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"Stabilization of Pavement Subgrade Using Fly Ash and Lime"

[1]Mohd. Imran Khan,(Assistant Professor) Dr. Ahmad Ali Khan,[2](Professor)
1Civil Engineering Department, Technocrat Institute of Technology, Bhopal Pin Code, 462022, Madhya Pradesh, India
2Civil Engineering Department, All saints College of Technology, Bhopal, Pin code 462036,Madhya Pradesh, India
Corresponding Author: 1Mohd. Imran Khan

ABSTRACT:*The study investigates the various physical properties of black cotton soil and flyash. The physical properties and engineering properties of BC Soil such as liquid limit, plastic limit, shrinkage limit, sieve analysis, specific gravity, optimum moisture content and maximum dry density and CBR. Liquid limit and plastic limit of BC soil mixed with varying percentage of flyash and lime such as 5, 10, 15, 20 25and 2,3,4 respectively. The proctor compaction test is to be conducted to determine the optimum moisture content and maximum dry density for plain BC soil and BC soil mixed with flyash and lime in varying percentage. CBR Test is to be conducted on plain BC soil, BC soil mixed with varying percentages of flyash and lime after 4 day soaking and without curing.*

Keywords: *Fly ash, lime, black cotton soil, pavement, etc.*

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I. Introduction

Soil stabilization means the improvement of the stability or bearing capacity of the soil by the use of controlled compaction, proportioning and the addition of suitable admixture or stabilizers. It deals with the physical, physio chemical and chemical methods to make the stabilized soil its purpose as pavement component material [1]. Fly ash is a waste product available from coal or liquate bearing thermal plants. Flyash can be advantageously used not only in the pavement construction work, but also provides an economic and useful avenve for disposal of flyash, which is now recognized by as a national environmental problem [1] [2]. Stabilization is being used for a variety of engineering works, the most common application being in the construction of road and air field pavements. Methods of stabilization may be grouped under two main types.

1. Modification or improvement of a soil property of the existing soil without any admixture.
2. Modification of the properties with the help of admixtures.

Objectives:

- To determine optimum percentage of flyash and lime by conducting tests such as liquid limit, plastic limit and plasticity index by varying the percentage of flyash and lime.
- To determine the optimum moisture content and maximum dry density by conducting the proctor compaction test.
- To determine the CBR value of BC soil mixed with different percentages of lime and flyash.
- To study the effect of curing on CBR values of BC soil mixed with lime and flyash.

II. Methodology

1. To determine the physical properties of soil and flyash.
2. Percentages of gravel, sand, clay and silt in the soil is determined.
3. The optimum flyash content is determined by mixing percentage of flyash such as 5, 10, 15, 20 and 25 with BC soil and conducting plastic and liquid limit tests.
4. The CBR value in determined for BC soil mixed with 25% flyash
5. The soaked CBR value is for BC soil mixed with 25% flyash after accelerated curing for 19 hours at 55°C temperature.
6. The CBR value in determined for BC soil mixed with 25% flyash as constant with varying percentage of lime such as 2%, 3% and 4% (after 4 days soaking).
7. The soaked CBR value is for BC soil mixed with 25% flyash as constant with varying percentages of lime such as 2%, 3% and 4% after accelerated curing for 19 hours at 55°C temperature.

III. Experimental Investigations

Physical tests :

Table 3.1:Determination of grain size distribution of the particle [4]

Sl No	Sieve size	Weight of soil retained (gm)	Correction (-ve) gms	Corrected weight gms	% retained	Cumulative % retained	Cumulative % finer
1	4.75mm	8	0.118	7.882	1.576	1.576	98.424
2	2.36mm	10	0.148	9.852	1.970	3.546	96.454
3	1mm	18	0.267	17.733	3.546	7.092	91.332
4	600µ	8	0.118	7.882	1.576	8.668	90.148
5	425µ	6	03088	5.912	1.184	9.852	88.964
6	300µ	6	0.088	5.912	1.184	11.036	88.194
7	212µ	4	0.059	3.941	0.788	11.874	88.176
8	150µ	0	0	0	0	11.874	88.176
9	75µ	2.36	0.038	2.592	0.518	12.342	87.658
10	Pan	0.3	0.004	0.296	0.0592	12.401	

Result

Percentage of gravel = 1.576%
Percentage of sand = 10. 766%
Percentage of silt and clay = 87.6%.

Table 3.2: Specific gravity of soil [4]

Sl. No	Particulars	Wt. in gm
01	Mass of pycnometer (M_1) gm	652
02	Mass of pycnometer + soil (M_2)gm	908
03	Mass of pycnometer + soil + water (M_3)gm	1630
04	Mass of pycnometer + water (M_4)gm	1470
05	Specific gravity G	2.67

Table 3.3: Specific gravity of flyash [4]

Sl. No	Particulars	Wt in gm
01	Mass of pycnometer (M_1) gm	26
02	Mass of pycnometer + flyash (M_2)gm	38
03	Mass of pycnometer + flyash+ kerosene (M_3)gm	76
04	Mass of pyconmeter + kerosene (M_4)gm	68
05	Specific gravity G	0.807
06	Specific gravity of flyash	2.42

Table 3.4: Results of plastic limit for varying percentage of flyash[4]

Sl No	**Soil +% of flyash**	**Particulars**	**Container No**	**Weight of container + wet soil (gm)**	**Weight of container + dry soil (gm)**	**Weight of empty container (gm)**	**Weight of water (gm)**	**Weight dry soil (gm)**	**Water content (%)**
1	Plain Soil	I	Y_2	20.782	17.242	8.588	3.54	8.654	40.905
2		II	H_{15}	20.863	17.722	9.975	3.114	7.747	70.19
3		III	H_7	20.7	17.462	9.68	3.238	7.782	41.5

		Avg							40.86
1	Plain soil + 5 % flyash	I	H_9	19.495	16.426	9.286	3.069	7.14	42.98
2		II	H_{13}	19.376	16.214	9.142	3.135	6.829	45.9
3		III	Y_2	21.00	17.37	9.19	3.622	8.18	44.26
		Avg							44.38
1	Plain soil + 10% flyash	I	34	18.137	17.62	9.102	0.517	8.57	6.09
2		II	18	21.212	15.62	9.09	5.58	6.334	85.5
3		III	M	17.925	15.59	9.801	2.32	5.79	40.11
		Avg							43.9
1	Soil +15 % flyash	I	H_{10}	21.892	17.93	9.419	3.962	8.511	46.55
2		II	B_8	22.271	17.904	8.618	4.367	9.286	47.02
3		III	B_9	20387	17.122	8.915	3.753	8.207	45.72
		Avg							46.43
1	Soil + 20% flyash	I	19	23.824	17.569	9.625	6.255	73944	78.73
		II	46	21.69	17.367	9.516	3.733	8.441	44.22
		III	K	21.56	18.09	9.242	3.466	8.852	32.15
		Avg							54.03
1	Soil + 25%flyash	I	13	22.961	18.131	9.137	3.83	8.994	53.7
		II	Y_2	22.567	18.063	9.196	3.504	8.867	50.79
		III	H_9	22.114	18.301	9.283	3.813	9.018	42.28
		Avg							48.92

Table 3.6: Results of plastic limit for varying percentage of flyash with 2% lime

Sl No	S0il + % of flyash +lime	Particulars	Container no	Weight of container + wet soil (gm)	Weight of container + dry soil (gm)	Weight of empty container (gm)	Weight of water (gm)	Weight of dry soil (gm)	Water content (%)
1	Soil +15 % flyash +2% lime	I	M	20.744	17.618	9.814	3.126	7.861	40.05
2		II	H	20.193	16.983	9.123	3.21	7.86	40.83
3		III	40	21.135	17.78	9.076	3.355	8.704	38.54
		Avg							39.80
1	Soil + 20% flyash+ 2% lime`	I	H	21.157	17.555	9.129	3.602	8.426	42.74
2		II	H_6	19.065	15.945	8.620	3.12	7.325	42.59
3		III	T	21.103	17.559	9.048	3.544	8.511	41.64
		Avg							42.323
1	Soil + 25%flyash + 2% lime	I	A	21.337	17.680	9.242	3.657	8.438	46.33
2		II	Y_2	19.114	15.929	9.194	3.185	6.735	47.29
3		III	34	19.871	16.485	9.087	3.386	7.399	45.769
		Avg							46.463

Table 3.7: Results of plastic limit for varying percentage of flyash with 3% lime

Sl No	S0il + % of flyash +lime	Particulars	Container no	Weight of container + wet soil (gm)	Weight of container + dry soil (gm)	Weight of emty container (gm)	Weight of water (gm)	Weight of dry soil (gm)	Water content (%)
1	Soil + 15.%	I	17	22.461	18.173	8.966	4.288	9.207	46.

	flyash + 3% lime								57
2		II	25	26.257	21.02	9.787	5.237	11.233	46.62
3		III	40	22.825	18.419	9.073	4.406	9.346	47.14
		Avg							46.77
1	Soil + 20% flyash +3 % lime	I	36	25.465	20.204	9.206	5.261	10.998	47.83
2		II	M	24.664	19.915	9.809	4.749	10.106	46.99
3		III	H_9	20.909	17.186	9.082	3.723	8.104	45.94
		Avg							46.92
1	Soil + 25%flyash + 3 % lime	I	M	26.35	20.88	9.807	5.47	11.073	49.39
2		II	H	24.710	19.694	9.138	5.016	10.556	47.51
3		III	B_8	22.526	17.973	8.628	4.553	9.345	48.72
		Avg							48.54

Table 3.8: Results of plastic limit for varying percentage of flyash with 4% lime

Sl No	S0il + % of flyash +lime	Particulars	Container no	Weight of container + wet soil (gm)	Weight of container + dry soil (gm)	Weight of emty container (gm)	Weight of water (gm)	Weight of dry soil (gm)	Water content (%)
1	Soil + 15.% flyash + 4% lime	I	M	21.353	17.693	9.808	3.662	7.883	46.45
2		II	36	20.783	17.134	9.204	3.649	7.93	46.015
3		III	H_7	23.104	18.733	9.080	4.371	9.653	45.28
		Avg							46.125
1	Soil + 20% flyash +4 % lime	I	H_7	21.567	17.551	9.080	4.016	8.47	47.4
2		II	M	17.334	14.921	9.808	2.413	5.113	47.19
3		III	36	21.892	17.868	9.205	4.026	8.663	46.47
		Avg							47.02
1	Soil + 25%flyash + 4 % lime	I	46	23.531	18.862	9.514	4.669	9.348	49.94
2		II	19	26.982	21.316	9.624	5.666	11.692	48.46
3		III	P_1	25.952	20.482	9.277	5.47	11.205	48.81
		Avg							49.07

Table 3.5: Results of liquid limit for varying percentage flyash

Sl No	Soil + % of flyash	Particulars	No of blows	Container no	Weight of container + wet soil (gm)	Weight of container + dry soil (gm)	Weight of empty container (gm)	Weight of water (gm)	Weight of dry soil (gm)	Water content
1	Plain	I	19	P	22.27	16.67	9.536	5.6	7.134	78.49

	soil	II	23	H_{16}	19.914	15.00	8.634	4.914	6.366	77.19
		III	45	20	20.452	15.67	9.376	4.782	6.294	75.9
		Avg								**77.5**
2	Plain + 5% flyash	I	13	B_8	25.25	1788	8.624	7.365	.9.261	79.52
		II	16	B_9	24.05	17.412	8.94	6.644	8.473	78.41
		III	28	K	21.77	16.326	9.246	5.444	7.08	76.84
		Avg								**77.5**
3	Plain + 10% flyash	I	14	19	24.45	18.631	9.634	6.819	8.997	75.79
		II	18	46	23.464	17.464	9.538	5.952	7.93	75.056
		III	29	H_{10}	23.715	17.668	9.43	6.046	8.235	73.45
		Avg								**74.2**

Table 3.6: Results of liquid limit for varying percentage of flyash :

Sl No	Soil + % of flyash	Particulars	No of blows	Container no	Weight of container + wet soil (gm)	Weight of container + dry soil (gm)	Weight of empty container (gm)	Weight of water (gm)	Weight of dry soil (gm)	Water content
1	Plain soil+15 % flyash	I	21	H	23.794	17.715	9.131	6.079	8.584	70.81
		II	23	9	23.12	17.37	9.19	5.75	8.181	70.28
		III	52	P_{10}	23.77	17.96	9.696	5.81	8.266	70.28
		Avg								**70.45**
2	Soil +20% flyash	I	16	40	23.516	17.752	9.048	5.764	8.704	77.35
		II	37	B_6	23.031	17.226	9.78	6.505	7.447	66.22
		III	55	A	22.691	17.408	9.244	5.283	8.164	64.47
		avg								69.34
3	Soil + 25 % flyash	I	14	34	22.001	16.615	9.088	5.386	7.527	71.15
		II	31	18	25.275	18.691	9.11	6.584	9.58	66.72
		III	48	M	23.015	17.692	9.78	5.343	7.87	65.86
		Avg								67.5

Table 3.11: Results of liquid limit for varying percentage of flyash with 2% of lime

Sl No	Soil + % of flyash	Particulars	No of blows	Container no	Weight of container + wet soil (gm)	Weight of container + dry soil (gm)	Weight of empty container (gm)	Weight of water (gm)	Weight of dry soil (gm)	Water content
1	Plain soil+15 % flyash 2% lime	I	11	36	24.407	18.154	9.206	6.253	8.648	72.30
		II	15	25	24.1	18.258	9.79	5.842	8.464	68.989
		III	39	H_7	24.643	18.444	9.272	6.199	9.172	67.758
		Avg								**68.5**
2	Soil +20% flyash +2 % lime	I	15	17	23.653	17.686	8.98	5.967	8.706	68.53
		II	25	15	24.787	18.45	9.191	6.337	9.259	68.44
		III	43	1	24.842	18.758	9.769	6.089	8.989	67.68
		Avg								**68.101**
3	Soil + 25 % flyash +2% lime	I	11	D	24.025	17.845	8.978	6.18	8.867	69.69
		II	20	19	24.470	18.506	9.624	5.964	8.882	67.14
		III	31	13	23.715	17.942	9.137	5.773	8.805	65.56
		Avg								**66**

Table 3.12: Results of liquid limit for varying percentage of flyash with 3% of lime

Sl No	Soil + % of flyash	Particulars	No of blows	Container no	Weight of container + wet soil (gm)	Weight of container + dry soil (gm)	Weight of empty container (gm)	Weight of water (gm)	Weight of dry soil (gm)	Water content
1	Plain soil+15 % flyash +3 % lime	I	12	17	20.335	15.880	8.979	4.455	6.901	64.555
		II	20	36	20.275	15.997	9.219	4.278	6.778	63.11
		III	36	M	20.620	16.484	9.810	4.136	6.674	61.97
		IV	44	40	20.030	15.858	9.072	4.172	6.786	61.47
		Avg								**63.1**
2	Soil +20% flyash +3 % lime	I	10	H	21.306	16.549	9.143	4.757	7.406	64.23
		II	14	R	19.972	15.749	9.153	4.223	6.596	64.02
		III	18	H_7	20.338	16.029	9.296	4.369	3.733	63.40
		IV	35	D	19.183	15.301	8.969	3.882	6.332	61.30
		Avg								**62.5**
3	Soil + 25 % flyash +3 % lime	I	10	A	23.313	17.675	9.255	5.455	8.42	64.78
		II	17	40	23.014	17.484	9.069	5.53	8.415	63.71
		III	43	H_{16}	19.423	15.181	8.636	4.242	6.545	62.81
		IV	48	1	23.571	18.173	9.782	5.398	8.391	.63.33
		Avg								**62.28**

Table 3.13: Results of liquid limit for varying percentage of flyash with 4% of lime

Sl No	Soil + % of flyash	Particulars	No of blows	Container no	Weight of container + wet soil (gm)	Weight of container + dry soil (gm)	Weight of empty container (gm)	Weight of water (gm)	Weight of dry soil (gm)	Water content
1	Plain soil+15 % flyash +4 % lime	I	10	Y_2	26.629	17.327	9.202	5.0302	8.125	65.25
		II	14	H_{16}	20.02	15.581	8.628	4.439	6.953	63.89
		III	20	K	21.370	16.641	9.249	4.729	7.392	63.77
		IV	33	H_{10}	22.667	17.563	9.433	5.104	8.13	62.77
		Avg								**63.5**
2	Soil +20% flyash +4 % lime	I	10	B_9	22.572	17.252	8.95	5.32	8.302	64.08
		II	15	H_{15}	21.219	16.690	9.485	4.529	7.205	62.859
		III	22	B_6	22.254	17.447	9.792	4.807	7.655	62.79
		IV	33	H_{17}	23.455	17.817	8.695	5.638	9.122	61.806
		Avg								**62.4**
3	Soil + 25 % flyash +4 % lime	I	13	36	22.429	17.228	9.235	5.201	7.993	65.069
		II	17	P_{10}	21.354	16.776	9.716	4.578	7.06	64.84
		III	21	B_6	22.227	17.343	9.786	4.884	7.557	61.62
		IV	29	B_9	21.222	16.462	8.956	4.76	7.506	59.4
		Avg								**60.0**

Variation of liquid limit, plastic limit and plasticity index with varying percentage of flyash are shown in fig 3.1. Optimum flyash content = 20%

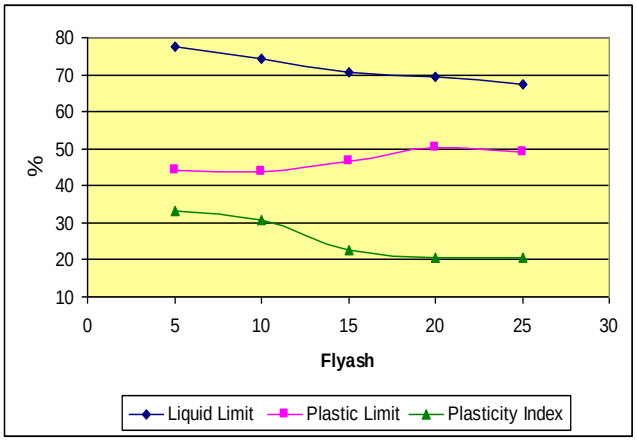

Fig. 3.1: Liquid limit and plastic limit for plain soil with 5 – 25% flyash Variation of liquid limit, plastic limit and plasticity index with varying percentage of flyash and 2%, 3% and 4% lime contents are show in fig 3.2, 3.3 & 3.4.

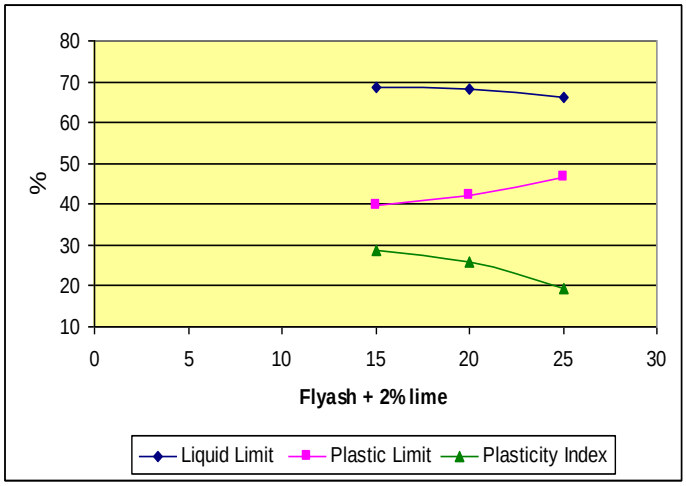

Fig. 3.2: Liquid limit and plastic limit for plain soil with 15 – 25% flyash with 2% lime

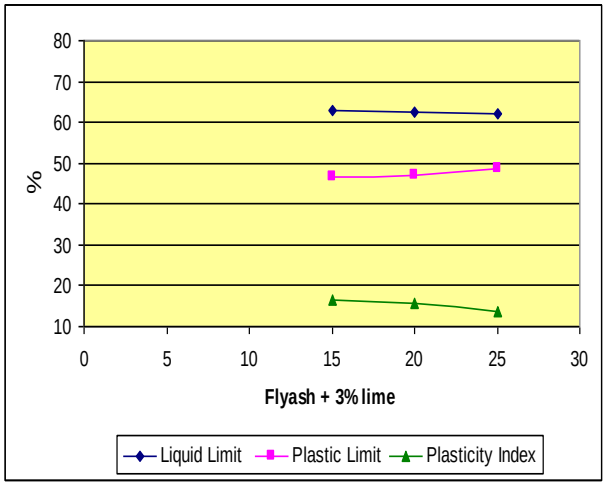

Fig. 3.3: Liquid limit and plastic limit for plain soil with 15 – 25% flyash with 3% lime

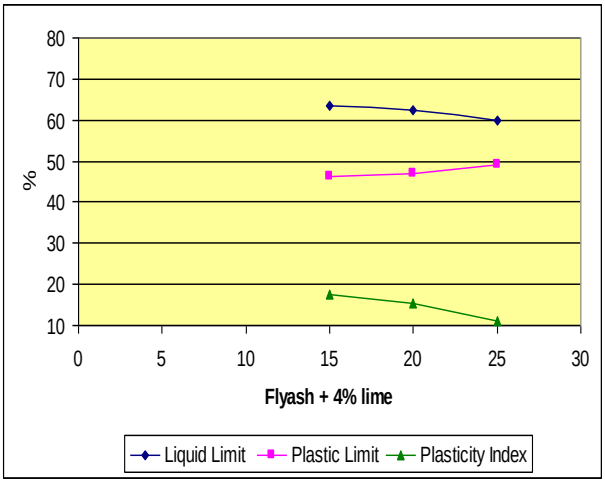

Fig. 3.4: Liquid limit and plastic limit for plain soil with 15 – 25% flyash with 4% lime

Table 3.14: Result of liquid limit plastic limit and plasticity index

	Liquid limit	Plastic limit	Plasticity index
Plain	77.5	40.86	36.64
25% flyash	67.5	48.92	19.58
25% + 2% (flyash + lime)	66	46.63	19.37
25% + 3% (flyash + lime)	62.28	48.54	13.74
25% + 4% (flyash + lime)	30	49.07	10.93

Table 3.25: Result of Proctor Compaction test

Particular	Maximum dry density Kg/cm³	Water content %
Plain	1.34	26.6
25% flyash	1.43	26.4
25% + 2% (flyash + lime)	1.36	27.4
25% + 3% (flyash + lime)	1.38	25.9
25% + 4% (flyash + lime)	1.35	26.8

Table 3.35: Results for Accelerated CBR test

Particulars	CBR value
Soil + 25% flyash	1.89
Soil + 25% flyash + 2 % lime	2.80
Soil + 25 % flyash + 3 % lime	3.029
Soil + 25 % flyash + 4 % lime	3.18

Table 3.31: Results for CBR test

Particulars	CBR value
Plain soil	0.86
Soil + 25% flyash	1.02

Soil + 25% flyash + 2 % lime	1.405
Soil + 25 % flyash + 3 % lime	1.75
Soil + 25 % flyash + 4 % lime	1.93

III. Conclusion

It can be seen that addition of flyash and lime can be consider as an suitable and stabilizing agent.
Liquid limit, plastic limit and plasticity index for plain soil are 77.5%, 40.8% and 36.7% respectively with addition of 25% flyash of BC soil. The above values are 67.5% the above values are 67.5%, 48.92% and 18.56% respectively. From this it reveals that by addition of flyash plasticity index and liquid limit reduced by 49.3 and 12.9% respectively. Whereas plastic limit is increased by 19.9%. this clearly indicates that the addition of flyash reduces the plasticity characteristics of BC soil and makes the soil non plastic.
It reveals that by addition of 25% flyash with 2% of lime the liquid limit and plasticity index reduced by 14.83% and 47.22% respectively whereas increase in plastic limit by 14.28%.
By addition of 25% flyash with 3% lime the liquid limit and plasticity index reduced by 19.63% and 62.56% where as increase in plastic limit by 18.97%.
By addition of 25% of flyash with 4% lime the liquid limit and plasticity index reduced by 22.58% and 70.21% where as increase in plastic limit by 20.26%.
The proctor compaction test determine the OMC and MDD the increase in MDD is 6.29% when compared to plain soil.
There is increase in CBR value with normal 4 days soaking is 55.44% more than the plain soil
There is an increase in CBR value for accelerated curing at 55^0c for 19hrs increase the value of CBR is 72.9% more than the plain soil.
From above results we are conclude that the addition of flyash with lime in BC soil which gives more strength to the subgrade.

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