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EFFECT OF FLYASH ON STABILIZATION OF EXPANSIVE SOILS

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ABSTRACT

Broad lab/field preliminaries have been done by different scientists and have shown promising outcomes for utilization of expansive soil after adjustment with added substances like sand, sediment, lime, fly ash, and so on As fly ash is uninhibitedly accessible, for projects nearby a Thermal Power Plants, it very well may be utilized for adjustment of expansive soils for different employments. The current paper portrays a review did to really look at the upgrades in the properties of extensive soil with fly debris in fluctuating rates. Both research facility preliminaries and field tests have been completed and results are accounted for in this paper. One of the major challenges in field application is intensive blending of the two materials (expansive soil and fly ash) in expected extent to shape a homogeneous mass. The paper portrays a strategy took on for setting these materials in layers of required thickness and working a "Disc Harrow". A preliminary bank of 30m length by 6m width by 0.6m high was effectively built and the in-situ tests did demonstrated its reasonableness for development of emabnkment, ash dykes, filling low-laying regions, and so on

Keywords – compaction, field tests, fly ash, laboratory tests, plastic clay, stabilization

I INTRODUCTION

For construction of an ash dyke at Ennore, North of Chennai city, it was found that the entire area is covered with plastic clay having liquid limit varying from 33 to 50%. The area was being used for cultivation and during summer, extensive shrinkage cracks exceeding 10mm width were noticed on the surface. The soil was not suitable in the present form for construction of ash dyke due to the following reasons:

1. Poor workability for compaction. The construction schedule was critical and it was necessary to carryout the work during monsoon when optimum moisture content cannot be achieved.
2. High compressibility and leading to dyke top settlement.
3. Inadequate shear strength for required slope stability.

Instead of borrowing a suitable soil from a long distance it was proposed to use the locally available plastic clay after stabilization with fly ash that was available in the power plant. Accordingly, a detailed literature review was carried out on the subject that was followed by laboratory tests and field tests. This paper describes the properties of natural clay, stabilized clay with varying percentage of fly ash and tests carried out in the field on lateral embankment built with blended soil and fly ash. The procedure adopted for mixing the soil with fly ash in the field and the test results have been described.

II LITERATURE REVIEW

Fly ash by itself has little cementatious value but in the presence of moisture it reacts chemically and forms cementatious compounds and attributes to the improvement of strength and compressibility characteristics of soils. It has a long history of use as an engineering material and has been successfully employed in geotechnical applications.

Erdal Cokca (2001): Effect of Flyash on expansive soil was studied by Erdal Cokca, Flyash consists of often hollow spheres of silicon, aluminium and iron oxides and unoxidized carbon. There are two major classes of flyash, class C and class F. The former is produced from burning anthracite or bituminous coal and the latter is produced from burning lignite and sub bituminous coal. Both the classes of fly ash are puzzolans, which are defined as siliceous and aluminous materials. Thus Fly ash can provide an array of divalent and trivalent cations (Ca^{2+},Al^{3+},Fe^{3+}etc) under ionized conditions that can promote flocculation of dispersed clay particles. Thus expansive soils can be potentially stabilized effectively by cation exchange using flyash. He carried out investigations using Soma Flyash and Tuncbilek flyash and added it to expansive soil at 0-25%. Specimens with flyash were cured for 7days and 28 days after which they were subjected to Oedometer free swell tests. And his experimental findings confirmed that the plasticity index, activity and swelling potential of the samples decreased with increasing percent stabilizer and curing time and the optimum content of flyash in decreasing the swell potential was found to be 20%. The changes in the physical properties and swelling potential is a result of additional silt size particles to some extent and due to chemical reactions that cause immediate flocculation of clay particles and the time dependent puzzolanic and self hardening properties of flyash and he concluded that both high –calcium and low calcium class C fly ashes can be recommended as effective stabilizing agents for improvement for improvement of expansive soils.

Pandian et.al. (2002). Studied the effect of two types of fly ashes Raichur fly ash (Class F) and Neyveli fly ash (Class C) on the CBR characteristics of the black cotton soil. The fly ash content was increased from 0 to 100%. Generally the CBR/strength is contributed by its cohesion and friction. The CBR of BC soil, which consists of predominantly of finer particles, is contributed by cohesion. The CBR of fly ash, which consists predominantly of coarser particles, is contributed by its frictional component. The low CBR of BC soil is attributed to the inherent low strength, which is due to the dominance of clay fraction. The addition of fly ash to BC soil increases the CBR of the mix up to the first optimum level due to the frictional resistance from fly ash in addition to the cohesion from BC soil. Further addition of fly ash beyond the optimum level causes a decrease up to 60% and then up to the second optimum level there is an increase. Thus the variation of CBR of fly ash-BC soil mixes can be attributed to the relative contribution of frictional or cohesive resistance from fly ash or BC soil, respectively. In Neyveli fly ash also there is an increase of strength with the increase in the fly ash content, here there will be additional puzzolonic reaction forming cementitious compounds resulting in good binding between BC soil and fly ash particles

Phanikumar and Sharma (2004): A similar study was carried out by Phanikumar and Sharma and the effect of fly ash on engineering properties of expansive soil through an experimental programme. The effect on parameters like free swell index (FSI), swell potential, swelling pressure, plasticity, compaction, strength and hydraulic conductivity of expansive soil was studied. The ash blended expansive soil with flyash contents of 0, 5, 10,15 and 20% on a dry weight basis and they inferred that increase in flyash content reduces plasticity characteristics and the FSI was reduced by about 50% by the addition of 20% fly ash. The hydraulic conductivity of expansive soils mixed with flyash decreases with an increase in flyash content, due to the increase in maximum dry unit weight with an increase in flyash content. When the flyash content increases there is a decrease in the optimum moisture content and the maximum dry unit weight increases. The effect of fly ash is akin to the increased compactive effort. Hence the expansive soil is rendered more stable. The undrained shear strength of the expansive soil blended with flyash increases with the increase in the ash content.

III LABORATORY TESTS

Following laboratory tests have been carried out as per IS: 2720. The tests were carried out both on natural soil and stabilized soil with fly ash collected from Ennore Thermal Power Plant.

(i) Grain Size Analysis
(ii) Atterberg Limit Test
(iii) Proctor Compaction Test
(iv) Unconfined Compression Test
(v) Permeability Test

After removing impurities like vegetation, stones etc. the soil was mixed with fly ash in varying proportion by volume. The Mixing was thoroughly carried out manually and the tests were conducted as per standard procedures.

The liquid limit and plastic limit of the soil with varying percentage of fly ash is given in Table 1. The proctor tests carried out is summarized in Fig.1. The grain size analysis of the borrow soil and the fly ash is shown in Fig. 2. Unconfined compression strength tests have been carried out on cylindrical samples of 36 mm diameter and 72 mm high prepared using miniature compaction apparatus with 15% moisture content. The samples were allowed to cure by air drying for 15 days. The samples were tested with a constant strain rate of 0.625 mm/min. The results are given in Table 2. The permeability of natural soil and stabilized soil was measured using a falling head test in the laboratory and results are given in Table 3.

IV FIELD TESTS

Field trails were carried out by constructing an embankment measuring 3 to 4m wide and 30m long. The height of the embankment was about 600mm. Each layer of 200mm loose thickness was placed with varying fly ash content. To achieve the desired fly ash content, the layers were placed such that fly ash layer is sandwiched between two soil layers as per the details given in Table 4.

For each trial mix, the required thickness of borrow soil was manually spread first. Above this, fly ash collected from the ESP of the Thermal Power Plant was spread. This was again followed by a third layer of soil. The layer of fly ash was sandwiched between two layers of soil to prevent it from flying off.

After this, a disc harrow equipment shown in Fig. 3 was used for uniform mixing of soil and fly ash. This equipment is a circular disc, which penetrates through the loosely placed layers and pulled horizontally by a tractor. The discs rotate in such a fashion that the soil is shuffled and mixed thoroughly. It was observed at site that after about eight passes of the disc harrow, the dry mixing of the two materials was quite satisfactory and with uniform colour of the mix.

After this, required quantity of water was manually sprayed over the layer to achieve the required moisture content of 15%, 6 passes of disc harrow were made for uniform mixing of additional water with the material already mixed. After 6 passes, the mixing of moisture was found to be uniform.

Though a sheep foot roller is ideally suited for compaction of plastic clay, after mixing with fly ash, there was considerable improvement in the workability, the compaction was therefore carried out with a 12 tonne smooth wheel roller. Each layer of mix prepared as above was compacted with 8 passes of the roller. The material after compaction was found to be quite hard and no significant penetration of the roller wheel was noticed during the last 2 passes. After compaction the thickness of the layer (initial loose thickness of 200mm) was found to be 120 to 130mm. Fig. 4 shows view of a compacted layer.

To check the adequacy of compaction, following control tests were carried out on each of the compacted layers.

(i) In-site density by core cutter
(ii) Natural moisture content
(iii) Light cone penetration tests

The results of the density observed based on core cutter is summarized in Table 5. As can be seen from this, the maximum dry density is obtained for moisture content between 12 to 14%. Among various percentage of fly ash used, the density is found to be maximum for 25% fly ash in the mix.

Cone penetration tests were also carried out from the compacted embankment. Typical results are given in Fig. 5.

V SUMMARY AND CONCLUSIONS

Based on laboratory and field tests, following conclusions have been made:

1. As the locally available borrow soil has generally high plasticity (LL > 50) it was difficult to use it directly for construction. The tests carried out with different proportion of FA indicated that the workability is maximum with 25% FA. Also the dry density observed is maximum for 25% FA.
2. The natural soil used for construction shall be dried with moisture content below 7%. If soil has more moisture it is difficult to mix with FA. Such soil shall be spread on surface and allowed to dry before construction.
3. Presence of dry clay lumps in the borrow soil increases the number of passes of disc harrow for mixing. It is therefore necessary to eliminate such soil lumps in the construction.
4. It is observed that placing of two different materials (local soil and FA) in three layers with FA layer sandwiched between soil layers and mixing them with disc harrow is workable. .
5. It is preferable to cover the compacted soil-FA bund with a suitable soil cover of minimum 500mm thickness. For this purpose suitable borrow soil of CI type (in limited quantity) shall be used.
6. Strict quality control shall be exercised with regard to quality of borrow soil, its natural moisture content, number of disc harrow passes, density and moisture content after compaction, etc.

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3. **Dr. S. R. Gandhi** is a Professor in the geotechnical division of IIT Madras. His area of research includes pile foundations, ground improvement, field instrumentation and monitoring. He has been associated with the fly ash utilization programme for considerable time. He has carried out two research projects on densification of fly ash in ash ponds at Vijayawada and Mettur using vibrofloatation and deep explosion techniques. He has been consultant to electricity boards and NTPC for design of ash dyke.

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TABLE 1: ATTERBERG LIMITS OF SOIL – FLY ASH MIXTURES

Sl. No.	Soil Type	Liquid Limit (%)	Plastic Limit (%)	Plasticity index (%)
1.	Soil alone	30	18	12
2.	Soil + 10% FA	28	20	8
3.	Soil + 20% FA	29	19	10
4.	Soil + 25% FA	30	19	11
5.	Soil + 30% FA	30	21	9
6.	Soil + 40% FA	NA	NA	NA
7.	Soil + 50% FA	NA	NA	NA

NA – Not applicable

TABLE 2: DETERMINATION OF UNCONFINED COMPRESSIVE STRENGTH OF SOIL – FLY ASH MIXTURE

Description	Soil	Soil +10%flyash	Soil +20%flyash	Soil +40%flyash	Soil +50%flyash
Sample dimension before test Dia (mm)	33	33	33.30	33.20	33.50
Height (mm)	71.20	71.20	71.30	71.40	71.90
Wetdensity (kN/m^3)	18.51	18.46	17.53	16.47	15.40
Water Content (%)	2.61	2.34	2.22	1.80	1.84
Dry Density (kN/m^3)	18.04	18.04	17.15	16.17	15.13
Unconfined compressive strength (kN/m^2)	2697	3533	2850	2160	1176

TABLE 3: PERMEABILITY TEST RESULTS

Sl. No.	Soil Mix	Permeability (m/sec.)
1	Borrow soil	13.6 x 10^{-7}
2	Borrow soil with 10% FA	9.14 x 10^{-7}
3	Borrow soil with 25% FA	6.9 x 10^{-7}

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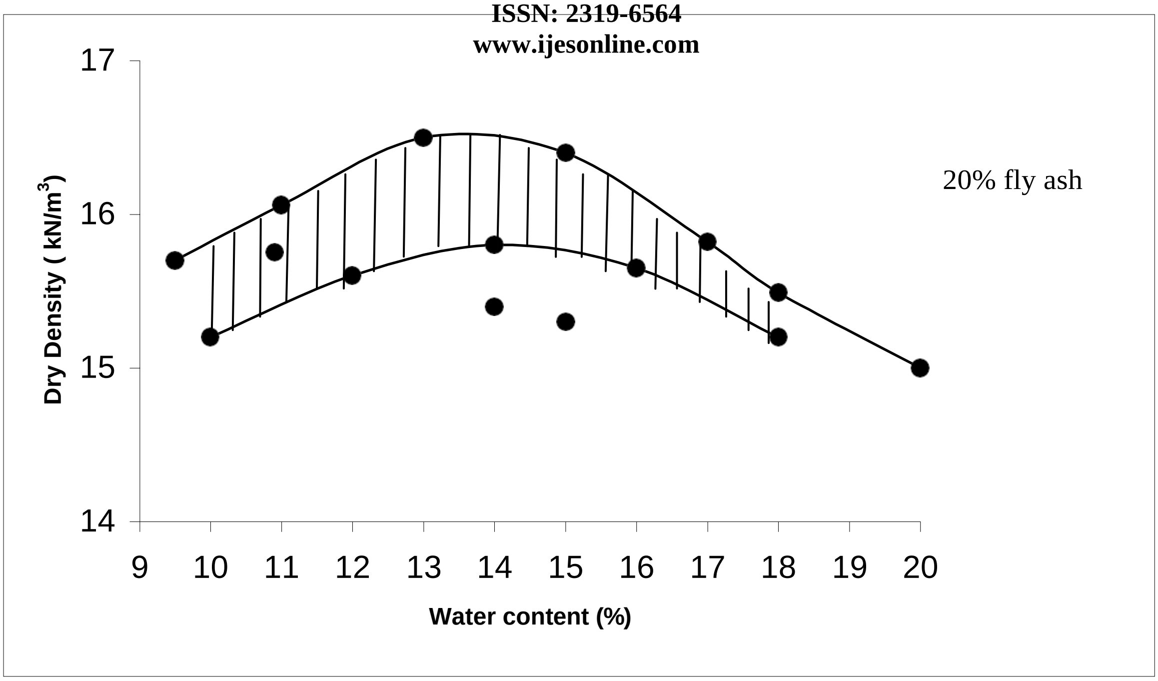
TABLE 4: THICKNESS OF LAYERS

Fly ash content (%)	Thickness of bottom soil layer (mm)	Thickness of middle FA layer (mm)	Thickness of top soil layer (mm)
10	90	20	90
20	80	40	80
25	75	50	75
35	70	70	60
50	100	100	-

TABLE 5: DENSITY AND MOISTURE CONTENT OF COMPACTED LAYER BY CORE CUTTER

Layer	Ash content (%)		1	2
I	20	γ_b	16.7	16.6
		w	10.0	13.0
		γ_d	15.2	14.7
II	20	γ_b	19.0	19.9
		w	14.0	17.0
		γ_d	16.7	17.0
III	20	γ_b	18.5	17.9
		w	17.0	18.0
		γ_d	15.8	15.2
IV	20	γ_b	17.6	17.6
		w	11.0	14.0
		γ_d	15.8	15.7

γ_b = Bulk unit weight in kN/m^3
w = Moisture content (%)
γ_d = Dry unit weight in kN/m^3



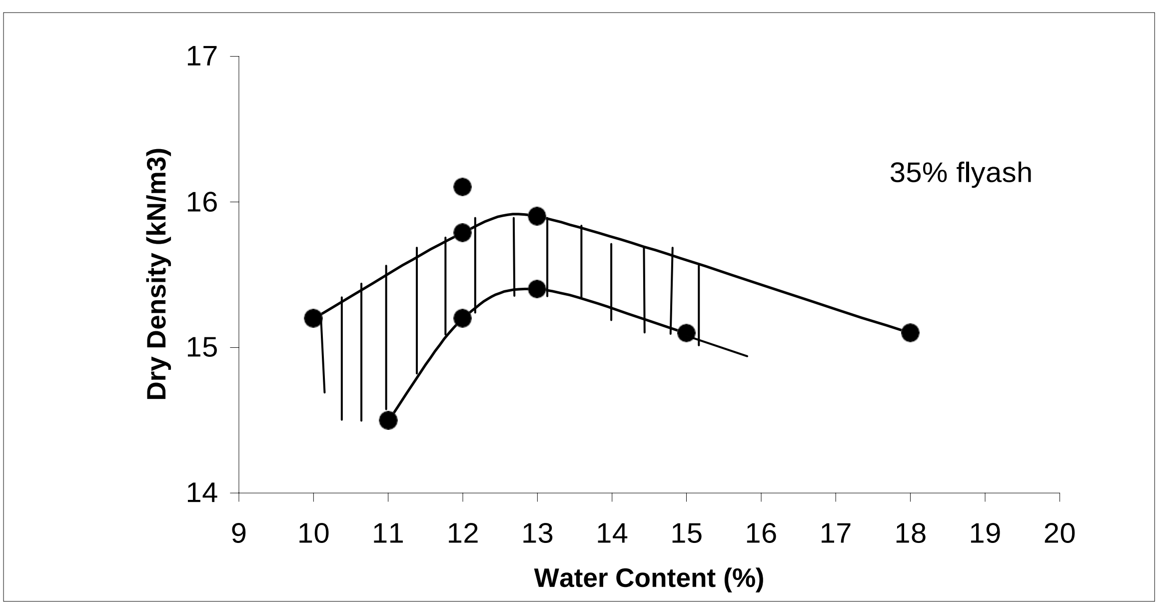


FIG 1. TYPICAL RELATIONSHIP BETWEEN DRY DENSITY AND WATER CONTENT

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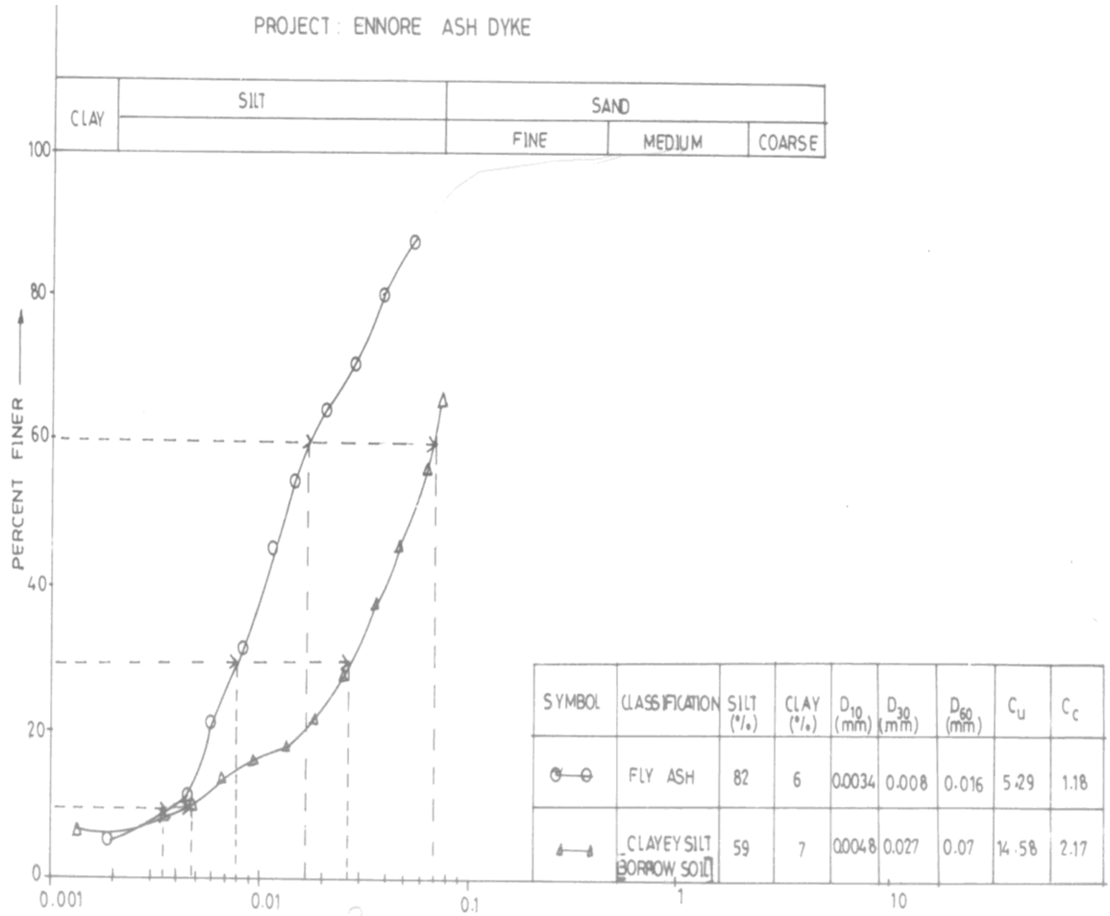

SYMBOL	CLASSIFICATION	SILT (%)	CLAY (%)	D_{10} (mm)	D_{30} (mm)	D_{60} (mm)	C_u	C_c
⊖—⊖	FLY ASH	82	6	0.0034	0.008	0.016	5.29	1.18
▲—▲	CLAYEY SILT BORROW SOIL	59	7	0.0048	0.027	0.07	14.58	2.17

Particle size(mm) ⟶

FIG 2.GRAIN SIZE ANALYSIS OF BORROW SOIL AND FLY ASH

FIG 3. SOIL – FLYASH MIXING WITH A DISC HARROW

FIG.4 – VIEW OF COMPACTED SURFACE (SOIL WITH 20% FA)

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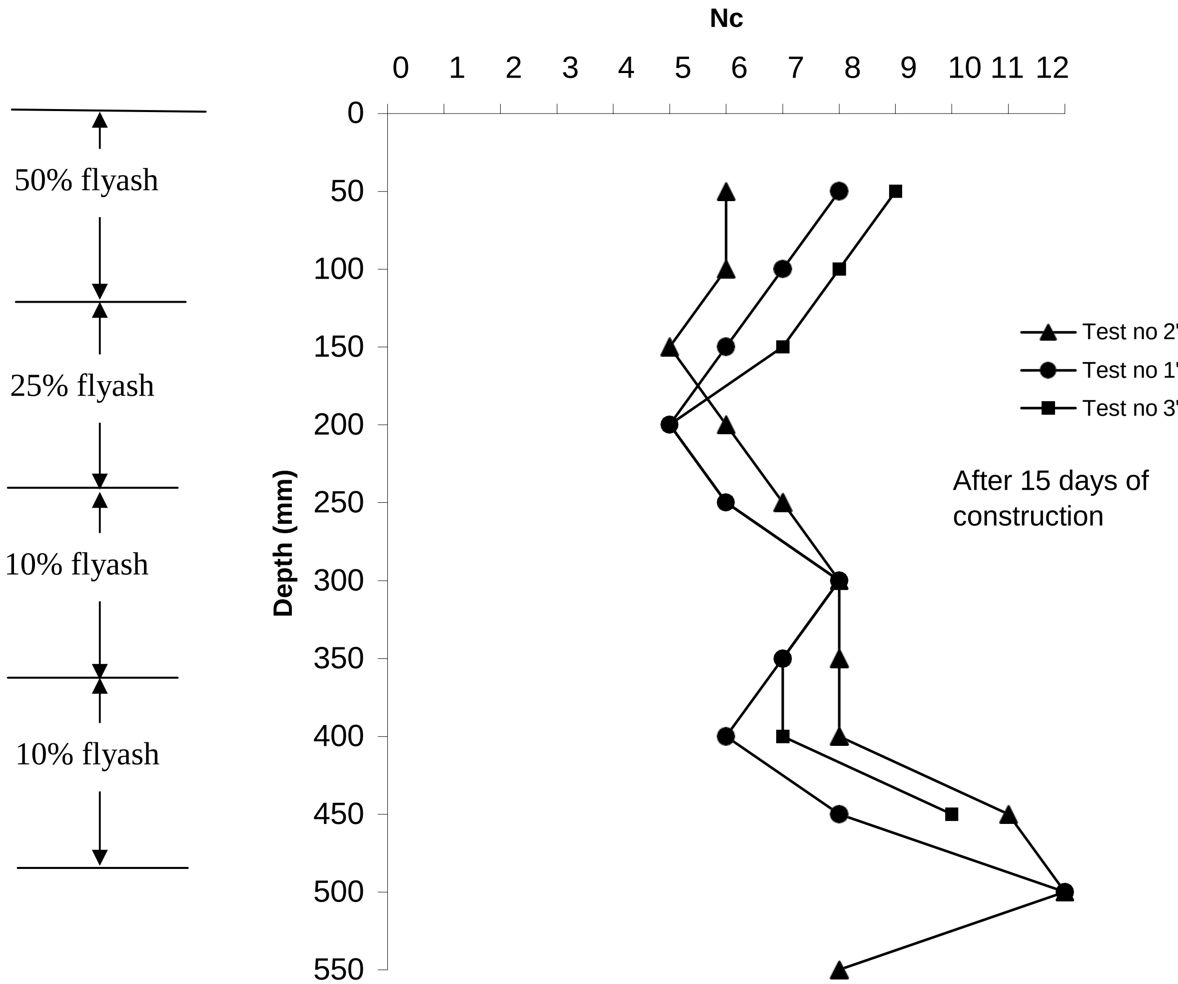

FIG 5. RESULTS OF LIGHT CONE PENETRATION TESTS