Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 2, Number 6; April-June, 2015 pp. 536-539

http://www.krishisanskriti.org/jceet.html

# Stabilization of Pond Ash using Lime and Slag

**T. Raj Priyanka[1], Swaraj Chowdhury[2] and S.P. Singh[3]**

*[1]M. Tech. Student Department of Civil Engineering NIT, Rourkela Room No.: B-323, KMS Hall of Residence NIT Rourkela - 769008*
*[2]M. Tech. Student Department of Civil Engineering NIT, Rourkela Room No.: D-009 VS Hall of Residence NIT Rourkela - 769008*
*[3]Department of Civil Engineering NIT, Rourkela*
*E-mail: [1]rajpriyanka936@gmail.com, [2]swaraj.marik@gmail.com, [3]spsingh@nitrkl.ac.in*

**Abstract—***Massive urbanization in the recent times has led a high increase in the power demands and eventually an increase in the production of pond ash generated as a waste material from thermal power plants. To decrease the environmental pollution and disposal problem of pond ash, it is imperative to utilize it. But pond ash as such does not have enough strength to be used in civil engineering construction. So, it is advisable to improve the engineering properties of the pond ash by stabilizing it by adding other materials. In the present study series of experiments have been conducted to investigate the effect of lime and ground granulated blast furnace slag(GGBS) on strength and hydraulic conductivity properties of pond ash. Lime as stabilizing agent in different proportions (0, 3, 6, 9, 15 %) and slag as an admixture in different proportions (0, 5, 10 and 15%) are added to the pond ash and the compaction characteristics of the resulted mixture were determined by standard proctor test, strength by Unconfined Compressive Strength test (UCS) and hydraulic conductivity by constant head permeability test. The UCS samples were cured for 0, 3, 7, 14 and 28 days at a constant temperature $27^0$C. The permeability samples are cured for 0 and 7 days. The results showed an increment of maximum dry density and decrease in optimum moisture content with an increasing lime content, slag and curing period. The results are examined and the combination of proportion of lime and pond ash which gives the best results is reported as the desired proportion for stabilization.*

## 1. INTRODUCTION

The tremendous increase in population and industrialization increased the demand of power supply which increased the production of pond ash from thermal power plants. Pond ash is mixture of flyash and bottom ash. It creates environmental pollution and health hazards. These hazardous effects can thus be reduced by utilizing pond ash in bulk in geotechnical engineering applications such as construction of embankments, as a backfill material, as a sub-base material, etc.by stabilizing it. Lime is the most commonly used method for improving the properties of pond ash.

Several attempts have been made to improve the engineering properties of pond ash to use as a construction material for roads. Factors like type and amount of lime used, curing period adopted are predominant to influence the strength of pond ash.

Ghosh [1] studied the suitability of stabilized pond ash for road base and sub base construction by conducting laboratory tests on Class F pond ash alone and stabilizing with varying percentages of lime (4, 6, and 10%) and Phospho Gypsum (PG) (0.5 and 1.0 %). An empirical model has been given to estimate the bearing ratio for the stabilized mixes through multiple regression analysis and a linear empirical relationship has been presented to estimate soaked bearing ratio from unsoaked bearing ratio of stabilized pond ash.

Chand and Subbarao [2] studied the effects of lime stabilization on the strength and durability aspects of a class F pond ash by stabilizing pond ash with different percentages of lime and curing the sample for various periods at 30°C. They derived good correlations for strength parameters from unconfined compressive strength (UCS) tests, point load strength tests, rebound hammer tests, and slake durability tests and also between UCS and slake durability index. Sreedhar and Kunduru [3] studied effect of lime on compaction and California bearing ratio (CBR) characteristics of pond ash by taking various substitution levels of lime including the role of curing period.

The present study involves the stabilization of pond ash by mixing hydrated lime of different percentages and Ground Granulated Blast Furnace Slag as admixture to improve the strength properties of the pond ash. The compaction and UCS test are conducted for determining maximum dry density (MDD), optimum moisture content (OMC) and strength respectively. The results are examined and the combination of proportion of lime, slag and pond ash which gives the required best results is reported as the desired proportion for stabilization.

Hogan and Meusel [4] studied the evaluation of a ground granulated blast furnace slag as a partial replacement for Portland cement in mortars and concrete. The ground slag was evaluated for strength-producing properties as well as durability performance by replacing 40 to 65% Portland cement with it. This study showed that the ground slag when used to replace 40 to 65% Portland cement significantly improved strengths, sulfate resistance, and alkali aggregate

reactivity. Yadu and Tripathi [5] evaluated the potential of granulated blast furnace slag (GBS) with fly ash to stabilize a soft soil using compaction and CBR test with different amounts of GBS, i.e. 3, 6, and 9% with different amount of fly ash i.e. 3%, 6%, 9% and 12%.

## 2. MATERIALS

The pond ash used in the present study was collected from NTPC, Angul. The specific gravity of pond ash as per IS: 2720 (Part-III) was noted as 2.04. Particle size distribution for the fly ash sample was obtained following the procedure described in IS: 2720- PART (IV).The properties of pond ash are given in the Table 1.

The Ground Granulated Blast Furnace Slag used as admixture in the present study.

The lime is used as stabilization agent for pond ash in the present study.0%, 3%, 6%, 9% and 15% lime and 0%, 5%, 10%, 15% are added to pond ash in successive steps. The mixture of pond ash, lime and slag is compacted using standard proctor test to obtain the MDD and OMC. The strength of the lime stabilized pond ash is obtained by conducting UCS maintaining MDD at OMC conditions and cured for 0, 3, 7, 14, 28 days.

## 3. RESULTS AND DISCUSSIONS

With an increase in lime content, the MDD values increases and OMC values decreases. Table 2 and 3 represent the values of MDD and OMC obtained in standard proctor test.

**Table 1: Engineering properties of Pond Ash**

| Parameter | Value | Units |
|---|---|---|
| Specific gravity | 2.04 | |
| Consistency | Non plastic | |
| Coefficient of uniformity, Cu | 4.65 | |
| Coefficient of curvature, Cc | 0.84 | |
| Standard proctor test results<br>Maximum dry density<br>Optimum water content | <br>1.185<br>27 | <br>g/cc<br>% |

**Table 2: Variation of MDD for different percentages of lime and slag**

| Slag (%) | Lime (%) | | | | |
|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 15 |
| 0 | 1.185 | 1.22 | 1.243 | 1.2612 | 1.296 |
| 5 | 1.225 | 1.256 | 1.272 | 1.29933 | 1.342 |
| 10 | 1.264 | 1.29 | 1.3137 | 1.3216 | 1.348 |
| 15 | 1.283 | 1.31 | 1.325 | 1.341 | 1.363 |

**Table 3: Variation of MDD and OMC for different percentages of lime**

| Slag (%) | Lime (%) | | | | |
|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 15 |
| 0 | 27 | 24 | 23 | 22 | 21 |
| 5 | 24 | 22 | 21 | 20 | 19 |
| 10 | 23 | 21 | 20 | 19 | 18 |
| 15 | 23 | 21 | 20 | 19 | 18 |

Fig. 1 and 2 indicate that the MDD values increases from 1.185 to 1.296g/ $cm^3$ and OMC values decreases from 27 to 21% respectively when the effect of lime is considered i.e there is no admixture added. The MDD values increases from 1.185 to 1.363g/ $cm^3$ and OMC values decreases from 27 to 18% respectively when the slag is added to lime stabilized pond ash.

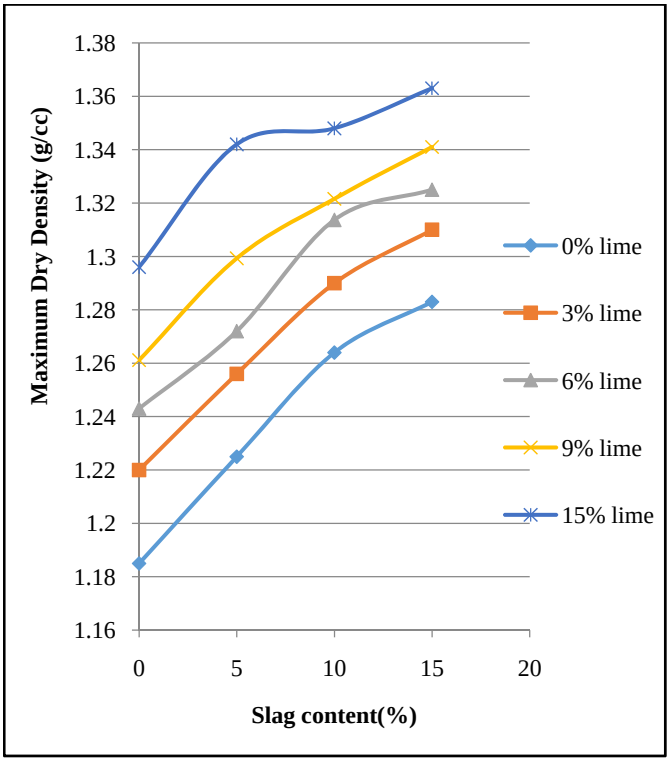


**Fig. 1: MDD for different % of lime and slag**

The compaction of lime stabilized pond ash does not show any appreciable change in compaction curve compared to unstabilized pond ash. This may be due to addition of less percentages of lime to pond ash or no availability of time for pozzolanic reaction to take place during compaction. The strength determined by UCS test are represented in Table 4.

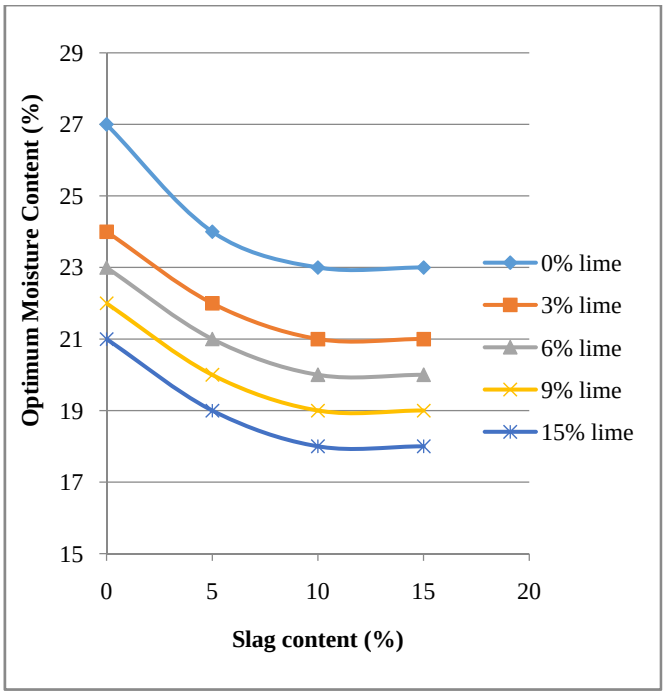


**Fig. 2: OMC for different % of lime and slag**

Table 4 Unconfined Compressive Strength (KPa) of samples at curing period of (a) 0 days (b) 3 days (c) 7 days (d) 14 days.

**Table 4(a)**

| Slag (%) | Lime (%) | | | | |
|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 15 |
| 0 | 38 | 76.8 | 111 | 125 | 186 |
| 5 | 52 | 80 | 119 | 131 | 200 |
| 10 | 64 | 85 | 124 | 137 | 207 |
| 15 | 59 | 116 | 133 | 175 | 359 |

**Table 4(b)**

| Slag (%) | Lime (%) | | | | |
|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 15 |
| 0 | 55 | 113 | 139 | 234 | 2 |
| 5 | 78 | 169 | 187 | 248 | 3 |
| 10 | 125 | 225 | 279 | 356 | 3 |
| 15 | 92 | 539 | 805 | 1153 | 9 |

**Table 4(c)**

| Slag (%) | Lime (%) | | | | |
|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 15 |
| 0 | 78 | 135 | 154 | 326 | 609 |
| 5 | 202 | 343 | 456 | 728 | 1798 |
| 10 | 187 | 504 | 650 | 1250 | 2209 |
| 15 | 167 | 991 | 1130 | 1658 | 2922 |

**Table 4(d)**

| Slag (%) | Lime (%) | | | | |
|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 15 |
| 0 | 126 | 149 | 209 | 392 | 1859 |
| 5 | 139 | 507 | 647 | 1407 | 2183 |
| 10 | 185 | 604 | 828 | 2099 | 2729 |
| 15 | 155 | 1399 | 1625 | 2508 | 4218 |

There is no remarkable change in the permeability of the pond ash, lime and slag mixture for 0 days curing as there is no time for pozzolanic reaction to take place. The permeability decreased from 9.71*10-5 to 7.51*10-5 for curing period of 7 days for only pond ash to pond ash stabilized with 15% lime and 15 % slag respectively. A similar trend of decrease in permeability is observed for curing period of 14 and 28 days. Table 5 shows the values of permeability (K) (x 10-5 cm/sec) of pond ash at various percentages of lime and blast furnace slag at 0 days and 7 days of curing.

Table 5 Permeability, K (x $10^{-5}$ cm/sec) of pond ash at various percentages of lime and blast furnace slag at (a) 0 days and (b) 7 days of curing.

**5(a)**

| Slag (%) | Lime (%) | | | | |
|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 15 |
| 0 | 10.1 | 9.83 | 9.59 | 9.21 | 8.89 |
| 5 | 9.68 | 9.46 | 9.13 | 8.93 | 8.67 |
| 10 | 9.44 | 9.23 | 9.005 | 8.71 | 8.46 |
| 15 | 9.21 | 9.07 | 8.84 | 8.49 | 8.19 |

**5(b)**

| Slag (%) | Lime (%) | | | | |
|---|---|---|---|---|---|
| | 0 | 3 | 6 | 9 | 15 |
| 0 | 9.71 | 9.589 | 9.327 | 9.146 | 8.546 |
| 5 | 9.52 | 9.27 | 9.016 | 8.763 | 8.192 |
| 10 | 9.205 | 9.067 | 8.934 | 8.587 | 7.986 |
| 15 | 8.987 | 8.641 | 8.351 | 8.014 | 7.51 |

## 4. CONCLUSIONS

The compaction and strength characteristics of pond ash stabilized with lime (0, 3, 6, 9, and 15%) and slag (0, 5, 10 and 15%) were studied with laboratory experiments. The specimens are cured for period of 0, 3, 7, 14 and 28 days. The following conclusions can be drawn from the analysis done in this paper:

- The variation of dry density with moisture content for lime stabilized pond ash is similar to that of unstabilized pond ash in the present study.
- The MDD values are found to increase and OMC values decreases with an increase in percentage of lime added as stabilizing agent and slag added as admixture to pond ash.
- With an increase in lime content (0-15%), the strength of lime stabilized pond ash increases for different curing periods at particular percentage of slag.

- The strength of the samples increases with an increase in curing period adopted for different percentages of lime and slag.
- When no lime is added i.e. at 0% lime, the strength of samples increases with an increase in percentage of slag added upto 10% only. Beyond which there is a decrease in strength of sample for different curing periods.
- With an increase in lime content the permeability of pond ash mixture decreses for a particular percentage of slag.
- Addition of slag decreases the permeability of pond ash, lime and slag mixture for a particular percentage of lime content.
- The hydraulic conductivity of the pond ash, lime and slag mixture decreases with increase in curing period.

**REFERENCES**

[1] Ghosh, A., "Compaction Characteristics and Bearing Ratio of Pond Ash Stabilized with Lime and Phosphogypsum", 1943. 10.1061/(ASCE)MT.1943-5533.0000028.

[2] Chand, S.K., Subbarao, S., "Strength and Slake Durability of Lime Stabilized Pond Ash", (ASCE), 19:7(601) 2007, pp. 0899-1561.

[3] Sreedhar, M.V.S., Kunduru, M., "Compaction and CBR characteristics of lime stabilised pond ash" IGC Paper No.L-071, 2011.

[4] Hogan, F. J. and Meusel, J. W., "Evaluation for Durability and Strength Development of a Ground Granulated Blast-Furnace Slag," Cement, Concrete and Aggregates, 3(1), 1981, pp.40-52.

[5] Yadu, L., Tripathi, R.K., "Stabilization Of Soft Soil With Granulated Blast Furnace Slag And Fly Ash", IJRETISSN: 2319-1163,2(2), 2013.