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VOLCANIC SAND IN ASPHALT CONCRETE

Dominador S. Pagbilao
Associate Professor

Benjamin D. Verdejo
Head/Assistant Professor

Romeo G. Lopez, Jr.
Civil Engineering Specialist

Department of Civil Engineering
Integrated Research and Training Center
Technological University of the Philippines
San Marcelino, Manila

ABSTRACT

Volcanic sand from three river sources, Abacan, Bacolor and Lubao, were investigated as an aggregate component of hot mix asphalt. Laboratory test samples of asphalt mixtures containing these materials were evaluated according to their Marshall properties and their sensitivity to moisture damage. The Marshall properties of mixtures containing volcanic sand as fine aggregate were found to be inadequate. The use of volcanic sand as a partial substitute to fine aggregate, on the other hand, do not adversely affect the Marshall properties of the mixtures significantly, however, their resistance to moisture damage were significantly reduced and the binder requirement were increased by 20%.

INTRODUCTION

The eruption of Mt. Pinatubo on July 1991 brought a great amount of volcanic sand which, because of its massive volume and impending threat as a lahar mudflow during rainy days, has become a big problem. To this date, its massive utilization and control of flow is a major concern of the government, and concerted efforts are being undertaken towards this effect. Technologists from both the government and non-government organizations are looking at possibilities of utilizing it, mainly as a construction material, while engineers are looking for ways of keeping its flow under control in order to reduce its damaging effects.

Exploratory studies on the properties of the volcanic sand to evaluate its potential use as a construction material have been made (Shimizu and Jorillo, 1992; Bernardo, et.al., 1993). Results of these studies suggested potential uses of Mt. Pinatubo volcanic sand as partial cement substitute, inexpensive filler for asphalt mixtures, fine aggregate for concrete hollow blocks, materials for frits, glazes, tiles, PVC fillers, etc.

The potential of volcanic sand as an aggregate component of asphalt mixtures, both as a total and as a partial substitute to ordinary fine aggregate, was evaluated. This paper presents the results of the investigation.

TEST PROGRAM

Materials and Mix Compositions

The objective of the investigation is to determine the suitability of volcanic sand as a total and as a partial substitute to ordinary fine aggregate in asphalt mixtures. Volcanic sand were obtained from three river sources, Abacan, Bacolor and Lubao, and the portion of the materials finer than 4.75 mm were taken as representative fine aggregate substitutes. Mountain quarry crushed aggregates from Angono, Rizal were taken as the ordinary mineral aggregates. The coarse aggregate (CA) has a maximum size of 9.75 mm and the S1 fine aggregate (FA) passed the 4.25 mm sieve. A penetration graded asphalt cement AC 60/70 was used as binder.

As a total fine aggregate substitute, each of the volcanic sand were combined with CA to form dense grading combinations that most nearly approximate the Fuller maximum density grading curve. The grading combinations of the three volcanic sand with CA are shown in Figure 1. As a partial fine aggregate substitute, volcanic sand from Bacolor and Lubao were combined with FA and CA to form dense grading that also approximate the Fuller curve. The combined grading curve of volcanic sand from Lubao, FA and CA is shown in Figure 2. This mix is henceforth called Mix A. The combined grading curve of sand from Bacolor, FA and CA mixture is shown in Figure 3, and the mix is henceforth called Mix B.

Method of Evaluation

The Marshall Stability test (ASTM D 1559), in conjunction with the Marshall design criteria (Asphalt D 1559), in conjunction with the Marshall design criteria (Asphalt Institute MS-2) is the most widely used single test procedure to determine the suitability of an asphalt mixture. The criteria in this test ensures a mix that is stable, durable and insusceptible to rutting, assuring top performance of the material as a pavement surfacing. Many countries have also adopted specifications related to the resistance of the mixture against the damaging effects of moisture, which is usually reflected as fatigue cracking and wheelpath rutting. Currently, several highway agencies apply either a resilient modulus cutoff ratio (ASTM D 4123) of 0.70 or an indirect tensile strength cutoff ratio (ASTM D 4867) of 0.75, while others specify both as necessary to control moisture susceptibility for both fatigue cracking and for wheelpath rutting field distresses (Lottman and Brejc, 1990).

In this research the mixtures containing volcanic sand as a total substitute to ordinary fine aggregate, were evaluated in accordance to the Marshall design criteria, while the mixtures containing volcanic sand as partial substitute to fine aggregate were evaluated both in accordance to the Marshall design criteria, while the mixtures containing volcanic sand as partial substitute to fine aggregate were evaluated both in accordance to the Marshall design criteria and the indirect tensile strength criteria.

TEST RESULTS

Volcanic Sand As Fine Aggregate

Marshall stability test specimens for each of the three mixes were prepared and tested according to ASTM D 1559 procedures. The summary evaluation of the test results are given in Table 1.

Table 1
Properties of Mixes with Total Fine Aggregate Substitution

VOLCANIC SAND	EVALUATION	RECOMMENDATION
Abacan	- very low stability - air void too high - optimum asphalt - content too high	- disregard-
Bacolor	- high stability - relatively high air void	modify mix design to approximate maximum density grading
Lubao	- sufficient stability - high air void	modify mix design to approximate maximum density grading

The mix with volcanic sand from Abacan has undesirable properties, with a slim chance of improving with modification in its grading. This is due to some inherent properties of the material which are unsuitable for asphalt mixes, e.g. very high absorption and very few fines, as can be seen in the grading combination of this mix (Figure 1). Thus, it was judged that the volcanic sand from this source is not suitable for asphalt mixes, whether as a partial or as a total substitute.

The other two mixes exhibited high stability with high air voids. The solution to the problem of high air voids is to modify the aggregate combination to a denser grading and this modification usually results favorably to an increase in stability. Therefore, the mixes with volcanic sand from Bacolor and Lubao were considered for modification in the aggregate grading by adding S1 crushed fine aggregate. With this addition, the volcanic sand functions as a partial substitute to ordinary FA.

Since the mixture did not pass the Marshall design criteria requirements, the test for moisture damage sensitivity was no longer pursued.

Volcanic Sand As A Partial Substitute to Fine Aggregate

Marshall Test Results

The test results of the two mixtures are presented in the Marshall property curves shown in Figures 4(a) to 4(f). The optimum asphalt content for the two mixtures are determined accordingly, as shown in Table 2. For evaluation of the mixtures according to the Marshall design criteria, the properties of optimum asphalt content were determined from the property curves and are shown in Table 3.

Table 2
Optimum Asphalt Content of Mixtures with Volcanic Sand as Partial Fine Aggregate Substitute

Mix	Asphalt Content at			Optimum Asphalt Content
	Maximum Density	Maximum Stabilty	4 % Air Void	
Mix A	7.00	7.00	7.35	7.12
Mix B	7.00	7.00	7.30	7.10

Table 3
Evaluation of Mixtures

Marshall Property	Design Criteria	Mix A	Mix B
Stability, kg	818 (min.)	1840	1310
Flow, 0.25 mm	8 -14	8.7	8.1
Air Void, %	3 -5	4.3	4.8
Void in Mineral Aggregate, %	15.2 (min.)	17.6	21.3
Void Filled with Asphalt, %	65 - 75	74	77

The Marshall properties of Mix A at the optimum asphalt content satisfies all the design criteria. The notable characteristic of this mixture is that the optimum asphalt content of 7.10% is very high. Ordinary dense graded mixes have optimum asphalt contents in the range of 4.8 to 5.3%. The increase of about 20% in the binder content is due to high absorption property of the volcanic sand incorporated, which constitutes about 24 % of the total aggregate weight.

The Marshall properties of Mix B also show satisfactory values except for the VFA requirement which slightly exceeds the maximum allowable value. The VFA criteria is included in order to limit maximum levels of VMA (Huber, 1992) which as it appears in the design criteria has no limits. Therefore, the results is to be interpreted as exceeding in VMA level. Referring to the combined grading curve of this mix in Figure 3, it can be seen that the mixture is deficient in fines. Hence the high value in VMA can be corrected by a slight addition of filler material. As with Mix A, this mix also required a high binder content, for the same reason that the volcanic sand incorporated was highly absorptive.

Moisture Damage Sensitivity

As indicated above, Mix A demonstrated properties that are acceptable for pavement surfacing. Mix B, with a little addition of mineral filler, is likely to satisfy the Marshall design requirements. As such, this mixture are further evaluated according to their resistance to moisture damage, in accordance with ASTM D 4867-88 procedure.

The results of moisture damage sensitivity test are shown in Table 4. The Tensile Strength Ratio (TSR) for both of the mixtures are 0.45 and 0.48 for Mix A and Mix B, respectively. These are very much below the cutoff ratio of 0.75 adopted by other agencies, and therefore indicate excessive moisture susceptibility of the mix and require treatment before paving (Lottman and Brejc, 1990).

Table 4
Moisture Damage Sensitivity Test Results

Property		Mix A	Mix B
Indirect Tensile Stregth, kg/mm^2	Dry	0.098	0.089
	Wet	0.044	0.041
Tensile Strength Ratio		0.45	0.49

Suggested methods of modification (Asphalt Institute, 1988) to improve resistance to moisture damage include addition of hydrated lime as mineral filler, increasing asphalt content, using higher viscosity grade of asphalt and blending other aggregates. All of these entail an increase in the cost of the material.

CONCLUSION

The result of the Marshall stability test on asphalt mixes using volcanic sand from Abacan, Bacolor and Lubao as fine aggregate showed that the properties of the mixes fall short of the desired properties of a good asphalt surfacing material. Thus, it is concluded that volcanic sand can not be used as a total substitute to ordinary mineral fine aggregates for asphalt mixtures.

Mixtures containing volcanic sand from Bacolor and Lubao as a partial substitute to ordinary fine aggregate, on the other hand, demonstrated adequate Marshall properties. The mixtures, however, have a very low tensile strength ratio, indicating high susceptibility to moisture damage effects. In addition, the binder requirement increased by about 20% of that required in mixtures using ordinary fine aggregates. Both of these are due to the incorporation of volcanic sand which have a very high absorptive property. Thus, the use of volcanic sand in asphalt mixtures is disadvantageous, both in the mechanical properties of the mix, and to the cost of the product.

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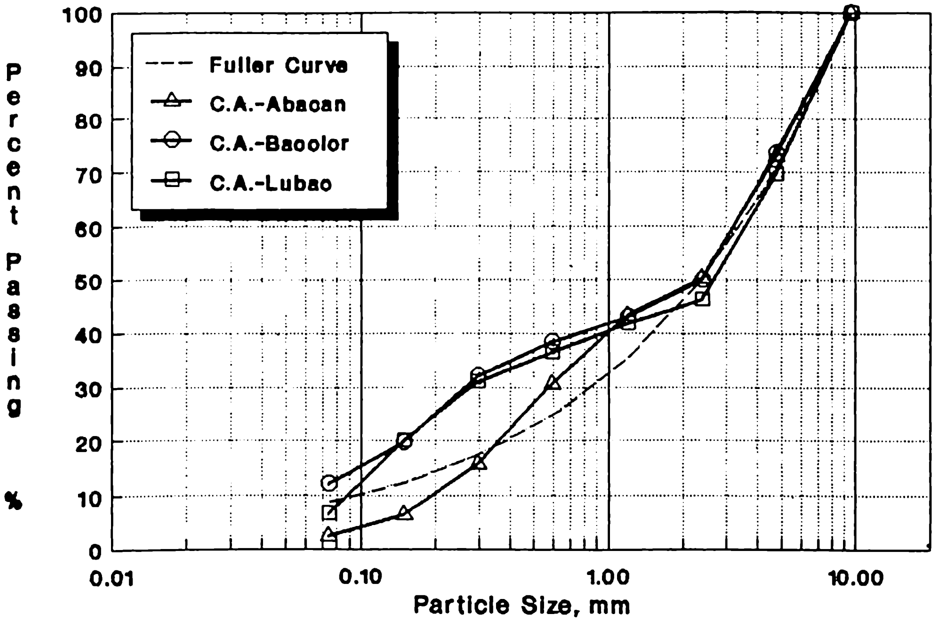

Figure 1
Volcanic Sand as Substitute to Fine Aggregate

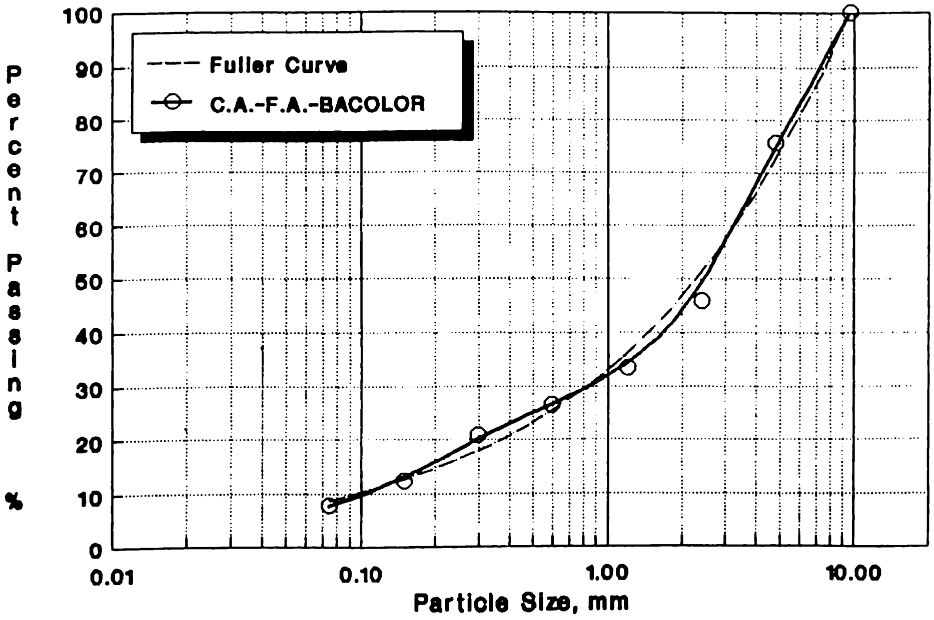

Figure 2
Volcanic Sand from Bacolor as
Partial Substitute to FA

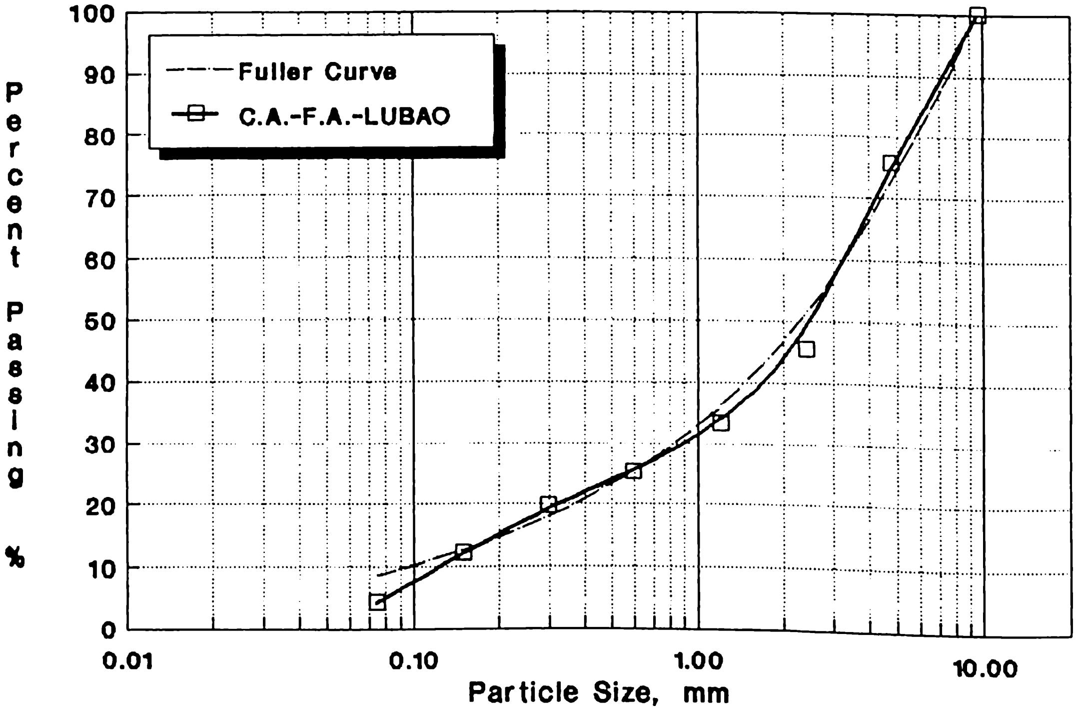

Figure 3
Volcanic Sand from Lubao as
Partial Substitute to FA

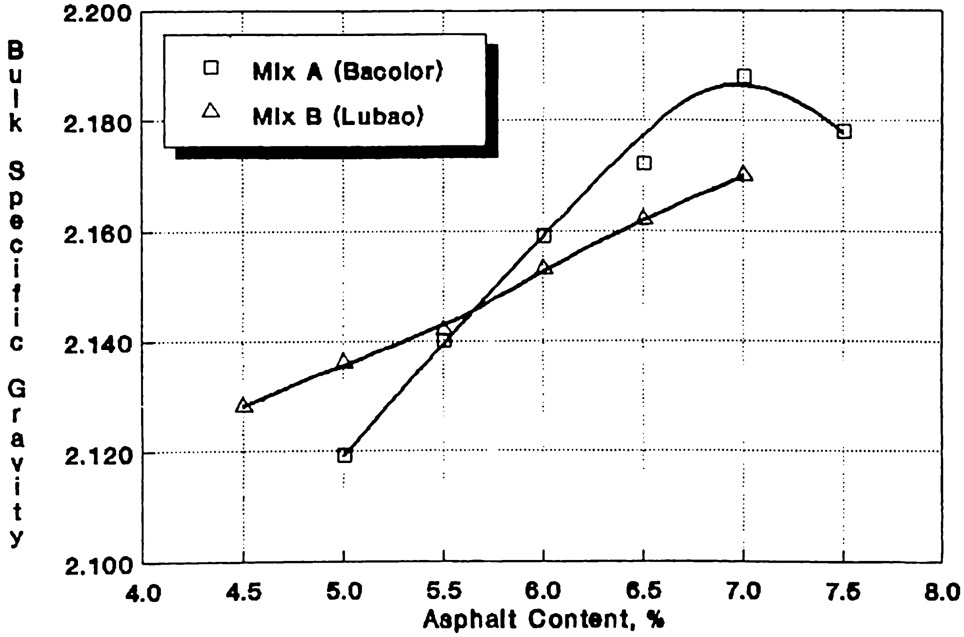

Figure 4(a)
Gmb vs A.C.

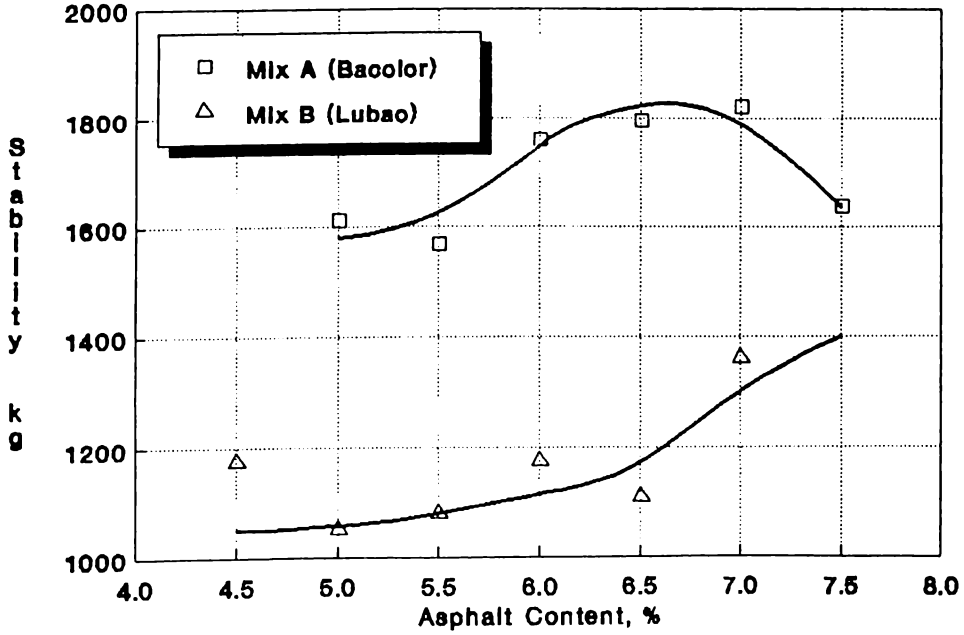

Figure 4(b)
Stability vs. A.C

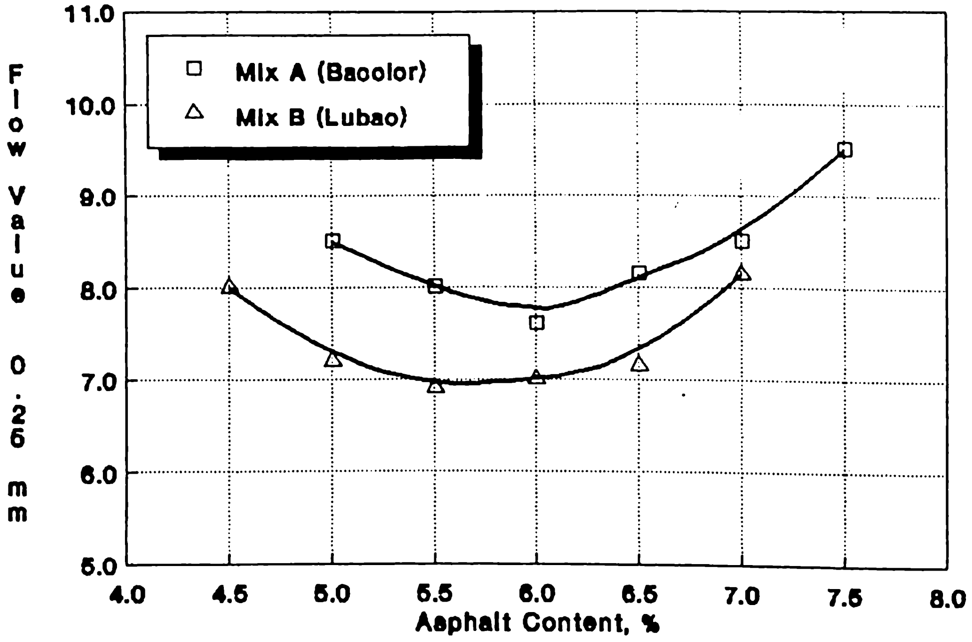

Figure 4(c)
FLow Value vs. A.C.

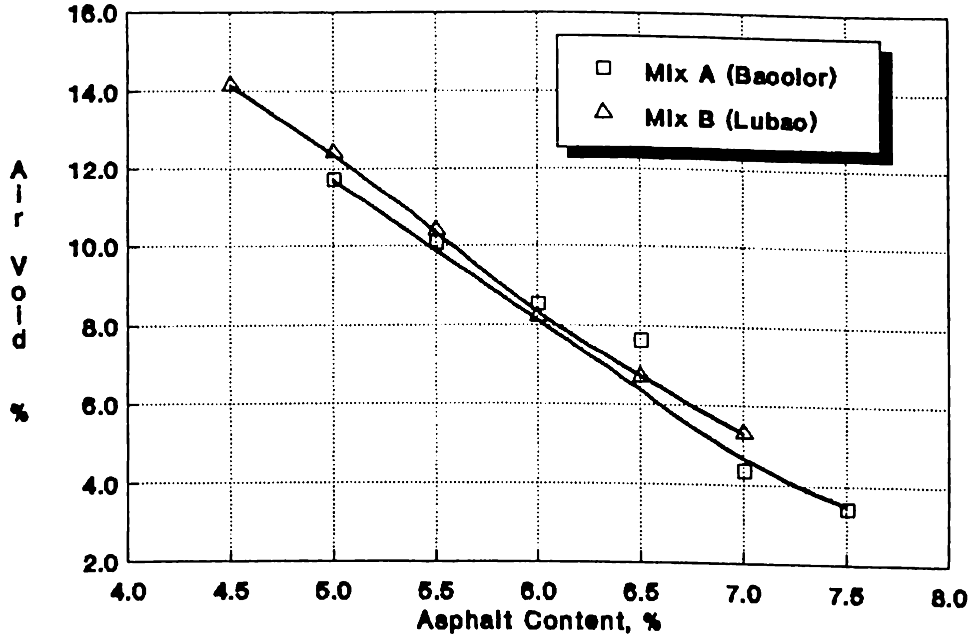

Figure 4(d)
Air Vold vs A.C.

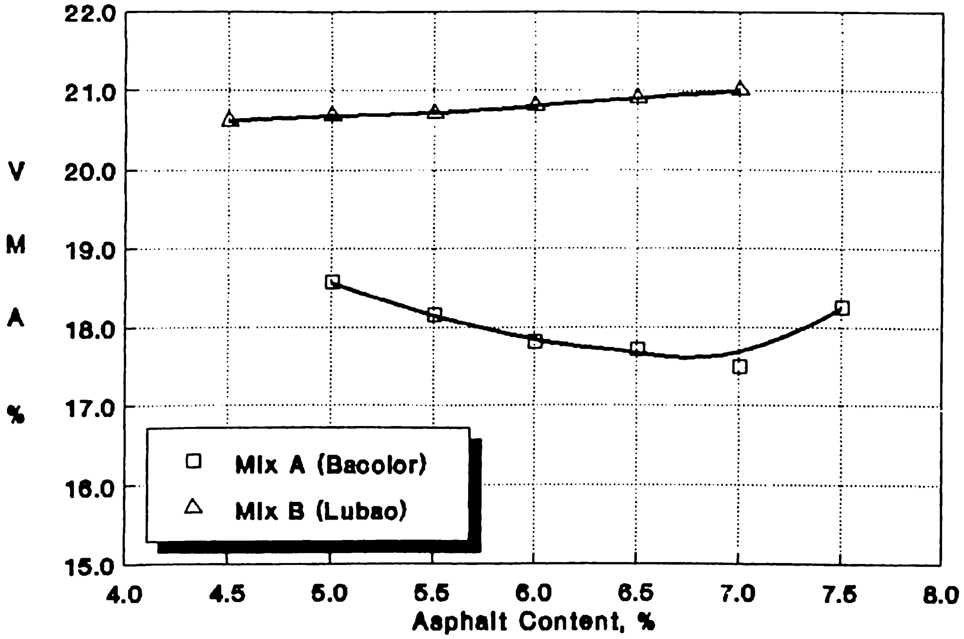

Figure 4(e)
V.M.A. vs. A.C.

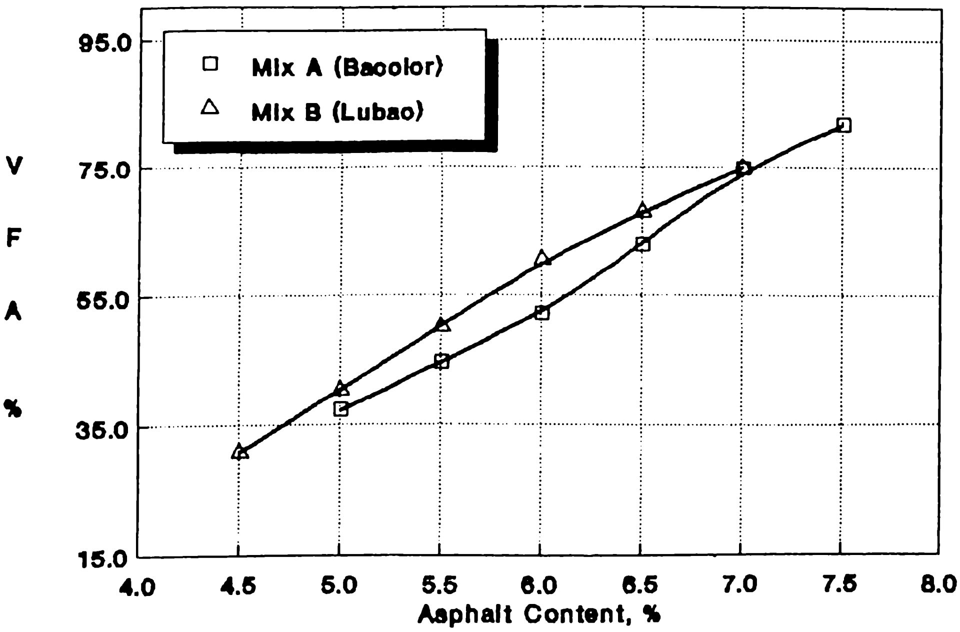

Figure 4(f)
V.F.A. vs. A.C.