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A study on strengthening of soil using stabilized flyash

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ABSTRACT

In the present study, I tried to prove soil stabilization using stabilized flyash. For the stabilization of flyash, we need to improve the flash properties by adding some admixtures. In the present study, we are using lime and sodium silicate as additives to improve the soil properties. Individual geotechnical parameters like grain size distribution, liquid limit, OMC, MDD, Specific gravity and angle of internal friction of Fly ash were determined and then Fly ash was mixed with different proportions of lime (2-15%) and sodium silicate (1-4%). These mixes were tested to obtain an optimum percentage of lime and sodium silicate. The variation in shear parameters like cohesion and angle of shearing resistance was studied by conducting the direct shear test. All the tests were performed after a time period of 3hours starting from the completion of preparation of the sample. Each test was performed for the normal stresses of 0.5kg/cm^2, 1kg/cm^2, 1.5kg/cm^2, 2kg/cm^2 and 2.5 kg/cm^2. The results are compiled in a graphical form to observe the trends for shear parameters. The results show remarkable improvement in strength characteristics for higher percentages of lime and sodium silicate. The Major challenge on behalf of engineers especially civil engineers is the disposal of industrial waste products and their storage. Nowadays most of the industries reusing the wastes in different areas like civil constructions, treatment of materials and others. This reuse of wastes is essential to overcome the hazardous effects of wastes on the environment. Fly Ash is one of the industrial wastes produced every year throughout the country. Fly ash is a fine powder obtained from burning of coal during the production of electricity. Disposal of Fly ash is a big problem, to minimize the disposal of Fly ash into large land, it was used as a construction material in civil engineering works like building materials embankments, and bricks making etc.

Keywords— *Density, Specific gravity, Density, Shear strength, Moisture content*

1. INTRODUCTION

Fly ash is a predominantly inorganic residue obtained from the flue gasses of furnaces at pulverized coal power plants. It has a small particle size less than 75µ in major percentage. These micron-sized earth elements consist primarily of silica, alumina, and iron. In India, about 70 million tonnes of coal ash is produced per year from burning about 200 million tonnes of coal per year for electric power generation. Coal-ash management poses a serious environmental problem for India and requires a mission-mode approach. Disposal of wastage requires costly land at thermal power plants and the transport of Fly ash to the ash ponds entail heavy expenditure. Considerable research and development work has been undertaken across the country towards confidence building and developing suitable technologies for the disposal and utilization of Fly ash in construction industries.

Highway engineers are utilizing bulk quantities of Fly ash in embankments and road constructions. Fly ash settles very negligible amount during the construction period and not afterward. Its lesser density is suitable for high embankments. Lime stabilized Fly ash gains cementitious properties due to the formation of silicates and aluminate hydrates at the time of pozzolanic reaction. Due to cementations properties, lime stabilized Fly ash gain in strength which is the better alternative for stable sub-grade or sub-base. Cement stabilized Fly ash has better performance in load carrying capacity and reduction of heave compared to lime or un-stabilized Fly ash sub-grade. By using additives like sodium silicate can increase the strength of lime stabilized Fly ash.

At present about 10% Ash is utilized in Ash dyke construction and landfilling and only about 3% of Ash is utilized in other construction industries. This is very much in contrast with 80% or more Fly ash used in developed countries for the manufacture of bricks, cellular concrete blocks, road construction, landfill application, ceramics, agriculture, insulating bricks, recovery of metals and dam constructions etc. Currently, about one-acre land is needed for one metric tonne of Ash disposal.

Malhotra and others report on the use of Fly ash in America in 2002 they estimate that only 30% of the Fly ash produced is used. Two-thirds are used in the concrete which has reached a maximum consumption figure. Foner and other emphasize the role of developing a new application of Fly ash in 1999. By pointing out that Israel would produce 1.3 megatonnes of coal ash per annum by 2001 and that 0.6 megatonnes could be used by the cement industry. In the U.K approximately 50% of the Fly ash produced is used whereas in India 6% Fly ash is used out of the total production.

2. METHODOLOGY

The tests for Index properties (GrainSizeAnalysis, Atterberg'sLimits, SpecificGravity, LightCompaction, DirectShear Test) of the soil are conducted with different Proportions Fly ash with lime and sodium silicate results are analyzed

3. RESULTS AND DISCUSSIONS

Fly ash was collected from the Thermal Power Plant. An experimental investigation was carried out to determine the engineering, Index and physical properties of Fly Ash. The properties and chemical composition of Fly Ash are shown below.

Table 1: The properties and chemical composition of Fly Ash

Property	Values
Gravel (%)	0
Sand (%)	28
Fines (%)	72
a. Silt (%)	72
b. Clay (%)	0
Liquid Limit (%)	28
Plastic Limit (%)	NP
Specific gravity	2.1
IS heavy Compaction	
Optimum moisture content (%)	21
Maximum dry density (g/cc)	1.28
California bearing ratio	3

3.1.The chemical composition of Fly ash

Table 2: Chemical composition of Fly ash

Compound Formula	Percentage
SiO2	59.83
Al2O3	30.48
CaO	1.74
MgO	0.86
TiO2	6.91
V2O5	0.09
ZnO	0.09

The chemical composition of laboratory hydrated lime is $Ca(OH)_2$, in this CaO is 90% pure.
The chemical composition of laboratory Sodium silicate (gel) $Na_2SiO_3.5H_2O$.

3.1.1 Grain size distribution: The test was carried out according to IS: 2720(part-IV). The set of sieves according to IS: 2720 are 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.425mm, 0.3mm, 0.15mm and 0.075mm.

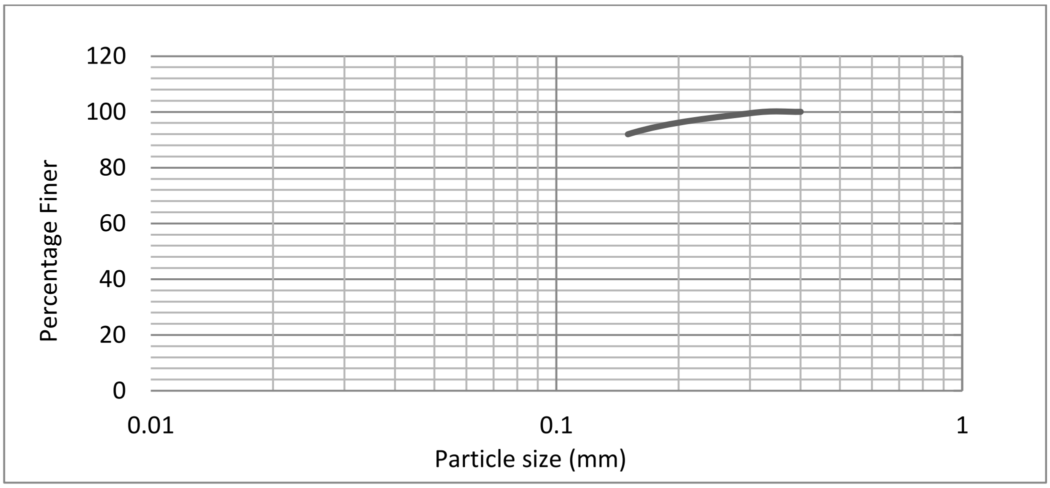


Fig. 1: Grain size distribution

Coefficient of uniformity: Cu = 28.89;
Coefficient of curvature: Cc = 2.13

3.2 Compaction characteristics

3.2.1 Compaction characteristics of fly ash lime mixes: Different percentages of lime by weight of dry Fly ash has taken and mixed with the Fly ash and tested for OMC and MDD as per IS: 2720 (part VII) - 1980.

Table 3: Different percentages of lime

LIME (%)	OMC (%)	MDD (g/cc)
0	21	1.28
2	21.4	1.26
4	21.8	1.24
6	22.3	1.23
8	22.8	1.21
10	23.3	1.18
12	23.6	1.16
15	24.0	1.14

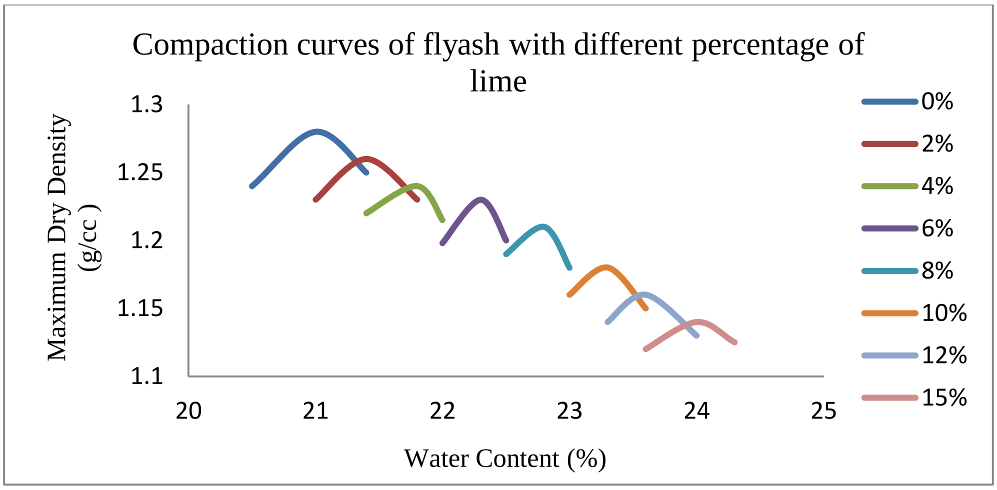


Fig. 2: Compaction curves of flyash with different percentage of lime

Table 3 and figure 2 show the variation of maximum dry density (MDD) and optimum moisture content (OMC) of Fly ash-Lime mixes. The MDD decreases significantly with increasing Lime content (0-15%) from 1.28 g/cc to 1.14 g/cc, and OMC increases with the increase of Lime(0-15%) from 21-24%. As Lime content increases more water is needed for the hydration process so that the OMC increases with increase in lime content.

3.2.2 Variation in Ø values for different percentage additions of lime: The variation in shear parameters was tested for Fly Ash samples at different percentages of water content. The samples were tested at Dry of optimum, OMC and Wet of Optimum conditions. All water contents tested at 0.5kg/cm^2,1.0kg/cm^2 and 2.0kg/cm^2 normal pressures respectively. Each test was conducted after a curing period of 3 hours. All samples were cured in a cover in which the water loss is negligible.

Table 4: Variation percentage of lime

% Of Lime	OMC (-2)	OMC (-1)	OMC	OMC (+1)	OMC (+2)	OMC (+3)
0	25	28	30	29	26	24
2	27	30	31	30	28	26
4	29	31	32	31	30	27
6	30	32	34	33	31	29
8	31	33	36	34	32	30
10	32	35	37	35	34	31
12	32	35	38	36	34	31
15	32	36	38	37	34	31

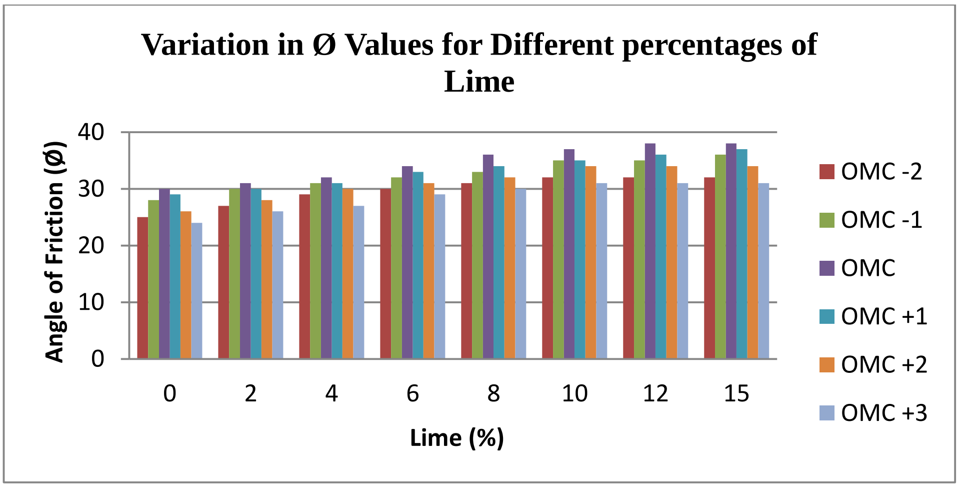
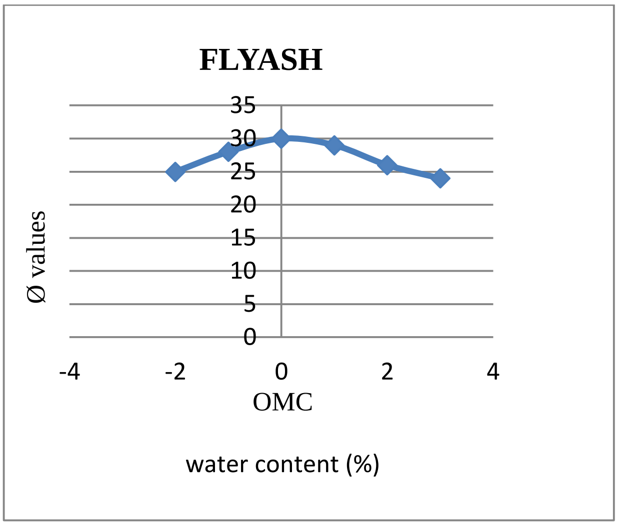


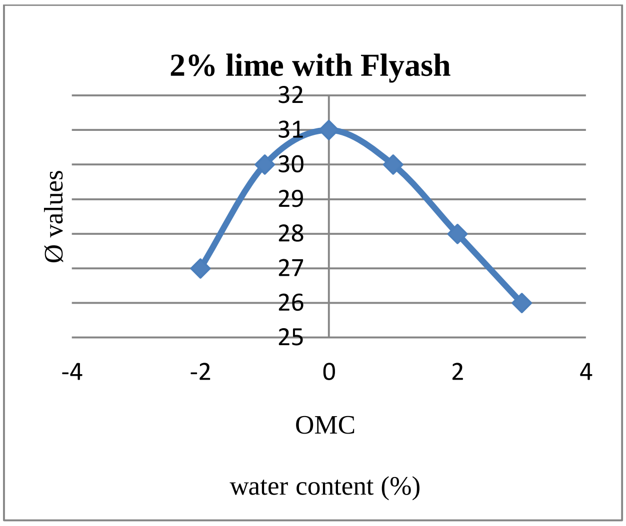
Fig. 3: Variation percentage of lime

The values are maximum for 15% addition of lime mix in which the friction among the particles is greater. The flocculation done in the mixes is effective with an increase in the percentage of lime. The friction values are greater at OMC water content, beyond that the values decreased because the increase in water content leads to the loss of friction among the particles. In Dry of Optimum conditions like OMC-2, OMC-1water contents also the values are lesser than OMC water content because the water content is not sufficient to form a flocculated structure in the mixes.

3.2.2.1 Variation of Ø values with different water contents: The Trend observed in the shearing resistance values for every percentage of lime and for all water contents are shown below.



(a)



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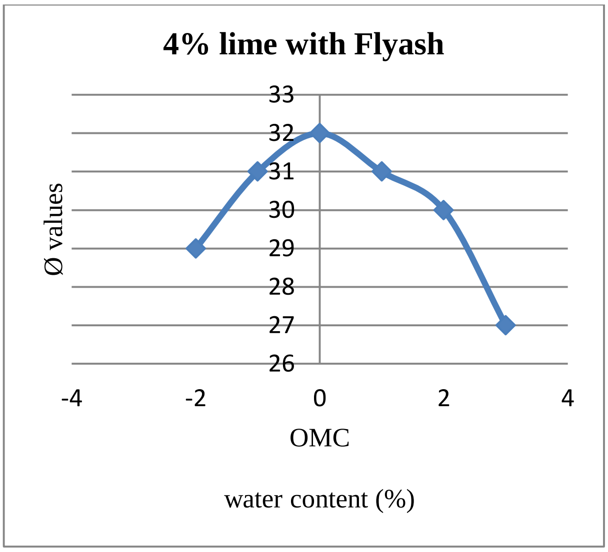

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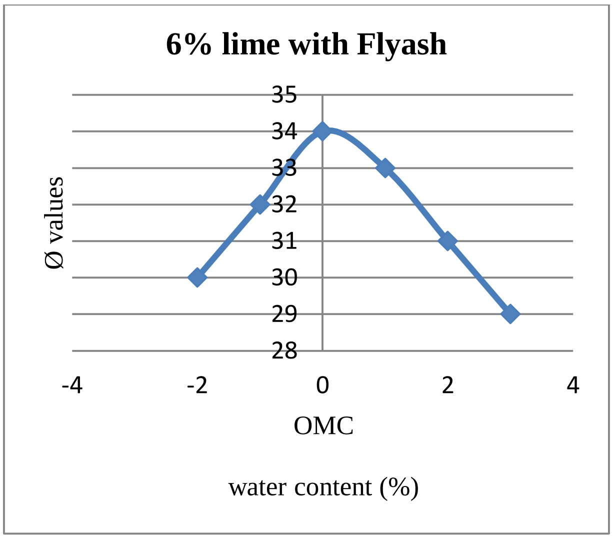

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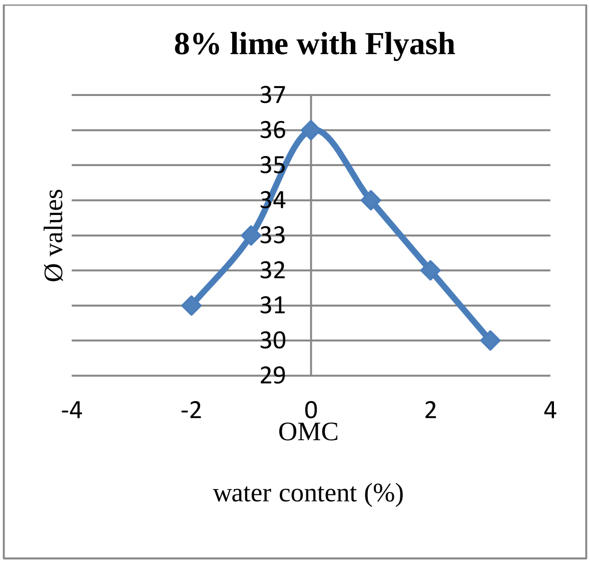

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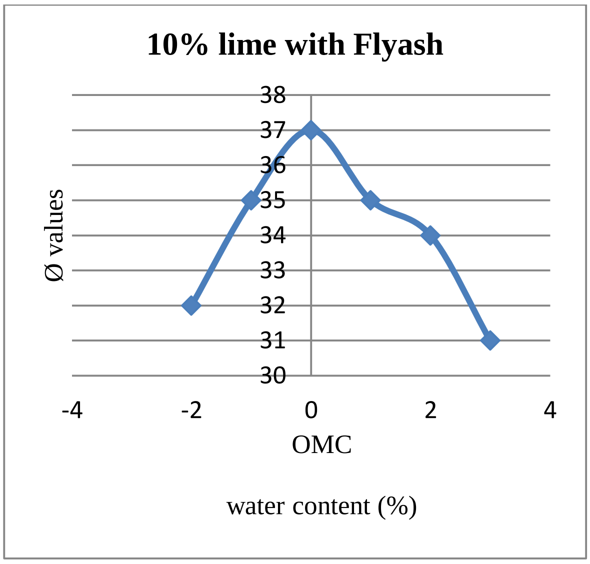

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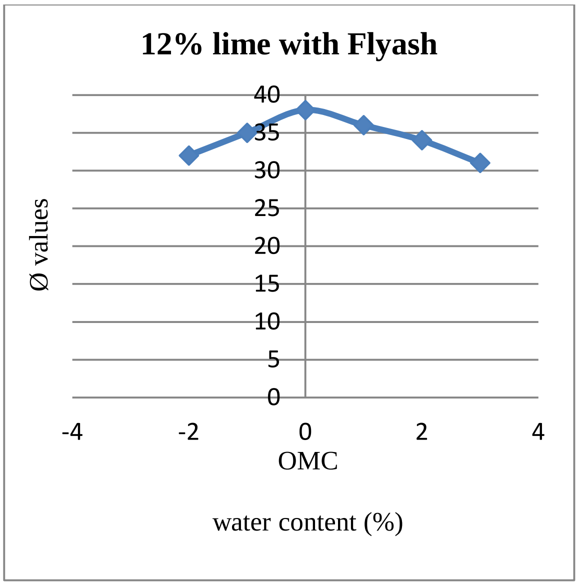

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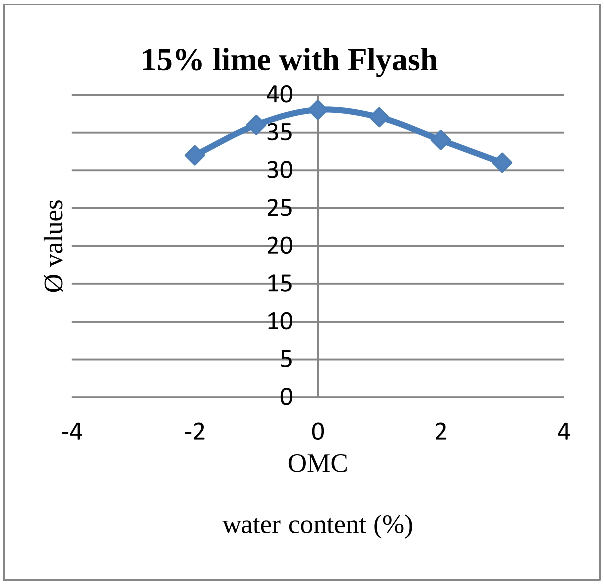

(h)

Fig. 4: Variation of Ø values with different water contents

The increase in shearing resistance was observed with an increase in the percentage of lime. The increase in lime content increases the percentage of calcium oxide which helps in improving the resisting capacity of fly ash samples. At OMC the values are maximum because of effective bonding among the particles of fly ash and lime. After OMC water content OMC(+1) have shown better resistance against shear compared to other water contents like OMC(-1), OMC(-2). This is due to active participation of calcium oxides and illuminates present in the stabilized mixes. Beyond OMC (+2) water content a decreased trend was observed because the further increase in water content makes the structure of the mix dispersed and weak. OMC (-1) water content has given better results than OMC(-2) water content due to the strong bond between the particles. This trend is the same for all percentage additions of lime. The increase in OMC values increased the shearing resistance whereas the decreases in MDD values do the same. The increase of values with an increase in the percentage of lime is not only due to an increase of calcium oxide but also due to the flocculated structure obtained in the mix. This flocculated structure forms chains in the mix so that a strong bond obtained in the mix. This mechanism involved in the mix helped in improving strengths.

4. CONCLUSIONS

From the study of Fly ash stabilized with lime, cement and sodium silicate at the compacted condition. The following conclusions have derived:

- Maximum strengths are due to the development of pozzolanic reaction between silica-alumina with calcium forming calcium silicate accumulate gel. These gels crystalline with time are responsible for the development of maximum strengths.
- Flocculation has taken place due to additives such as lime and sodium silicate with time.
- The shearing resistance values are maximum at 15% addition of lime in lime + Fly Ash mixes i.e. 38.
- Addition of 15% lime with 4% sodium silicate gives shearing resistance value 42 which is the maximum value among all other values.
- The values are less at both Dry of optimum and Wet of Optimum conditions because of formation of Dispersed Structure.
- The values are minimum at OMC-2 water content for all percentages of lime and sodium silicate additions because the water content is not sufficient to form flocculated structure.
- For all proportions of mixes, the values are maximum at OMC water content in which the flocculation is effective.

5. SUMMARY

- Fly Ash is an industrial waste obtained by burning of coal. The major quantity of Fly Ash was obtained from thermal power plants. The quality and quantity of Fly Ash depend on the quality of coal burning at specified temperatures. Most of the Indian coal contains 20-40% of Fly Ash.
- In this study, an attempt has been made for the bulk utilization of Fly Ash. Fly Ash is freely available at their disposed site except for transportation cost. To avoid bulk utilization of land and environmental pollution (air and water), the inherent qualities of Fly Ash to attain cementitious properties like less compression, no volume change and variation in permeability makes their utilization in various geotechnical applications.

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