# BEHAVIOUR OF CUTBACK ASPHALT-SAND MIXTURES

**M.F. Ghanem, M.A. Ghoniem, and Y.T. Attallah**
Transportation Engineering Department, Faculty of Engineering,
Alexandria University, Alexandria, Egypt.

ABSTRACT

The purpose of this study is to investigate the behaviour of the cutback asphalt-sand mixtures under unconfined compressive strength and Marshall tests, in order to make a comparison between the results of both tests Marshall and unconfined compressive tests were carried out on different cutback asphalt contents and for two sandy soils. Test results obtained during the Marshall and compressive strength tests showed a good correlation between the Marshall stability and the compressive strength values on which the relationship between them was developed.

## INTRODUCTION

The basic principles of soil-asphalt stabilization, as applied to highway and air field construction, are methods of designing and mixing local soil or aggregate with asphaltic material to form a stable and water-proofed base course Properly constructed soil-asphalt base courses resist deformation through the cementing action of the asphalt which binds the soil particles together The thin coating of asphalt around the soil particles also provides a high degree of water proofing which is considered further aid to resist deformation.

In many areas where suitable flexible base materials are not available, or would have to be imported at considerable expense, local soils can be mixed with asphaltic materials to form satisfactory base courses at a lower cost Interior flexible base-course materials can be made satisfactory by soil asphalt stabilization.

Experimental work was conducted to study the effect of liquid asphalt which is the cutback asphalt on strength and characteristics of sandy soils using the Marshall and compressive strength tests in mixture characterization The effect of different factors on the mixtures properties was evaluated.

The relation between Marshall stability and compressive strength was developed from test results obtained at different mix compositions and curing conditions.

## MATERIALS

### *Raw Materials*

Two types of sandy soils, which cover the Egyptian west desert, were used in this investigation The first soil sample (Sand 76) was taken from surficial layer within one meter below ground surface, Kilometer 76 + 00 of Alexandria-Cairo desert road and second soil sample (Sand 92) was taken from top layer one meter below surface Kilometer 92 + 00 of Alexandria-Cairo desert road

The grain size distribution curves for soil samples are shown in Figure (1) According to grain size analysis curves shown in Figure (1) and the AASHTO system of soil classification; the two soils samples fall under the A-1-b (0) group (coarse sand either or without a well graded soil binder).

### *Cutback Asphalt*

The type of cutback used to prepare the sand-asphalt mixtures was RC-2 (or RC-250 according to the new specification) It was obtained from "El-Nasr" Petroleum Company, Amreyah, Alexandria distillation test of the RC-250 cutback was performed according to ASTM Designation D 402-76 The test results are shown in Table 1.

**Table 1**. Distillation of Rapid-Curing Cutback Asphalt.

| | |
|---|---|
| Total Volume | = 200 $cm^3$ |
| Asphaltic Residue (R) | = 156 $cm^3$ |
| Total Distillate recovered to 360°C (680 °F) (TD) | = 44 $cm^3$ |
| Total Distillate (TD, percent) | = 22 |
| Boiling Point | = 191 °C |
| Volume of Distillate | |
| Up to 225 °C (437 °F) | = 18 $cm^3$ |
| Up to 260 °C (500 °F) | = 32 $cm^3$ |
| Up to 316 °C (600 °F) | = 40 $cm^3$ |
| Up to 360 °C (680 °F) | = 44 $cm^3$ |
| Distillate, Volume Percent of Total Distillate to 360 °C (680 °F) | |
| Up to 225 °C (437 °F) | = 78 |
| Up to 260 °C (500 °F) | = 43.2 |
| Up to 316 °C (600 °F) | = 72.7 |
| Up to 360 °C (680 °F) | = 90.9 |
| Residue from Distillate to 360 °C (680 °F), Percent | = 100.0 |
| Volume by Difference | = 78 |
| Test on Residue from Distillation | |
| Penetration (100 gm-5 seconds) | = 99 |

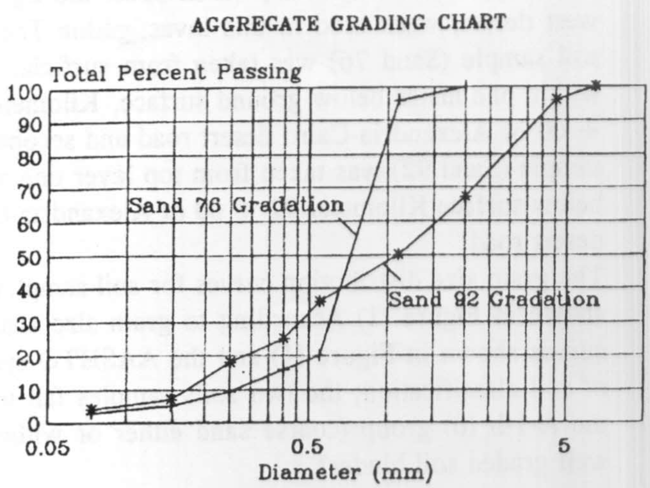



*Figure 1 : Sand Gradation (Sand 76 and Sand 92)*

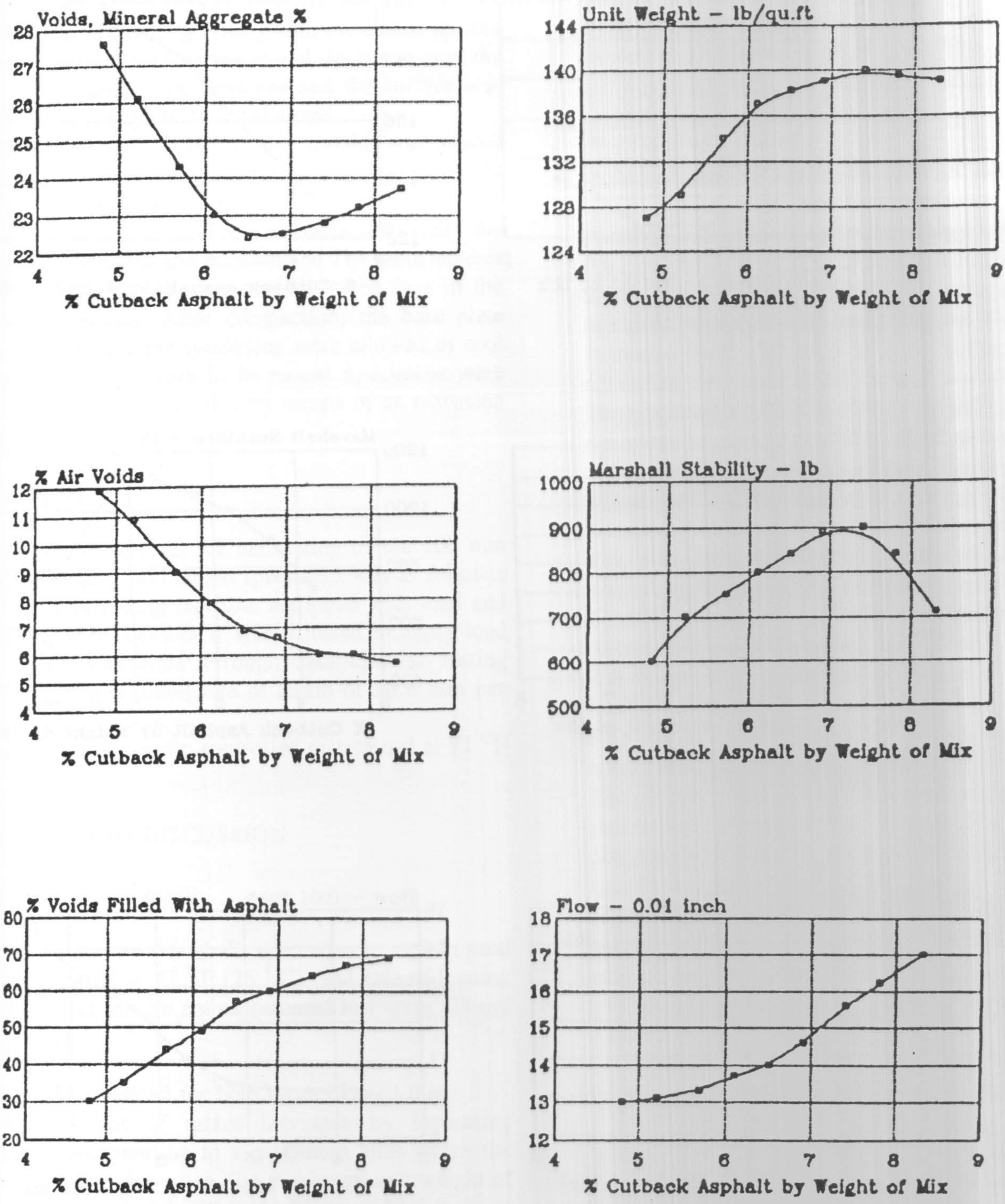
## TESTING PROGRAM

### *Preparation of Test Specimens*

Cylindrical test specimens of 100 mm diameter with 62.5 mm height were prepared at 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, and 9.0 % cutback asphalt The amount of each size fraction was weighted into separate pans The mixing pans were placed in the oven and they were heated to a temperature 25xF (13.9xC) above the mixing temperature The cutback asphalt was heated rapidly and carefully to avoid appreciable loss of solvent to a temperature that made it flow easily (not higher than the predetermined mixing temperature).

A crater was formed in the hot blended fractions, the mixing pan and contents were placed on the balance and the required amount of asphalt was weighted At this point the mixing temperature was checked if it was within the limits of mixing temperature Immediately the mixing trowel was introduced in the mixing pan and the total weight of the mix components plus mixing equipment was determined The sand and cutback asphalt were mixed with the trowel until a uniform mixture was obtained

The mixtures were cured in the oven maintained at the compaction temperature plus 20 °F (11.1 °C) to allow for heat loss during handling of the mix Curing was carried out in the mixing bowel and controlled by verifying the weight at intervals of 15 minutes initially and less than 10 minutes as the weight of the mix at the predetermined solvent loss was approached.




e 2. Cutback asphalt-sand mixture design curves for mixtures prepared with RC-250 cutback asphalt and sand 76.

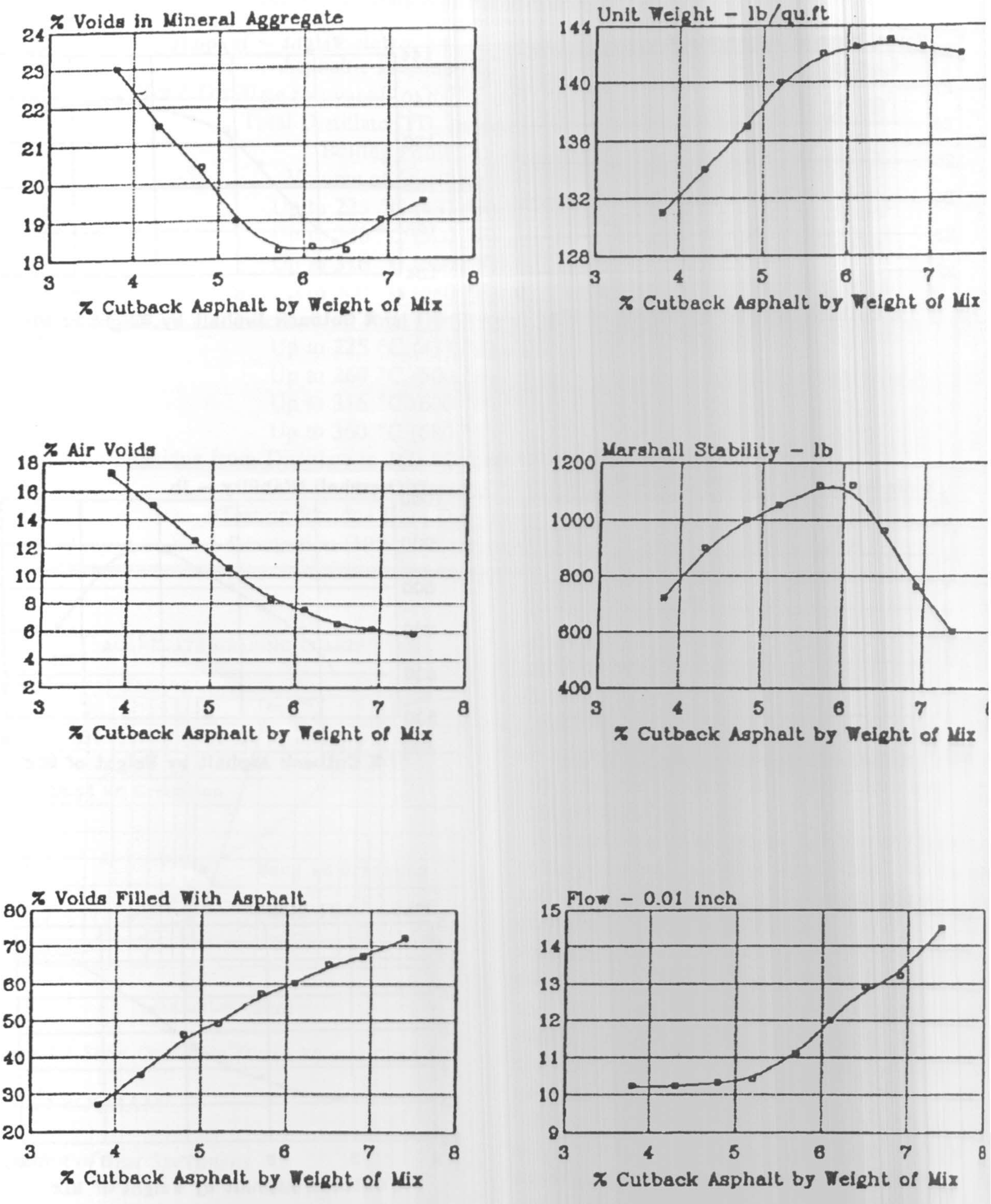



Figure 3. Cutback asphalt-sand mixture design curves for mixtures prepared with RC-250 cutback asphalt a
92.

*Compaction of Specimens*

The entire batch was placed in the mould, the mixture was spaded vigorously with the heated spatula 15 times around the perimeter and 10 times over the interior The collar was removed and the surface was smoothed to a slightly rounded shape.

The collar was replaced, the mould was placed assembly on the compaction pedestal in the mould holder 75 blows were applied with the compaction hammer Base plate and collar were removed, the mould was reversed and reassembled The same number of compaction blows were applied to the face of the reversed specimen After compaction, the base plate was removed and the specimens were allowed to cool to ambient temperature in its mould Specimens were removed from their moulds by means of an extrusion jack.

*Equipment*

The equipment used for the testing of the 100 mm diameter x 62.5 mm height specimens was as follow:s

1. Universal testing machine equipped with load and deformation devices It was adjusted to apply load on test specimens through semi-circular testing heads at a constant rate of strain of 50.8 mm per minute.
2. Air bath, automatic controlled maintained at 77 $^{\circ}$F (25 $^{\circ}$C)

RESULTS AND DISCUSSION

*Marshall Test Results*

The results of Marshall on cutback asphalt-sand mixtures tested at 77 $^{\circ}$F (25 $^{\circ}$C) and rate of loading 50.8 mm per minute are represented in Figure (2) and Figure (3)

It could be noticed for both types of sand that :

- Unit weight of mixes increases by increasing cutback content up to a maximum after which the unit weight decreases The maximum unit weight of mixture prepared with sand 76 was 139.6 lb/ft$^3$ at 7.5 % cutback asphalt content and it was 141.3 lb/ft$^3$ at 6.5 % cutback asphalt content for mixture prepared with sand 92.
- The stability value increases with increasing cutback asphalt content up to a maximum after which the stability decreases. The maximum stability values were 900 lbs at 7 % cutback asphalt content and 1100 lbs at 6% cutback asphalt content for mixtures prepared with sand 76 and sand 92 respectively.
- The flow value increases with increasing cutback asphalt content It could be seen in the mixture design curves, that the flow value for mixtures prepared with sand 76 increased from 13.00 (unit of 0.01 in.) at 5 % cutback asphalt content to 17.1 units at 9 % cutback asphalt content Also, for mixtures prepared with sand 92, the flow value increased from 10.2 units at 4 % cutback asphalt content to 14.2 units at 8% cutback asphalt content.
- The percent voids in the mineral aggregate decreases to a minimum value then increases with increasing cutback asphalt content These minimum values are 22.4% and 18.14% for mixtures prepared with Sand 76 and Sand 92 respectively.
- The percent air voids decreases with increasing cutback asphalt content For mixtures prepared with Sand 76, the percent air voids decreased from 19.8 % at 5.0 % cutback asphalt content to 7.46 % at 9.0 % cutback asphalt content, while it decreased from 17.1 % at 4.0 % cutback asphalt content to 5.55 % at 8.0 % cutback asphalt content for mixtures prepared with Sand 92.
- The percent voids filled with asphalt increases with increasing cutback asphalt content For mixtures prepared with Sand 76, the percent voids filled with asphalt increased from 28.23 % at 5.0 % cutback asphalt content to 68.27 % at 9.0 % cutback asphalt content while it increased from 25.5 % at 4 % cutback asphalt content to 71.29 % at 8.0 % cutback asphalt content for mixtures prepared with Sand 92.

*Compressive Strength Test Results*

Cutback asphalt-sand mixtures were prepared and tested according to the procedures discussed before The results obtained at the same nine cutback asphalt contents are shown in Figure (4) for mixtures prepared with sand 76 and Sand 92 respectively.

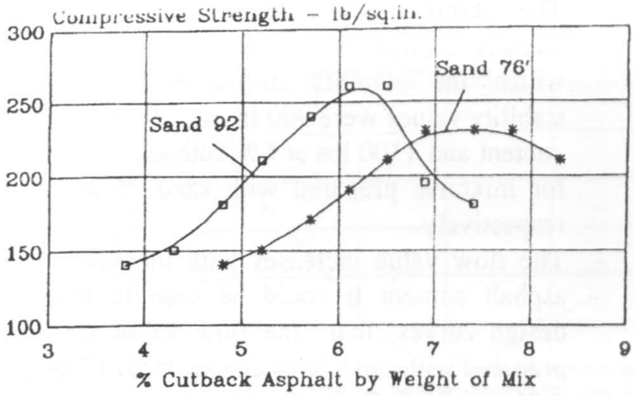



**Figure 4**. Compressive strength for cutback asphalt-sand mixtures prepared with RC-250.

It can be seen that the compressive strength of mixtures prepared with both sands increases with increasing cutback asphalt content up to a maximum after which the compressive strength decreases The maximum compressive strength for mixtures prepared with Sand 76 was 235 psi at 7.5 % cutback asphalt content, and 252 psi at 6.5 % cutback asphalt content for mixtures prepared with Sand 92.

*Relation between Marshall Stability and Compressive Strength*

In order to obtain a relationship between the Marshall stability and the compressive strength, both Marshall and compressive strength test results on sand-asphalt mixtures prepared with both sands at different asphalt contents are plotted in Figure (5).

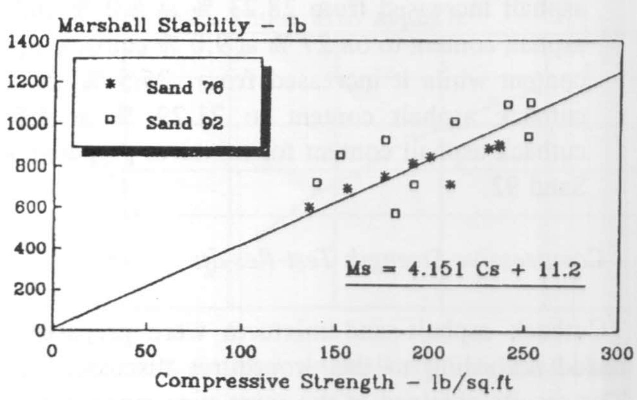



**Figure 5.** Marshall stability-compressive strength relation for cutback asphalt-sand mixtures prepared with RC-250.

It may be noticed from Figure (5) that the Marshal stability in lbs can be related to the compressiv strength in psi as follows:

$$Ms = A + B\ Cs$$

where

Ms= Marshall stability lbs
Cs= Compressive strength psi
A = Constant lbs
B= Slope inch$^2$

The values of the two constants A and B can be estimated from the strength line relationship between Ms and Cs values obtained from the test results The analysis of test results showed that :

- For mixtures prepared RC-250 cutback asphalt and sand 76, the relationship between Marshall stability and compressive strength is :
  $Ms = 3.89\ Cs + 33.5$
- For mixtures prepared RC-250 cutback asphalt and sand 92, the relationship between Marshall stability and compressive strength is :
  $Ms = 4.41\ Cs - 11.1$

## CONCLUSIONS

The main conclusions deduced from this investigation can be summarized as follows :

1. Sandy soils can be stabilized satisfactorily with cutback asphalt The asphalt provides strength to sand by acting as a binding or cementing agent.
2. The optimum cutback asphalt content for max stability determined from Marshall stability test is generally the same that determined from unconfined test results.
3. For a given cutback asphalt-sand mixture, the compressive strength computed as the average stress from Marshall test results is generally lower than the unconfined compressive strength. Therefore, another criteria must be developed for the application of unconfined compressive test in the design of cutback asphalt mixtures.
4. The analysis of test results obtained in this investigation indicated that the compressive strength

may be related to the Marshall stability as follows:

$$Ms = 4.151\ Cs + 11.20$$

where

Ms = Marshall stability in pounds
Cs = Compressive strength in pounds per square inches

## REFERENCES


[1] Attallah, YT., "Stabilization of Sandy Soils With Asphalt", M.Sc. Thesis, *Faculty of Engineering, Alexandria University, Alexandria, Egypt*, 1985.

[2] Highway Research Board, *Soil and Slope Stabilization and Moisture and Density Determination*, Bulletin No 309, 1967.

[3] Walker, F.K., and Hicks, R.G., "The Use of Sand Asphalt In Highway Construction", Proceedings, *Association of Asphalt Paving Technologists*, vol. 45, pp. 4 29-452, February 1976.

[4] Woods, K.B., Berry, D.S., and Goetz, W.H., *Highway Engineering Handbook*, McGraw-Hill Book Company Inc., New York, Toronto, London, 1960.

[5] The Asphalt Institute, *Mix Design Method for Liquid Asphalt Mixtures*, An advisory Supplement to Mix Design Methods for Asphalt Concrete (MS-2), February 1974.

[6] American Society for Testing and Materials, "Book of Standards", Part 15, 1980.