Geotechnical Characterization and Morphological Properties of Two Low Lime Indian Fly Ashes and Their Prospective For Improved Utilization

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Abstract— **Among the different non-renewable sources, coal is just one of the crucial and also is considered as the core raw material for the generation of power and plays a critical function for meeting the more than enhancing non-renewable fuel sources needs in India and also throughout the world. The demand for power supply has exponentially heightened nowadays scheduled to increasing Urbanization and industrialisation phenomena. Subsequently, this development has increased the variety of power offering thermal power plants that use coal as a burning fuel to produce electricity. The mineral deposit that is left behind after the burning of coal is the fly ash. The Electro-Static Precipitator (ESP) of the power plants obtains these fly ashes. Fly ash is a primary product of thermal power plants that harmfully affect land, water and air. Production of fly ash comes with two significant concerns safe disposal and management of fly ash. In India, today accessibility of fly ash created from the coal-based thermal power plant has surpassed 130 million tons as well as most likely to rise in coming years. The application of fly ashes requires to be boosted to handle this waste stream, which is feasible by recognising the geotechnical and also geo-environmental practices of fly ash. This paper comparative investigated physical, chemical and engineering properties (grain size, specific gravity, compaction characteristics, and unconfined compression strength & California bearing ratio) of Indian fly ash. Two low lime fly ashes from Singrauli and vindhyachal thermal power plants, in and around Uttar Pradesh and Madhya Pradesh have been used in the study. The recyclables Fly ash after oven dried were taken for scanning electron microscopy (SEM), X-ray diffraction (XRD) studies.**

Keywords: **- Fly ash; UCS; CBR; Grain size; Soil compaction; Unconfined Compression strength.**

I. INTRODUCTION

Coal-based thermal power plants have been a significant resource of power generation in India, where 75% of the complete power acquired from the coal-based thermal power plant. Thermal power Plants commonly utilise coal of reduced qualities with coal burning ash material as high as 30 to 50 %. Greater classes of coal are booked for metallurgical applications. When pulverised nonrenewable fuel source is shed in a furnace at the power terminals, it generates sensible ash called "Fly ash" which emerges out of the furnace in addition to flue gases. Fly ash make up concerning 75-85 % of the overall ash developed. The continuing to be a coarser portion of the fly ash is up to the bottommost of the furnace where it sinters to create "Base ash". High ash coal suggests even more damage of the plant and also equipment, reduced thermal efficiency of the central heating boiler, slogging, choking and also scaling of the heater and too most significant of them all, generation of a vast quantity of fly ash. India rates 4th on the world in the generated of coal ash as by-product waste after USSR, U.S.A. as well as China. The fly ash is a very different product where products of comparable dimension might have various chemistry as well as mineralogy. There is a variant of fly ash homes from multiple resources, from very same support however with time (Yudhbir and Honjo 1991; Winter and Clarke 2002) and also with collection factor and also variant in load generation (Lee et al. 1999). The variant in high calcium fly ash is anticipated to be greater than reduced calcium fly ash (Diamond 1986). For that reason, it comes to be essential to define fly ash from various resources before utilising it as a building and construction product. The particular fly ash as the geotechnical material has been evaluated by many researchers (Raymond, 1961; DiGioia and Nuzzo, 1972; Sherwood, 1975; Leonard and Bailey, 1982; Toth et al., 1988; Yudhbir et al., 1990);Yudhbir and Honjo, 1991;Indraratna et al., 1991; Pandian et al., 1998; Sridharan et al., 1998; Cocka, 2001;Nishikawa et al., 2002; Sridharan, 2002;; Winter and Clarke, 2002) Hence in this study fly, ash from Singrauli and vindhyachal thermal power plants are collected and characterised based on physical-chemical, mineralogical and morphological properties. Also, the compaction, UCS behaviour, CBR and hydraulic conductivity of both the fly ashes are considered. Based on the current study bulk amount of fly ash can be utilised in a road construction application. This characterisation of fly ash can help the researcher and stakeholders to decide whether stabilisation of fly ash is required.

II. Study Area

The Vindhyachal Thermal power plant lies in Singrauli area in the Indian state of Madhya Pradesh. Among the Coal-Fired thermal power plant of NTPC, it is the biggest thermal power plant in India, with a setup capability of 4760 MW. The coal for the nuclear power plant is gotten from Nigahi as well as Amlohari mines, as well as the water is acquired from the discharge canal of Singrauli Super Thermal Power Plant.

Singrauli Thermal power plant is situated at Shaktinagar in Sonebhadra area in the Indian state of Uttar Pradesh. The Thermal power plant is the first Thermal power plant of NTPC. It resources coal from Jayant and also Bina mines as well as water from Rihand Storage tank. The states making money from this Thermal power plant are Uttar Pradesh, Uttranchal, Rajasthan, Punjab, Haryana, Jammu & Kashmir and also Himachal Pradesh and even the Union Territories of Delhi as well as Chandigarhhighway

III. Simple Colletion

The fly ash utilised in the here and now research was accumulated in a completely dry state from electrostatic precipitators of CPP-II of Singrauli as well as vindhyachal thermal power plant. Throughout the burning of shattered coal in the suspension-fired furnace of the thermal power device, the unpredictable issue is evaporated, and also most of the carbon is burnt. The nutrition issue connected with the coal, such as clay-based, quartz and even feldspar damage down or slag to differing level. The finer pollutants that get away with flue vapours are gathered as fly ash utilising electrostatic precipitators in receptacles as well as keep. The repositories have small electrical outlets. Gunny bag made from solid poly-coated 100 % cotton with 50kg ability each were utilised to collect the completely dry fly ash. The chute of receptacles was gradually opened up, and also the bags were packed. The mouth of each bag was secured instantaneously after collection as well as the same was once again put in one more polypack to avoid climatic impacts. The specific bags were carried with thorough treatment from the plant to research laboratory as well as maintained in a protected as well as took care of setting. Samples of fly ash were used out according to a requirement of the test.

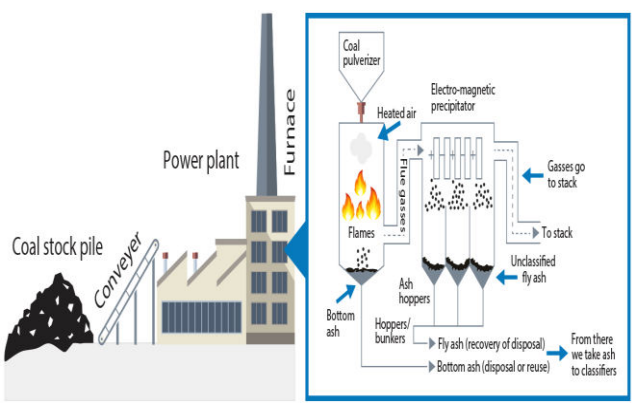

Figure 1: A plan layout of generation and collection of fly ash (Google image)

IV. Properties of Fly Ash

The specific physical and also chemical property of fly ash vary depending upon the beginning of coal, kind of plant, shedding procedure, the not natural chemical structure of coal. The level of pulverisation, discharge control types systems, taking care of as well as collection systems and so on fly ash is of two types, i.e. at the Class C as well as Class F. Class F is created from burning of anthracite as well as bituminous coal. It includes a real percentage of lime (Cao). Class F fly ash (pozzolans) has silicon as well as aluminium product that itself very own little or, no cementitious importance. It reacts chemically with lime as well as concrete at space temperature to produce cementitious substances. (Chu T.Y., et al., 1955).

1. *Physical Properties of Fly Ashes*

a. Specific gravity

The specific gravity of the fly ash was figured out making use of the volumetric flask approach based on IS: 2720-Part 3 (1980). The details gravity of fly ash is established by substantially upon its iron and also carbon content. The presence of iron content elevates its particular gravity while extra carbon content reduces its specific gravity. Details gravity, G, of the fly ashes and also lime sludge was established according to (ASTM D854; 2006) making use of pycnometer as well as kerosene, and also a typical worth of three tests have been reported. The fly ash was collected in a completely dry state as well as remained in the loosened phase. The fly ash utilised had a grainy setup with a tool to a dark grey colour standing for reduced lime material (Meyers J.F. et alia; 1976). The specific gravity of Singrauli and also Vindhyachal were 2.13 and even 2.19 accurately. As a whole, specific gravity of coal fly ashes exists around 2.0 yet can differ to a substantial level of 1.6 to 3.1 (Kim B., Prezzi M., as well as Salgado R.; 2005). The variety of specific gravity of Indian coal ashes as reported by (Sridharan A. as well as PrakashK.; 2000) is 1.46 to 2.66. The reason for a reduced particular gravity results from the presence of a lot of hollow cenospheres where the entrapped air cannot be gotten rid of, or the variant in the chemical make-up, specifically the iron material, or both (Moghal A.A.B.; 2010). The distinction of particular gravity of the coal ash is the outcome of a mix of several elements such as rank, fragment form as well as chemical structure.

b. Loss of Ignition

Loss on ignition of fly ash was identified based on IS: 1760-Part 1(1991). The loss on ignition (LOI) was established utilising muffle furnace at a temperature level of 1000 ± 25 °C. The LOI was located to be as 2.0 as well as 2.95 for Singrauli and also Vindhyachal respectively. The loss on ignition (LOI) standing for the unburned carbon is exceptionally much less for fly ash than Vindhyachal fly ash. The maximum limitation for LOI defined by (ASTM C 618; 2008) for class F fly ash is typically 6% and also can be as much as 12 %.

Table 1: Physical properties of Singrauli and Vindhyachal fly ash

Property	Singrauli	Vindhyachal
Colour	Grey	Grey
Specific gravity, G	2.13	2.19
Loss on ignition, %	2.0	2.95

c. Specific surface area

The surface area of particles is significant because it manages the overall adsorption ability. The surface area of fly ash particles usually differs vice versa with the particles dimension (i.e., the smaller sized the particles, the bigger the surface area). The details area was figured out by Blain's air permeability test. The specific surface area of Singrauli as well as Vindhyachal was revealed to be 4450 cm^2/g and also 4590 cm^2/g, exactly.

d. Consistency Limits

The properties such as liquid limit, plastic limit, and plasticity index are most frequently use of in the geotechnical field. These attributes are not just essential in a category as well as recognition; however additionally in forecasting design practices such as strength, hydraulic conductivity, and also compressibility. Liquid limit test in today research was carried out by the cone penetration technique (British criteria) due to its simpleness and also reproducibility of results outcomes. Liquid limit values of Singrauli, as well as Vindhyachal, were observed to be 31.47% as well as 36.5%, accurately. Considering that the fly ashes are non-plastic, a plastic limit, as well as plasticity index values, do not develop for them

Figure 2: fly ash Consistency Limits and pH testing in Civil Engineering & Mining Department IIT (BHU) by Sunil Kumar

e. Grain size distribution

The completely dry and also wet evaluation was carried out by sieve as well as hydrometer test specifically according to Indian conventional IS 2720 treatment to identify the grain size of Singrauli fly ash as well as Vindhyachal fly ash. The particle-size distribution curves of Singrauli, as well as Vindhyachal, exist. It is observed that Singrauli has higher finer particle material than Vindhyachal. The gradation is decided based on co-efficient of uniformity (Cu) and co-efficient of curvature (Cc) obtained from particle size distribution curve. The coefficient of uniformity ($Cu = D_{60}/D_{10}$) is 4.75 & 4.37 Singrauli and Vindhyachal respectively. Co-efficient of curvature ($Cc = (D_{30})^2/(D_{10} \times D_{60})$) is 1.85 & 1.78 Singrauli and Vindhyachal respectively.

The co-efficient of uniformity and curvature are calculated as

$$\mathbf{Cu = (D_{60}/D_{10})}$$

$$\mathbf{Cc = (D_{30})^2/ (D^{10} \times D_{60})}$$

Where

D_{10} = Equivalent particle diameter corresponding to 10% fines on particle size distribution curve

D_{30}= Equivalent particle diameter corresponding to 30% fines on particle size distribution curve

D_{60} = Equivalent particle diameter corresponding to 60% fines on particle size distribution curve

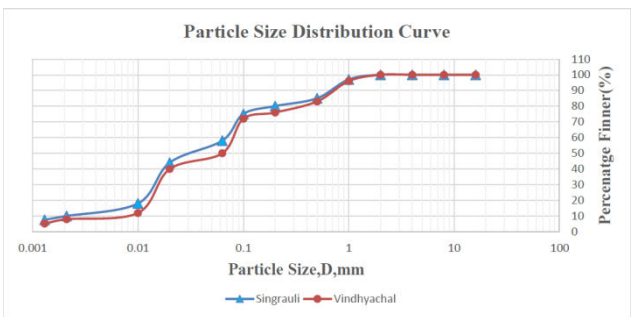

Figure03: Particle size distribution curve of Singrauli and Vindhyachal

Table 2: Consistency Limits & Grain size distribution of Singrauli and Vindhyachal fly ash

Property	Singrauli	Vindhyachal
Atterberg limit		
Liquid Limit (%)	31.47	36.5
Plastic Limit (%)	Non Plastic	Non Plastic
Shrinkage Limit (%)	----	-----
Plasticity Index (%) PI=(LL-PL)	----	------
Sieve Analysis (%)		
Gravel (>4.75mm)	---	-----
Sand (4.75mm-0.075mm)	21.67	23.65
Coarse Sand	0	0
Medium Sand	0	0.65
Fine Sand	21.67	23
Silt (0.075mm-0.002mm)	75.41	73.98
Coarse Silt	48.21	50.07
Medium Silt	16	15.68
Fine Silt	11.2	8.23
Clay (<0.002mm)	2.92	2.37
Coefficient of uniformity(Cu)	4.75	4.37
Coefficient of Curvature (Cc)	1.85	1.78

2. Chemical Properties

a. pH

The pH worths of the Singrauli, as well as Vindhyachal ashes, were figured out by electrometric treatment. 30 gm of the completely dry fly ash was included in 75 cc of pure water in a 100 cc beaker. The suspension was mixed thoroughly, covered with a glass plate, and also left standing for an hour with periodic mixing. The suspension was once again mixed well before the test. The electrode linked to the electronic pH meter was dipped right into the remedy and also the worth of pH read. Three tastings of Singrauli and also Vindhyachal fly ash were evaluated as well as the standard of the three values was taken as the pH of the fly ash. The pH value of the Vindhyachal fly ash remained in the series of 8.1 to 8.3 with a typical value of 8.2. This suggested that the Vindhyachal fly ash was a little alkaline in nature. The pH of Singraulifly remained in the series of 7.20 to 7.25 with a typical value of 7.23. This suggested the acidic nature of Singrauli fly ash.

b. Chemical Compositions of Fly Ash

The chemical composition of fly ashes usually depends upon the beginning of the coal utilised in the thermal power plant. The chemical composition of fly ashes was identified using the facilities available at the Chemistry Department (BHU) as well as Central Instrument Facility (CIF) at IIT (BHU) Varanasi. It was established by X-ray fluorescence spectrometry as well as atomic absorption spectrophotometry based on the requirements and also exists in Table 3. The chemical structures of both fly ashes as well as revealed in percents relative to the weight of fly ash. Like various other fly ashes, these fly ashes likewise consist of vast quantities of silica and also alumina as well as little amounts of Fe_2O_3, CaO, TiO_2 as well as K_2O. The amount of $SiO_2 + Al_2O_3 + Fe_2O_3$ estimated to 95.15% and also 93.79% for Singrauli as well as Vindhyachal respectfully, which is higher than the 70% suggested by the ASTM C 618 criterion for pozzolans.

Table 3: Chemical composition of fly ashes

Element	Singrauli	Vindhyachal	Remark
Silica (SiO_2)	53.98	53.00	
Alumina (Al_2O_3)	34.19	33.98	
Ferric (Fe_2O_3)	6.98	6.81	
$SiO_2 + Al_2O_3 + Fe_2O_3$	95.15	93.79	70 (Minimum)
Magnesium (MgO)	0.512	0.57	
Titanium (TiO_2)	0.47	0.49	
Potassium (K_2O)	0.815	1.48	
Calcium (CaO)	0.56	0.52	
Phosphorus (P_2O_5)	0.12	0.13	
Sodium (Na_2O)	0.30	0.33	
Sulphur (SO_3)	0.073	0.075	6 (Maximum)
LOI	2.0	2.95	

1. Scanning Electron Micrograph

The morphological qualities of fly ashes were researched by scanning electron microscopic method. A small portion of the product was maintained in the oven at 105ºC for 24 hours for drying. The sampling was installed on a Zeiss EVO 18 machine by me. A thin performing layer of gold concerning 50 Å density was covered on the sampling surface area with the help of sputter coater Emitech K550X. Zeiss EVO collection scanning electron microscopic EVO 18 was to check out the morphology of the products. Figure 4 (a), as well as 4 (b), reveals the scanning electron micrograph of Singrauli as well as Vindhyachal at 5000 times magnifying. It showed that round, as well as smooth particles of numerous dimension varieties, existed in the fly ash. The distribution of particles is acknowledged fig. 4(b), the reveals that the dimension much less than 10 micron was a lot more in Vindhyachal; nonetheless, one particle of 12 microns was likewise observed. It can be seen from 4 (a) particles much less than 4 microns existed and also one particle of dimension 8 microns was located. Therefore Singrauli has better particles as compared to Vindhyachal. The surface area morphology of Vindhyachal exposes that it has a rough surface compared to that of Singrauli.

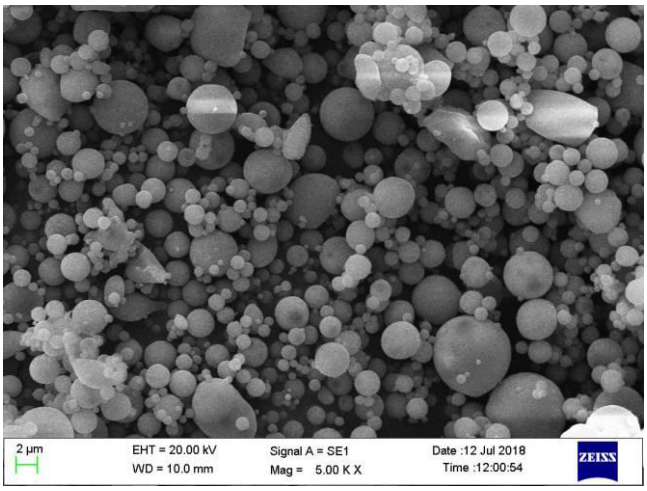

Figure 4: (a) SEM Image of Singrauli NTPC fly ash

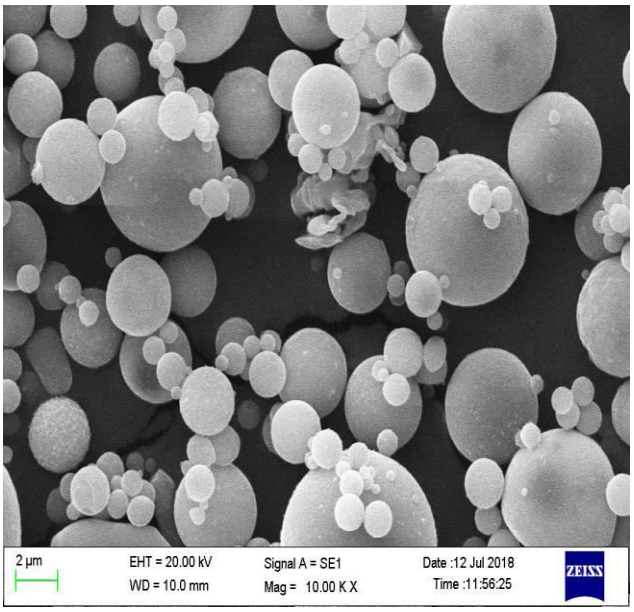

Figure 4: (b) SEM Image of Vindhyachal NTPC fly ash

1. *X-ray Diffractograms*

The visibility of various stages in fly ashes requires complete X-ray (XRD) diagnosis. It is recognized that multiple steps of fly ashes generate different diffraction patterns. This makes X-ray diffraction a capable device for the research study. In the here, XRD was performed making use of XRD-Miniflex 600/ Dtex (Rigaku made in Japan) machine. The samplings were checked from 2 theta values = 10 ° to 90 °. This test performed in the Central Instrument Facility (CIF) at IIT (BHU) Varanasi with the help of Akhilesh Paswan. The data source of the 2000 JCPDS-International Centre for Diffraction Information was utilised to recognise the mineralogical stages. The crystalline phases existing were determined from the tops in the pattern. XRD pattern revealed the existence of crystalline phases Quartz (SiO_2), Hematite (Fe_2O_3), Mullite (Aluminium Silicate), Sillimanite, Melilite (Calcium Magnesium, Aluminium, Silicate) in Singrauli and also Vindhyachal as in number 5(a) and even 5(b) indeed.

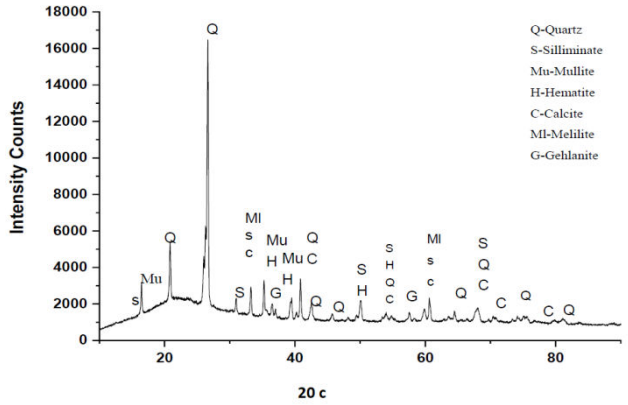

Figure 5 (a): X-ray diffraction pattern of Singrauli NTPC fly ash

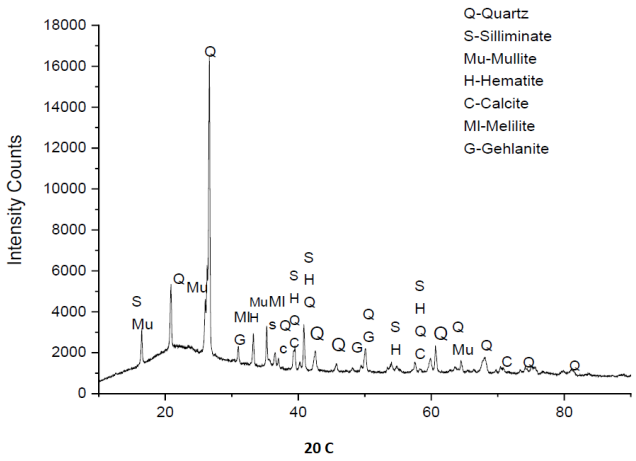

Figure 5 (b): X-ray diffraction pattern of Vindhyachal NTPC fly ash

V. GEOTECHNICAL CHARACTERISTICS

a. *Compaction characteristics*

The density of coal ashes is a significant parameter regulates the strength, compressibility, as well as permeability in the structure. Fly ashes show significant variation in compaction due to the difference like fly ash produced from the same power plant over time (Yudhbir V. and Honjo Y. ,1991). The difference of dry density with moisture content for fly ashes is less associated with that for a well-graded soil, both consuming the same medium grain size (Moulton K. L., 1978). According to the research study, the Maximum dry density & optimum moisture content values were identified by using the typical compaction test treatment according to IS 2720 (Methods of test for soils, 1990). From the experiment, maximum dry density and optimum moisture content were determined. Maximum dry density values of Singrauli and Vindhyachal were detected to be 1356 kg/m3 and 1265kg/m3, and the optimum moisture content values were 21.65% and 24 %, respectively. These values are representative of typical silty loam soils, which show better drainage and infiltration.

b. *Strength behaviour*

The strength behaviour of fly ashes shows the outstanding value in their usage for various geotechnical treatments. The unconfined compressive strength assessment of the sampling is the ratio of failure load and cross-sectional area of the sampling when it is not subjected to any confining Pressure. It might be utilized as an among style

specifications of base/subbase of roadway, embankment and so on.

Table 4: Percent increase in UCS on curing

Curing period	Percentage increase in strength	
	Singrauli	Vindhyachal
0-7	27	25
7-14	34	31
14-28	64	68
28-56	78	81

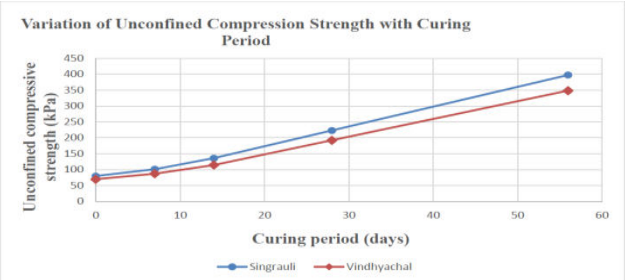

Figure 6: Disparity of unconfined compressive strength with optimum moisture content

The best benefit of pozzolanic products such as fly ash is that the cohesion enhances with the curing duration raising consequently the stability of structures. The increases of UCS with the upturn in the curing period were reported by (Das and Yudhbir; 2005) das, and yudhbir with Panki and Parichha fly ash. The samples were arranged, cured and tested as per IS 2720 and sheared at a strain rate of 0.4064 mm/min. The compacted specimens were kept in a moisture chamber maintained at 25°C and relative moisture of more than 95% and preserved for 7 and 28 days. From the stress-strain curves, the scale of peak stress and strain values consistent to peak stress was noted. Usually, most of the fly ashes display lowers unconfined compressive strength both in dry and fully soaking conditions due to the absence of cohesion for dry fly ash and loss of seeming cohesion upon total saturation (Digioa A.M. and Nuzzo W.C., 1972). Thus, it can be seen from that for both fly ashes the unconfined compressive strength increases with curing period.

c. California bearing ratio

Usage of fly ash in the construction of the roadway, as well as railway embankments, is an action Intensely gone after internationally to get rid of the ecological as well as financial problems related to importing high-quality construction products from nearby lands. Initiatives to prevent the issue have promoted the rate of interest in making use of different products such as fly ashes which are environmentally secure and also financially feasible. For the usage in expressway embankments, fly ash, as well as lower ash mixes, were located to contrast positively with traditional granular products (Yudhbir V. and Honjo Y; 1991).CBR values of fly ashes differ substantially depending upon the sort of fly ash, nature, curing periods, and also the problem under which the test is carried out. In this research study, the CBR test was performed on fly ashes after treating the compressed samplings for 1, 7, as well as 14 days.

As the soaking CBR values are to be used for the design of pavements since it shows the worst case according to ASTMD1883-07E2, a series of soaked tests were also shown for all the mixes after curing the moulds for 1, 7, as well as 14 days. The loads consistent to different depths of penetration for Singrauli and Vindhyachal after curing for 1, 7, and 14 days are recorded and the loads essential for 2.5mm and 5mm penetrations obtained and existing in Table 5. The higher loads essential for deeper penetration for fly ashes are due to the material possessing higher stiffness at lower strain levels.

Thus, higher CBR values are detected for 5mm depth compared to the 2.5mm depth of penetration for pozzolanic fly ashes as may be understood from the results obtainable in Table 5. It is also detected from here that the CBR of Vindhyachal if higher than that of Singrauli. This may be due to more quantity of coarser fraction in Vindhyachal as compared to Singrauli.

Table 5: Variation of CBR values for Singrauli and Vindhyachal under unsoaked and soaked conditions and at different curing periods**.**

Mixed	1 day		1 day		7 day		7 day		14day		14day	
	Unsoked		Soked		Unsoked		Soked		Unsoked		Soked	
	2.5mm	5mm	2.5mm	5mm	2.5mm	5mm	2.5mm	5mm	2.5mm	5mm	2.5mm	5mm
Singrauli	26.8	34.65	1.19	1.0	39.96	42.36	29.36	34.21	42.36	42.98	41.70	40.21
Vindhyachal	28.9	35.98	1.3	1.	48.40	45.68	40.78	39.90	54.97	56.36	52.36	53.96

d. Hydraulic Conductivity

Hydraulic conductivity is an essential standard in the style of linings to consist of leachate movement, dykes to get ahead the loss of water, embankments in addition to the safety of inclines and also as a subbase product (Moghal A.A.B., 2010). The hydraulic conductivity of well-compressed fly ash has been discovered to vary from 10-4 to 10-6 cm/s, which is about comparable to the regular variety of permeability in the structure of silty sand to silty clay soils (Hough B. K., 1977). The hydraulic conductivity of fly ash is influenced by its density or level of compaction, its grain dimension circulation, pozzolanic task, as well as its inner pore structure (Pandian N. S. and Balasubramanian S., 1999., Rajasekhar C. 1995). The hydraulic conductivity of fly ash is commonly pretentious by its density or degree of compaction, particle size distribution, and internal pore structure. Given that fly ash includes almost entirely of spherically shaped particles, they become densely packed at the time of compaction, consequential in the reduce of hydraulic conductivity values. The hydraulic conductivity of fly ash is high related to its particles dimension as well as non-plastic nature and also is comparable to the attributes of non-plastic products such as silts. According to a research study for hydraulic conductivity, evaluated according to ASTM D2166. The hydraulic conductivity mould with the compressed sampling was maintained in a moisture chamber preserved at a temperature level 25°C and also

family member moisture higher than 95% and also treated for 7, 14, as well as 28 days. At the end of each curing duration, the hydraulic conductivity values were figured out for both fly ashes. Number 8 reveals the variant in hydraulic conductivity worths with curing duration. Lower hydraulic conductivity values are observed for Singrauli as compared to Vindhyachal and also might result from the finer particles dimension of Singrauli. Furthermore, with the rise in curing duration, a nominal decline in hydraulic conductivity values is observed which can be credited to the development of pozzolanic substances obstructing the pores

as well as lowering the liquid transmission. The hydraulic conductivity can better reduction upon associate it with lime, concrete, clay and so on.

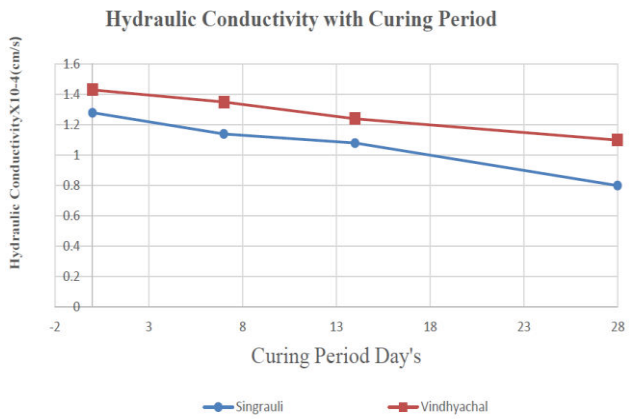

Figure 7: Variation of Hydraulic Conductivity with curing period

e. Free Swell Index

The free swell index is just one of one of the most generally utilised straightforward test for obtaining an estimate of the swell capacity of any product. This test was initially suggested by (Holtz W. G. and Gibbs H. J., 1956) as well as is revealed in cc or mL per one gram of product. The treatment developed by Rao as well as (Rao S. M. and Sridharan A., 1985) has been adhered to in research study for identifying the complimentary swell index. An oven-dried powdered sample of fly ash of 10 g was immersed in 40mL of distilled water in a 100 mL standard finished cylinder. The suspension was continuously mixed for thorough mixing and also was enabled to equilibrate for 24 h to guarantee complete wetting of the sample. The suspension was after that made up to the 100 mL mark by appropriate mixing. The cylinder was enclosed with a cap and also left uninterrupted for an additional duration of 24 h at which time the quantity inhabited by the sample particles on settling was kept in mind. After the suspension got to balance value, sediment quantity was kept in mind. The complimentary swell index was after that computed as sediment values per gram of fly ash; to be precise,

(Free Swell Index = Vd /W in cc/gm)

Somewhere **Vd** is the equilibrium volume of the oven-dried up fly ash sample reviewed from the finished cylindrical tube as well as **W** the weight of the oven-dried fly ash sample. The free swell index values come to be are 1.17 and also 1.1 cm3/ g for Singrauli and Vindhyachal, exactly. Established on these values, both fly ashes can be identified as a non-swelling kind. (Sridharan A. and Prakash K., 2000).

VI. CONCLUSIONS

Singrauli, as well as Vindhyachal fly ash, were tested for use as a geotechnical product. SEM and also XRD methods are made use of to test the morphology and also mineralogy of fly ash. Based upon penetrating for investigation complying with are the major final thoughts.

1. The physical properties, particle size, consistency limit, surface area, very considerably for the fly ashes. Singrauli has greater finer particle content than Vindhyachal.
2. The chemical investigation shows that the sum of silica, alumina and ferric is more than 70% as specified by ASTM and is sufficient to form pozzolanic products.
3. SEM and XRD methods help to research the geotechnical behaviour of fly ash. The surface morphological components reveal that Vindhyachal has a rougher surface compared to that of Singrauli. Both fly ashes have quartz and mullite phases in them primarily.
4. Consequent to curing, both fly ashes establish enough unconfined compressive strength and stiffness as disclosed from the CBR characteristics. The strength and stiffness can be enhanced further by maintaining it with cement, gypsum and lime.

The hydraulic conductivity of well-compacted fly ash has indeed been certainly located to range from 10− 4 to 10− 6 cm/s, that is roughly identical to the typically wide range of permeability of silty sand to silty clay soils.

6. Further stabilisation of Singrauli and Vindhyachal fly ash could deliver a possibility to use it in different geotechnical applications by enhancing the UCS, stiffness and durability and reducing the hydraulic conductivity.

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