VARIATION IN TEMPERATURE AND MECHANICAL PROPERTIES OF ASPHALTIC CONCRETE DUE TO STORAGE IN SURGE BINS

By

John L. Hearld
Research Specialist III

and

Larkin D. Lay
Research Specialist II

Under General Supervision of

S. C. Shah
Acting Bituminous Research Engineer

Research Report No. 67

Research Project No. 72-2B(B)

Conducted by
LOUISIANA DEPARTMENT OF HIGHWAYS
Research and Development Section
In Cooperation with
U. S. Department of Transporation
FEDERAL HIGHWAY ADMINISTRATION

March 1973

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

IMPLEMENTATION

The Department's present specification for allowable storage time of asphaltic concrete will be changed to reflect the maximum allowable time reported in this study.

INTRODUCTION

The Louisiana Department of Highways specifications on asphaltic concrete allow the contractors to use silos or surge bins for storage of asphaltic concrete mixtures. However, the maximum allowable storage time of the hot mix, if the contractor elects to use such a facility, is set up arbitrarily. The present allowable time for heated silos is established according to the maximum size of aggregate in the mix and the type of heating system used in the storage facility. For unheated surge bins, the maximum allowable storage time is two hours.

This study was initiated to seek data relative to the effect of storage and temperature on the physical properties of asphaltic concrete. However, temperature was considered a major criteria for storage time.

The scope of the study was confined to unheated surge bins at a hot mix plant during a late summer period. The mixture evaluated was a wearing course sand-gravel mix with 3/4 inch maximum size aggregate.

METHOD OF PROCEDURE

During the time this study was initiated only one hot mix contractor in the State had the surge bin facility available. Therefore, the data acquisition is within the confines of a single unheated surge bin facility. Figure 1 is a photograph of the surge bin system. The hot mix is loaded into the surge bin from the top by means of a conveyor trolley. The unloading method is of the drop bucket type and is controlled electronically. The surge bin used in this study had a capacity of 200 tons.

Sampling and Testing

Samples of hot mix were taken during each one-third of the surge bin loading. The loading of the surge bin took approximately one and one-half hours and during this period temperatures were taken periodically (approximately every 9 to 12 tons). The samples were used for molding the Marshall specimens, running the gradation analysis and making the Abson recovery of asphalt cement for penetration-viscosity determinations.

After loading of the surge bin was completed, it was sealed for a period of 19 hours. After this undisturbed period of 19 hours, the bin was partially unloaded every four hours during the working hours for temperature measurements. Concurrently, during this unloading operation, samples were obtained for determination of Marshall test properties, gradation and Abson recovery. This procedure was followed for each succeeding 24 hour period up to 51 hours. At this time the temperature in the surge bin had dropped to the lower limit of the LDH standard specifications (275° F) and hence was unloaded.

Preliminary analysis of the temperature data indicated a need for a more precise method of obtaining temperature within the surge bin itself rather than in the truck beds. Therefore, it was felt that installation of the thermocouple wires at various points in the surge bin would give a more accurate and overall average of these temperatures. This was accomplished by placement of 15 thermocouple wires in three lengths of conduit. The first conduit was placed 12 to 18 inches from the wall of the surge bin, the second at five feet from the wall and the third at eight feet from the wall. All thermocouples were placed to take readings at five foot intervals from top to bottom, with the first reading being one foot from the bottom. These thermocouples were connected to a Honeywell Automatic Temperature Recorder that printed temperature of each wire at 12 minute intervals. These readings were taken for a total of 64 hours. The hot mix in the surge bin was then unloaded due to the currently allowable temperature being reached. Due to some malfunction, thermocouple lead 13 failed to show any temperature recording during the evaluation period.

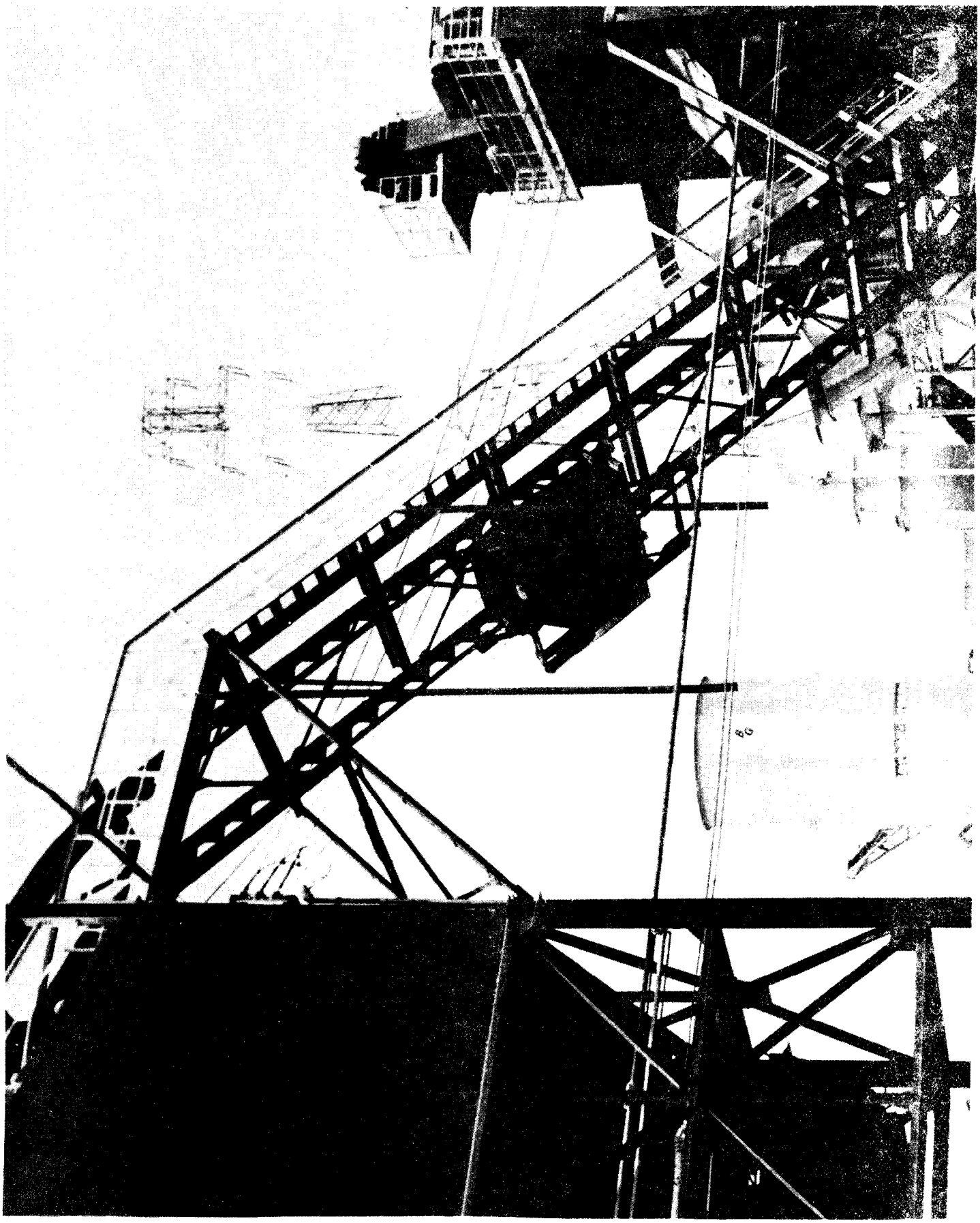


Figure 1 - The Surge Bin System

Figure 2 shows a cross-section of the storage bin with corresponding locations of the thermocouple leads. The surge bin system also has a built-in temperature measuring device, the lead wire of which is located at the discharge gate of the bin. The temperature is indicated on the dial gauge.

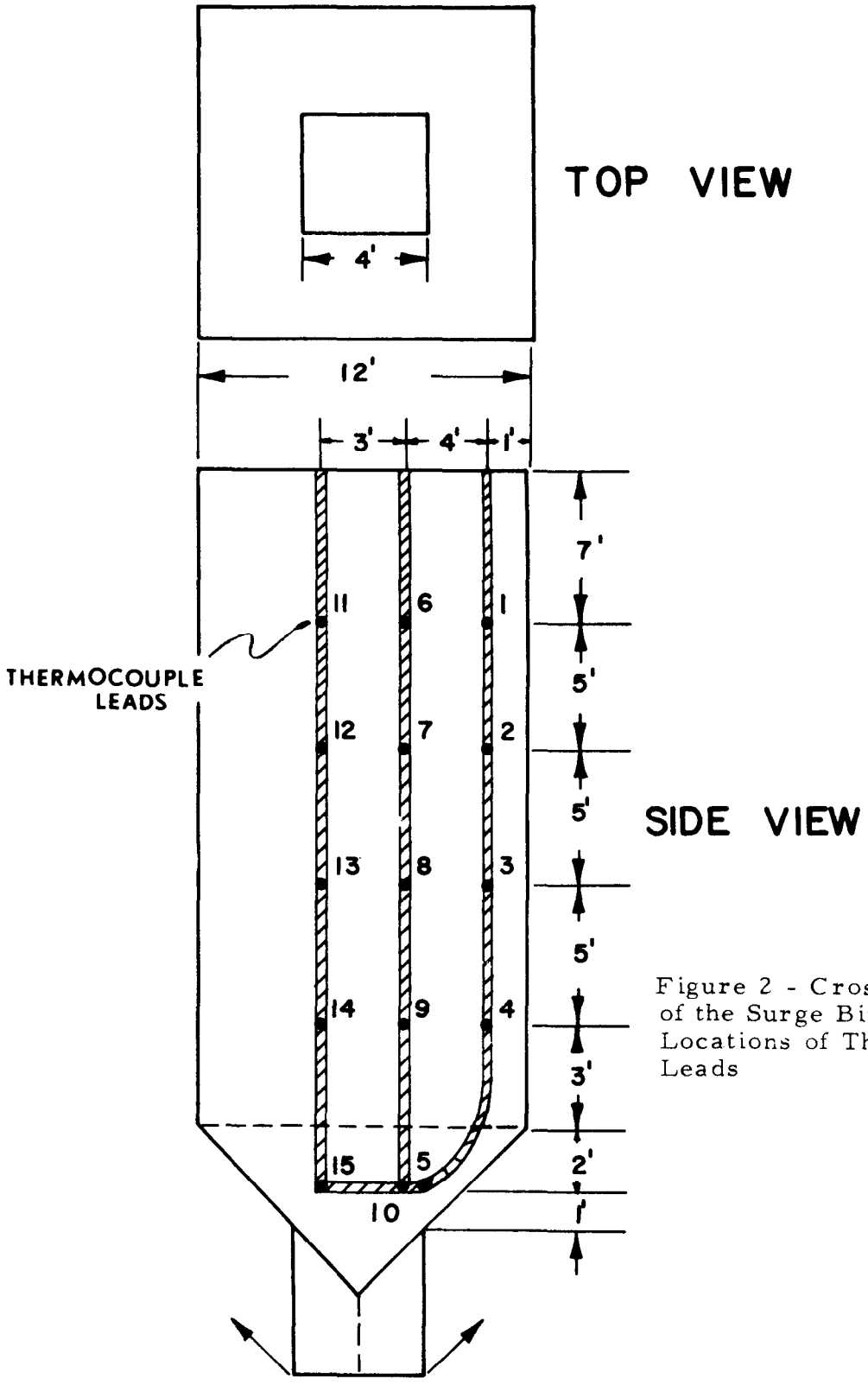


Figure 2 - Cross-Section of the Surge Bin Showing Locations of Thermocouple Leads

TEST RESULTS

Marshall Test Results

To investigate the effect of storage time on the Marshall test properties of hot mix, specimens were molded at different time periods during the loading, storage and unloading of the surge bin.

A total of nine briquettes were molded during the loading period. This was representative of each one-third of the total mix in the surge bin. In the following two days, three briquettes were molded every four hours during working hours as the surge bin was being unloaded.

Table 1 shows the Marshall test properties of the molded specimens. The storage time does seem to have had some effect on the stability of the mix as is indicated by an increase in these values for all mixes taken after the initial loading. However, these values are within the magnitude of variation generally encountered on a hot mix project. Figure 3 is a graphical representation of data shown in Table 1.

Table 1

COMPARISON OF RESULTS OF LOADING AND STORAGE TIME ON AVERAGE MARSHALL TEST PROPERTIES

	Loading	19hrs.	23hrs.	27hrs.	43hrs.	47hrs.	51hrs.
Temperature, ^{o}F	355	345	340	330	300	300	290
Specific Gravity	2.33	2.33	2.34	2.33	2.32	2.31	2.34
Voids - %	4.9	4.9	4.5	4.9	5.3	5.7	4.5
Stability, lb.	1302	1865	1815	2082	1604	1877	1776
Flow	7	6	6	6	5	6	7

Penetration and Viscosity of Asphalt Cement Recovered by the Abson Method

At the time that Marshall specimens were prepared, samples were taken to recover the asphalt cement to test the effect of storage time on the penetration and viscosity. Table 2 lists the penetration-viscosity of the recovered asphalt. Figure 3 is a graphical representation of data shown in Table 2. By comparing these results to the stabilities, it appears that the hardening of the asphalt cement, because of storage, may have contributed to the increase in stability values discussed in the preceding section.

Although stability is one of the criteria for a good hot mix, it is also known that when the viscosity of the asphalt cement increases four fold from the original due to oxidation, this also increases the possibility of brittle mix with subsequent cracking and early failure of the roadway.

Table 2

EFFECT OF STORAGE ON PROPERTIES OF RECOVERED ASPHALT

	Org.	Loading	19hrs.	23hrs.	27hrs.	43hrs.	47hrs.	51hrs.
Penetration @77F	60	51	47	46	39	43	42	48
Viscosity @140F	4268	10790	12392	13813	25232	18728	17658	16144

Gradation Analysis

The gradation of the extracted aggregate for each loading and unloading sample is shown in Table 3. Comparison of loading and unloading data indicates some segregation of the finer material. However, the magnitude of the segregation, as indicated by increase in the material passing the No. 40, 80 and 200 sieve, is within the bounds of the job mix formula for the mix.

Time-Temperature Relationship

The most important element to be considered in the storage of asphaltic concrete in silos or surge bins is the time-temperature relationship. The hot mix must remain at a workable temperature to insure success of a good laydown on the job site. Because of temperature variations in the surge bin, whether in depth or distance from the side wall, the hot mix must be removed at the time the the coldest portion falls below the current specification limits.

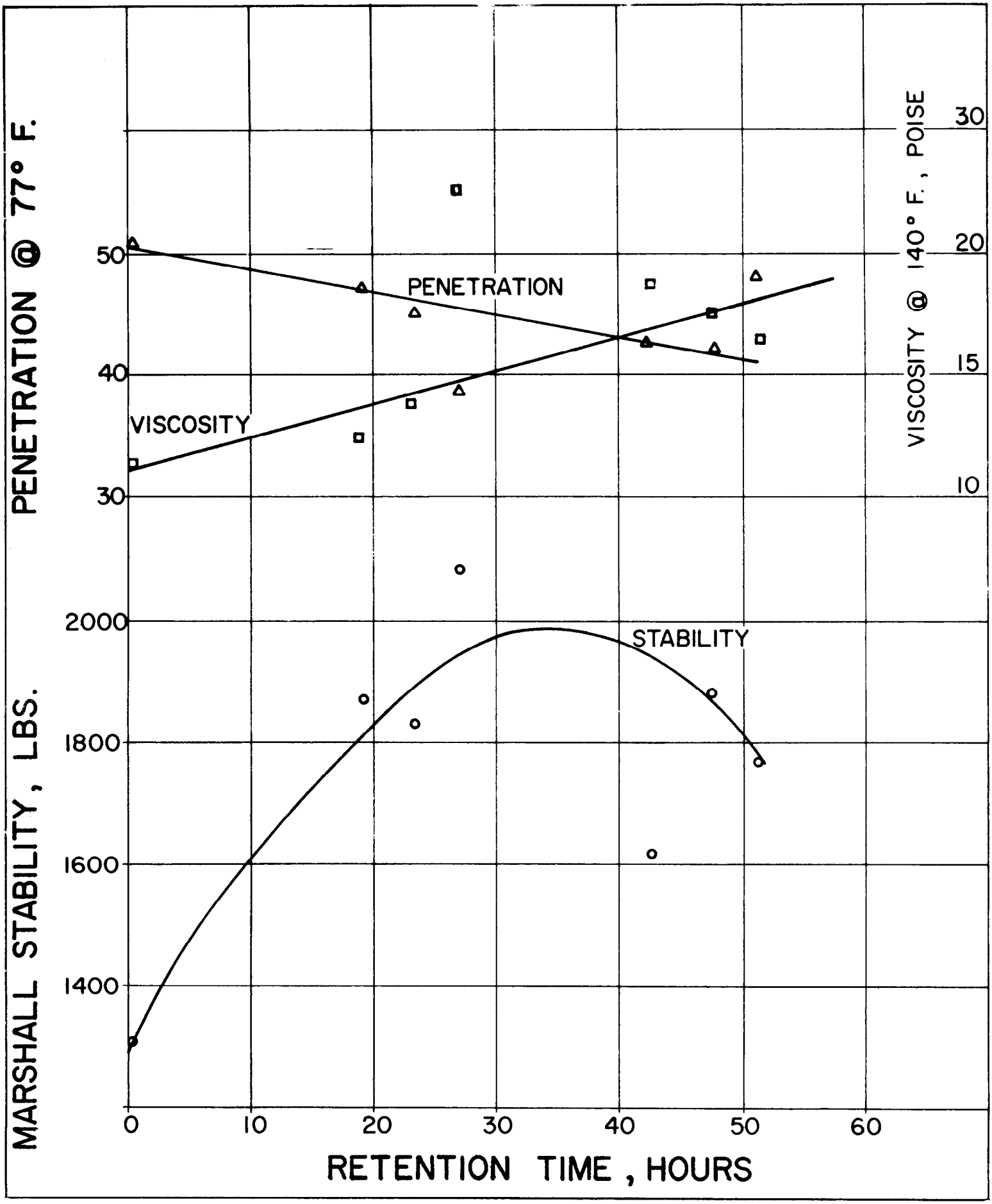


Figure 3 - Effect of Storage Time on the Stability and Penetration-Viscosity of Recovered Asphalts

TABLE 3

GRADATION OF EXTRACTED AGGREGATE

U. S. Sieve	Pugmill	Loading Period				Unloading Period				
		1st 1/3	2nd 1/3	3rd 1/3	19 hrs.	23 hrs.	27 hrs.	43 hrs.	47 hrs.	51 hrs.
		PERCENT PASSING								
3/4 in.	100.0	100.0	100.0	100.0	100.0	100.0	98.8	100.0	100.0	100.0
1/2 in.	96.4	97.1	97.7	95.5	99.1	96.2	95.1	95.8	96.5	94.1
3/8 in.	85.6	86.4	84.3	87.4	87.6	84.7	82.2	84.4	86.9	83.1
No. 4	62.7	65.8	58.5	66.7	66.4	62.5	62.8	64.4	64.9	62.9
No. 10	50.2	52.7	48.0	51.9	53.1	50.1	50.6	51,0	51.7	50.8
No. 40	25.1	27.4	24.1	24.5	29.8	27.2	28.2	28.4	28.8	27.6
No. 80	9.6	11.1	10.1	9.1	16.0	12.8	14.1	13.3	15.3	13.0
No. 200	4.0	5.0	5.1	4.3	7.3	5.9	6.3	5.9	6.6	5.9
% AC	5.5	5.0	4.9	5.1	5.3	5.0	5.1	5.0	5.0	4.8

Table 4 is a listing of the temperature data for the storage period. The temperatures were averaged for each four hour interval for various depths, distances from the side wall and the entire surge bin. Figure 4 is a graphical representation of the time-temperature relationship for different depths in the surge bin. The data in the table and the figure warrant the following comments:

1. If 275°F is considered the minimum lay down temperature for hot mix, then nine to twelve hours seems to be the maximum storage time before removal of the entire stockpile of hot mix in the surge bin. This means that anytime any portion of the surge bin reaches a minimum of 275°F, whether it be the top, middle or bottom, the complete stockpile of hot mix must be removed so that it will still be acceptable on the jobsite.

2. For the completely charged bin, the temperature drop seems to be the least in the middle and bottom portion of the surge bin. Likewise, the top layer indicates the largest drop in temperature during the storage period.

3. The temperature drop decreases towards the center of the surge bin.

4. The largest drop in temperature, from the initial to the final period, was indicated by thermocouples 5 and 11 (126F) and the least by thermocouples 14 and 15 (0F and 3F).

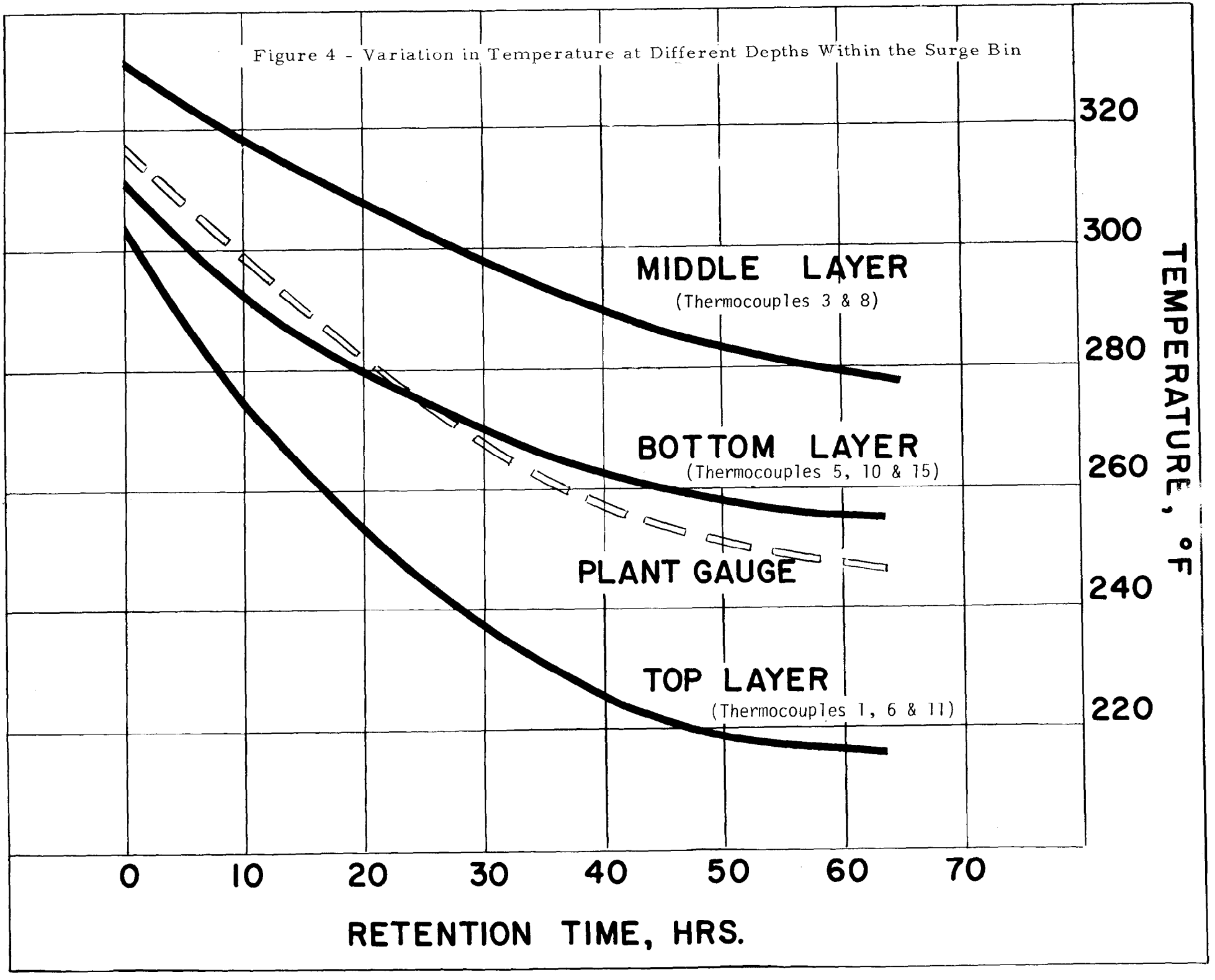
5. The temperature indicated by the plant gauge cannot be considered as the true temperature for retention time determination, since it measures the temperature of the botoom layers only.

TABLE 4
AVERAGE TEMPERATURE VARIATION IN SURGE BIN
(DEG. FAHR)

Interval Hour	1 thru 15	1 thru 5	6 thru 10	11 thru 15	Thermocouple Lead 1, 6, 11	2, 7, 12	3, 8	4, 9, 14	5, 10, 15
1-4	316	314	321	311	307	316	329	318	311
	(40)	(20)	(38)	(17)	(13)	(40)	(12)	(13)	(10)
5-8	305	299	315	298	289	300	323	314	301
	(58)	(36)	(53)	(48)	(13)	(31)	(23)	(3)	(40)
9-12	296	288	309	291	274	292	318	311	292
	(82)	(54)	(68)	(58)	(22)	(64)	(31)	(9)	(66)
13-16	290	280	303	286	264	285	313	308	285
	(94)	(63)	(67)	(63)	(27)	(64)	(36)	(16)	(80)
17-20	285	274	298	283	256	282	309	305	280
	(99)	(66)	(83)	(71)	(30)	(57)	(40)	(22)	(89)
21-24	280	268	293	278	248	277	305	302	275
	(93)	(69)	(82)	(80)	(37)	(60)	(40)	(28)	(97)
25-28	275	263	289	274	241	271	302	299	271
	(112)	(71)	(96)	(90)	(43)	(65)	(41)	(34)	(106)
29-32	272	260	285	270	237	266	299	297	269
	(114)	(72)	(93)	(96)	(45)	(71)	(58)	(39)	(110)
33-36	269	257	282	268	233	262	296	294	267
	(112)	(70)	(96)	(97)	(46)	(72)	(43)	(43)	(111)
37-40	267	254	279	268	230	261	293	292	265
	(112)	(68)	(98)	(101)	(46)	(66)	(56)	(46)	(112)
41-44	264	250	275	269	226	262	289	289	262
	(117)	(68)	(99)	(107)	(46)	(53)	(43)	(51)	(115)
45-48	262	247	271	268	223	259	287	287	259
	(121)	(69)	(101)	(110)	(47)	(51)	(43)	(57)	(118)
49-52	259	245	269	265	220	255	284	285	257
	(123)	(69)	(102)	(113)	(49)	(56)	(44)	(59)	(120)
53-56	257	242	266	264	218	251	282	283	256
	(125)	(66)	(102)	(113)	(49)	(59)	(44)	(63)	(124)
57-60	255	240	264	263	217	250	279	282	255
	(123)	(64)	(102)	(115)	(48)	(56)	(44)	(66)	(119)
61-64	254	239	262	263	215	248	277	281	254
	(124)	(62)	(101)	(117)	(48)	(54)	(56)	(70)	(124)

Note: Numbers in parentheses represent the range of temperatures recorded during the interval for the thermocouples indicated.

Figure 4 - Variation in Temperature at Different Depths Within the Surge Bin



CONCLUSIONS AND RECOMMENDATIONS

Based on the laboratory and field results on sand-gravel wearing course mix, it is shown that:

1. Storage of asphaltic concrete in unheated insulated surge bins without inert gas should be limited to a maximum time of 12 hours. After this period of time the changes in the physical properties of the asphalt and the average temperature drop warrant the removal of the hot mix from storage.

2. The one temperature recording in the surge bin, as provided by the gauge recorder, cannot be regarded as the true temperature at various locations within the surge bin.

3. Anytime any portion of the surge bin reaches a minimum of 275° F, whether it be the top, middle or bottom, the complete stockpile of hot mix must be removed so that it will still be acceptable on the jobsite.

It is recommended that the presently specified time of two hours maximum for storage of hot mix in unheated surge bins be revised to reflect the findings reported herein. Furthermore, it is also recommended that evaluation of storage time be extended to surge bins at other plants in the State with emphasis on the effect due to seasonal weather conditions and different size and type of aggregates.