C. Grain Size Analysis Result Analysis

Here's an analysis ofthe grain size distribution:

- Gravel(75-19 mm): 1.60% of the sample falls into the gravel size category.
- Sand (4.75-0.075 mm): 10.9% of the sample falls into the sand size category. This can be Further broken down into: Coarse sand (4.75-2.00 mm): 0.90% ,Medium sand (2.00-0.425 mm): 4.7% &Fine sand (0.425-0.075 mm): 5.3%
- Silt and Clay (particles smaller than 0.075 mm): 87.5% of the sample falls into the silt And clay size category.

D. Modified Proctor Test Result Analysis

- Dry Density (g/cm³): The data sheet shows the Dry Density for five different moisture Content values. The Dry Density increases as the moisture content increases up to a certain Point, and then starts to decrease. The highest Dry Density is 1.695 g/cm³ at a moisture Content of 22.00%, which is considered the Maximum Dry Density (MDD).
- Optimum Moisture Content (OMC): The Optimum Moisture Content (OMC) is the Moisture content at which the Maximum Dry Density (MDD) is achieved. In this case, the OMC is 22.00%

E. Cbr Test Result Analysis Noramal Black Soil

The report shows the results of the CBR test for three soil samples (moulds 24, 25, and 26).
The CBR values for the three samples are:

- Mould 24: 16.75 corrected load at 2.5 mm penetration, 26.80 corrected load at 5.0 mm Penetration
- Mould 25: 33.50 corrected load at 2.5 mm penetration, 53.60 corrected load at 5.0mm penetration
- Mould 26: 40.20 corrected load at 2.5 mm penetration, 60.30 corrected load at 5.0 mm penetration
- The CBR values are all relatively low, which indicates that the soils are weak and may not be Suitable for use in pavements without additional treatment. The report does not specify what The soils will be used for, but the CBR values are typically used to design the thickness of Pavement layers.
- CBR VALUE IS :- 2.82%

F. CBR Test Result Analysis Black Soil + Geotextile

The report shows the results of the CBR test for three soil samples (moulds, 25, 26, and 34). The
CBR values for the three samples are:

- Penetration Mould 25: 20.10corrected load at 2.5 mm penetration, 30.15 corrected Load at 5.0 mm
- Penetration Mould 26: 30.15 corrected load at 2.5 mmpenetratioloa50.25 corrected Load at 5.0 mm
- Penetration Mould 34: 43.55 corrected load at 2.5 mm penetration, 60.30 corrected Load at 5.0 mm
- Penetration The CBR values are all relatively low, which indicates that the soils are weak and

May not be suitable for use in pavements without additional treatment. The report does not Specify what the soils will be used for, but the CBR values are typically used to design the Thickness of Pavement layers
CBR VALUE IS :- 3.05%

G. CBR Test Result Analysis Black Soil + Fiber

The report shows the results of the CBR test for three soil samples (moulds, 33, 31, and 35). The
CBR values for the three samples are:

- Penetration Mould 33: 16.75 corrected load at 2.5 mm penetration, 26.80 corrected load at 5.0 mm
- Penetration Mould 31: 20.10 corrected load at 2.5 mm penetration, 33.50 corrected load at 5.0 mm
- Penetration Mould 35: 33.50 corrected load at 2.5 mm penetration, 50.25 corrected load at 5.0 mm
- Penetration The CBR values are all relatively low, which indicates that the soils are weak and may not be suitable for use in pavements without additional treatment. The report does not specify what the soils will be used for, but the CBR values are typically used to design the thickness of Pavement layers
- CBR VALUE IS :- 2.40%

H. CBR Test Result Analysis Black Soil + Plastic Chips

The report shows the results of the CBR test for three soil samples (moulds, 20, 21, and 25). The
CBR values for the three samples are:

- Penetration Mould 20: 43.55 corrected load at 2.5 mm penetration, 60.30 corrected load at 5.0 mm
- Penetration Mould 21: 46.90 corrected load at 2.5 mm penetration, 67.00 corrected load at 5.0 mm
- Penetration Mould 25: 56.95 corrected load at 2.5 mm penetration, 73.70 corrected load at 5.0 mm
- Penetration The CBR values are all relatively low, which indicates that the soils are weak and may not be suitable for use in pavements without additional treatment. The report does not specify what the soils will be used for, but the CBR values are typically used to design the thickness of Pavement layers
- CBR VALUE IS : 4.00 %

I. CBR Test Result Analysis Black Soil + Plastic Rings

The report shows the results of the CBR test for three soil samples (moulds, 30, 34, and 31). The
CBR values for the three samples are:

- Penetration Mould 25: 23.45 corrected load at 2.5 mm penetration, 33.50 corrected load at 5.0 mm
- Penetration Mould 26: 36.85 corrected load at 2.5 mm penetration, 60.30 corrected load at 5.0 min
- Penetration Mould 34: 46.90 corrected load at 2.5 mm penetration, 63.65 corrected load at 5.0 mm
- Penetration The CBR values are all relatively low, which indicates that the soils are weak and May not be suitable for use in pavements without additional treatment. The report does not Specify what the soils will be used for, but the CBR values are typically used to design the Thickness of Pavement layers
- CBR VALUE IS :- 3.35 %

V. CONCLUSION

Black cotton soil, despite its weakness, can be boosted for embankments using plastic waste. Crushed plastic or strips mixed in the soil improve its strength and reduce swelling. This creates a Stronger, more stable material for building embankments. However, this method doesn’t address the core issue for subgrades – shrinkage and swelling with Moisture changes. Embankments sit above ground with less water exposure, but subgrades are Directly impacted by seasonal variations. The treated soil might still experience these drastic volume Changes, causing cracks and compromising the structural integrity of the road or building above.

In short, plastic waste strengthens black cotton soil for embankments, but it doesn’t address the Moisture sensitivity that plagues subgrades.

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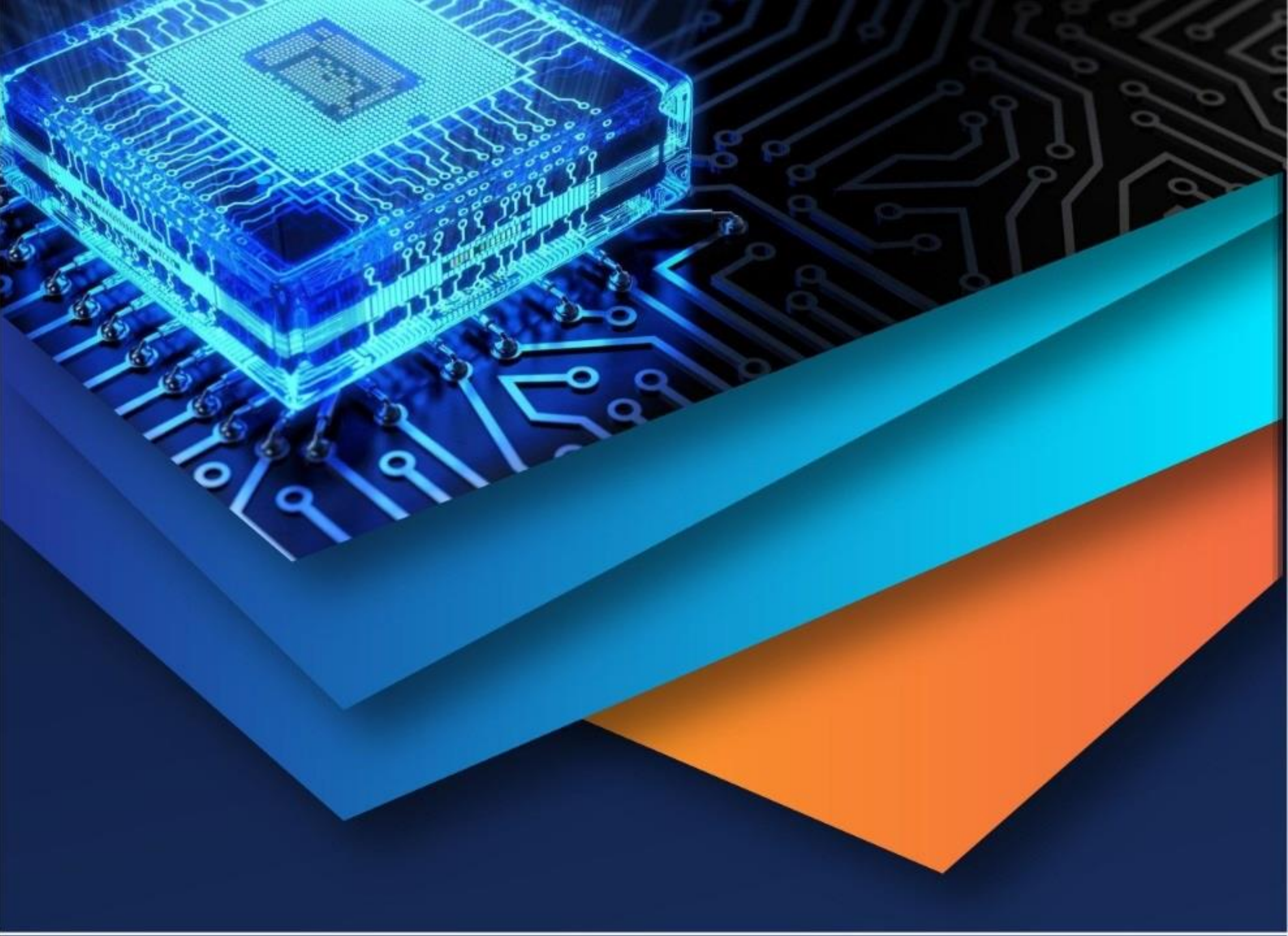

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