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AN ANALYSIS OF THE CBR VALUE OF SOIL STABILIZED WITH THERMAL POWER PLANT WASTE FLY ASH AND ADMIXTURES FOR THE DESIGN OF SUBGRADE IN FLEXIBLE PAVEMENTS

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ABSTRACT: At present, the yearly production of fly ash from the burning of coal in thermal plants is over 100 million tons. The current research seeks to employ waste fly ash in pavement subgrade and investigate the impact of fly ash on soil engineering qualities and subgrade strength as measured by the California Bearing Ratio (CBR) value after fly ash addition. Laboratory studies were done before replacing 5% to 25% of the subgrade's soil with fly ash. In pavement design, the CBR value is often used to evaluate the sub grade's strength. This research employed CBR unsoaked and soaked testing for various soil-fly ash mixture proportions and discovered the ideal fly ash dose for use in road building. According to experimental findings, adding up to 20% fly ash will increase the maximum dry density, but adding more than that won't make a difference in terms of CBR. Fly ash raises the CBR value, which will cause the pavement thickness to be reduced.

KEYWORD:Fly ash,CaliforniaBearingRatio,MaximumDryDensity,Optimummoisturecontent.

1. INTRODUCTION

The design of the pavement, embankment construction is crucial. Large quantities of dirt are need for embankment building. It might be difficult to get appropriate soil in certain places, and expansive soil can be a major obstacle when building a pavement. Typically, replacing poor soil with stronger crushed rock material is one method used to strengthen weak soils. Engineers discover more ecologically friendly and cost-effective alternatives to this method since it is not economically viable. India ranks fourth in the world for the production of coal ash as a waste by-product, with coal accounting for 30–40% of the country's electricity generation. Fly ash recycling and disposal are difficult nowadays since they need a significant quantity of land. Different engineering features of soil might arise via chemical stabilisation. The use of these goods has advanced as a result of this field's affordability and by-product availability. The efficiency of fly ash in enhancing the strength and engineering qualities of soil has to be evaluated. The compaction characteristic of the soil is one of the key elements in the building of roadways, airport pavements, and embankments. The strength of the subgrade under pavement is expressed in terms of the California Bearing Ratio (CBR) value. Compaction qualities are tested in a lab for various ratios of soil-fly ash combinations, and the CBR test is used to gauge the mixture's strength. The improvement in the different engineering features of the soil after the addition of fly ash is evaluated, and the ideal amount of fly ash to be employed efficiently in pavement subgrade is identified.

2. LITRATURE REVIEW

Ansu Thomas et al., 2015 concluded that the addition of fly ash to the soil improves the index properties and found that optimum moisture content decreases and maximum dry density increases due to the addition offly ash [1].

Mahesh et al., 2013 concluded that the addition offly ash reduces the swelling characteristics of soils and improves the CBR value. They also observed that addition offly ash beyond 20% is not significant [2].

Mahajan and Parbat they have conducted experiments on soil-fly ash mixtures. The fly ash content varies from 10 to 50%. They found that swelling and plasticity properties can be reduced and maximum density is increased due to addition of fly ash [3].

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3. MATERIALS & METHODOLOGY

•**Red soil -** According to the core cutter technique, soil has an in-situ density of 13.73 kN/m3 and a water content of 6.8%. In a lab, soil's numerous engineering qualities are examined, and the findings are compiled in Table 1. The ideal moisture content of soil is 22%, and its dry unit weight is 15.5 kN/m3. According to a study on grain size, the soil's composition is 15% sand, 77% silt, and 8% clay. Liquid limits in soil are 40% and plastic limits are 22%. The soil's CBR values are 5% and 3%, respectively, in both the moist and unsoaked conditions.

Table 1: Engineering Properties of Soil

Sr. No	**Tests**	**Reds oil**
1	Specificgravity	2.68
2	Atterberg'slimits	
	Liquidlimit(%)	40
	Plasticlimit (%)	22
	Plasticityindex(%)	18
3	Grainsizedistribution	
	Gravel(%)	0
	Sand (%)	15
	Silt (%)	77
	Clay(%)	8
4	SoilClassification	
	HRBclassification	A-6
	ISclassification	CI
5	Lightcompaction	
	Maximumdrydensity(kN/m^3)	15.5
	Optimummoisturecontent(%)	22
6	Californiabearingratio	
	Unsoaked(%)	5
	Soaked(%)	3

•**Fly Ash-**fly ash is a coal combustion product composed of fine particles that are thrown out of boiler with flue gases. It is the by-product from burning coal in thermal power plants. For present study "class Fly ash was used. Fly ash is added in different proportions to the soil. The chemical composition of fly ash is tabulated in Table 2.

Table 2: Chemical Composition of Fly Ash

Content	**%By mass**
Silicondioxide	1.30
Aluminumoxide	25.70
Ferricoxide	5.30
Calciumoxide	5.60
Potassiumoxide	0.60
Sodiumoxide	0.40
Magnesiumoxide	2.10

•**SoilFly ash Mixtures-**Various proportions of soil-fly ash mixture that are used in present investigations are arranged in Table 3. In the present investigation we are replacing the soil by fly ash percentage by weight.

Sr.No.	**Mixtureof soil-fly ash**
1.	Soil+0%fly ash

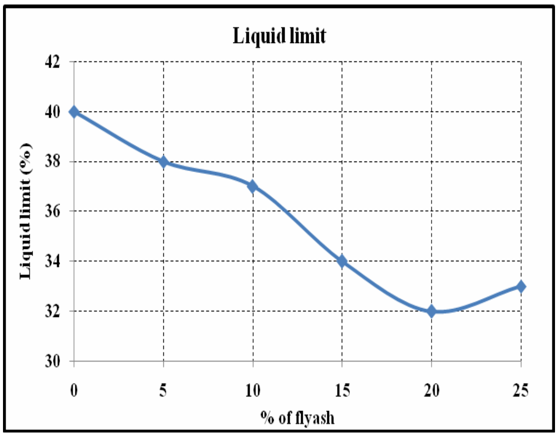
2.	95% soil+5% fly ash
3.	90%soil+10% fly ash
4.	85%soil+15% fly ash
5.	80%soil+20% fly ash
6.	75%soil+25% fly ash

4.RESULTS & DISCUSSION

1.Atterberg's Limits

Atterberg's limits are tested as per IS: 2720 part-V. It is observed that liquid limit and plastic limit goes on decreases up to certain addition of fly ash. Due to the addition of fly ash the voids in flocculated soil are filled by finer particles of fly ash this will decreases the plasticity of soil. Figure 1 shows the variation of Liquid limit with the addition of fly ash.

Figure 1: Variation of liquid limit



2. Light Compaction Method

For present investigation, standard proctor method was used as per IS: 2720 part-VII. 3kg of sample is compacted in 3 layers and each layer is tamped 25 blows. The variation of maximum dry density with addition of fly ash is shown in figure 2. As the addition of fly ash increases, the maximum dry density increases up to 20% addition of fly ash and then further addition will reduce maximum dry density.

Figure 2: Variation of Maximum Dry Density

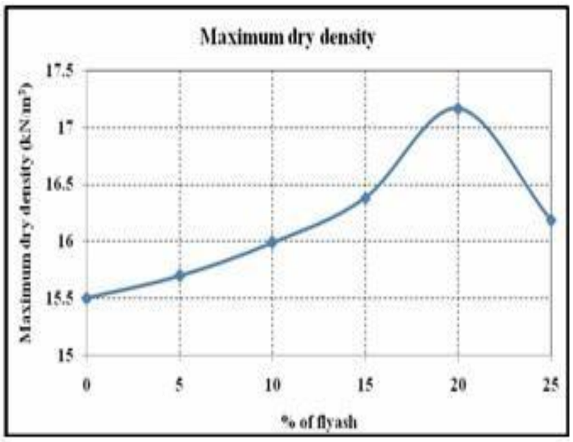


Figure 3 shows the variation of Optimum moisture content with the addition of fly ash. Optimum moisture content decreases up to 15 % of addition of fly ash and further addition will increase the optimum moisture content of the mixture. It is due to the pozzolanic activity of fly ash; it absorbs more water.

Figure 3: Variation of optimum moisture content

3.California Bearing Ratio

California bearing ratio is used to evaluate the strength of the subgrade soil. Unsoaked and soaked CBR tests are conducted for different proportions of the soil-fly ash mixtures. Test was conducted as per IS: 2720 part-16.Optimum moisture content varies due to the replacement of fly ash. This will affect the compaction characteristics of the mix. So, there are two series of tests were conducted for unsoaked and 4 days-soaked conditions.

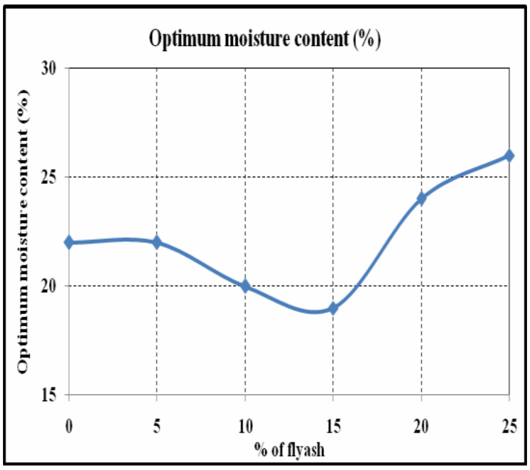
•Constant OMC i.e., OMC of soil was taken for blending all the soil-fly ash proportions.

•OMC varies due to addition of fly ash. The OMC of the mix is determined using light compaction and it is used for blending soil-fly ash proportions.

Table 4: Test & Experiments

Sr. No	TEST CONDITION
1	UnsoakedwithconstantOMC
2	4dayssoakedwith OMCofmix
3	UnsoakedwithdifferentOMC
4	4dayssoakedwith OMCofmix

Table 5 shows the CBR test results for constant optimum moisture content i.e., OMC of soil was taken for blending all the



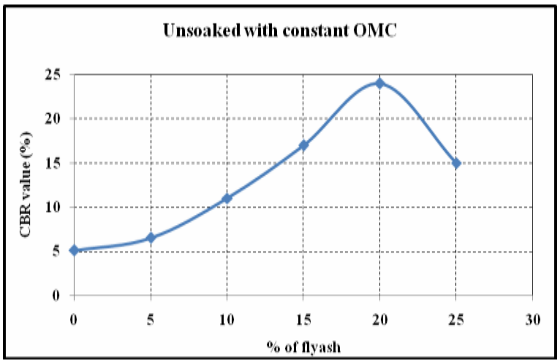
soil-fly ash mixture. It is observed that up to 20% of addition of fly ash will shows good improvement in CBR value.

Table 5: CBR Test Result with Constant OMC

Soil-fly ash mixture	CBR Unsoaked value (%)	CBR Soaked value(%)
Soil+0%fly ash	5.12	3
95% soil+5% fly ash	6.5	4.5
90%soil+10% fly ash	11	8.8
85%soil+15% fly ash	17	14
80%soil+20% fly ash	24	21
75%soil+25% fly ash	15	11

The variation of CBR value for unsoaked condition with constant OMC is shown in figure 4. It shows improvement up to 20% addition of fly ash. Further addition of fly ash will reduce the CBR value. For 20% addition of fly ash CBR value of the soil increases from 5% to 24%. This is because of the cementing property of fly ash.

Figure 4: Variation of CBR unsoaked value with constant OMC



The variation of CBR value for soaked condition with constant OMC is shown in figure 5. It shows improvement up to 20%fly ash addition. Further addition of fly ash will reduce the CBR value. For 20% addition of fly ash CBR value of the soil increases from 3% to 21%. Soaked CBR value is considered for design of pavement as per IRC: 37 (2001) guidelines. Fly ash shows good improvement in soaked condition which indicates a favourable change that fly ash have good drainage property and can be used effectively in pavement subgrade.

Figure 5: Variation of CBR soaked value with constant OMC

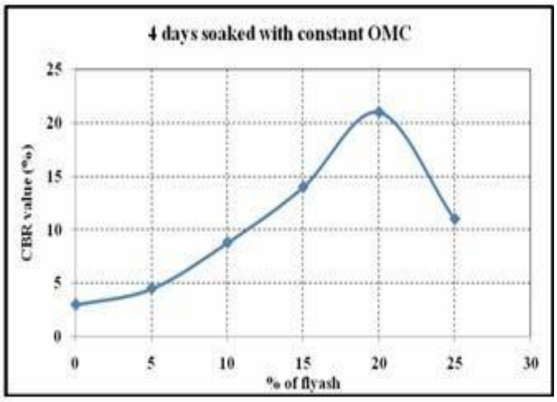


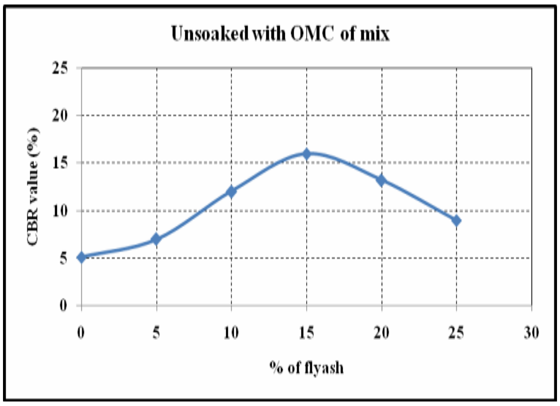
Table 6 shows the CBR test results for optimum moisture content of the mixes. OMC varies due to addition of fly ash. The OMC of the mix is determined using light compaction and it is used for blending soil-fly ash proportions. It is observed that up to 15% of addition of fly ash will shows good improvement in CBR value.

Table 6: CBR Test Result with Constant OMC Mix

Soil-fly ash mixture	**CBR Unsoaked value**	**CBR soaked value**
Soil+0%fly ash	5.12	3
95% soil+5% fly ash	7	5.2
90%soil+10% fly ash	12	9.5
85%soil+15% fly ash	16	12.5
80%soil+20% fly ash	13.2	9.8
75%soil+25% fly ash	9	7

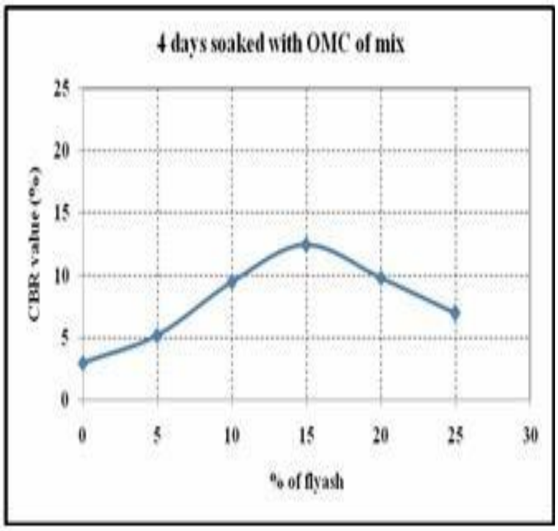
The variation of CBR value for unsoaked condition with OMC of mixes is shown in figure 6. It shows improvement up to 15%fly ash addition. Further addition of fly ash will reduce the CBR value. For 15% addition of fly ash CBR value of the soil increases from 5% to 16%. It is observed that the addition of fly ash to the soil up to 15% to 20% is favourable.

Figure 6. Variation of CBR unsoaked



value with OMC of mix

The variation of CBR value for soaked condition with OMC of mixes is shown in figure 7. It shows improvement up to 15%



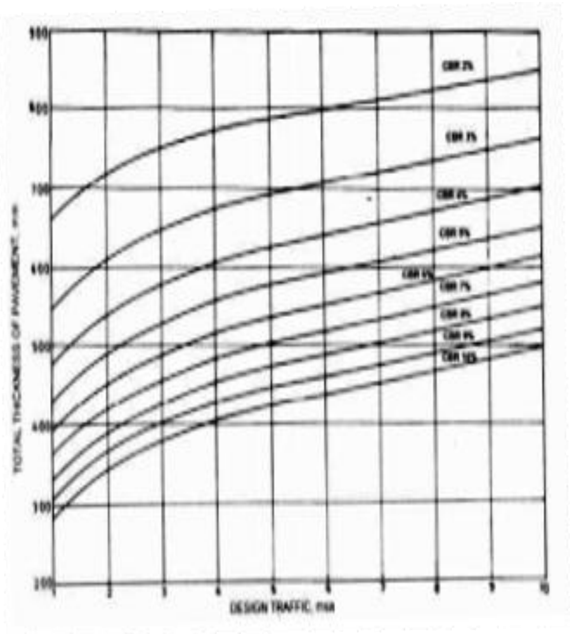
addition of fly ash. Further addition of fly ash will reduce the CBR value. For 15% addition of fly ash CBR value increases from 3% to 12.5%.

Figure 7: Variation of CBR soaked value with OMC of mix

4. Flexible pavement Designed IRC: 37-2001)

The flexible pavement is designed according to the code specifications as per IRC: 37-2001 using CBR values obtained from test results. The cumulative traffic of 1msa is considered for pavement design. Generally, CBR soaked value is considered for the pavement design. The soil taken for the investigation has CBR value of 3% and the same soil with 20% addition of fly ash contributes to the increase in CBR value of 21%. This increase in CBR value will reduce the total thickness of pavement. However, as per IRC: 37 (2001) guidelines the minimum thickness of pavement should be provided.

Fig. 8 Pavement thickness design chart for traffic1–10



5.CONCLUSIONS

The addition of fly ash to the soil will show improvement in the engineering properties of soil. The following conclusions were made on above results and discussions.

•The addition of fly ash to the soil will reduce the liquid and plastic limits.

•Plasticity index of the soil decreases with the addition of fly ash which indicates favourable change since it increases the workability of mix.

•Addition of fly ash up to 20% brings improvement in the compaction characteristics. i.e., the maximum dry density increases and optimum moisture content decreases.

•The unsoaked CBR value of soil at constant optimum moisture content is increased from 5% to 24% and soaked CBR value of soil at constant optimum moisture content is increased from 3% to 21% by the addition of 20% fly ash.

•The unsoaked CBR value of soil at optimum moisture content of mixes is increased from 5% to 16% and soaked CBR value of soil at constant optimum moisture content is increased from 3% to 12.5% by the addition of 15% fly ash.

•The addition of fly ash will reduce the thickness of pavement. For traffic of 1msa granular sub-base thickness is reduced by 185 mm.

•From experimental results, we observed that, the optimum dosage of fly ash is 15 to 20% to use effectively in pavement subgrade. Beyond 20% addition of fly ash is not significant.

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