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Impact Of Curing Temperature On The Strength Of Lime Preserve Fly Ash

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Abstract : **Fly Ash in India is about 112 million tones with 65000 acre of land being occupied.In recent times the usage of fly ash as one of the dominant construction material. To enhance and improve the properties of fly-ash by stabilizing with lime. In this work aimedto evaluation of the impact of lime as stabilizing material to the fly ash. The geo-engineering properties of fly ash alongfly ash with different proportion of lime were conducted. Following tests light and heavy compaction test, unconfined compressive strength test, permeability test and CBR tests were studied for fly-ash sample. The stabilized fly-ash was done by adding lime with varying (2%, 4%, 8% & 10%) percentages. The UCS samples were cured for 7, 14, and 28 Days with different temperatures of 10^{o}, 27^{o}, and 50^{o}.**

The potential and efficiency of adding disposed fly ash from Mae Moh Electric Power Plant, Thailand, into cement-admixed clay were studied by means of a series of UC and physical tests (Jongpradist et al. 2010). An experimental study was conducted to investigate the long-term performance of fly ash stabilized two fine-grained soil sub-bases (Shafique et al. 2009).

A number of researches on study of using fly ash in the field of geotechnical engineering has been reported, such as the preserve of soil in compaction works of highway embankment or slope without cement or lime (Edil et al.2006; Kim et al. 2005; Prabakar et al. 2004) with cement (Kaniraj and Havanagi 1999) and with cement and fiber reinforcement (Kaniraj and Havanagi 2001).

Numerous studies on application of fly ash as bulk fill material are also available (Raymond 1958; DiGioia and Nuzzo 1972; Gray and Lin 1972; Joshi et al. 1975) which demonstrated the possibility of utilizing huge amount of fly ash in the construction of embankments, dykes, and road subgrades. A wide range of soils can be stabilized using fly ash (Chu et al. 1955; Geocker et al. 1956; Viskochil et al. 1957; Ghosh et al. 1973; Vasquez and Alonso 1981; Lo and Wardani 2002). Other uses of fly ash are land reclamation (Kim and Chun 1994), and injection grouting (Joshi et al. 1981). Ghosh et al. (2005) demonstrated the use of fly ash as foundation medium reinforced with jute-geotextiles. Undrained shear strength parameters of fly ash were reported by Raymond (1961).

Keywords: **Fly Ash; Class F Fly Ash; Class C Fly Ash; Lime; Stabilization Methods; Mechanical Stabilization; Cement Stabilization; Lime Stabilization; Bituminous Stabilization; Stabilization by Geo-Textiles;**

INTRODUCTION

Fly Ash is a side-effect material produced by warm force plants from ignition of Pulverized coal. This is a fine buildup delivered from the consumed coal is conveyed in the vent gas, separated by electrostatic precipitators, and gathered in a field of containers. This buildup which is collected is called as fly debris and is viewed as a modern waste which can be utilized in the construction industry. Fly debris is one of the major modern squanders utilized as a construction material. The fly debris can either be discarded in the dry structure or the wet strategy wherein it can also be blended in with water and released as slurry into areas called debris lakes. Removal of residual squander is probably the best test looked by the assembling ventures in India.

In numerous nations, including India, coal is utilized as an essential fuel in warm power stations and in different businesses. Four nations, specifically, China, India, Poland, and the United States, together produce in excess of 270 million tons of fly debris consistently and not exactly half of it is utilized. The coal hold of India is around 200 billion tons and its yearly production reaches 250 million tones roughly. In contrast to the created nations, in India, the ash content present in the coal which is utilized for power age is around 30-40%. The generation of debris has expanded to around 131 million ton during 2010-11 and is required to become further.

In India significant wellspring of intensity age is coal based warm force plants .where about 57% of the absolute force got is from coal-based warm force plant. High debris content is discovered to be in scope of 30% to half in Indian coal. The quantum of Fly Ash delivered depends on the nature of coal utilized and the working states of warm force plants. By and by the annual creation of Fly Ash in India is around 112 million tons with 65000 section of land of land being occupied by debris lakes and is required to cross 225 million tons constantly 2017. Such a huge quantity causes testing issues, as land use, wellbeing risks and environmental threats. Both in removal just as in use, most extreme consideration must be taken to safeguard the enthusiasm of human life, natural life and condition. At the point when pummeled coal is scorched to generate heat, the buildup contains 80% Fly Ash and 20% base debris.

Fig.1 Dry removal of fly-debris

LIME:

One of the most settled made advancement material is lime for instance CaO or Ca(OH)2, which is a by-consequence of expended lime stone (CaCO3), is the most settled urbanized improvement materials. Man has been using it for more than 2000 years earlier. The Romans had used soil-lime mixes for development of roads purposes. Nevertheless, its utility in the serious geotechnical planning was restricted until 1945, by and large due to the nonappearance of genuine appreciation of the subject. Today, adjustment of soils or waste materials by lime is when in doubt commonly used in a couple of developments, for example, interstates, incline affirmation, barriers, railways, air terminals, foundation base, canalizing, etc. This is on a very basic level in light of the straightforwardness of advancement, joined with ease of this innovation and for the most part because it is a most economical improvement material that gives an additional fascination in the creators. A couple of investigation works have been represented highlighting the useful effect of lime in improving the introduction of waste materials. With genuine structure and advancement strategies, lime treatment artificially changes reasonable waste into usable materials. Lime, either alone or in blend in with various materials, can be used to treat a scope of soil types.

RELATED WORK

Sherwood and Ryley (1970) presented a report on self-hardening characteristics of fly ashes. He said that the presence of free lime in the form of calcium oxide or calcium hydroxide controls the self-hardening characteristics of fly ashes.

Gray and Lin (1972) reported a study on the variation of specific gravity of the coal ash and they showed that the combination of many factors such as gradation, particle shape and chemical composition is responsible for variation in specific gravity.

Sharma et al. (1992) studied stabilization of expansive soil using mixture of fly ash, gypsum and blast furnace slag. They found that fly ash, gypsum and blast furnace slag in the proportion of 6: 12: 18 decreased the swelling pressure of the soil from 248 kN/m2 to 17 kN/m2 and increased the unconfined compressive strength by 300%.

Srivastava et al. (1997) studied the change in micro structure and fabric of expansive soil due to addition of fly ash and lime sludge from SEM photograph and found changes in micro structure and fabric when 16% fly ash and 16% lime sludge were added to expansive soil. Srivastava et al. (1999) have also described the results of experiments carried out to study the consolidation and swelling behaviour of expansive soil stabilized with lime sludge and fly ash and the best stabilizing effect was obtained with 16% of fly ash and 16% of lime sludge.

Cokca (2001) used up to 25% of Class-C fly ash (18.98 % of CaO) and the treated specimens were cured for 7 days and 28 days. The swelling pressure is found to decrease by 75% after 7 days curing and 79% with 28 days curing at 20% addition of fly ash.

Pandian et al. (2001) had made an effort to stabilize expansive soil with a class –F Fly ash and found that the fly ash could be an effective additive (about 20%) to improve the CBR of Black cotton soil (about 200%) significantly.

Turker and Cokca (2004) used Class C and Class F type fly ash along with sand for stabilization of expansive soil. As expected Class C fly ash was more effective and the free swell decreased with curing period. The best performance was observed with soil , Class C fly ash and sand as 75% , 15% and 10% respectively after 28 days of curing.

Satyanarayana et al. (2004) studied the combined effect of addition of fly ash and lime on engineering properties of expansive soil and found that the optimum proportions of soil: fly ash: lime should be 70:30:4 for construction of roads and embankments.

Phani Kumar and Sharma (2004) observed that plasticity, hydraulic conductivity and swelling properties of the expansive soil fly ash blends decreased and the dry unit weight and strength increased with increase in fly ash content. The resistance to penetration of the blends increased significantly with an increase in fly ash content for given water content. They presented a statistical model to predict the undrained shear strength of the treated soil.

RESULTS AND PROCESS DISCUSSION

COMPACTION CHARACTERISTICS:

The compaction characteristics of fly-ash& Lime mixture, showing optimum moisture content (OMC) and maximum dry density (MDD) of the compacted samples. Table 1.1 shows that OMC increased with increase in lime percentage and higher than normal fly-ash. Whereas MDD value increases with higher percentage as compared to normal fly-ash.

Table 1.1OMC & MDD for LimeStabilized fly-ash

Lime content (%)	Maximum dry density, MDD (g/cc)	Optimum moisture content, OMC (%)
0	1.12	40.5
2	1.085	43
4	1.089	42
8	1.097	41.5
10	1.101	41.3

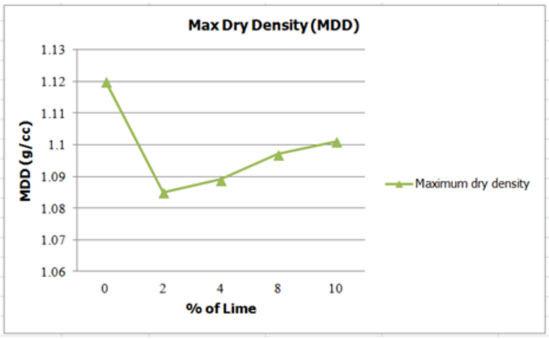

Fig.2.1 Maximum Dry Density for Lime Stabilized Fly-ash.

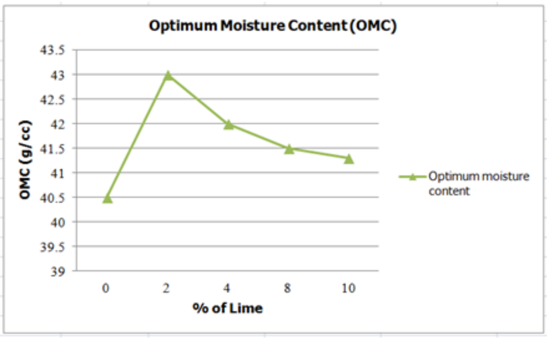

Fig.2.2Optimum Moisture Content for Lime Stabilized Fly-Ash

4.2UNCONFINED COMPRESSIVE STRENGTH (UCS):

The increase in strength for lime stabilized fly-ash for 7, 14,and 28Days with varying temperature 10°, 27°, & 50°.The sample was prepared with 50mm dia and 100mm heights. Table 1.2 shows UCS value of lime stabilized fly-ash. It is observed that fly-ashmixed with lime has more strength than untreated fly-ash.

Fig.3.3: Samples Are Cured At Different Temperature with Wax Coating

Table 1.2: Unconfined compressive strength of lime Stabilized Fly-Ash cured at 10°C

Lime content (%)	7days		14 days		28 days	
	Failure stress(σ) in kPa	Failure strain(ε) in %	Failure stress(σ) in kPa	Failure strain(ε) in %	Failure stress(σ) in kPa	Failure strain(ε) in %
0	185.3	3	209.48	3	234.8	2.75
2	310.76	2.75	335.56	2.25	421.44	2
4	445.67	2.75	448.47	2.5	528.05	2
8	501.24	2.5	620.01	2.75	1112.22	2.5
10	534.33	2.75	733.24	3	1734.47	2.5

Table 1.3: Unconfined compressive strength of lime Stabilized Fly-Ash cured at 27°C

Lime content (%)	7days		14 days		28 days	
	Failure stress(σ) in kPa	Failure strain(ε) in %	Failure stress(σ) in kPa	Failure strain(ε) in %	Failure stress(σ) in kPa	Failure strain(ε) in %
0	195.94	2.5	217.21	2.5	267.56	3
2	350.36	2.25	366.3	2	438.14	2.25
4	460.7	2	467.35	2	545.26	2.75
8	824.16	2.25	1150.3	2.5	1210.74	2.75
10	1204.87	2.75	1880.64	2.75	2202.8	3.25

Table 1.4: Unconfined compressive strength of lime Stabilized Fly-Ash cured at 50°C

Lime content (%)	7days		14 days		28 days	
	Failure stress(σ) in kPa	Failure strain(ε) in %	Failure stress(σ) in kPa	Failure strain(ε) in %	Failure stress(σ) in kPa	Failure strain(ε) in %
0	200.64	2.5	219.21	2.5	286.26	2.5
2	356.43	2.25	368.36	2	438.14	2.25
4	464.48	2	475.35	2.25	589.23	3
8	969.79	2.25	1183.46	2.5	1292.67	3
10	1649.07	2.5	2126.02	3	3176.95	2.5

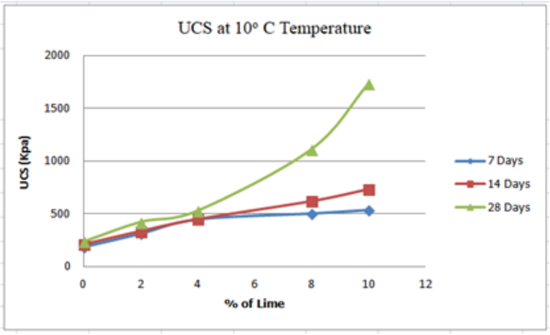

Fig.3.4: Lime Content vs. Unconfined Compressive Strength at Temperature 10°C

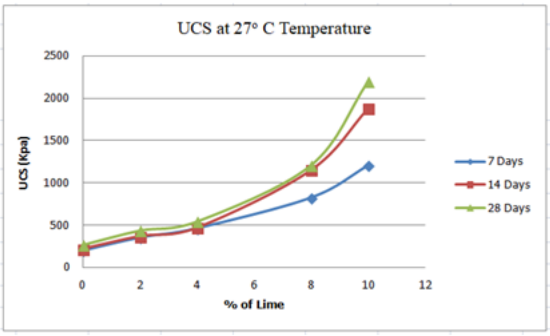

Fig.3.5: Lime Content vs. Unconfined Compressive Strength at Temperature 27°C

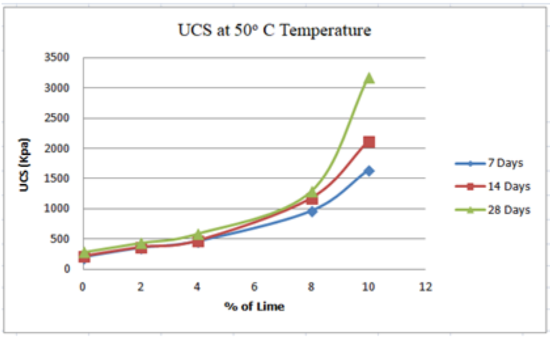

Fig.3.6: Lime Content vs. Unconfined Compressive Strength at Temperature 50°C

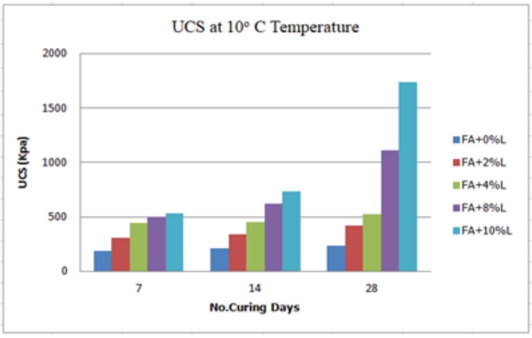

Fig.3.7:Curing Days vs. Unconfined Compressive Strength at Temperature 10°C

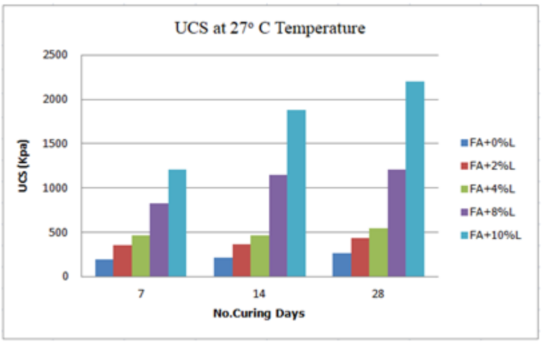

Fig.3.8:Curing Days vs. Unconfined Compressive Strength at Temperature 27°C

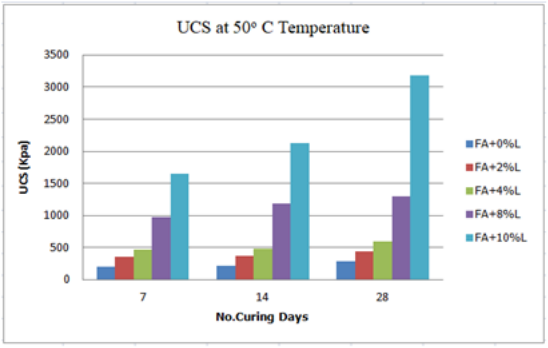

Fig.3.9:Curing Days vs. Unconfined Compressive Strength at Temperature 50°C

4.3 CALIFORNIA BEARING RATIO:

To study the effect of curing period the fly ash and lime stabilized Fly ash samples with different percentage of lime (0%, 2%, 4%, 8%, and 10%) were prepared at a MDD and OMC .To study the effect of pozzolanic reaction of lime on CBR value of stabilized fly ash these samples were subjected to a curing period of 7&28 days for a soaking period of 4 days for soaked samples.

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Fig.3.10: LimeStabilized FlyAshSubjectedTo28DaysofCuringPeriod.

Table 1.5: CBR Test Result of Fly Ash and Stabilized Fly Ash at 7 Days.

Lime content in %	Soaked CBR value		Unsoaked CBR value	
	CBR Value at 2.5 mm Penetration (%)	CBR value at 5mm Penetration (%)	CBR Value at 2.5 mm Penetration (%)	CBR value at 5mm Penetration (%)
0	1.15	1.03	21.89	21.53
2	30.90	29.30	35.80	35.50
4	36.30	35.80	38.27	38.00
8	41.20	40.90	52.03	49.33
10	50.40	48.80	60.93	59.04

Table 1.6: CBR Test Result of Fly Ash and Stabilized Fly Ash at 28 Days

Lime content in %	Soaked CBR value		Unsoaked CBR value	
	CBR Value at 2.5 mm Penetration (%)	CBR value at 5mm Penetration (%)	CBR Value at 2.5 mm Penetration (%)	CBR value at 5mm Penetration (%)
0	2.30	2.10	23.71	22.90
2	41.50	40.20	42.32	39.08
4	58.50	56.90	60.13	54.73
8	114.40	109.80	118.40	110.30
10	162.10	159.40	177.48	171.27

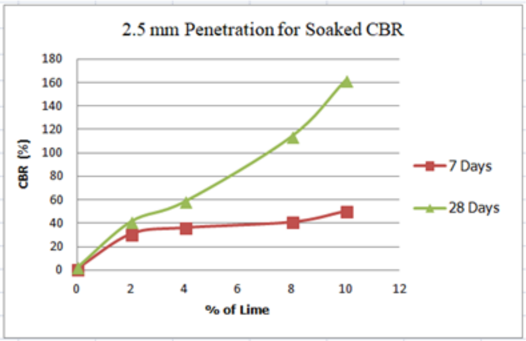

Fig-4: 2.5 mm Penetration of Soaked CBR vs. Lime Content.

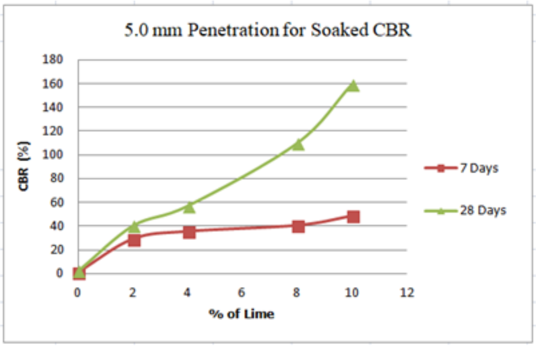

Fig-5: 5.0 mm Penetration of Soaked CBR vs. Lime Content.

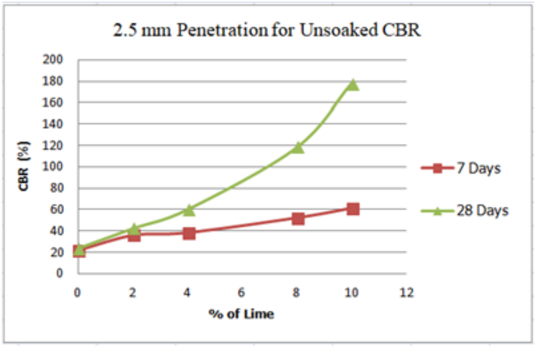

Fig-6: 2.5 mm Penetration of UnsoakedCBR vs. Lime Content.

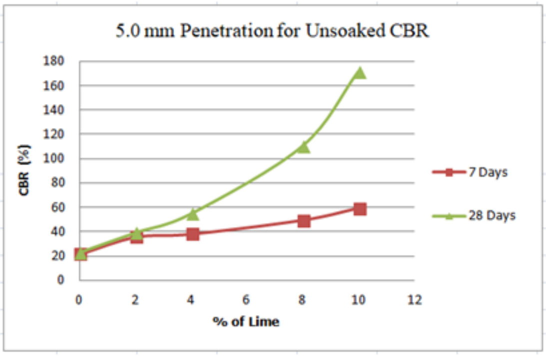

Fig-7: 5.0 mm Penetration of UnsoakedCBR vs. Lime Content.

CONCLUSION

Based on the results obtained and comparisons made in the present study, the following conclusions are made. Investigate strength properties of lime stabilized fly ash effects of lime content, curing period and curing temperature on the strength properties are carried out. Based on the experimental investigations the following main conclusions are arrived at:

- The Maximum Dry Density (MDD) and Optimum Moisture content value of the limestabilized fly-ashincreases with the addition of lime.The maximum value of MDD was observed for a mixture of limeat 10% to fly ash content by weight. The MDD values consistently increases.
- Drydensityofcompactedspecimensisfoundtochangefrom1.12to1.236g/cc. Thisshowsthatflyashsamplerespondsverypoorlytothecompactionfactor.
- Howeverhigherlimecontenttendstoincrease theMDDvalueasthe specificgravity oflimeishigherthanthatofthefly-ashparticles.
- The Unconfined Compressive Strength (UCS) of the fly ash increases with variation of lime content showed similar trend in CBR test.
- With the increasing Curing period of lime stabilized fly-ash the strength of UCS and CBR values also increased.
- With the increase of Curing Temperature the UCS and CBR for lime stabilizes fly-ashstrength is increased.
- Both the unsoaked and soaked CBR values are found to increase with lime content up to 4% beyond which the increment is marginal. This trend is observed for specimens cured for 7 and 28 days showed a continuous increase in CBR value with lime content. This indicates that the reaction of lime with fly ash is slow and a higher curing period is needed to complete the pozzolanic reaction.

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