STABILITY AND FLOW CHARACTERISTICS

OF

BITUMINOUS CONCRETE AT LOW TEMPERATURES

Report R74-1

January 1974

VERMONT DEPARTMENT OF HIGHWAYS

John T. Gray, Commissioner

E. H. Stickney, Chief Engineer

A. W. Lane, Materials Engineer

Report Prepared By

Bituminous Concrete Section

INTRODUCTION

In the past few years, there has been increasing concern about low temperatures and their effects on roadways. One concern relates to the stability and flow of bituminous concrete at these low temperatures. Stability of a compacted mixture may be defined as its resistance to displacement or deformation. In the field, the term implies resistance to shoving and rutting caused by the action of traffic. Flow is a measure of plasticity and flexibility of the compacted mixture. These two properties are easily measured by the Marshall Method for design and control of bituminous paving mixtures and was used as a guideline for these tests. The objective of the Marshall Method is to predetermine structural properties of a paving mixture by actual measurement.

PROCEDURE

A Type III mix was designed according to the Marshall Method and sampled as outlined in Report 72-1[1]. Marshall briquetts were then made, weighed in air and water, measured and the information recorded. The briquetts were placed in a bath that was capable of automatically controlling various temperatures within a very close tolerance for a 20 minute to one hour period. Immediately after removing the specimen from the bath, it was put in the Marshall compression machine and tested for stability and flow. The tests were run at $0^{\circ}C$, $4^{\circ}C$, $15^{\circ}C$, $30^{\circ}C$, $45^{\circ}C$ and $60^{\circ}C$ in an ethylene glycol solution because of the low temperatures.

The Marshall Method calls for a briquett approximately 2.5 inches in thickness. It was found at the lower temperatures the Marshall compression machine was reaching its limits with the 2.5 inch briquetts. Therefore, the Marshall briquetts were reduced to a thickness of between 1 and $1\frac{1}{4}$ inches.

Some penetration tests were also run on the asphalt cement that was used in the briquetts. The asphalt cement was brought to the test temperatures in the bath with the ethylene glycol solution and then a penetration test was run. The standard test is at 25°C with a 100 gram weighted needle for 5 seconds. However, at 0°C and 4°C, a 200 gram weighted needle and 60 seconds was used.

RESULTS AND DISCUSSION

In the standard Marshall Method(2), it is extremely difficult to seat the flowmeter, start the mechanism, read the Marshall dial at maximum load while simultaneously removing the flowmeter and then stop the machine within a few seconds. Care must be taken to release the pressure on the guide sleeve of the flowmeter instantly, otherwise the flow reading results could be of questionable value.

By using briquetts of the standard thickness (2.5 inches), the Marshall compression machine approached capacity when the bath temperature was lowered to 15°C. Therefore, the thickness was reduced to between 1 and 1¼ inches and the bath temperature lowered to 4°C and 0°C. In this manner, the briquetts were able to be tested, even though the results were again approaching the capacity of the machine which is a dial reading of 641.

For stability, there is a standard correlation table for varying specimen thicknesses from 1 inch to 3 inch so that the results from the 1 inch to 1¼ inch Marshalls could be calculated without any difficulties. The results showed that when the temperatures were lowered, the stability increased substantially.

For flow, there is no standard calibration correlation chart supplied for the Marshall Method. It is suspected by some that the flow might be influenced by the thickness of the specimen. The Corps of Engineers(3) original studies states that the specimen thickness has little effect on flow but their conclusion was based on briquetts thicker than 1.5 inches. A study by Dah-Yinn Lee[4] says that both Marshall stability and flow should be corrected to properly evaluate and compare specimens of nonuniform and nonstandard thickness. Our results indicate that the flow values increase slightly when the temperature is lowered. No correction was made for thickness.

The ethylene glycol solution used had little or no visual effect on the Marshall's but during the test for penetration, the needle point was hard to see due to the color of the solution. At 25°C, the penetration results averaged 109 and at 4°C, the penetration was 45. These tests were run with different weights and times as indicated earlier, therefore, the penetration results are not in direct ratio.

CONCLUSION

This limited investigation, conducted by the Bituminous Concrete Section of the Materials Division, has indicated that the stability value increases substantially as the temperature decreases while the flow value does not show any great change when either the temperature or thickness is varied.

REFERENCES

(1) Procedures for Recovery of Asphalt Cement in Marshall Method Design Specimens.

(2) The Marshall Method for the Design and Control of Bituminous Paving Mixtures.

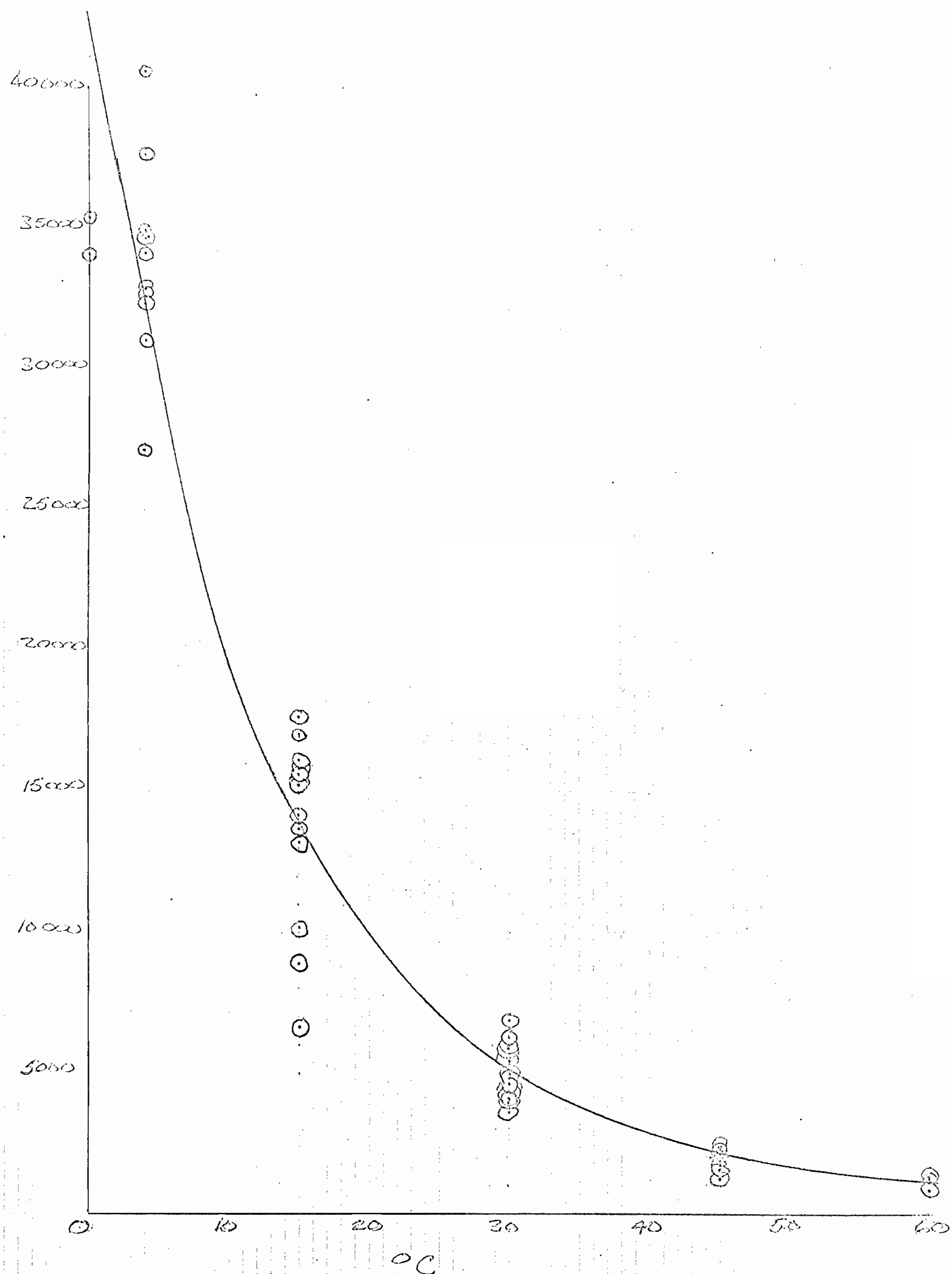
(3) ASTM STP No. 252 Application of the Marshall Method to Hot Mix Design.

(4) HRR #273 "Evaluation of Marshall Stability and Flow Values of Asphaltic Paving Mixtures".

TABLE I

Temperature	0°C		4°C		15°C		30°C		45°C		60°C	
Test No	Stability	Flow	Stability	Flow	Stability	Flow	Stability	Flow	Stability	Flow	Stability	Flow
1	35432	--	37610	14	13655	8	4083	7	1553	5	824	3
2	34134	7	34735	17	16122	15	4576	10	1768	5	1216	8
3	46897	15	40650	15	15593	10	4016	10	1853	11	1290	8
4	47816	14	35095	15	17063	9	3670	15	2200	8		
5			27145	16	17660	15	6222	10	2412	10		
6			32459	12	15205	10	4835	15	2182	10		
7			34127	14	13170	20	4995	13	2093	10		
8			32629	18	15829	8	5988	14	1285	14		
9			32985	12	14153	12	4942	12	2071	7		
10			34753	13	10110	18	4998	8	2198	12		
11			31054	13	8977	5	5942	9	2264	13		
12					6683	4	5560	10				
13					15356	15	6920					

STABILITY VS TEMPERATURE



FLOW VS TEMPERATURE