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Effect of Additives on Strength Properties of Soil with Emphasis on Compaction Time Lag

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Abstract—*A study was undertaken to evaluate the effect of time lag on the strength properties of soil treated with two additives like fly ash and phosphogypsum. Here time lag is referred as the elapsed time interval between the addition of additive and water to the soil & compaction of the mixture. Strength properties like California bearing ratio and Unconfined compressive strength are carried out for the soil treated with different percentages(5%,10%,15%) of fly ash and combination of fly ash and phosphogypsum(5%,10%,15%) following immediate compaction and compaction time lag i.e., up to two hours at half an hour intervals and 24 hours. At immediate compaction there is increase in strength properties with increase in the content of fly ash, fly ash and phosphogypsum. California bearing ratio at immediate compaction for the soil treated with fly ash, combination of fly ash and phosphogypsum indicates the strength values with minute variations. Unconfined compressive strength at immediate compaction indicates that the strength is more for the soil treated with fly ash than the fly ash - phosphogypsum treated soil. Unconfined compressive strength following compaction time lag with respective curing days (7, 14, 21, 28 days) is carried out, there is increase in the strength with increase in curing days even though there is time lag. With increase in time lag up to two hours at half an hour interval and 24 hours there is decrease in the strength properties, but for the time lag up to twohours observed that not as much variationsin terms of strength compared to immediate compaction.*

1. INTRODUCTION:

Chemical stabilization is the improvement of soils to have a better performance for various engineering applications such as pavements, embankmentsetc. It helps in altering certain physical properties like enhancement of strength & bearing capacity, reduction of expansiveness& plasticity which leads to creation of more suitable and stable conditions. From the past days the most commonly used chemical additives are lime and cement which are effective in its improvement but by the invention of new emerging trends, lot of new stabilizers came into existence. One such type of stabilizer used here are industrial by products i.e., flyash and phosphogypsum obtained from thermal power plant and phosphoric fertilizer industry.

Stabilization is not only the criteria for the enrichment of soil but it also require a successful and a proper compaction. Prior to the construction in field firstly the soil is to be pulverized, additive is to be introduced followed by mixing it with water and finally soil is compacted to achieve the maximum density by using various equipment. Practically this activity may cause time lag between mixing and compaction due to unforeseen conditions like hitches or technical breaks for logical reasons may also lead to delay of compaction. Due to this lag in time the soil-additive-water particles try to bind together in the loosest state and disruption of these aggregations required to densify the soil may not help to gain the entire strength.

This paper reports the strength properties variations following compaction time lag up to two hours at half an hour intervals i.e.,0,0.5,1,1.5,2 and 24 hours.

2. LITERATURE REVIEW:

From the past few decades, researchers studied the behavior of stabilized soils using lime, cement, flyashetc. They concentrated on the parameters like soil type, type of admixture, curing but there is no thorough study of time lag or delay. In order to have better mix uniformity and workability time lag is helpful in breaking down clods explained by McDowell [1].Due to improper mixing and delayed compaction after initial mixing of soil and lime lead to most of the failures associated with lime treated bases in Louisiana said by Taylor and Arman [2].Mitchell and Hooper [3] explained the effect of time lag in terms of compaction of an expansive clay treated with 4 percent dolomite hydrated lime. The time lag caused deleterious impact on unconfined compressive strength, swelling characteristics, density at constant comp active effort, however the time lag is eliminated if extra compaction effort is provided. Depending on the type of admixture added to the soil compaction delay is followed sometimes like if quick lime is usedinstead of hydrated lime it does not require a prompt compaction(Marta Di Sante et al., 2015[4]).

3. MATERIALS USED:

SOIL(S): Representative soil was collected from the nearby fields of Bowrampet village, Hyderabad in the state of

Telangana. The soil is excavated at a certain depth and collected in bags and oven dried before conducting the tests.

STABILIZERS: Thestabilizers used here are fly ash(FA) and phosphogypsum(PG).

4. EXPERIMENTAL WORK:

The properties of original soil are listed in table 1and the compaction characteristics i.e., optimum moisture content(OMC) and maximum dry density (MDD) of original soil,soil stabilized with fly ash and combination of fly ash and phosphogypsum are listed in table 2.Themaximum dry density increased and optimum moisture content decreased with increase in fly ash content and phosphogypsum when compared to original soil.

The strength properties that are carried out are California bearing ratio(CBR) under soaked condition and Unconfined compressive strength(UCS) at respective curing days(0,7,14,21,28) following time lag at 0,0.5,1,1.5,2 and 24 hours i.e., the time lag is carried out after mixing the soil-additive-water prior to compaction. The mixed soil sample is placed in plastic bags to prevent the moisture loss and maintained at room temperature.

TABLE 1: PROPERTIES OF ORIGINAL SOIL

Soil property	Value
Specific gravity	2.55
Free swell index(%)	60
Liquid Limit(%)	47
Plastic Limit(%)	24.31
Plasticity Index(%)	22.69
Soil Classification	CI
Optimum moisture content(%)	15.86
Maximum dry density(g/cc)	1.77
Unconfined compression strength(kg/cm^2)	5.6
California bearing ratio	2

TABLE 2: COMPACTION VALUES OF MIX PROPORTIONS

MIX PROPORTIONS	OMC(%)	MDD(g/cc)
Soil	20.5	1.45
Soil +5%FA	15.15	1.71
Soil +10%FA	18.22	1.67
Soil +15%FA	16.67	1.7
Soil+2.5%FA+2.5%PG	19.81	1.65
Soil +5%FA+5%PG	20.96	1.59
Soil +7.5%FA+7.5%PG	16.79	1.71

5. RESULTS AND DISCUSSIONS:

The CBR under soaked condition is carried out at 0,0.5,1,1.5,2 and 24 hours and the CBR for original soil is 2 .With increase in compaction time lag for original soil there is increase in strength for 0.5,1 hours and there is slight decrease for 1.5,2,24 hours. The figure 1 shows the CBR values for the original soil and the soil treated with fly ash and figure 2 shows CBR values for the original soil and the soil treated with fly ash and phosphogypsum. From the figures 1 & 2 it is observed that there is increase in strength for 0.5,1 hour compared to immediate compaction and there is decrease for 1.5,2 hour but of less change. It is observed that there is decrease in strength for longer time lag or delay i.e., for 24 hours.

Figure 1: CBR and time lag in hours for 5%,10%,15% fly ash

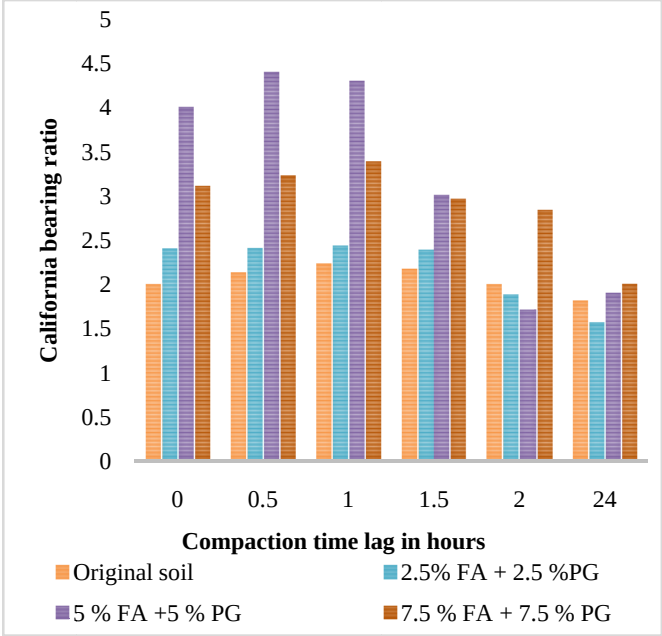

Figure 2: CBR and time lag in hours for 5%,10%,15% fly ash and phosphogypsum

The Unconfined compressive strength(UCS) for the original soil with time lag increased with slight variations for 0,0.5,1,1.5,2 hours and decreased for 24 hours.The UCS for 0,0.5,1,1.5,2 hours are 5.6,5.02,6.13,5.82,5.71 kg/cm^2 and for 24 hours is 4.23 kg/cm^2.

The UCS following compaction time lag for the soil treated with fly ash is shown in figures 3,4,5 and the soil treated with fly ash and phosphogypsum is shown in figures 6,7,8.From the figures 3,4.5 it is observed that there is increase in UCS for 0.5,1 hours compared to immediate compaction and slight decrease in strength for 1.5,2 hours and 24 hours.From the figures 6,7,8 it is observed that there is increase in strength for 1.5,2 hours compared to immediate compaction and there is slight decrease for 0.5,1 and 24 hours.

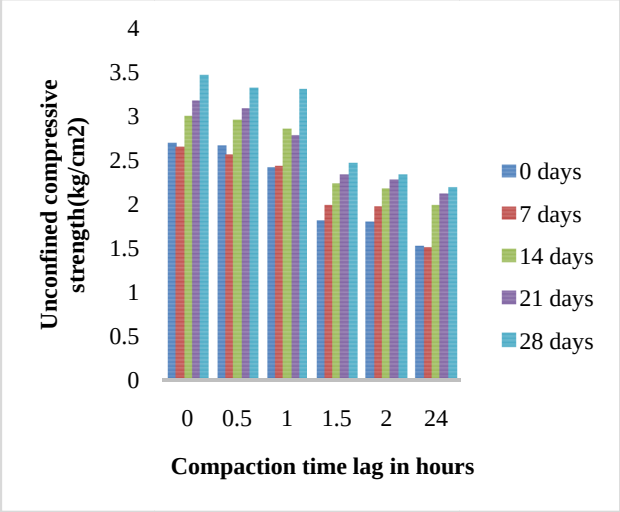

Figure 3: UCS and time lag in hours for 5% fly ash at curing days

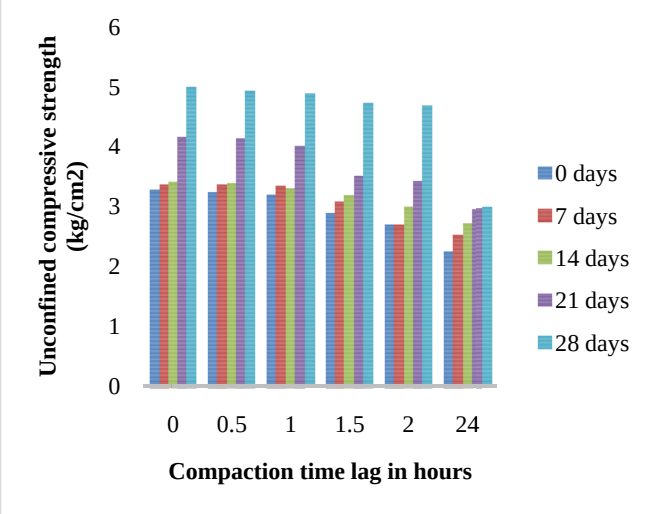

Figure 4: UCS and time lag in hours for 10%fly ash at curing days

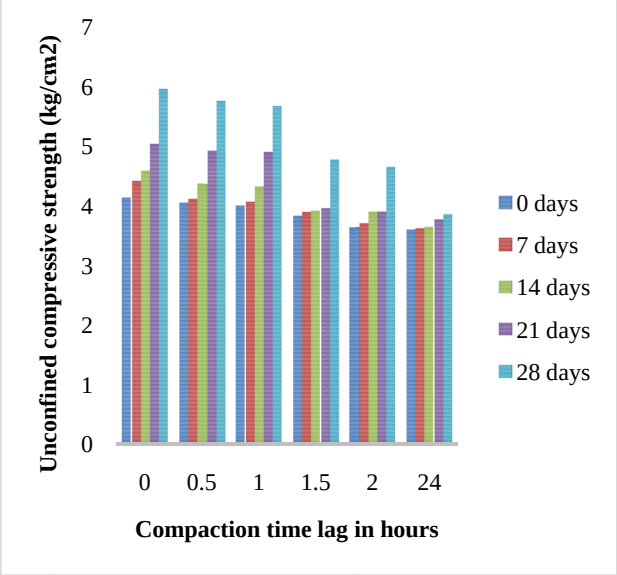

Figure 5: UCS and time lag in hours for 15% fly ash at curing days

Compaction time lag should be allowed depending on the type of soil and the type of additive added. Time lag allowed helps for chemical reactions to break down and it also make highly expansive soils workable[5].

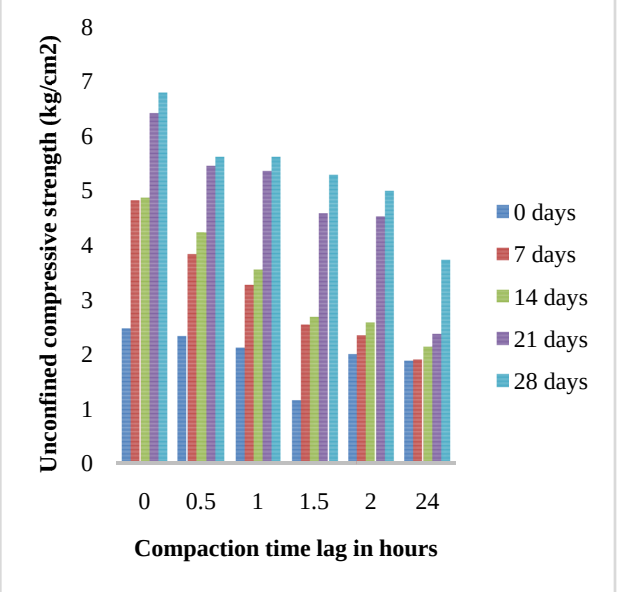

Figure 6: UCS and time lag in hours for 5% fly ash and phosphogypsum at curing days

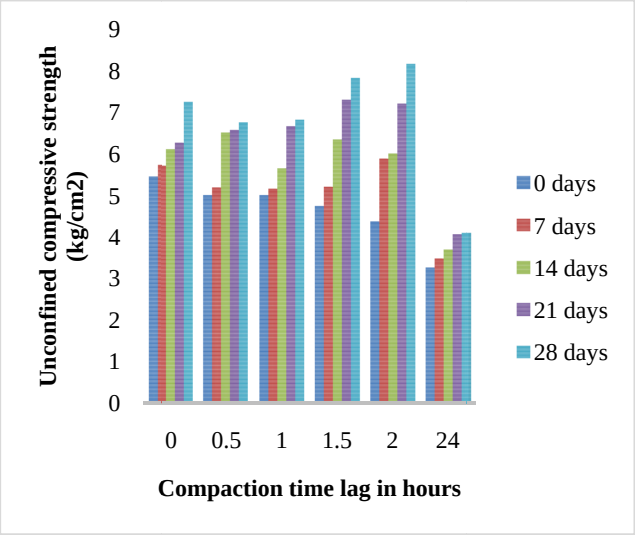

Figure 7: UCS and time lag in hours for 10% fly ash and phosphogypsum at curing days

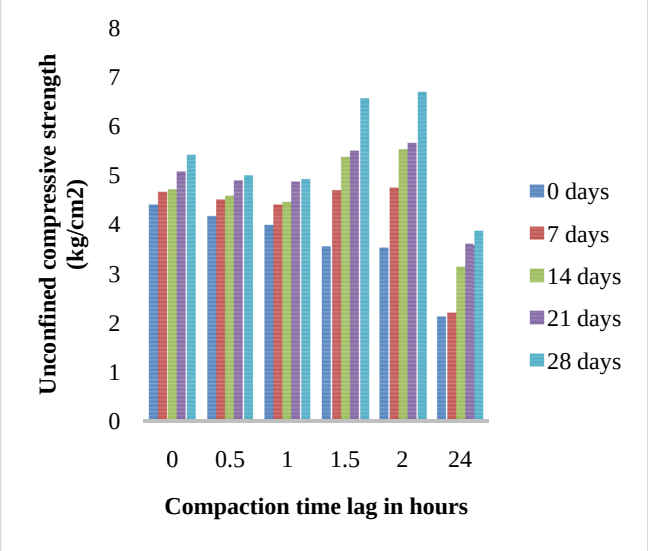

Figure 8: UCS and time lag in hours for 15% fly ash and phosphogypsum at curing days

From the figures 6,7,8 it is observed that there is increase in strength(UCS) with increase in compaction time lag at short time lag, here up to 2 hours at half an hour intervals and decrease in strength for 24 hours.Here along with fly ash, phosphogypsum is added which turned to increase in strength(UCS) compared to soil treated with only fly ash.

The strength properties CBR and UCS are performed according to Indian Standard codes[6,7].

6. CONCLUSIONS:

Treatment of soil using fly ash, fly ash and phosphogypsum there is an increase in the strength properties when compared to untreated soils at immediate compaction. The fly ash treated soils and fly ash-phosphogypum treated soils following compaction time lag has attained strength at short time intervals and decrease in strength at 24 hours. The soil used in this paper can be allowed for a time lag up to two hours whereas for higher time lag is not advantageous.

Hence it is concluded that increase in compaction delay for long time leads to decrease in the strength characteristics. Instead of using stabilisers like cement, lime it is better to use industrial by products like fly ash and phosphogypsum which helps to solve environmental issues.

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