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تهديكم اللجنة التحضيرية للمؤتمر العلمي الثاني تحياتها وترد اعلامكم بان بحثكم

الموسوم :

STRENGTH CHARACTERISTIC OF SOIL STABILIZED WITH LIME AND FLYAHS IN YEMEN

مقبول للالقاء في المؤتمر والنشر في مجلة الهندسة والتنمية.

مع التقدير .....

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جمهورية العراق - بغداد - باب المعظم / ص.ب ١٤٩٥٠ / تلفون : ٤١٥٨٣٥١ و ٤١٨٣٥٢

STRENGTH CHARACTERISTIC OF SOIL STABILIZED WITH LIME AND FLYASH IN YEMEN

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ABSTRACT

The present investigation is concerned with study of silty fine sand and two types of lime eash of them subjected to the unconfined compression test. soil-lime and soil-lime- flyash mixture were subjected to the unconfined compression test with different percentages. The test results reveal that the soil stabilized with 20 percent of both limes show twice peak stress. Soil-lime cured with oven dried as well as air dried, show a steady increase in the strength with increase in lime up to 20% beyond this value, the contribution of lime is marginal, which also yield optimum strength, the study found that 10persent of both lime- flyash-soil mixtures indicates an optimum strength, which can be economical in lime percentages used.

1- INTRODUCTION

Stabilization in a broad sense, incorporates the various methods employed for modifying the properties of a soil to improve its engineering performance . the main objective of stabilizaion is to increase the strength / stability of soil and to reduce the construction cost by making best use of the locally available materials .

After unification of Yemen it is a need to renew and constructe a transportation net to connect the entire country by a modren net transportation . it is found in some places there is a shortage in natural materials used to constructe a road, and it is expensive to brougth construction materials from a far places so that , it is better to fined an alternative like soil-cement and soil-lime stabilization, keeping in maind that strenght, stability and duraibility are importents . the final goal is availability of local materials to reduce the cost of construction of road specially for low traffic in a far places.

In this regards several research workers have been used different methods of soil stabilization :there are large deposite of sandy and silty soils along the coastal area, and flood plains of the Indian rivers (Jalota and Patle , 1985). One of the low cost solutions (Ghosh, et,al., 1973 and Geocker et.al , 1956) for road construction in cohesionless soils . To use flyash and lime as stabilizing materials (Pandey and Mondal , 1988) studied strength , elastic modulus and fatigue. The present papers concentrates on the study of percentages of mixtures of two types of limes with silty fine sand soil as well as soil-lime-flyash, curing relationship and strength carachteristic of the mixtures in depth.

2- LABORATORY INVESTIGATION

A comprehensive study was made with the objective of studing the effect of limes alone and limes- flyash stabilization on the curing and strength of silty fine sand .

The research include :

1- Determination of unconfined compressive strenght of 38mm diameter and 76mm high cylindrical specimens of soil, limes, lime-soil and lime-flyash- soil mixture after 3 days of accelerated curing at 60° C and normal laboratory temperature curing up to 30 days.

2- Determination of (a) unconfined compressive strength at different strain levels for soil , limes, soil-lime and soil-lime-flyash and (b) secant modulus at different strain level for all the materials .

3- Development of correlation (a) between unconfined compressive strenght and lime percentage . (b) between unconfined compressive strength and flyash percentage and (c) between unconfined compressive strenght and curing .

3- TEST MATERIALS

3.1 Soil

The soil used in the present study was silty fine sand with slighty plasticity collected and brought from Abiyan government (150 km north of Aden City). The soil was tested in the filed and in laboratory of Faculity of Engineering . The engineering properties are shwon in Table 1 the partical size distribution is in Fig .1

3.2 Lime

Two types of limes have been used to mixed with soil as a stabilize material. Both the limes are locally available in the market, consider lime-1 local name Abiyan lime and lime-2 local name Saada lime . It was then slaked in the laboratory , dried and sieved through 0.3mm sieve.

3.3 Flyash

Flyash , may be consider as a waste material available in most of Yemen house which can be easily available , chemically content of the following elements of Silica , Alamina and Calcium Oxide. The reactive noncrystalline, Silica and Alumina react with lime in the presence of water forming a cementing material which binds soil particles.

3.4 Quantity of water

The soil-lime and soil-lime-flyash mixure was thoroughly mixed in dry condition and then the water added was always maintain as optimum moisture content which found by compaction test as 20% by weight of dry mixed.

3.5 Mix Composition :

a- soil-lime mixture :both lime was used in the present study have been mixed with the soil in percent by weight of the following range :5%,10%,20%,and 30%.

b- soil-lime-flyash mixture: In the present study both the lime were mixed with soil and also mixed with flyash in different percentages by weight are given below:

Soil(%)	Lime(%)	Flyash(%)	Combination
100	5	5	100:5:5
100	5	10	100:5:10
100	5	15	100:5:15
100	10	10	100:10:10
100	10	20	100:10:20
100	10	30	100:10:30

4- CURING

Two type of curing have been adopted in the present study are:

- Air dry curing : The specimens of the soil-lime and soil-lime-flyash after demoulded kept for different period of curing in an open air dry, dried for different period of curing of 24 hour, 10 ,20 and 30 days at laboratory temperature .

- Oven dry curing : On the other hand the demould specimens was kept in oven for 3 days at 60° C temperature. accelerated curing (Anday, 1963).

5- COMPREESSIVE TEST

According to the period of the curing as per plan the soil-lime stabilized specimens where subjected to the compressive strength was conducted by using the unconfined compression machine, the specimens where placed at the lower plates and pressed carefully by upper plate, dial gauge was fixed at the lower plate, the axial load was applied with strain of 1.5 r.p.m. till the specimen was faild.

The failure of the soil ,lime soil - lime as well as soil - lime - flyash stabilized specimens after testing are shwon in Fig.2 respectively .It can be obtian from this figure that the failure pattern of the soil-lime and soil-lime -flyash stabilized specimens are failed at an angle of 45° approximately which can be indicate that the soil particles are bounded with quantity of lime and also flyash strongly. Total number of specimens were 120 specimens.

6- EXPERIMENTAL PROCEDURE

The follwing experimental procedure was adopted :

1. The soil used in this study was dried up and cleaned .
2. The soil was stored carefully and kept away from atmospheric moisture variation .
3. Both limes and flyash have been sieved and stored away from moisture variation .
4. Lime and flyash percentages by weight was obtained and kept ready.
5. Soil,lime, flyash and water mixed thoroughly with certain percentage making a paste which placed in the module by means of 3 layers and eash layer was compacted manually by rod.
6. The soil , lime , and flyash stabilized specimen was rmoved from the mould crefully and kept for different period to dry.
7. After a certain curing period the specimen was subjected to unconfined compressive strength .

7- RESULTS AND DISCUSSION

7-1 STRENGTH OF SOIL

In the present study , soil samples has been tested in the unconfined compressive machine taking in to account that the dry density and its water content similar as that found in compaction test($\gamma d = 18.9 kN/m^3$ and $\omega = 19.8$). Two specimen were tested and the results shwon in Fig 3 it can be seen from the figure that as the strength increase. the corresponding axial strain also increase . For example soil exhibits a peak strength of (45kPa and a failure axial strain of 0.15).

7-2 STRENGTH OF LIME

The results of unconfined compression tests conducted on lime-1 and lime-2 are presented and discussed . Figures 4 and 5 present the stress-strain curves obtained for lime -1 and lime -2 respectively at various curing period , it can be generally seen from these figures that the peak stress and corresponding axial strain increase with increase in curing period . For example lime-1 at 24 hrs . period exhibits a peak stress of (12.5.kPa) and failure axial strain of (0. 02) . whereas these values at 2 weeks of curing period are (130kPa) and (0.022) respectively . It can also be notied that lime -2 exhibits higher strength and stiffer than lime -1.

The results show that in case lime -1 cured in oven for 3 days at 60°C and cured by air dried for 2 weeks there is a marginal differences . But in case of lime -2 the results show a significant differences .

7.3 STRENGTH OF SOIL STABILIZED WITH LIME

Figures 6 and 7 show the results of the unconfined compression tests conducted on siol stabilized with lime -1 and lime -2 at different percentages . These figures present the stress - strain curves obtain for soil stabilized with lime -1 and lime -2 resbectively , which cured in oven for 3 deys at 60 °C . It can be generally seen from these figures that the peak stress and corresponding axial strain increase with increase in lime percentages . Broadly it can be seen that the stress- strain behavioure of soil stabilized with limes specimens is similar to the soil and limes specimens .

A COMPARSION: Typical stress-strain curves obtained at different strain levels for soil , lime-1, lime-2 and soil stabilized with 20 percent of both limes cured in oven at 60°C for 3 days are illustrated in Fig 8 for comparison, it can be generally seen that as the stress increase the corresponding axial strain also increase as reported earlier. For example soil stabilized with lime -1 exhibits a peak stress of (650 kPa) and a failure axial strain of (0.025). It can be noticed that the soil stabilized by 20 percent of both limes show marginal variation in peak stress . It can be concluded that the soil stabilized with 20 percent of both limes shows twice peak stress when compare with peak stress of lime.
Table 2 and Fig 9 show the results of the unconfined compression test conducted on soil stabilized with lime -1 at different percentage , cured in air dried for 30 days. It can observed from the figure that as lime percent increase the peak stress also increase . For example soil stabilized with 5 percent of lime exhibits a peak stress of (550 kPa) whereas this value at 20 percent of lime is (1225 kPa). It can be noticed that at 30 percent of lime marginal peak stress observed (1250 kPa) when compare with 20 percent.

7-4 STRENGTH OF SOIL STABILIZED WITH LIME FLYASH

a) OVEN DRIED :

Case 1: the results of unconfined compressive strength of soil stabilized with 5 percent of lime and with different percentage of flyash are given in Fig 10. It can be observed from this figure that as percentages of flyash increases the peak stress also increase .

Case 2: the result of U.C.test (unconfined comprssive) of soil stabilized with 10 percent of lime and different percentages of flyash are given in Fig 11 .It can be observed from this figure that as the percentages of flyash increase the peak stress decreases . For example soil stabilized with 10 percent of lime and 10 percent of flyash exhibits a peak stress of (950 kPa) where as soil stabilized with 10 percent of lime and 30 percent of flyash gives peak stress of (440kPa)this may be due to an increase in finer percentage in specimen.

b) AIR DRIDE :

Case 1: The result of U.C. test of soil stabilized with 10 persent of lime and with different percentages of flyash cured in air dried for 10 days are shown in Fig 12 . It can be observed from this figure that as percentages of flyash increase the peak stress decreases . Similar observation has been found in case of oven dried with the different that in, oven dried the peak stress smaller than air dried .

Case 2: The results of U.C.test of soil stabilized with 5 percent of lime and with different percentages of flyash cured in air dried for 20 and 30 days are shown in Fig 13 and 14 respectively. It can be found from these figures that as the percentage of flyash increase the peak stress also increases. Similar observation has been obtined in case of oven dried .

Case 3: Figures 15 and 16 show the results of the U.C. test conducted on soil stabilized with 10 percent of lime and with different percentages of flyash cured in air dried for 20 and 30 days respectively.It can be observed from this figures that as the percentages of flyash increase the peak stress decreases. Similar observation has been found in case of oven dried and air dried for 10 days . It can be concluded that, the strength of the stabilized soil with lime and flyash increase with increase curing period, but the increse in percentages of flyash decrease the strength of the stabilized soil.

A COMPARISON: Typical stress-strain curves obtained at different strain levels for soil ,lime, ,soil stabilized with 20 percent of lime-1 and soil stabilized with 10 percent lime and 10 percent of flyash cured in air dried for 20 days are illustrated in Fig.17 for comparison. It can be generally seen that as the peak stess increase the corresponding axial strain also increase as reported earlier . It can be observed that the soil stabilized with 10% lime -10% flyash shows a 70% increase in peak stress when compare with peak stress of soil stabilized with 20 % of lime . This can be concluded that the soil stabilized with 10% lime and 10% flyash gives a higher peak stress as well as economical in lime percentages.

7-5 SECANT MODULUS :

To under stand the strength charactristic of soil , limes and soil-lime /soil-lime- flyash in-isolation tests were conducted on eash of these materials and the relationship between their secant modulus and strain were obtained as per the procedure suggested by Richards and Scott, (1986). Such variations between secant modulus and strain on semi–log plot are presented in Fig.18.

The figure shows that the sand exhibit a relatively rapid drop in modulus with strain and failure strain is around(0.15). it can be seen from this figure that both limes exhibit a relative rapid in modulus with strain and failure strain is around (0.25-0.3). It is also seen that lime -2 exhibits a higher modulus up to (0.025) strain , shows higher modulus at higher strain when compared with lime -1. Similar behaviour has been found in case of soil stabilized with lime -1 and lime -2 it is evident that soil stabilized with lime -1 exhibits a modulus higher than soil stabilized with lime-2,which may be due to lower strain failure of lime-2 . In the case of soil stabilized with lime -1 and flyash exhibit a modulus lower than lime- 2 and also lower than soil stabilized with both limes with a failure strain of around(0.5), which indicated that the mixture can pickup the stresses and still perform its function without failure at higher strain .

7-6 LIME PERCENTAGES AND STRNGTH

As it is mentioned before the lime percentages used in the present study was 5,10,20 and 30%, stabilized with soil show an important in strength with different types of curing . The variation of unconfined compressive strength as peak stress of soil with different percentages of lime cured with two method of curing i.e oven dry at 60°C for 3 days and air dried at laboratory temperature for 30 days are presented in Fig 19. It found that in both conditions of curing there was a steady increase in the strength with an increase in lime percent up to 20% beyond this value , the contribution of lime is marginal . This indicates that for a given value of 20% an optimum lime percentages can be obtained to yield the optimum strength . It is also seen that dried method exhibits higher strength when compare with oven dry for 3 days st 60°C . For example the strength of soil stabilized with 20 percent

of lime gives strength of (650 kPa) when oven dried in other hand strength of (1240 kPa) when air dried , which is mean that suitable in construction field and economical in developing countries.

7-7 FLYASH PERCENTAGES AND STRENGTH

a) 5 percent of lime :

Herein, the percentage of lime was 5 % as a constant percent , as a stabilize material with soil both mixed with different percentages of flyash of 5, 10 and 15 % by weight cured by oven and air dried are given in Table 3 The stress - strain behaviour of unconfined compressive strength as peak stress of soil stabilized with lime and flyash are presented in Fig.20 . In general it can be seen from the table and figure that as the flyash and curing period increase the strength also increase . It can be observed that the strngth of 20 days curing are similar with oven dry.

b) 10 Percent of lime :

Similarly the lime percent kept constant at 10% , as astabilize material with soil both mixed with different percentages of flyash of 10, 20 and 30 by weight cured by oven and air dried are shown in Table 4. The stress -strain relationships are given in Fig.21. It can be observed from the table and figure that the strength decreases as the flyash percentages increase, this may be due to an increase in finer percentage in specimen as mentioned before. The 10 percent of flyash in soil stabilized with 10 percent of lime exhibits higher strength when compare with 10 percent of flyash with soil stabilized with 5 percent of lime shows a reduction in strength . (Table 3 and Fig.20) which can be indicate that a distinct percentage of lime and flyash can be used .

7-8 CURING AND STRENGTH

The variation of unconfined compressive strength with curing periods in days (air dried)for soil stabilized with 10 percent of lime and different percentages of flyash are presented in Fig 22. It can be found that for the case of (100:10:10) i.e. soil stabilized with 10 percent and 10 percent of flyash exhibit higher strength with increase in curing periods . But in other cases of (100:10:20)and (100:10:30)the strength decreases with increase in curing periods significantly.

8- CONCLUSIONS

On the basis of experimental studies on silty fine sand stabilized with different percentages of two types of lime i.e lime -1 and lime-2, the same soil was also stabilized with 5 and 10 percent of lime -1 and with different percentages of flyash , two types of curing has been adopted, the following main conclusion have been arrived.

1. The results of unconfined compressive test conducted on soil stabilized with both limes at different percentages show that the peak stress increase with increase in lime percentages .

2. Soil stabilized with lime cured with oven dried as well as air dried , show a steady increase in the strength with increase in lime percent upto 20% beyond this value , the contribution of lime is marginal .

3. Soil stabilized with 20 percent of lime indicates an optimum lime percentages can be obtained to yield the optimum strength .

4. Soil stabilized with different lime percentages cured with air dried exhibit higher strength than oven dry . Which indicated that suitable and economical in field construction .

5. The study found that the 10 percent of flyash mixed with soil stabilized with 10 percent of lime indicates an optimum lime and flyash percentages can be obtained to yield the optimum strength as well as strength increase in periods of curing by air dried .

6. Soil stabilized with 10 percent of lime and 10 percent of flyash shows 70% increase in peak stress when compare with peak stress of soil stabilized with 20 percent of lime , which can be economical in lime percentages used

9-REFERENCES

Anday, M.C.(1963),"Curing lime stabilized soils" Highway Research Record, 29 Washington, PP-13-26

Ghosh, R.K, Chadda, L.R, Pant, C.S. and Sharma, R.K (1973). "Stabilization of Alluvial Soils with both lime and Flyash",J.Ind. Roads Congress, 35-2:481-511

Goecker, W.L., Moh, Z.C,Davidson, D.T and Chu, T.Y(1956). "Stabilization of Fine and Course Grained Soils With Lime and Flyash Mixture" , Highway Research Bulletin 129, PP.63-82.

Jalota, A.V.and Patel, N.M(1985) "Regional Deposits-Alluvial Soils", Indian Contribution to Geotechnical Engineering, Rep. PP.31-35.

Pandey, B.B and Mondal, B(1988)"Curing and Strength of Sea-sand Stabilized with Lime and Flyash",Indian Geotechnical Conference, VoL.I PP.191-194.

Richards, E.A and Scott, J.D. (1986)"Stress-Strain Properties of Geotextiles" Proc. 3rd. Int. Con. on Geotextiles, Vienna, Vol.IV, PP.873-878.

Table 1: Engineering properties of soil

Engineering properties	numerical values
Average field moisture	12.747 %
Average field density	1.311 g/cc
Soil type	Silty fine sand
Percentage of coarse silt	18 %
Percentage of fine sand	47 %
Percentage of medium sand	8 %
Specific gravity	2.7
Optimum moisture content	19.852 %
Proctors dry density	1.865 g/cc
Liquid limit	48 %
Plastic limit	24%
Plastic index	24 %
Shrinkage limit	40.523 %
Shrinkage ratio	1.554
Degree of Shrinkage	13.699 %

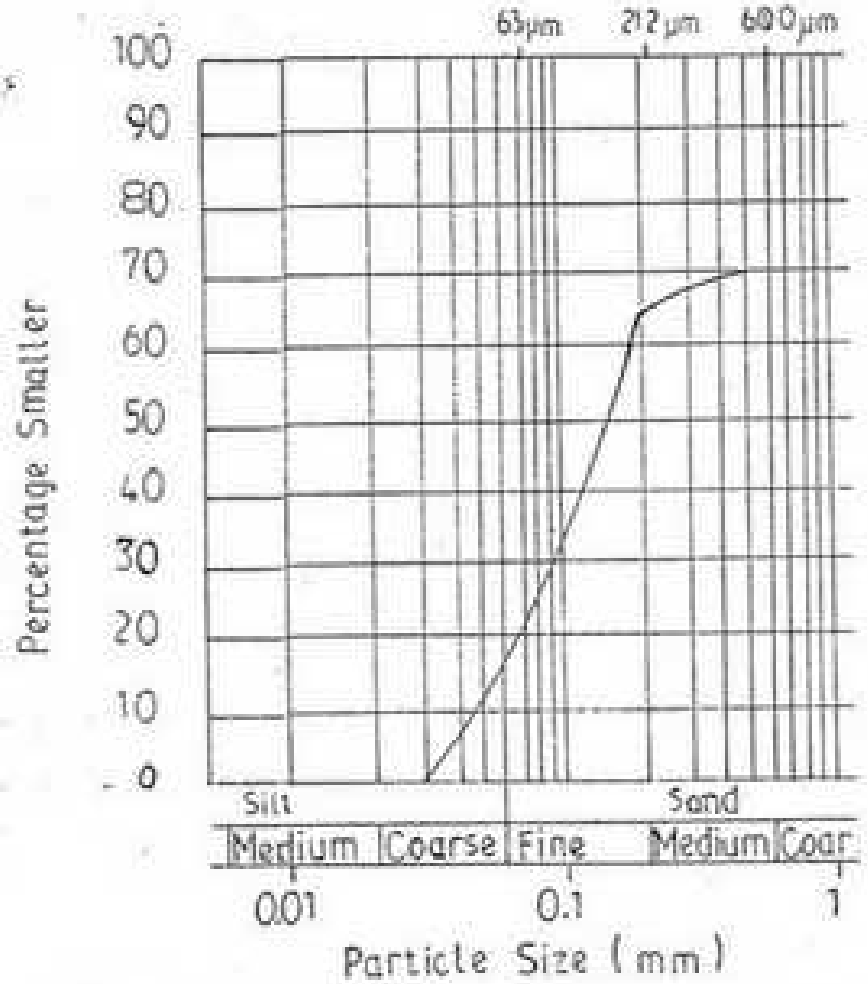


Fig.1 Grain Size Distribution Curve For Soil Sample

Table 2: compressive strength of soil stabilized with different percentages of lime-1

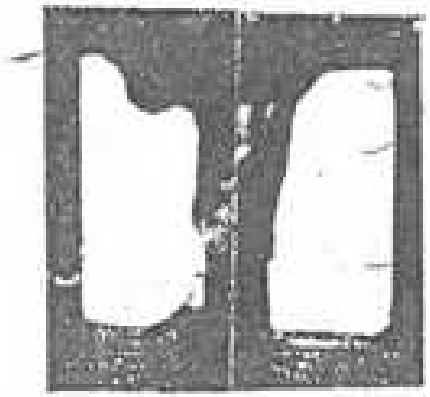
Curing	Maximum yield stress (kPa) Percentage of lime			
	5 %	10	20	30
Oven dried	300	350	650	725
30 days at lab. temperature	550	725	1225	1250

Table 3: compressive strength of soil stabilized with 5 % of lime and different percentages of flyash

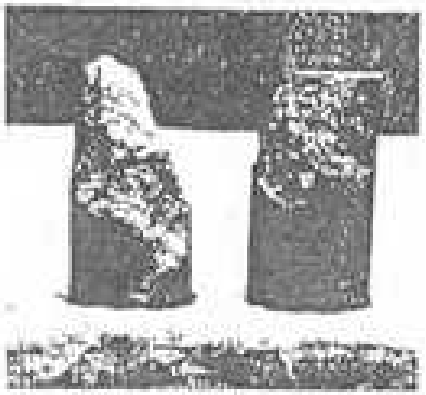
Curing	Maximum yield stress (kPa) percentag of flyash		
	5	10	15
Oven dried	150	325	325
20 days	250	290	300
30 days	300	425	725

Table 4: compressive strength of soil stabilize with 10 % of lime and different percentages of flyash

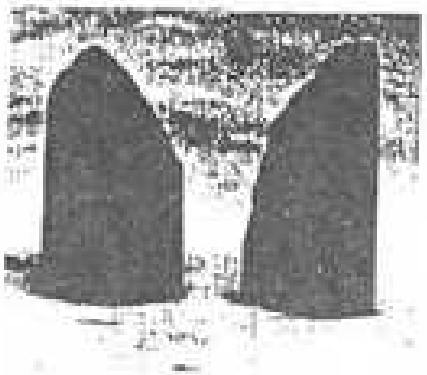
Curing period	Maximum yield stress (kPa) percentages of flyash		
	10	20	30
Oven dried	550	850	425
10 days	1030	827	790
20 days	1100	900	650
30 days	1225	850	500



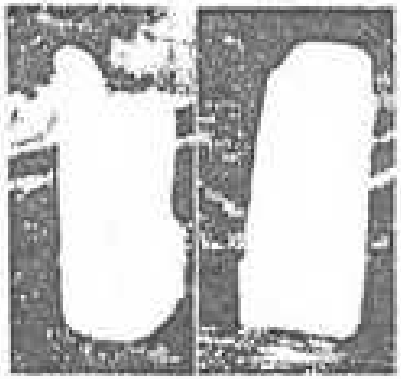
(a) Apiyan Lime (Lime_1)



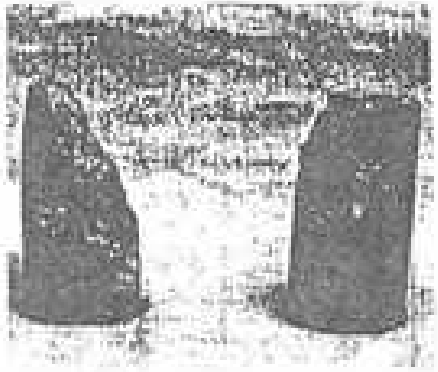
(a) Oven Dry



(a) Oven Dry

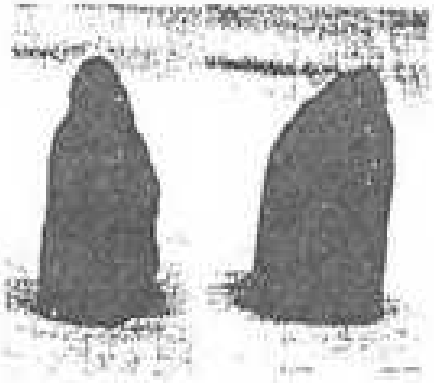


(b) Saada Lime (Lime_2)



(b) Air Dried

Soil_Lime



(b) Air Dried

Soil_Lime_Flyash

Fig. 2: Failure Pattern Of Specimens

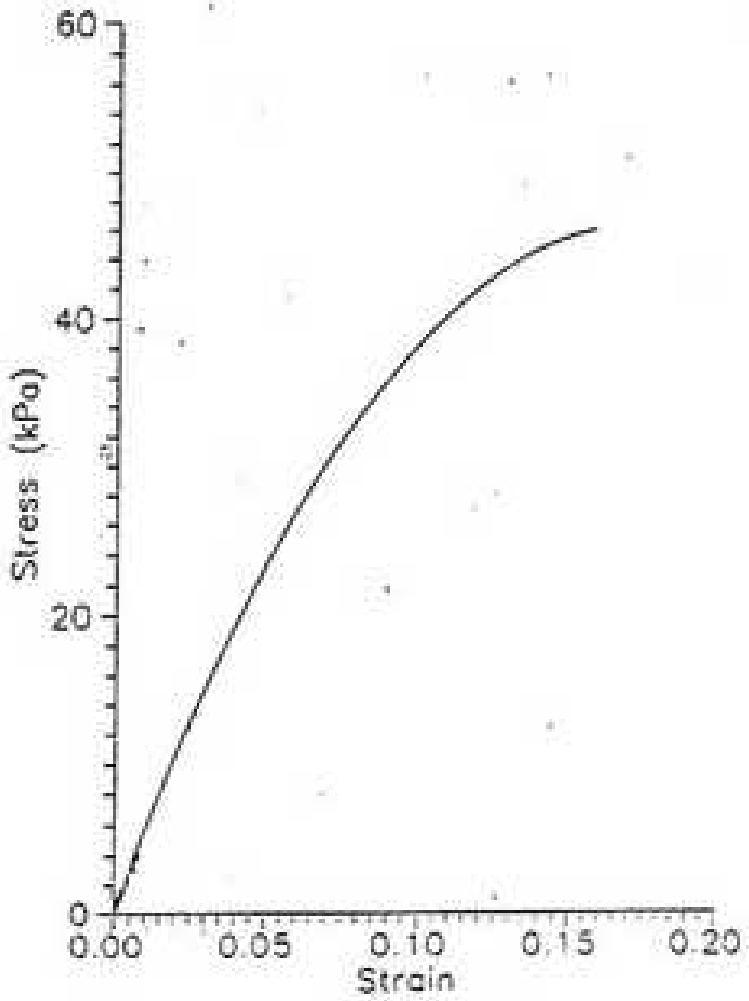


Fig. 3: UNCONFINED COMPRESSIVE STRENGTH OF SOIL

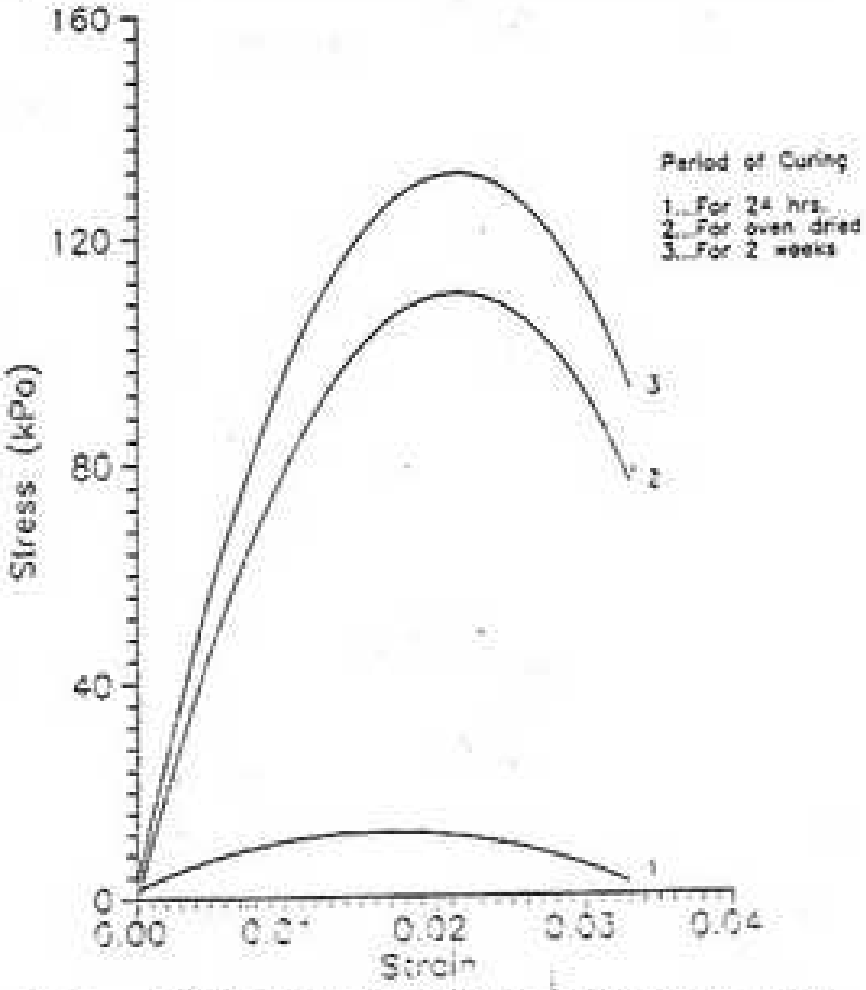


Fig. 4: UNCONFINED COMPRESSIVE STRENGTH OF LIME-1

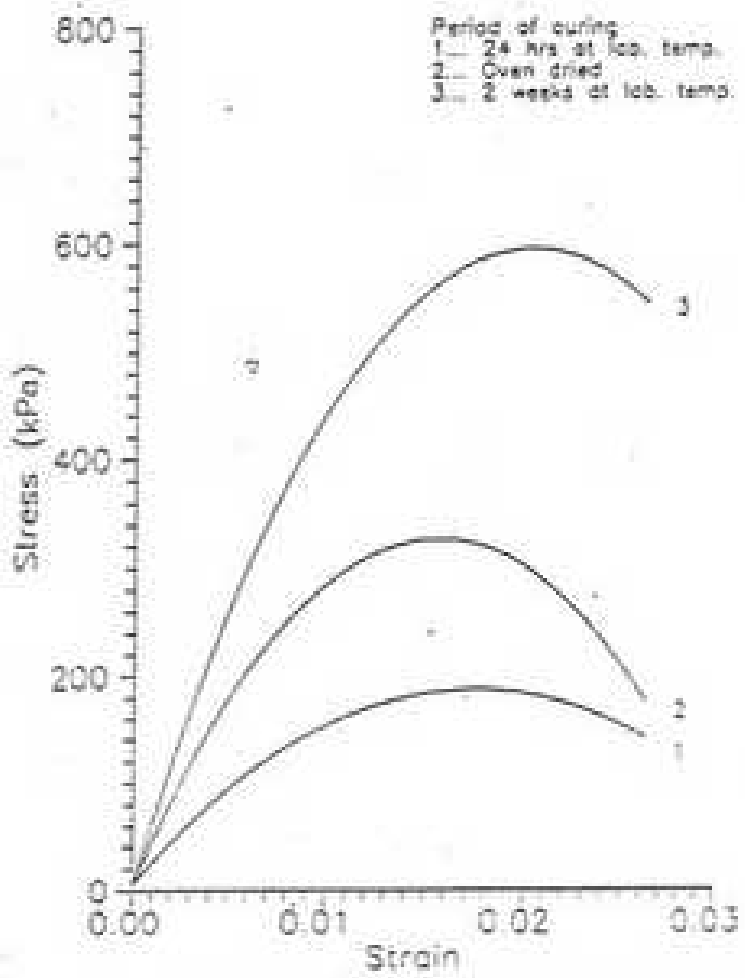


Fig. 5: UNCONFINED COMPRESSIVE STRENGTH OF LIME-2

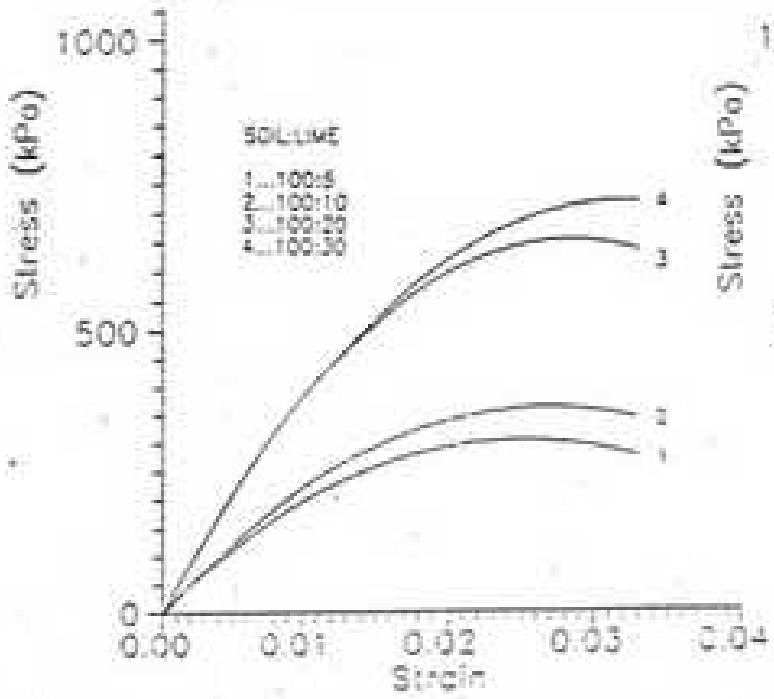


Fig. 6: UNCONFINED COMPRESSIVE STRENGTH FOR SOIL + LIME-1, CURED FOR 3 DAYS AT 40 C IN OVEN

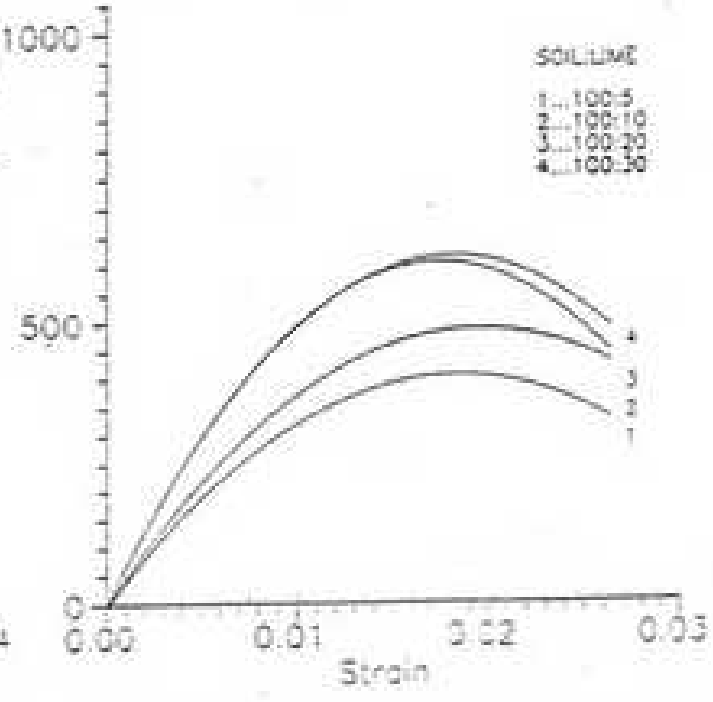


Fig. 7: UNCONFINED COMPRESSIVE STRENGTH OF SOIL:LIME-2

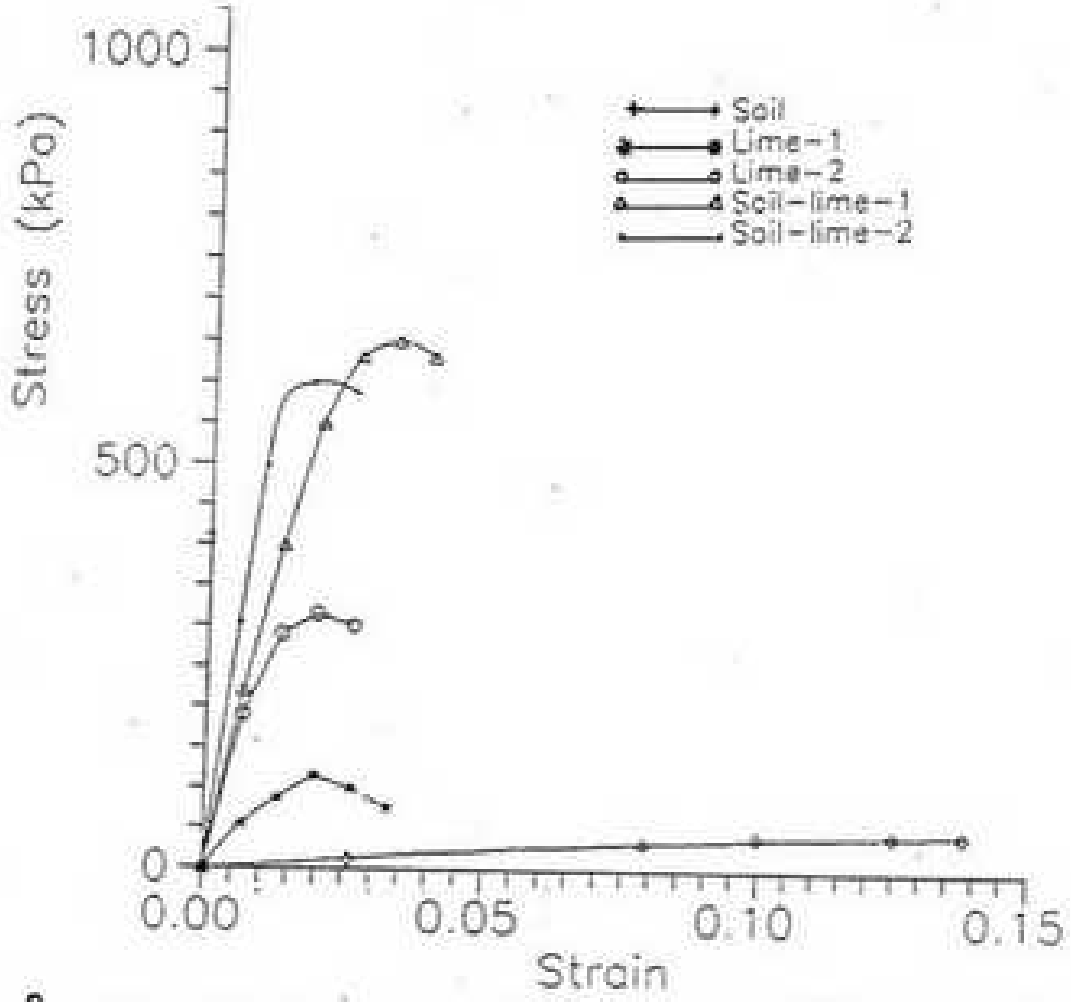


Fig.8: Unconfined compressive stress at different strain levels for soil, lime and soil stabilized with lime

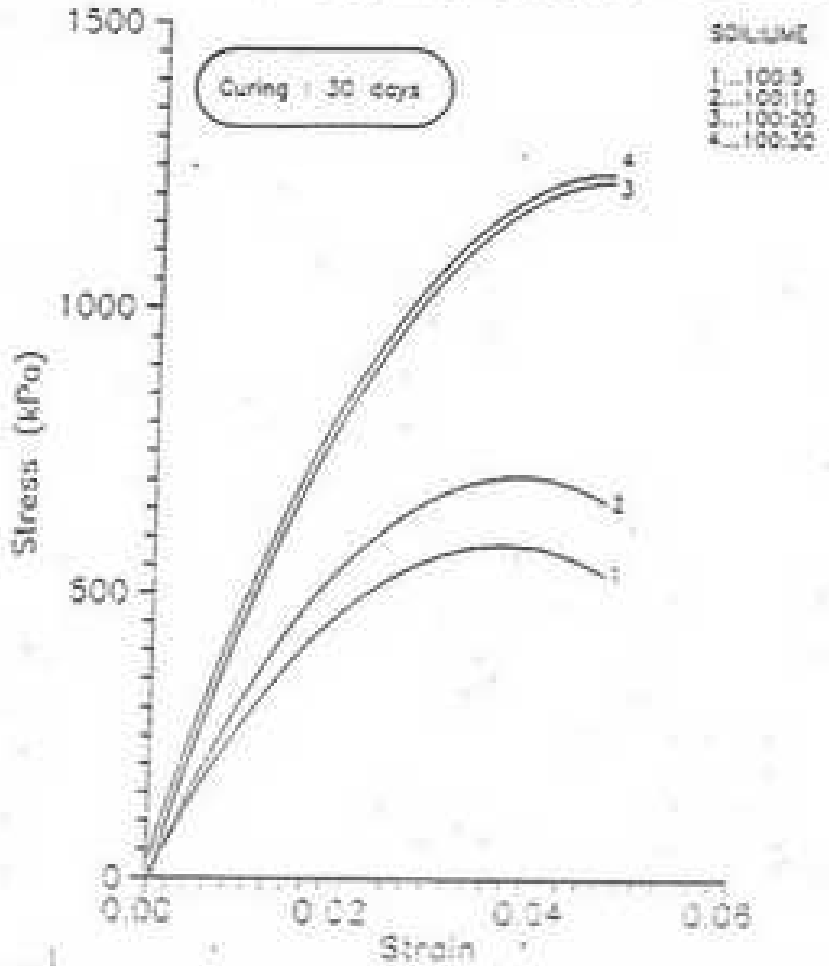


Fig.9: UNCONFINED COMPRESSIVE STRENGTH OF SOIL:LIME-1

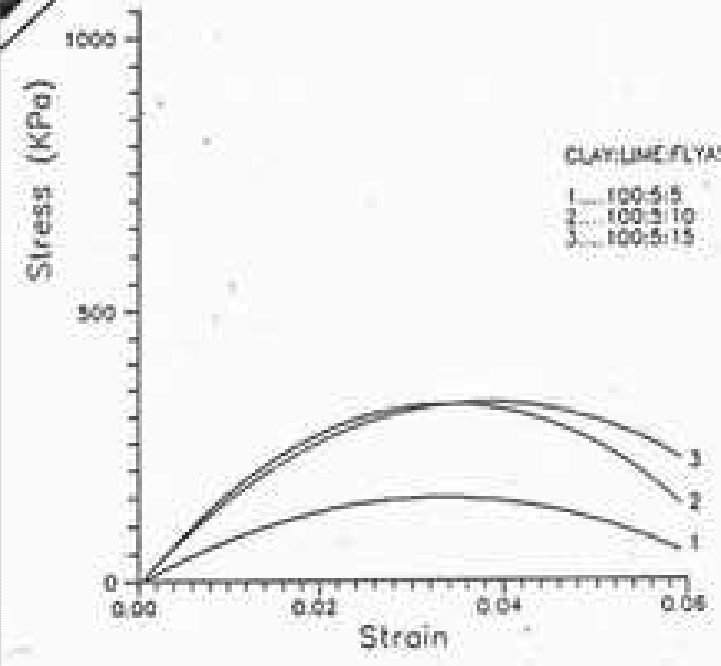


Fig.10 : UNCONFINED COMPRESSIVE STRENGHT OF SOIL:LIME:FLYASH

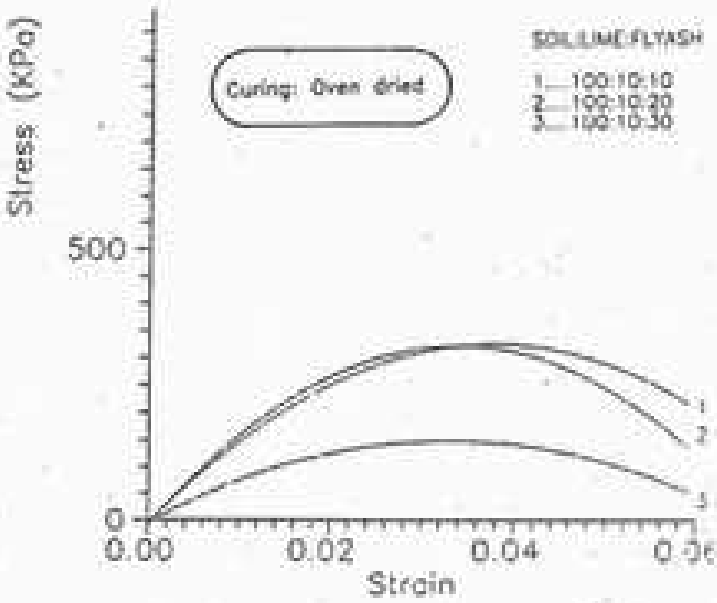


Fig.11 : UNCONFINED COMPRESSIVE STRENGHT OF SOIL:LIME:FLYASH

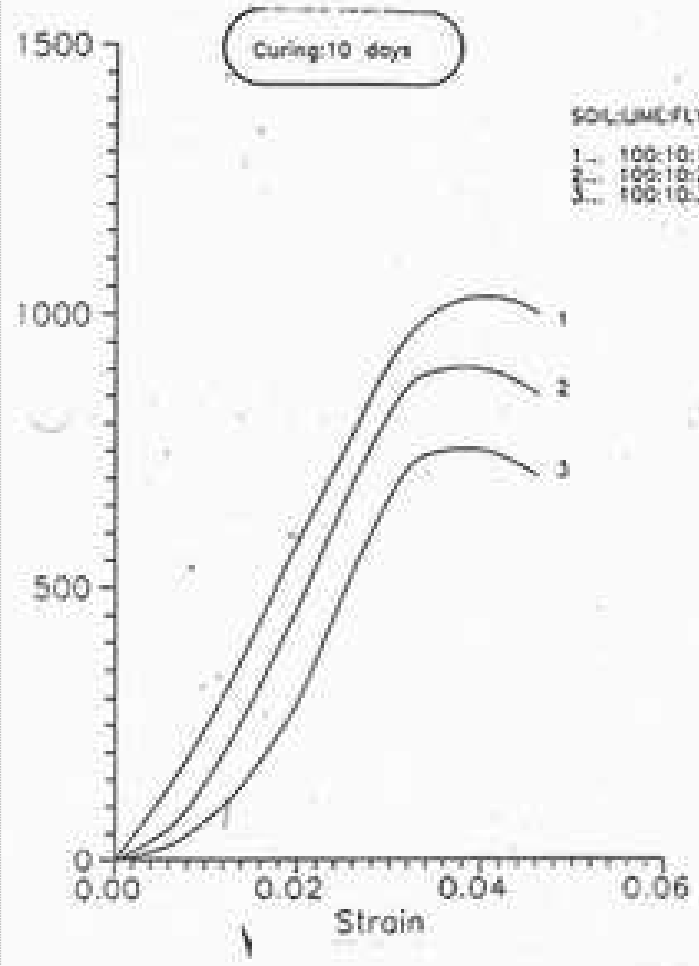


Fig.12 : UNCONFINED COMPRESSIVE STRENGTH OF SOIL:LIME:FLYASH

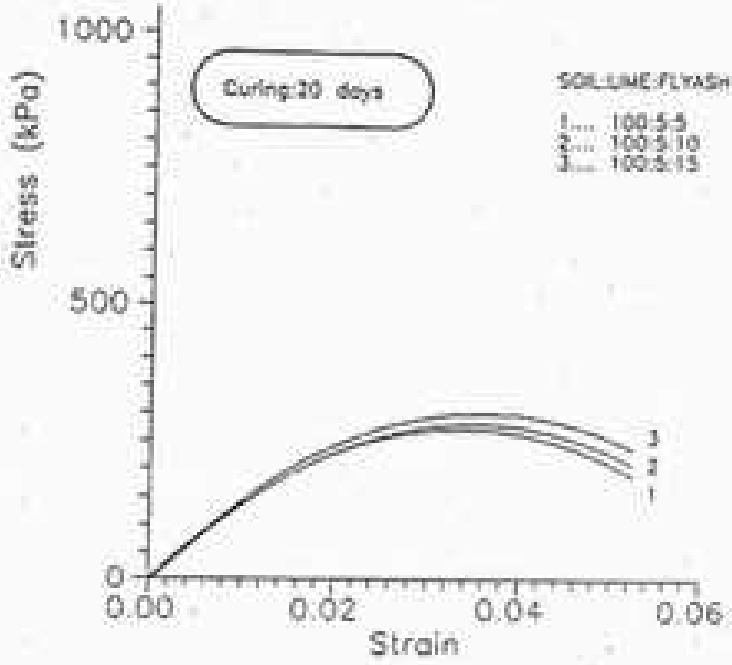


Fig.13 : UNCONFINED COMPRESSIVE STRENGHT OF SOIL:LIME:FLYASH

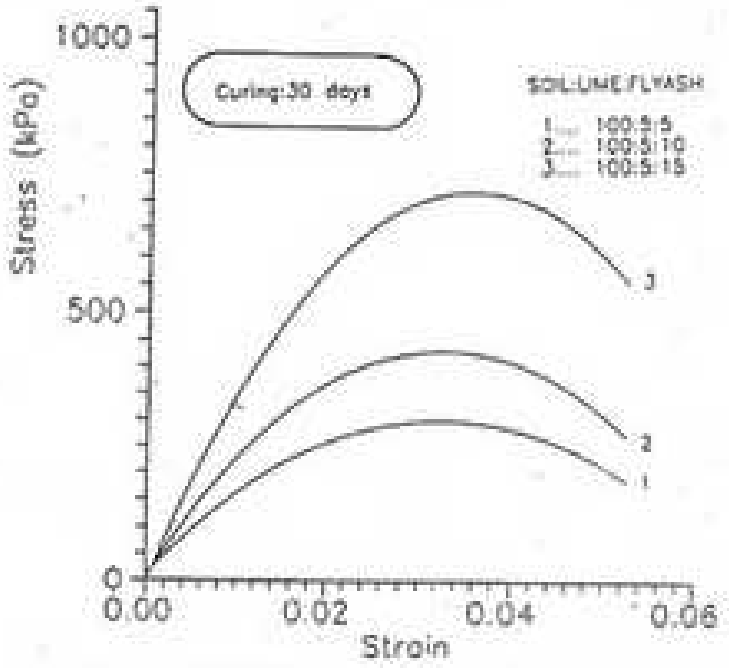


Fig.14: UNCONFINED COMPRESSIVE STRENGHT OF SOIL:LIME:FLYASH

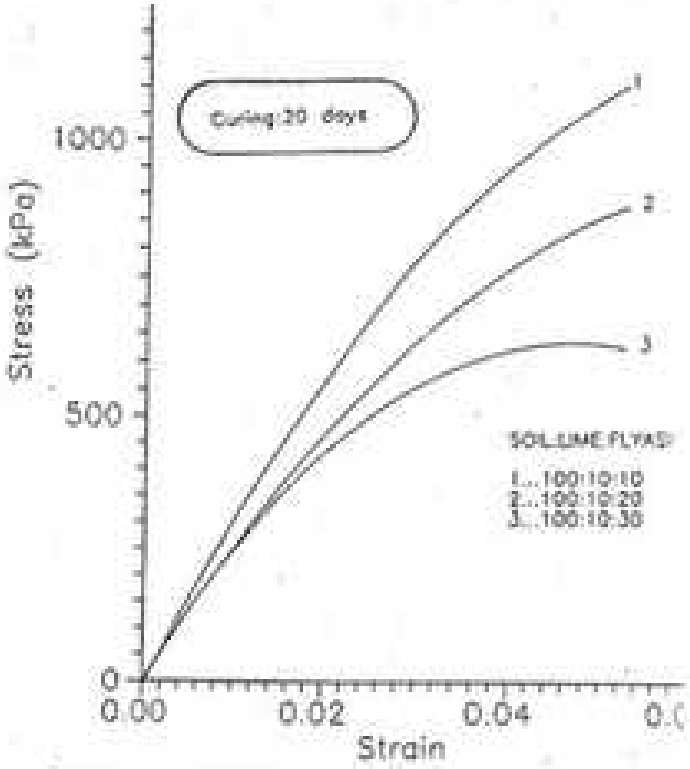


Fig.15: UNCONFINED COMPRESSIVE STRENGHT OF SOIL:LIME:FLYASH

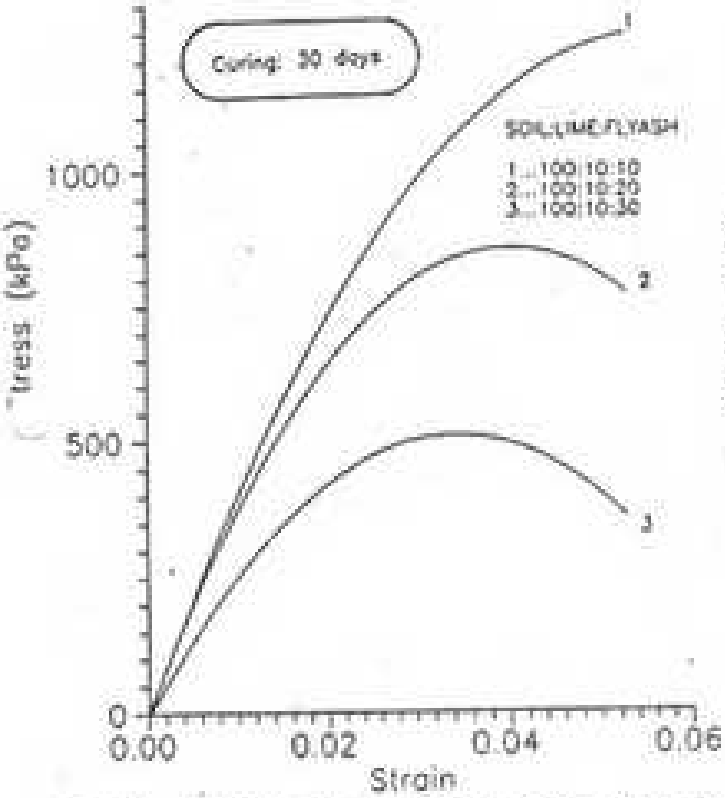


Fig.16: UNCONFINED COMPRESSIVE STRENGHT OF SOIL:LIME:FLYASH

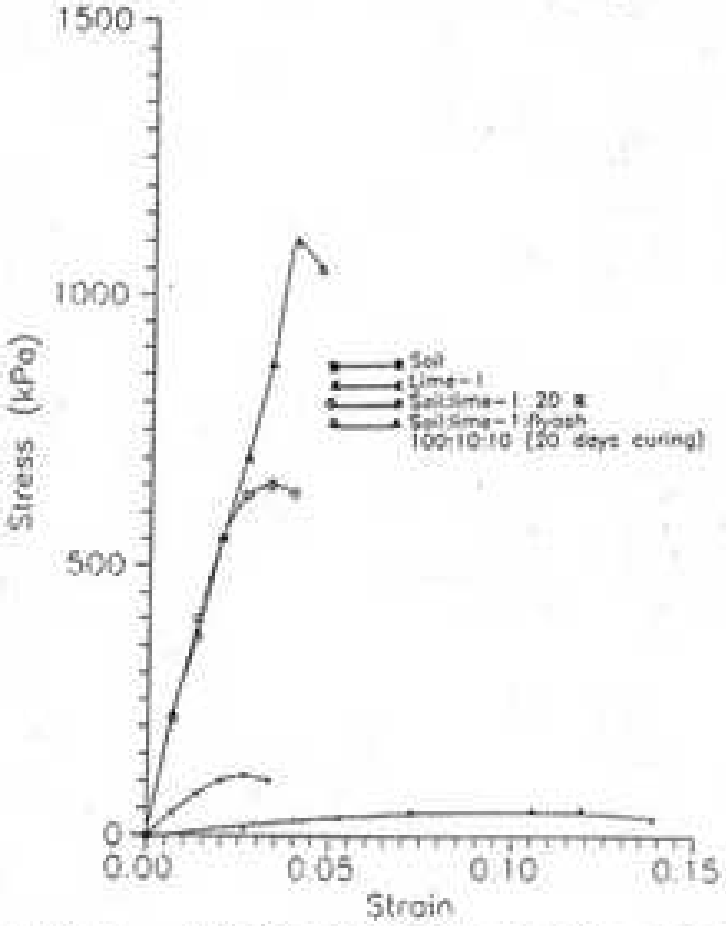


Fig.17: UNCURIFINED COMPRESSION STRESS AT DIFFERENT STRAIN LEVELS FOR DIFFERENT MATERIALS

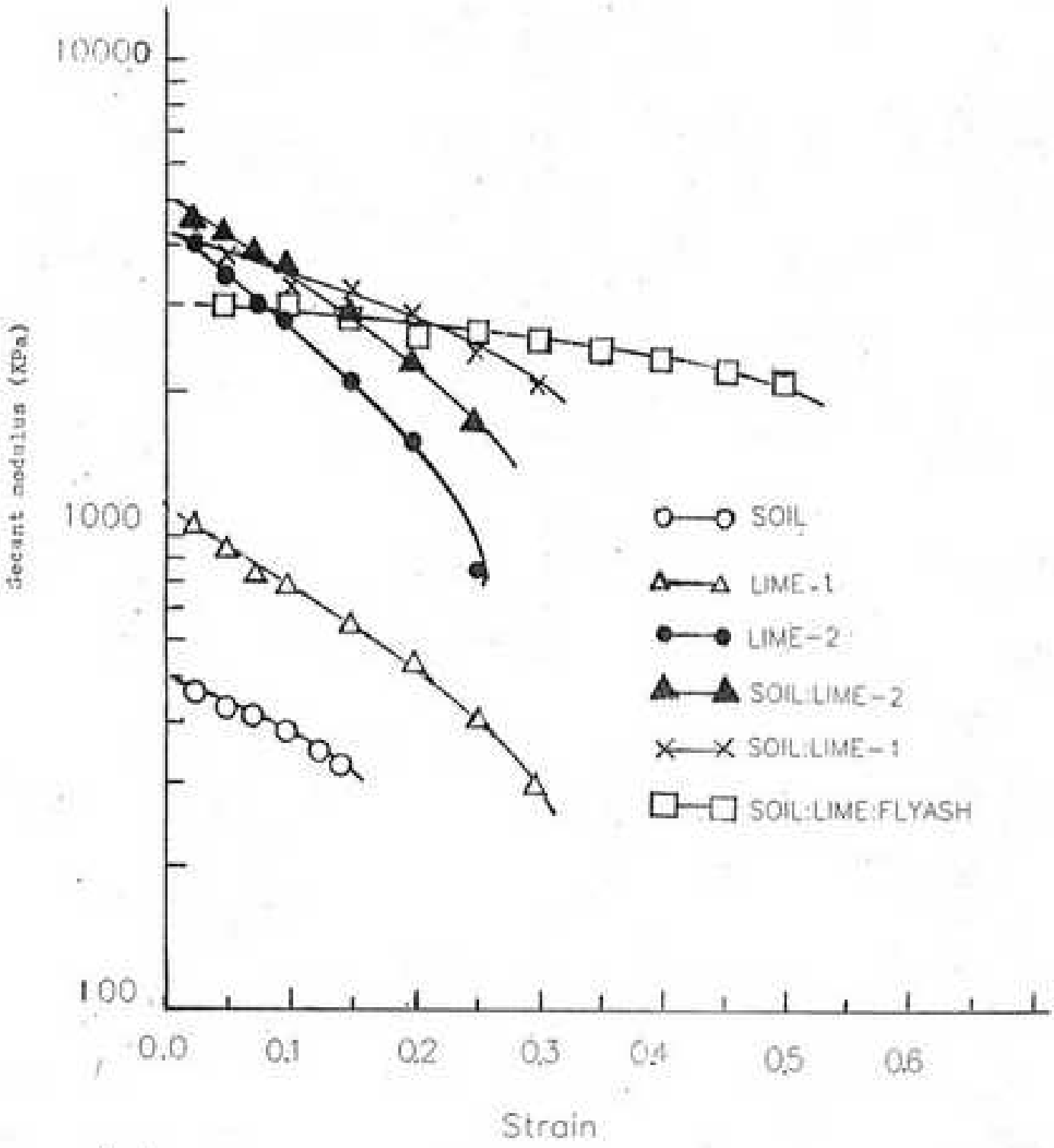


Fig. 18: Secant Moduli for Different Materials

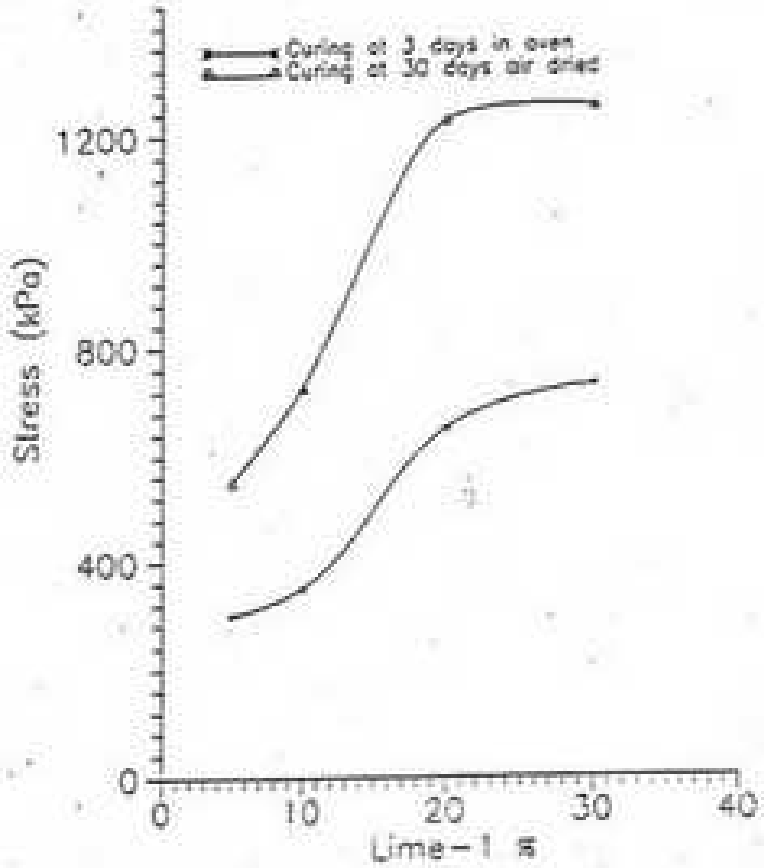


Fig.19: Variation of unconfined strength with different percentages of lime-I

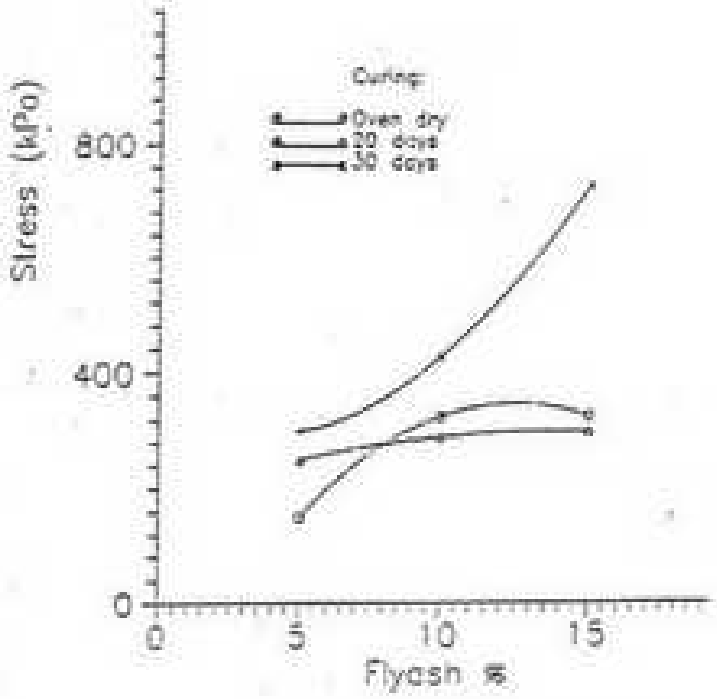


Fig.20: Variation of strength with different percentages of flyash. (5% lime)

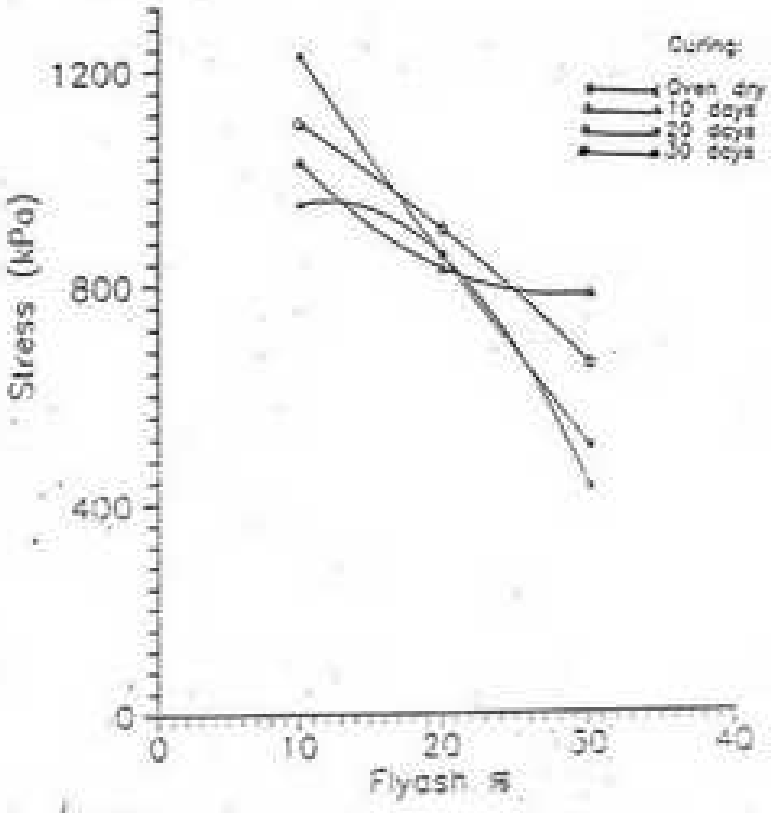


Fig.21: Variation of strength with different percentages of flyash. (10% lime)

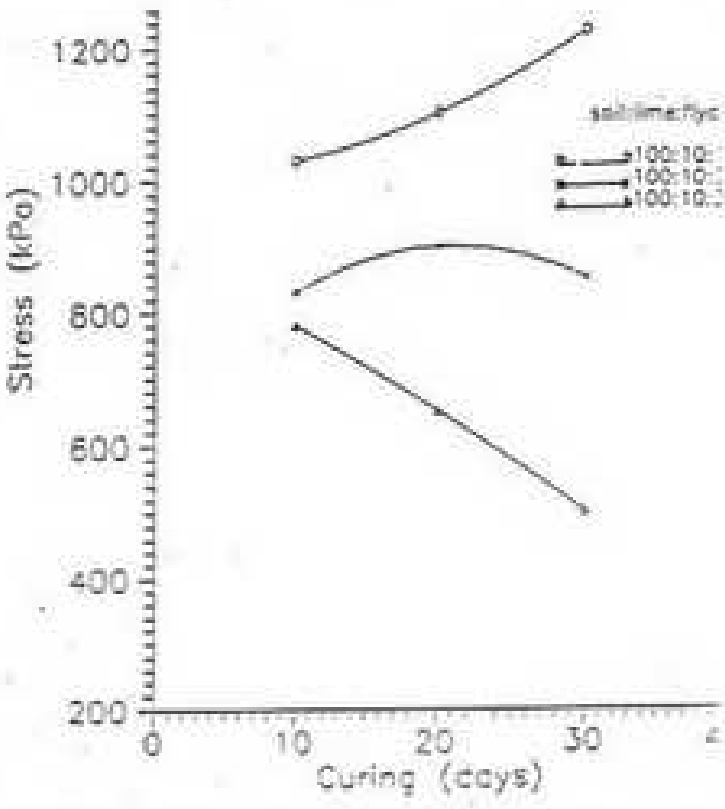


Fig.22: Variation of unconfined strength with curin