# CHARACTERISTICS OF SUBGRADE SOIL AND BASE MATERIALS AVAILABLE IN EGYPT DELTA.

BY

Dr. Eng. M.El-Shabrawy

Lecturer in Highway and Traffic Engineering, Faculty of Engineering, Mansourah University.

The paper presents the results of a study performed to determine the main characteristics of the subgrade soil and base materials avaliable in the middle region of the delta area of Egypt. Three governorates are considered for the study they are Sharkia, Dakhlia and Suez, All samples are taken out from existing or under construction regional roads for subgrade soil and from materials delivered by contractors brought from Sharkia and Suez desert for base materials.

A previous study (1) was carried recently to determine the characteristics of subgrade soil in lower Egypt in which samples were taken mainly from major roads. In this study samples were taken from what are called "Regional Roads" which are local roads in governorates subsidized and supervised by the governorate authorities other than the ministry of transport. Moreover samples in this study include base materials as gravel mix which is avaliable in Sharkia and Suez desert, calcium crushed stone and bazalt crushed stone which are avaliable in Suez desert and always brought up to roads by contractors. The paper intersted in determining the main characteristics of each type and in obtaining some average values to help the highwaymen for a good supervision and constructing better roads.

## 1- The Aim of the Study:

This study aims to study the behaviour of the avaliable subgrade soil and base materials used in road construction in the delta area. It is hoped to define some measures in which the workers in the highway field can use to perform some quality control when choosing materials and to help the decision makers during the road construction. Surely, measures presented here are not an end in themselves but they are good rough values accelerating the quality control process.

This paper is intersted in:

a) For subgrade soil:

1. determining an average value for subgrade soil grain size distribution using AASH soil classification.

2. suggesting an approximate range for liquid limit and plasticity index for the local soil.
3. determining average values for the maximum dry density and optimum moisture content for the local soil.
4. determining an average value for the maximum soil strength.

b) For base and subbase materials:

1. determining an average grain size distribution for the avaliable base materials. Materials are:
   - gravel mix from Sharkia desert at Belbies and El-Asher of Ramadan.
   - calcium crushed stone from Sharkia and Suez desert
   - bazalt crushed stone from Suez desert.
2. determining average values for the above materials representing:
   - los Anglos abbrasion.
   - degree of absorbtion.
   - maximum dry density and optimum moisture content.

## 2- Sampling:

The following samples are taken out from places shown on the attached map.

- ten subgrade samples numbered from 1 to 10.
- five gravel mix samples numbered from 11 to 15.
- five calcium crushed stone samples numbered from 16 to 20.
- two bazalt crushed stone samples numbered from 21 to 22.

## 3- Testing Program:

A complete laboratory program was performed on the considered samples as:

a) for subgrade soil:
- Sieve analysis.
- Atterberge limits.
- Standard proctor compaction test.
- CBR test.

b) for base materials:
- Sieve analysis.
- Atterberge limits (liquid limit and plastic limit).
- Los Anglos abbrasion test.
- Determining degree of absorbtion.
- Standard proctor test.

## 4- Results of Tests:

### a) For subgrade soils:

#### 1. Sieve analysis:

Since soil classification provides the engineer with a good tool for predicting the behaviour of the subgrade soil performance and it depends upon some few and simple procedures, so it is the first test to be applied on soil samples. Results are grouped into three groups as:

- Group 1. Excllent to good (A1, A2 and A3), all the samples taken out from Sharkia region were found to be A2 or A3.
- Group 2. Fair (A4 and A5). no sample was found to lie in this group.
- Group 3. Poor (A6 and A7). all the samples taken out from Dakhlia region were found to lie in this group.

#### 2. Soil consistency:

Values of liquid limit and plastic limit are determined for all samples. Table 2 shows values of liquid limit and plasticity index and it can be seen that:

- The range of the liquid limit is quite wide, It reaches 49.2 in Sharkia area and 41 in Dakhlia area.
- The range of plasticity index reaches 32.5 in Sharkia area and 18.0 in Dakhlia.

The obtained results are justified since soil in Sharkia area is mostly A2-6 and A2-7 while in Dakhlia it is A6 and A7 and these soils having great percentages of fines passing sieve 200 and it has been proved (   ) that the higher the percent passing sieve 200, the wider the range of the probable plasticity index values.

#### 3. Soil strength:

The design of pavement thickness is based mainly on the subgrade strength. The california Bearing Ratio (CBR) test is the most used method and the most acceptable and applicable test in determining the soil strength and hence the thickness of pavement layers.

A relation between the CBR value and the soil classification in lower Egypt area has been produced (1) in a graphical form using both the AASHTo and FAA classification.

Since the strength of the soil depends, beside other factors upon the liquid and plastic limits, so average values for CBR have been suggested for each class of plasticity index. Approximate average values of CBR have been obtained for each class of avaliable soils in the eastern part of the delta. Results are shown in Figs. (2 and 3).

It is clear from figures that the range of probable CBR values is quite wide and accurate tests are essential.

b) Base Materials:

1. Sieve analysis:

Figure (5) shows the gradation of the gravel mix samples. The range is quite short and it seems to be finer than the AASHTo specifications and needs an improvement in the form of mixing it with coarser material. Moreover it is not recommended to use the gravel mix in the Sharkia and Suez desert in base courses but it can be used for subbase courses due to its gradation and the expected maximum dry density and the probable volume changes.

The range of sieve gradation of calcium crushed stone is quite wide since it depends upon the size of sieves of different crushers used and it is difficult to obtain an average gradation to represent all samples. In general most of the calcium crushed stone is acceptable from the gradation point of view.

For bazalt crushed stone sieve analysis shows that the two samples considered in this study are coarser than the specifications and hence bazalt crushed stone needs a great effort in working to obtain good results. Sieve analysis of the two samples is shown in Fig.(7).

2. Los Anglos Abbrasion Values and Absorbtion:

The specifications define the allowable los anglos factor of the base material to be less than or equal to 40%. All considered samples have given a lower value than the standard which means that all calcium and bazalt crushed stones are acceptable. The range of los anglos factor is 13.1.

All samples have given a degree of absorbtion less than 10% which is defined by specifications. It means that all crushed stone samples are acceptable from the absorbtion point of view. The range of degree of absorbtion is 3.8%.

### 3. Maximum Dry Density and Optimum Moisture Content:

The maximum dry density and the corresponding optimum moisture content for the tested samples can be averaged as:

| | Max. dry density $t/m^3$ | o.m.c. % |
|---|---|---|
| Gravel mix. | 2.19 | 6.9 |
| Calcium crushed stone | 2.01 | 12.0 |
| Bazalt crushed stone | 1.95 | 5.8 |

It is noted that the range of both the maximum dry density and the optimum moisture content are quite short and hence the average values are good approximations.

## 5- Conclusions and Recommendations:

This work aimed to more understanding of the basic fundemental properties of the local subgrade soil and base materials avaliable in the eastern part of the Egyptian delta (Sharkia, Dakhlia and Suez governorates).
Before listing the set of conclusions obtained and recommendations it should be recognized that the shown figures and interrelationships are merely approximate but they are good enough for estimating soil and material properties and in expecting their behaviour in working. Also the results of this study may be valuable for comparison and material choice purposes. The study showed that:

1. Most of the soil avaliable in Sharkia area is A2-6 and A2-7 except in very few places it may be A3 especially at Sharkia borders with Suez and Ismalia.
2. Most of the soil avaliable in Dakhlia area is A6 and A7 where A2-6 was found in the agricultural area of Gamasa.
3. The range of liquid limit and plasticity index of the avaliable soils are wide for the same class of soil which means simply that a good dealy and suitable equipments are required for good results.
4. The maximum dry density for soils are ranged as:

| Soil class | Max. $\gamma_d$ From | Max. $\gamma_d$ To | o.m.c. From | o.m.c. To |
|---|---|---|---|---|
| A2-6 | 1.83 | 1.51 | 14.3 | 26.0 |
| A2-7 | 1.60 | 1.50 | 26.4 | 28.1 |
| A3 | 2.18 | 1.97 | 12.0 | 13.0 |
| A7-5 | 1.61 | 1.35 | 20.5 | 27.0 |

5. The strength of the subgrade soil has a great wide in which tests are necessary for each type and in each site and no average value of soil strength can be obtained.

6. The gradation of the avaliable gravel mix is not satisfactory and a great care must be paid in using gravel mix in base courses but it can be used for subbase purposes, due to gradation and strength.
7. The calcium crushed stone can be used for base courses due to satisfactory gradation and los anglos value but a care must be paid to the degree of absorbtion.
8. Bazalt crushed stone can be used for base courses due to its satisfaction of los Anglos values and absorbtion but care must be given to the gradation for easy working.

Finally, the figures and results obtained in this study are of great importance and value to the highway people in both the design and construction stages but tests should be applied for individual cases as possible.

## 6- ACKNOWLEDGEMENT:

The author wishes to express his thanks and gratitude to the staff of Sharkia road laboratory specially Miss vivean and also to the engineers of Sharkia and Dakhlia govenorates specially Eng. Shetwi of Mansourah University.

## REFERENCES:

1. Gadallah, A.A. (1984). "Subgrade soil characteristics in Lower Egypt Region", Arab Roads, Cairo. 3rd edition for 1984, pp. 24-36.
2. Shawki, A.M. (1982). "A Research on soil stabilization" 1st Report by Scientific Research and Technology on soil stabilization, period 23/9/1981 to 30/6/1982.
3. Osman, A. (1983). "Highway Engineering" Part 2, Cairo.
4. El-Shabrawy, M. (1985). "Lecturer notes on Highway Engineering", El-Mansourah.

C. 130 M.El. Shabrawy

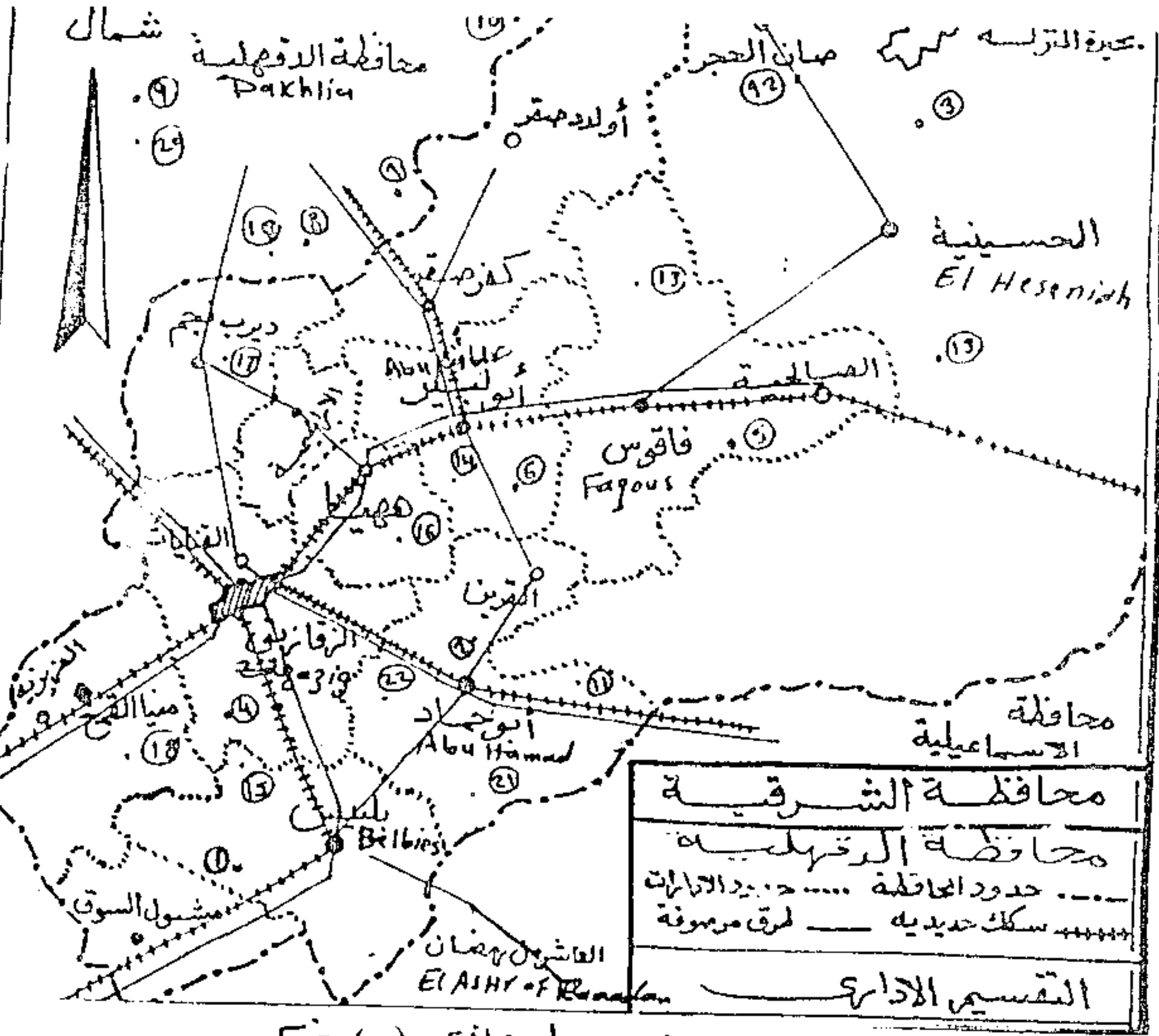



Fig (1) site Locations.

| | | |
|---|---|---|
| (1) Belbis | (2) Abu-Hammad | (3)El-Hesseniah |
| (4)El-Zagazig | (5) Faqous | (6)Abu-Kabir |
| (7)El-Sinbliwean | (8) Berken | (9)Gamasa |
| (10)Dekerns | (11)Abu-Hammad | (12)El-Hessinea |
| (13)Faqous | (14)Abu-Kabir | (15)Belbis |
| (16)Hehia | (17)DiarbNegem | (18)Minea-ELkamh |
| (19)El-Sinblwean | (20)Gamasa | (21),(22)Abu-Hamad |

Note:

Locations 1,2,3,4,5,6,7 For Sharkia Subdrade Soil

Locations 7,8,9,10 For Dakhlia Subgrade Soil

Locations 11,12,13,14,15,16,17,18 For Sharkia Base Material and Sub-base Materials.

Locations 19,20,2 For Dakhlia Base and Sub-base

Locations 21,22 For Bazalt Base Courses.

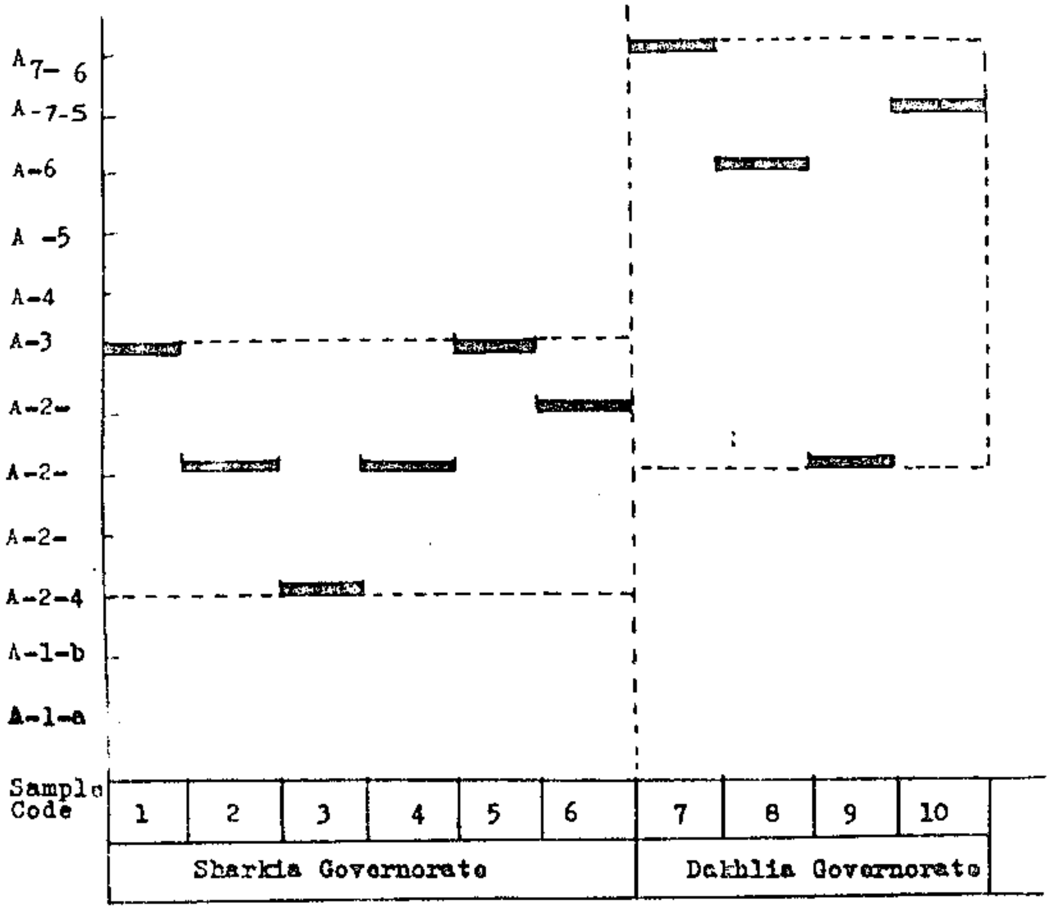



Fig.(2) Distrubtion of Soil Calsses.

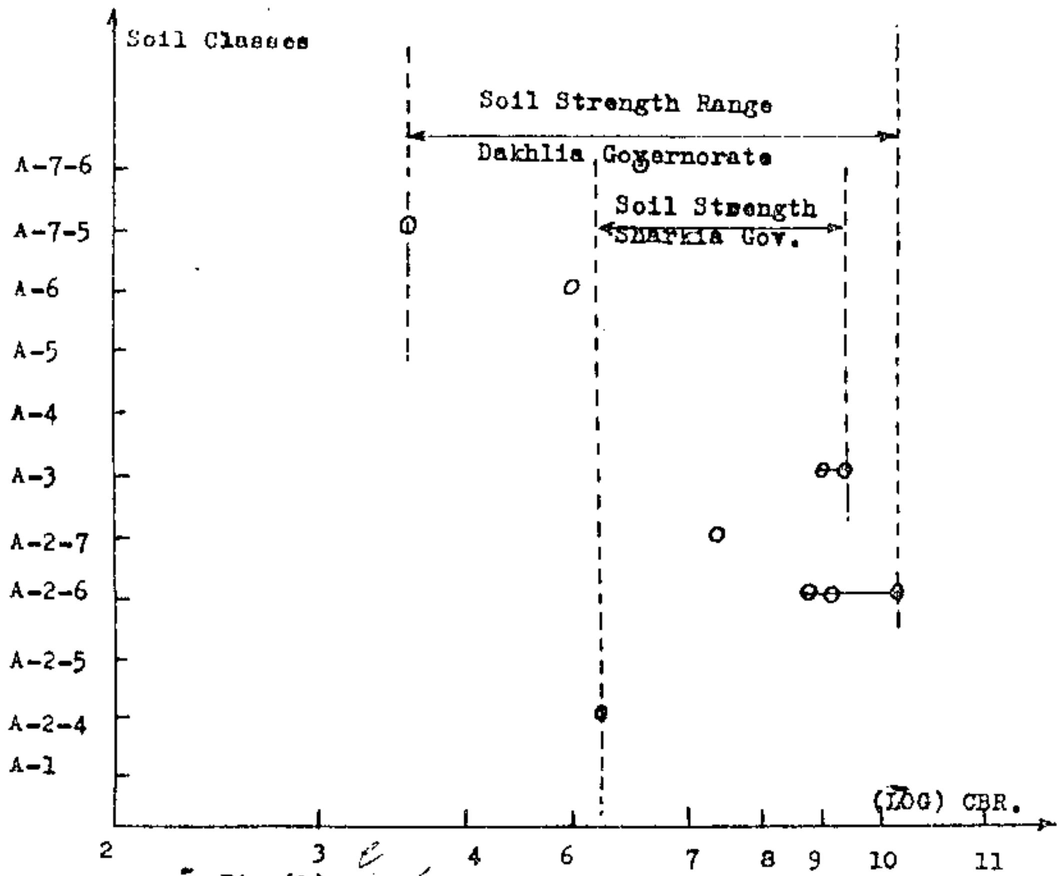



Fig.(3) RElation Between Soil Strength And Soil Classes

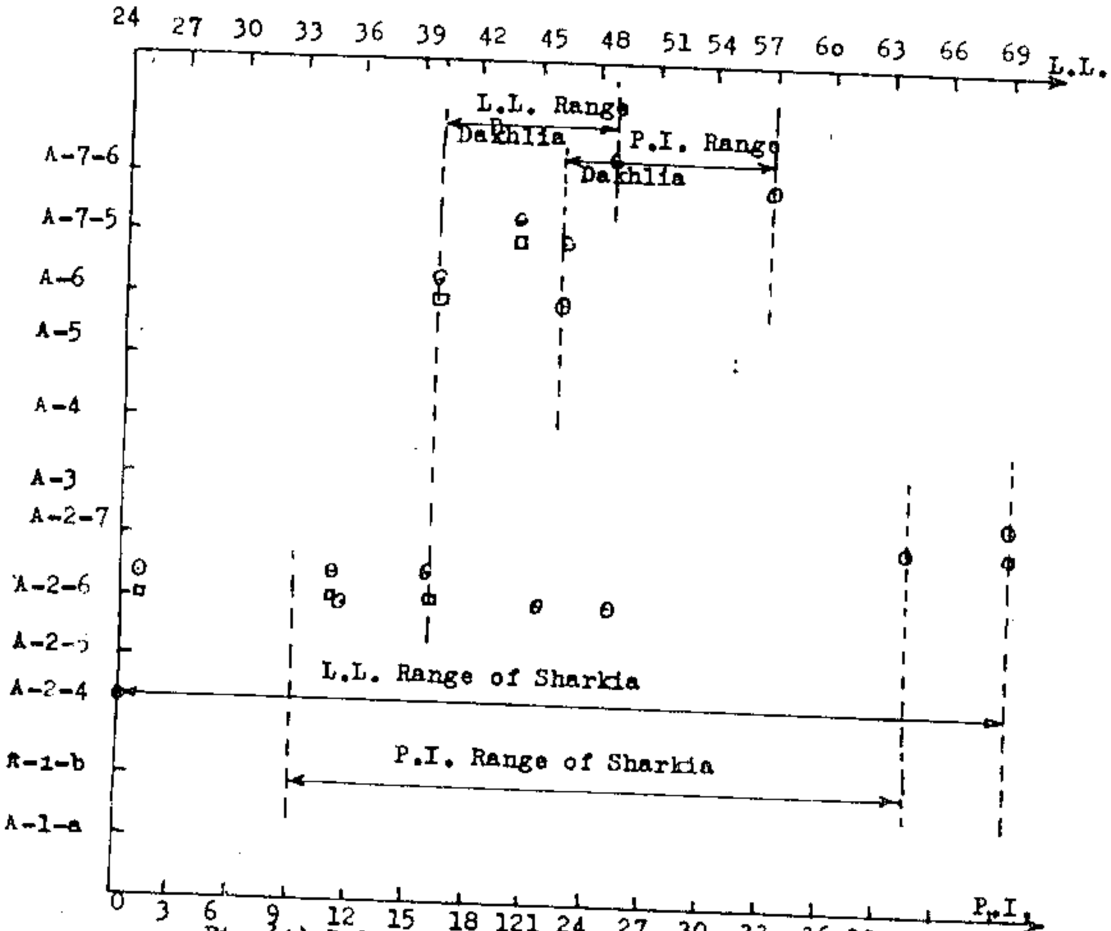
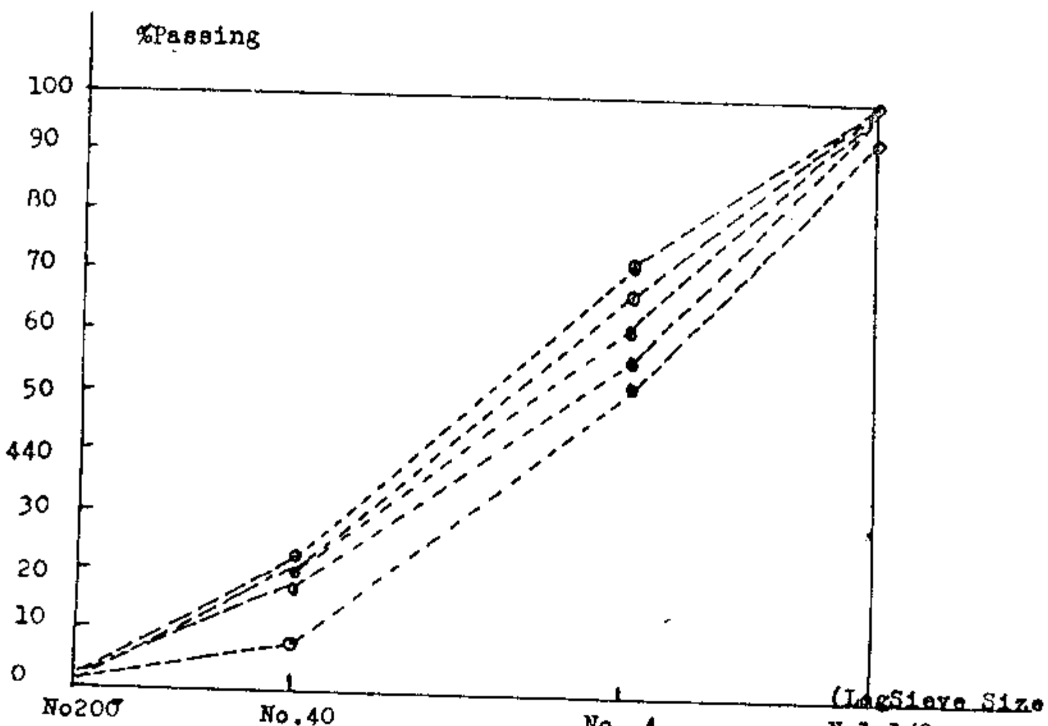
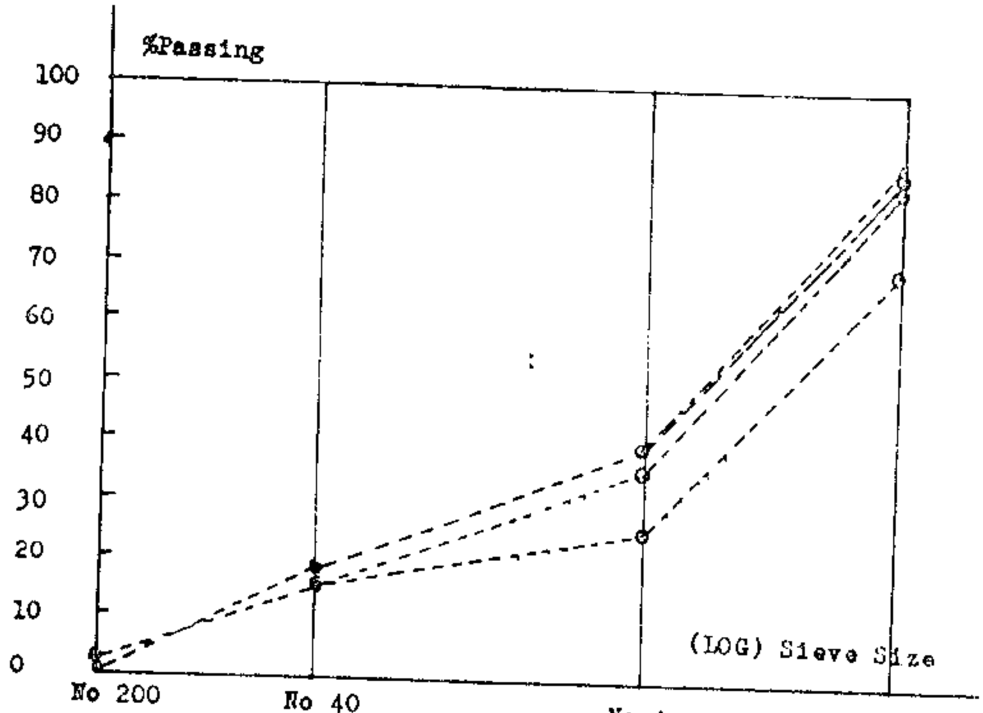



Fig.(4) Relation Between Plasticity Index (P.I) and Liquid Limit (L.L.) and Soil Classes.




Fig(5) Sieve Analysis Of Gravel Mixes




Fig(6) Sieve Analysis of Calcium Crushed Stone.

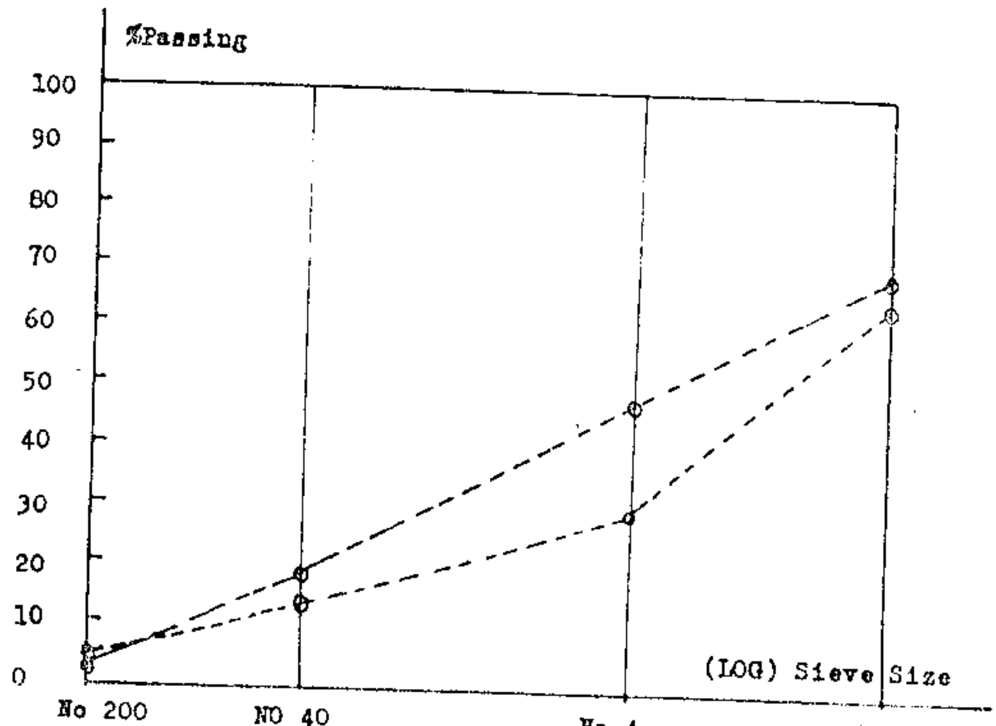



Fig (7) Sieve Analysis of Bazalt Crushed Stone.

Table 2: Base and Subbose Data

| Site code on map | Type of material | Gradation 11/2" | No. 4 | No. 40 | No. 200 | Degree of Absorb-tion | Los Anglos % | max. d t/m$^2$ | O.m.c. % | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | Grorel mix | 100 | 60.1 | 20.3 | 1.2 | | | 2.20 | 12.5 | Abu Hammad-Sharkia |
| 12 | " " | 100 | 57.6 | 17.1 | 1.7 | | | 2.32 | 16.3 | El-Hessienah " |
| 13 | " " | 95.7 | 51.7 | 8.3 | 0.5 | | | 2.20 | 9.2 | Faqous-Sharkia |
| 14 | " " | 100 | 67.9 | 20.0 | 0.7 | | | 2.22 | 5.7 | Abu Kabir-Sharkia |
| 15 | " " | 100 | 71.2 | 19.1 | 1.3 | | | 2.00 | 6.9 | Belbies-Sharkia |
| 16 | Calcuium store | 69.7 | 24.5 | 16.4 | 1.2 | 8.1 | 31.5 | 2.00 | 12.0 | Hehia-Sharkia |
| 17 | " | 83.5 | 35.5 | 16.4 | 1.2 | 6.8 | 28.4 | 2.00 | 9.2 | Deiarb Negem-Sharkia |
| 18 | " | 83.7 | 37.4 | 18.6 | 1.0 | 6.8 | 26.4 | 2.09 | 7.4 | Minea El-Kamh " |
| 19 | " | 69.0 | 24.5 | 16.5 | 5.0 | 7.2 | 28.5 | 2.10 | 10.86 | El-Sinbliwan-Dakhlia |
| 20 | " | 85.0 | 35.2 | 11.7 | 1.6 | 5.9 | 28.5 | 2.15 | 5.7 | Gamasa-Dakhlia |
| 21 | Bazalt store | 64.1 | 29.0 | 14.7 | 2.4 | 0.5 | 33.7 | 1.95 | 6.8 | Abu Hammad-Sharkia |
| 22 | " | 67.7 | 46.1 | 17.2 | 1.8 | 0.5 | 40.2 | 2.01 | 6.8 | Abu Hammad-Sharkia |

Table 1: Subgrade Soil Data.

| Site code on map | Type of soil AASH TO | Atterberge limot L.L. | Atterberge limot P.I | max. d t/m$^3$ | m.c. % | CBR % | notes |
|---|---|---|---|---|---|---|---|
| 1 | A3 | - | NP | 2.18 | 13 | 9.3 | Belbis-Sharkia |
| 2 | A2-6 | 25 | 10.8 | 1.67 | 12.3 | 8.9 | Abu Hamad-Sharkia |
| 3 | A2-4 | 24 | 9.0 | 1.59 | 11.1 | 6.2 | El-Heseniah-Sharkia |
| 4 | A2-6 | 35 | 21.1 | 1.83 | 14.3 | 9.1 | El-Zagazig-Sharkia |
| 5 | A3 | - | NP | 2.05 | 12.0 | 9.0 | Faqous-Sharkia |
| 6 | A2-7 | 69.4 | 39.9 | 1.85 | 20.2 | 7.3 | Abu-Kabir-Sharkia |
| 7 | A7-6 | 48.4 | 30.0 | 1.54 | 21.5 | 6.66 | El-Senbliwen-Dakhlia |
| 8 | A6 | 40 | 22.0 | 1.75 | 16.0 | 6.0 | Berken-Dakhlia |
| 9 | A2-6 | 40 | 25.0 | 1.51 | 26.0 | 10.2 | Gamasa-Dakhlia |
| 10 | A7-5 | 44.5 | 22.5 | 1.61 | 20.5 | 3.7 | Dakerns-Dakhlia |