BEHAVIOUR OF ASPHALTIC MIXTURES UNDER UNCONFINED COMPRESSIVE STRENGTH AND MARSHALL TESTS

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ABSTRACT

The aim of thisstudy is to investigate the behaviour of asphaltic mixtures under unconfined compressive strength and Marchall tests, in order to make a comparison between the results of both tests. Marchall and uncondined compression tests were carried out on asphaltic mixture with different asphalt contents and at two different testing and rates of loading. The study indicated that, for a given asphalt, the Marchall stress is lower than the unconfined compressive strength.

INTRODUCTION

The design of asphaltic mixtures presents a most complex problem, which has yet to be solved. While various design methods have been proposed, none of them can be considered as fully satisfactory at this. One of the more widely known of these methods is Marshall stability test, which is a type of unconfined compressive test in which a cylindrical specimen, 100 mm in diameter by 62.5 mm height is compressed radially at a constant rate strain of 50 mm/minute. The maximum load in newtons which is sustained by specimen is recorded as the Marshall stability value, and the deformation at failure, in units of 0.25 mm, is recorded as the Marshall flow value. This has been adopted by the corps of Engineers, U's. Army for designing asphaltic concrete pavements for airports. It has been also adopted by several state highway departments.

The study aims to establish a comparison between the results of both Marshall and unconfined compressive strenth tests for the asphaltic mixture containing different amount of asphalt and at two different testing conditions, since the maximum safe stress level can be determined also, by using the unconfined compression test.

MATERIALS

The materials used in this investigation were the available and local materials most frequently used by the Egyptian Highway Department.

Aggregate

Calcarious aggregates were used as the coarse aggregate portion in the hot mixtures under study. These materials were secured from "EL-MARKAB" quarry which lies at Alexandria-Cairo desert road about 60 km far from Alexandria.

Sand

Silicious sand secured from desert road at about 100 Kms from Alexandria was used as the fine aggregate portion in the hot mixtures under study.

Calcarious Aggregate Dust

Calcarious aggregate dust secured from "EL MARKAB" quarries was used as mineral filler passing No 200 was about 100 % Table (1) indicates the results of chemical tests performed on coarse aggregate, fine aggregate and minereal filler.

Selected Binder

Table 1. Chemical characteristics of Mineral Aggregates.

Sample No characteristics	1 Gravel	2 Sand	3 Mineral Filler
- Loss on Ignition, %	36.67	3.08	38.86
- Acid Insoluble Residue (mainly Silica)	17.45	91.46	11.42
- Trivalent Oxides $R_2 0_3$, %	1.28	1.6	2.35
Calcium as C_a0, % Magnesium as Mgo, %	38.27 6.00	2.80 0.80	40.13 6.67
- Sulphate as SO_3, %	0.23	0.09	0.26

Asphalt cement 60-70 which is a production of the Alexandria Petroleum Company, Mex, Alexandria, was used in this investigation.

Tests were perfurmed in the laboratories of the same company to determine the characteristics of asphalt cement. Test results are shown in Table (2), [1].

TESTING PROGRAM

Preparation Of Test Specimens

Cylindrical test specimens of 100 mm diameter with 62.5 mm height were prepared at 4.0, 4.5, 5.0, and 6 % asphalt. The amount of each size fraction required to produce a compacted specimen was weighed into separate pans and placed in the oven and they were heated to a temperature of about 180 $\pm$ 5°C. The amount of preheated asphalt cemennt was determined and thoroughly mixed with aggregates. The prepared mixture was placed in the mould and compacted by applying 75 blows on each of the speciments.

After compaction process the specimens were allowed to cool to ambient temperature in its mould and then extruded by means of hydraulic jack. The test specimens were immersed in a water bath for a period of 30 minutes at constant temperature of 60°C. The specimens were removed from the water bath and tested according to Marshall test or the unconfined compressive strength test. Six specimens were prepared at each asphalt content, and then tested in Marshall. Hall of these specimens were under the standard Marshall testing conditions, i.e., at 60° and rate of loading 50.8 mm/min. the other were tested under the unconfined test conditions, i.e., 25°C and 1.27 mm, min loading rate in order to compare the Marshall test result directly with the unconfined test results [2].

TESTING APPARATUS

A Triaxial testing machine (Model T-118) was used to determine the unconfined compressive strength of the asphaltic mixtures. The vertical load was applied at the prementioned temperatures and rates of loading, the compressive strength in netwons per square meter was determined by divising the maximum vertical load at failure by the original cross sectional area of the test specimens.

A universal testing machine (Model AP-1000) was used to determine the Marshall stability. The machine was adjusted to apply load on test specimens through semicircuular testing heads at the desired rate of loading.

Two dial gauges with accuracy of 0.025 mm were used to measure the deformation or the flow value for the test specimens in both tests.

MARSHALL TEST RESULTS

Marshall test results for the asphaltic concrete mixtures tested at 60°C and rate of loading 50.8 mm/min are

Table 2. Characteristics of asphalt cement.

Specification Designation	ASTM Designation	RESULTS
Penetration, 77° F, 100 gm, 5 Sec	D 5	67
R and B softening point, °F	D 36	122.72
Ductility at 77 °, cm	D 113	more than 100
Flash point by cleve land Open Cup, °F	D 92	655
Solubility in CCL_4, %	D 4	99
Kinematic Viscosity at 275°F, Cst	D 2170	360.4
Wax Content % y wgt.	---	1.84
Specific Gravity at 15/4°C	D 70	1.0460
Specific Gravity at 60/60°F	D 70	1.0466

shown in Figure (1). From this Figure it is clear that: 5.0 % Asphalt content is necessary to achieeve the max. stability as well as the max. density.

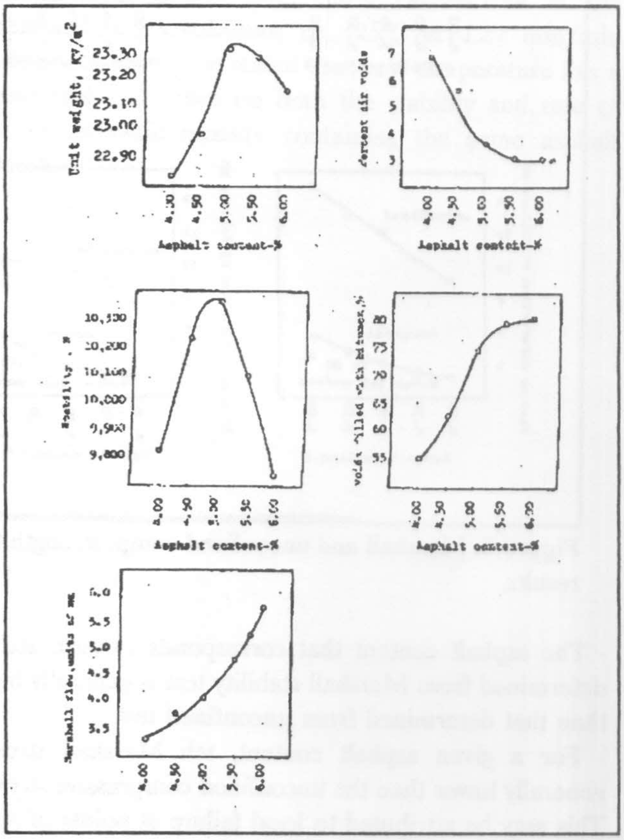

Figure 1. Marshall test results.

The max. stability value is 10368 Newton and the max. density is 23.32 KN/m^3.

- The rate of increase in flow for mixes containing less than 5 % A C is less than this rate for mixes containing more than 5 % AC.
- The percent voids in the mineral aggregate decreases to a minimum vallue, then increases with increasing asphalt content. The minimum value is 14.85 % at 5.0 % asphalt content too.
- The rate of decrease in the percent air voids for mixes containing less than 5% AC, is more than this rate for mixes with AC more than 5 %.
- The rate of increase in the percent voids filled with asphalt for mixes containing less than 5% AC is more than this rate for mixes with AC more than 5 %.

The AC contents corresponding to maximum stability maximum unit weight, and to appropriatee percentages of voids in total mix (4%), and aggregate voids filled with binder (80%) as obtained from Figure (1) are recorded in the following table:

Property Binder Content% (AC %)	unit weight	stability	4% VIM	80% VFB
	5.10	4.80	4.80	5.70

UNCONFINED COMPRESSIVE STRENGTH RESULTS

The test results obtained at the five different asphalt contents and representing the average of the three specimens tested at 60°C and rate of loading equal to 50.8 mm/min, and at 25°C and a rate of loading 1.27 mm/min, are shown in Figure (2), refering to Figure (2) it may be noticed that:

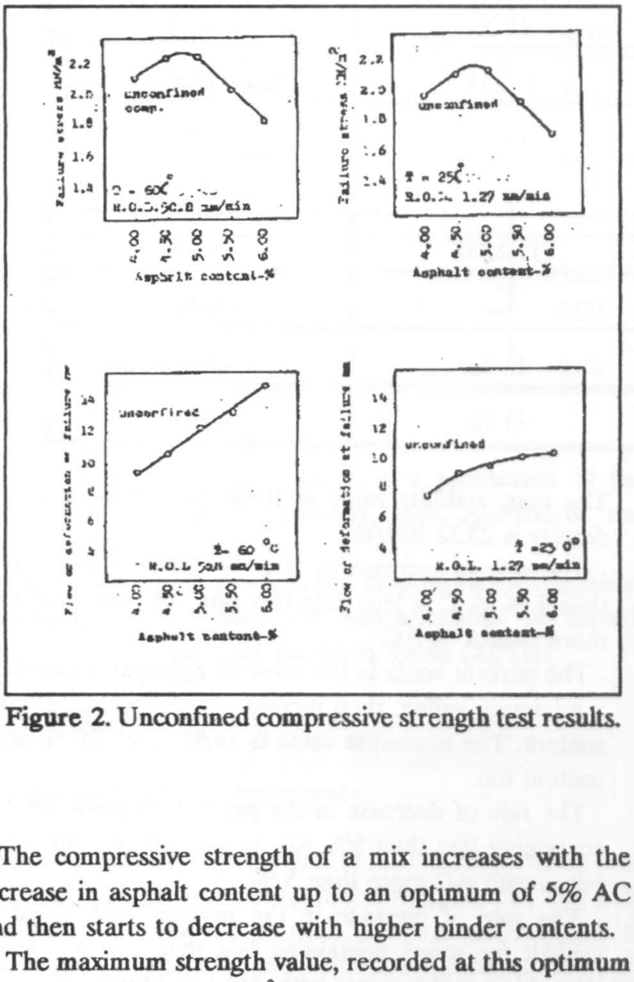

Figure 2. Unconfined compressive strength test results.

- The compressive strength of a mix increases with the increase in asphalt content up to an optimum of 5% AC and then starts to decrease with higher binder contents.

The maximum strength value, recorded at this optimum content was 2.278 MN/m^2 for specimens tested at T= 60 °C and rate of loading 50,8 mm/min. and 2.141 MN/m^2 for specimens tested at T = 25°C and rate of loading 1.27 mm/min.

- The strain value of the mix increases with increasing asphalt content. For example, the strain recorded for mixes containing 4 % AC were 11.94 % & 14.53 % at standard unconfined and Marshall test conditions, respectively.

In addition the stain recorded for mixes containing 6% AC were 19.43 % & 23.82 % at standard unconfined and Marshall test conditions respectively.

COMPARISON OF UNCONFINED AND MARSHALL TEST RESULTS

Marshall and unconfined specimens were prepared and tested at the same conditions of loading and temperature, so that direct comparisons of the strength tests could be made. According to Mculauglin [3], the Marshall stability converted to a hypothetical stress value by dividing the Marchall stability value by the cross-sectional area.

Figure (3) shows compressive strength in MN/m^2 and flow or vertical unconfined compressive deformation calculated from Marshall and unconfined compression tests, plotted against the various asphalt contents assigned in the testing program of this investigation. Referring to this Figure, it may be observed that:

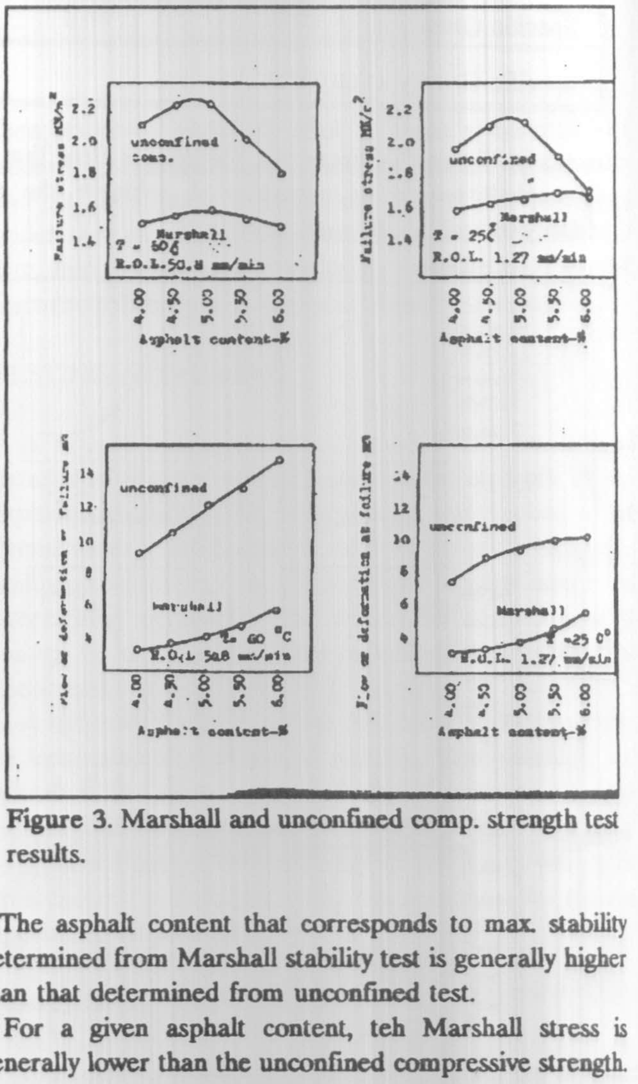

Figure 3. Marshall and unconfined comp. strength test results.

- The asphalt content that corresponds to max. stability determined from Marshall stability test is generally higher than that determined from unconfined test.
- For a given asphalt content, teh Marshall stress is generally lower than the unconfined compressive strength. This may be attributed to local failure at points of higher

stress concentration that may take place at the specimen ends in Marshall tests.

- The asphalt content corresponding to maximum stability is clearly defined from the sharp shape of teh curves respresenting the results of unconfined compression tests in Figure (3). On the other hand, Marshall test curves are too flat that the optimum value has a relatively wide range.

- The compressive strain, recorded from unconfined compression tests,, increases, with the increase in asphalt content of asphaltic mixtures. The rate of this increase was contant for mixes tested at 60°C where it was diminshing for mixes tested at 25 °. On the other hand, the Marshall flow generally increases but at a higher rate with the increase of increase of asphalt contents for all mixes tested at both 25°C testing temperatures.

CONCLUSION

The following are the main conclusions drawn from this investigation:

1. Comparing the Marshall test results performed under the Marshall standard test conditions; i.e. 60°C and 50.8 mm/min loading rate with those carried out at the unconfined test conditions; i.e., 25°C & 1.27 mm/min loading rate, it may be stated that, test temperature has a considerable influence on both the stability and rate of flow of asphaltic mixture containing the same asphalt content.

2. The optimum asphalt content for max. stability determined from Marshall stability test is generally higher than that determined from unconfined test results.

3. For given asphaltic 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 compression test in the design of asphaltic mixtures.

4. The failure compressive strain of asphaltic mixtures, increases with the increase in their bitumen content. Under unconfined compression, the rate of this increase was constant when tested at 60°C, but it was dominating for mixes tested at 25°C. On the other hand, the Marshall flow generally increases but at a higher rate with the increase of asphalt content in the mix when tested at 50°C or 60°C.

REFERENCES

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