



Alkaline Activation of Sandy Soil Using Potassium Hydroxide & Fly Ash

¹Ankit Kumar , ² Dr. Brahmdeo Yadav

¹M.Tech Scholar , ² Associate professor , Department of civil engineering
B.I.T. Sindri , Dhanbad , India

Abstract : In this research endeavour, the utilization of alkali-activated fly ash as a potential stabilizing agent for sandy soil was examined. The study incorporated the addition of 12 M potassium hydroxide, an alkaline activator, to a mixture of Sandy soil and fly ash. Subsequent unconfined compressive strength assessments were conducted on specimens to be fabricated with varying fly ash/solid ratios—10%, 20%, 30%, and 40%—and were subjected for a curing duration of 7 days at a temperature of 60°C. The results indicated that the alkaline activation of sandy soil using a Potassium hydroxide solution as the activator is a viable approach for stabilizing sandy soils.

Keywords : Sandy soil , Stabilizing agent , Alkaline activator , Potassium hydroxide , Flyash

1. INTRODUCTION :

During the production of electricity at power stations, coal gas emissions yield fly ash, a fine micro sized glass powder. Silica, alumina, and iron dominate these micro sized earth elements. Pozzolanas are siliceous / aluminous materials that create cement with alkali and water. Fly ash is the most famous and widely used pozzolana. Fly ash today comes from coal-fired power stations. Before combustion , these power facilities ground coal to powder form. Flue gases released after combustion contain these particles, which are extracted by electrostatic precipitators and sandbags [1]. Utilizing fly ash more efficiently in geotechnical engineering would result in significant environmental benefits, reducing soil and water pollution. Fly ash is often categorized into two types, type C and type F, based on its chemical composition . Fly ash type F has a SiO₂, Al₂O₃, and Fe₂O₃ content of above 70% (by weight) and a CaO content of less than 20%. Type C fly ash has a composition with a weight percentage of SiO₂, Al₂O₃, and Fe₂O₃ that is less than 70%, and CaO concentration that is greater than 10%. Fly ash particles usually have a spherical shape and vary in size from 0.5 µm to 100 µm. The chemical composition of these particles mostly comprises silicon dioxide (SiO₂), which exists in two distinct forms: amorphous, characterized by a rounded and smooth structure, and crystalline, characterized by a sharp, pointed structure. Additionally, the particles contain aluminium oxide (Al₂O₃) and iron oxide (Fe₂O₃) [2, 3]

2. MATERIALS

2.1 SOIL

The soil was collected from the bank of Damodar river in the Sindri region of Dhanbad district. Various geotechnical properties of sand such as specific gravity, water content and grain size distribution was determined. Physical and geotechnical properties of soil such as specific gravity, grain size distribution characteristics are listed below

Table 1 : Physical and Geotechnical properties of Soil

1	Specific Gravity	2.54
2	Coefficient of uniformity (Cu)	1.68
3	Coefficient of Curvature (Cc)	0.88

2.2 FLY ASH

Fly ash was collected from powerplant of (BSP) Bokaro steel plant. Specific gravity of fly ash was calculated by pycnometer method. Fly ash has been classified into 2 categories depending upon their calcium oxide content as class F & C. Chemical Composition of Fly ash was determined at the Central Research Facility (IIT ISM DHANBAD) by X-Ray Fluorescence Test. In my case it is class F fly ash.

Table 2 : Physical and Chemical properties of fly ash

Specific gravity	1.81
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Table 3 : Chemical Composition of Flyash

Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₂ O ₅	K ₂ O	CaO	TiO ₂	MnO	Fe ₂ O ₃
Mass%	Mass%	Mass%	Mass%	Mass%	Mass%	Mass%	Mass%	Mass%	Mass%
0.0827	0.6897	30.67	54.96	0.7922	1.7241	1.8372	2.3012	0.0522	6.8746

Table 4 : materials and environmental conditions adopted

Raw materials	Fly ash, Sand
Alkali activator	12 M KOH
Curing time	7 days
Curing temperature	60°C

2.3 KOH (POTASSIUM HYDROXIDE)

KOH pellets having 84% purity is used in this research work. These pellets were ordered from a Surat based company named as CYNOR LABORATORY. Dissociation of KOH is an exothermic reaction therefore a thick glass flask was used to prepare this solution. KOH is a deliquescent material, therefore it was preserved carefully in an air tight container.

3. METHODOLOGY

3.1 SIEVE ANALYSIS

A popular laboratory method for figuring out the particle size distribution of granular materials like crushed rock, aggregates, and soil is sieve analysis. In the fields of geotechnical engineering, civil engineering, and building material testing, it is an essential technique. Classifying soil types, gradation, and material appropriateness for building are all done using the results of sieve analysis.

3.1 STANDARD PROCTOR TEST

We must be aware of the soil's compaction characteristics before beginning soil compaction in the field. This test gives us an understanding of the soil's compaction characteristics. KOH solution range that enables the needed density to be achieved with the least amount of compactive effort. This test gives information on the material's behaviour with varying KOH contents. This test was performed as per IS: 2720 Part VII- 1974 .

3.2 UNCONFINED COMPRESSIVE STRENGTH

The unconfined compressive strength (UCS) test is a laboratory procedure used to measure the compressive strength of materials like soil, rock, and concrete without the application of lateral confining pressure. It is one of the simplest and most widely used tests for determining the strength of materials, particularly cohesive soils. Cohesive soil is placed under ucs compression machine and then the compressive load is applied . . Confining pressure is zero in case of ucs test . Failure occurs along the weakest shear plane as in this case it should be roughly 45 degree . Fly ash and soil were mixed in 4 percentages of 10% , 20% , 30%, 40% . Four samples were compacted at their respective optimum KOH content solution was added to these mixture at their respective optimum KOH content .

4. EXPERIMENTAL RESULTS AND DISCUSSION

4.1 EFFECT OF FLY ASH AND KOH

To determine the effect of fly ash activated with KOH in various proportions, several tests were performed on each sample, and we calculated OMC, MDD, UCS, and CBR values on each sample. Now, by observing test results, we can determine the optimum or economical percentage of fly ash with sand to achieve good strength.

Table 5 : description of specimen of soil and fly ash

Serial no	Soil (%)	Fly ash
1	90	10
2	80	20
3	70	30
4	60	40

4.1.1 Effect of fly ash on maximum dry density (MDD) and optimum KOH content

Change in maximum dry density and optimum KOH content with increase in percentage of FA are illustrated in the table and graph below .

FLY ASH	10	20	30	40
MDD (gm/ cc)	1.72	1.708	1.62	1.61
OKC (%)	15	16	20	23

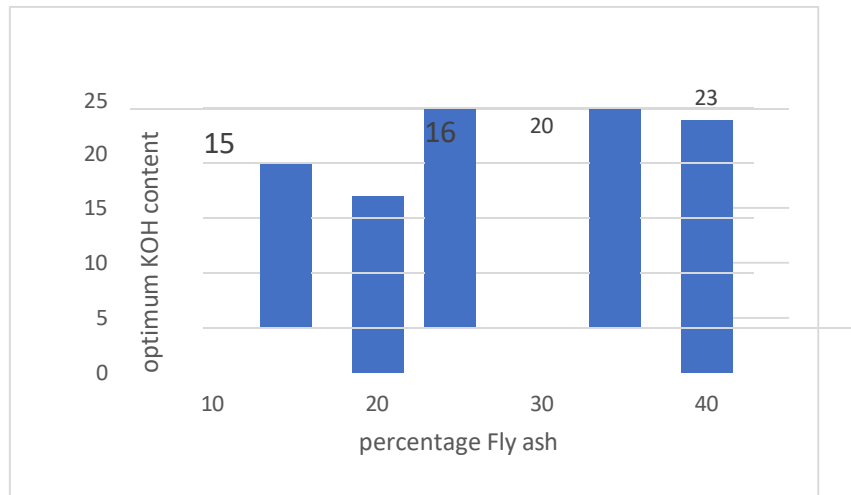


FIG 1 : variation of optimum KOH content with percentage fly ash

The value of MDD is ranging from 1.61 g/cc to 1.72 g/cc as fly ash content increases from 10% to 40%. The value of maximum dry density increases because flyash reacts with KOH and forms ASH gel which binds soil particles and decreases the amount of voids in soil and due to this unit weight of sample increases. With increase in percentage of fly ash optimum KOH content of sample increases due to decrease in amount of void in sample.

4.1.2 EFFECT OF FLYASH AND KOH ON UNCONFINED COMPRESSIVE STRENGTH

Increasing the percentage of fly ash activated with KOH first resulted in increase of strength then a decrease in strength was observed. This may be due to the excess fly ash which remains unreacted might be causing decrease in strength.

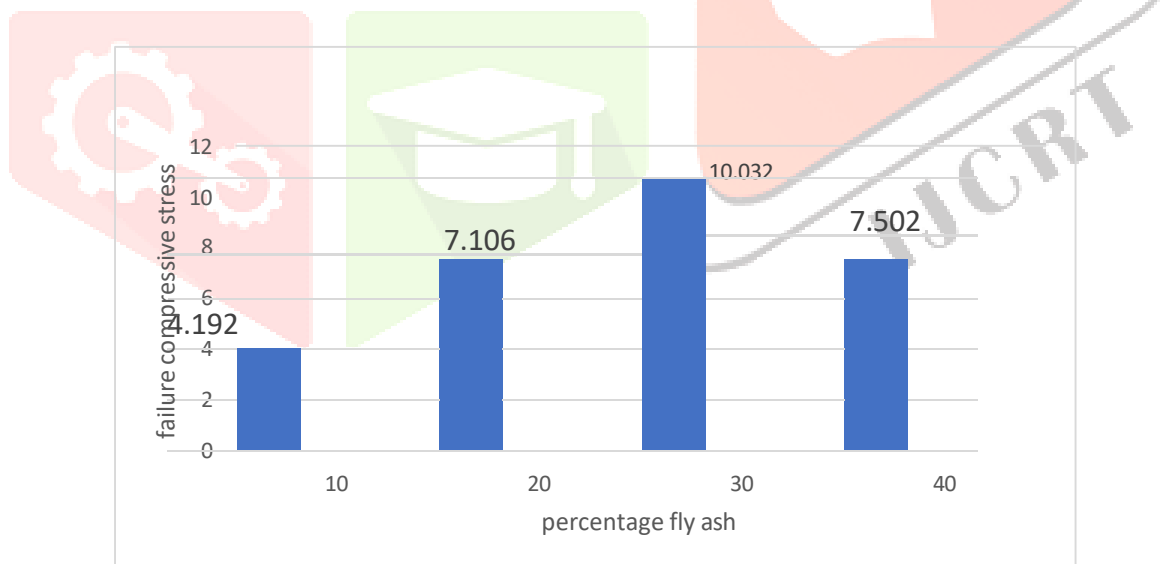


FIG 2 : variation of failure compressive stress with percentage fly ash

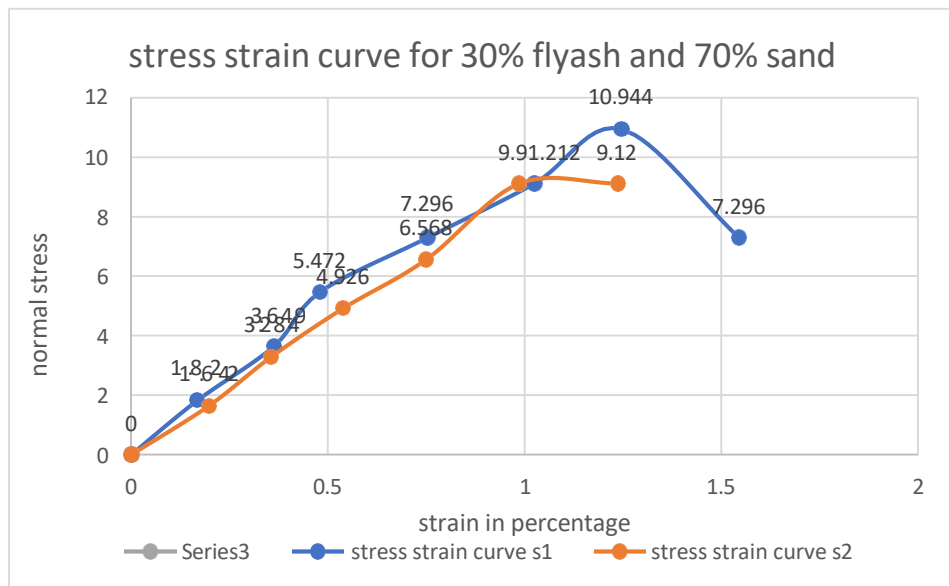


FIG 3 : Normal stress VS strain curve for 30% FA , 70% sand and 12M KOH solution .

5. CONCLUSIONS

The findings make it possible to draw the following conclusions of various experiments performed on several sample of natural soil mixed with fly ash :

- 1.) Experiment was performed on sandy soil
- 2.) When fly ash activated with KOH was mixed with sandy soil then maximum dry density observed was 1.61gm/cc to 1.72gm/cc .
- 3.) From economical point of view it is better to mix 30% Fly ash which have 1.62gm/cc maximum dry density .
- 4.) With increase in fly ash content from 10 % to 40 % , unconfined compressive strength from 4.192KN/m² to 10.032 KN/m² .
- 5.) From strength point of view 30% fly ash mixed with 70 % sand was found to be most effective in terms of strength when cured at a temperature of 60 degree celsius for 7 days . Brittle failure in sand was observed .

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