FINAL REPORT

SEGREGATION OF ASPHALT MIXES CAUSED BY SURGE SILOS

by

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ABSTRACT

Segregation of asphalt mixes continues to be a problem in Virginia, particularly with base mixes and coarse surface mixes. Although the problem is encountered primarily on jobs using surge silos, it has been related to other factors such as mix design and handling or paving techniques.

This report discusses changes in equipment and production procedures that reportedly have alleviated the problem, including specifications devised to eliminate segregation in the surge bin. Also discussed is a field project in which an attempt was made to prevent segregation by changes to the equipment and the production and paving processes.

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PURPOSE AND SCOPE

Over the past 15 to 20 years, surge and storage silos have been used to store hot plant mix so as to achieve increased flexibility in production and decreased production costs. A surge silo enables a plant to supply more than one type of mix at any one time, and economy is realized by shortened truck loading times, increased plant production, and increased rate of paving.(1,2)

In 1980 segregation attributed to the use of surge silos occurred on two paving projects in Virginia. Subsequently, it was suggested at a meeting of the Research Council's bituminous research advisory committee that a limited investigation of the segregation problem caused by surge silos be undertaken. The purpose of this investigation was (1) to determine the extent of the problem statewide by a questionnaire survey, and (2) to examine literature and make personal contacts to seek possible solutions. It was anticipated that the solutions could be tried in the field if segregation was encountered in 1981.

QUESTIONNAIRE SURVEY

A questionnaire was distributed to the state's eight district materials engineers and seven replies were received. The purpose was (1) to determine the extent of the segregation problem and whether similar types of segregation were common to all districts, and (2) to solicit information on any means that had proven successful in alleviating or eliminating the problem.

Approximately 20 surge silos have been or are being used by paving contractors who supply asphalt mixes to the Virginia Department of Highways and Transportation. These are distinguished from storage silos on the basis of how long the

mix is stored. Usually, a mix is stored in a surge silo for less than 12 hours, whereas it is left in storage silos for longer periods.(3)

All districts have used or presently use surge silos; however, most of the usage is concentrated in the Culpeper, Richmond, Staunton, and Suffolk districts. Five of the seven districts responding to the questionnaire have experienced segregation in asphalt mix supplied from surge silos, and the remaining two have had little experience with the silos. In all cases where problems were noted, segregated areas were detected visually at regular intervals in the pavement, and these areas appeared to coincide with the beginning or end of each truckload of mix. In most cases the segregation was not detected by the routine gradation analysis performed on the mix sampled from the truck at the hot mix plant. If the mix was segregated in the truck, the sampling procedure was not such as to detect it.

Base and intermediate mixes were reported to be more prone to segregate than were fine surface mixes.

In Virginia, various methods have been used in attempting to correct the segregation, the most common being:

1. loading trucks with 3 dumps (front, rear, and middle of truck) rather than with a single dump;

2. modifying the hot mix plant and silo;

3. maintaining plant mix at a level above the cone of the silo;

4. dumping paver wings a minimum number of times; and

5. changing the source of materials and the mix design.

In the reported attempts at correction, segregation was eliminated in only two of nine cases. Although improvements were noted in six of nine cases, the segregation was still considered detrimental to the quality of the pavement. In only one case was the use of the silo disallowed when modifications proved to be ineffective. No one seemed to consider the segregation to be related to a specific brand of silo.

LITERATURE SEARCH AND PERSONAL CONTACTS

A literature search was made and highway departments, national organizations, and equipment manufacturers were contacted for information on the causes of segregation in mixes and solutions to the problem.

Causes of Segregation

Much of the information gathered in the literature search was similar to that obtained in the questionnaire survey and was cited by the persons contacted during the study. Brock has noted that segregation can be introduced if the mix is discharged from a conveyor or stationary chute into a silo.(4) Sometimes, however, segregation that originates in the cold feed bin, drum-mixer, and hot bins is erroneously attributed to the use of a silo.

West Virginia officials contacted indicated that they had encountered problems with the silo only when it was operated at low levels or when trucks were loaded through an empty silo.* North Carolina reported having detected some problems with coarse mixes, and they attributed these to the use of a silo on the basis of inspections of plant mix before it was introduced into the silos and after it was dumped into the truck.**

Another source of segregation can be the manner in which the mix is transferred from the silo to the truck. If the mix is dumped in the center of the truck body, the coarse material tends to roll to the edges.

Finally, segregation can occur during the paving operation. Here, problems can be encountered with mixes that are prone to segregate, and in the case of a mix that has become partially segregated, the problem may be exacerbated.

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*G. W. Steele: personal correspondence October 1981.

**J. E. Grady, Jr.: personal correspondence Nobember 1981.

Solutions to the Problem

In the technical bulletin previously cited,[4] Brock lists some modifications to silos that can be undertaken to eliminate segregation. Improved methods of charging the silo use a batcher or rotating chute. A batcher collects mix at the top of the silo and drops it when full. It is important that material be dropped straight into the center of the batcher and that the batcher be allowed to fill completely each time before dumping. A rotating chute deposits mix vertically as it rotates around the silo. It is important that it be designed to deposit the mix the proper distance from the edge of the silo and also that it be checked to ensure that a hole does not form as indicated in Figure 1.[4] Brock reports that "All bins being manufactured today are equipped with either a batcher or rotating chute."

Foster has noted that it is possible to add baffles in the silo to prevent segregation, and that placing a cone inside the silo near the discharge gates reportedly helps remix the material (Figure 2).[5]

Upon noting their porblems with segregation, the West Virginia officials revised their specifications. They now specify that "Permission may be granted for bin usage that consistently results in mixtures that have gradation and temperature properties of no less quality than specified mixtures discharged directly from the plant's mixing operation...." They also specify that "affixed to each bin and visible to the loading operator shall be an indicating device, which will be activated when the material in the bin reaches the top of the sloped portion of the bin."

To overcome its problem with coarse mixes, North Carolina does not require the use of specific equipment to prevent segregation, rather it attempts to minimize the problem by requiring that "the mixture meet the job mix formula requirements upon discharge from the storage bin...." Producers have used some of the methods cited in the responses to the previously discussed questionnaire.

In 1973, New Jersey conducted a study to develop a procedure for evaluating surge and storage bins for acceptance.[6] The effects of storage on the properties of the binder, maintenance of the temperature of the mix, and segregation were determined and a sampling and testing plan was devised. Before a silo is approved samples are taken at specified intervals when the silo is being filled and at similar intervals when

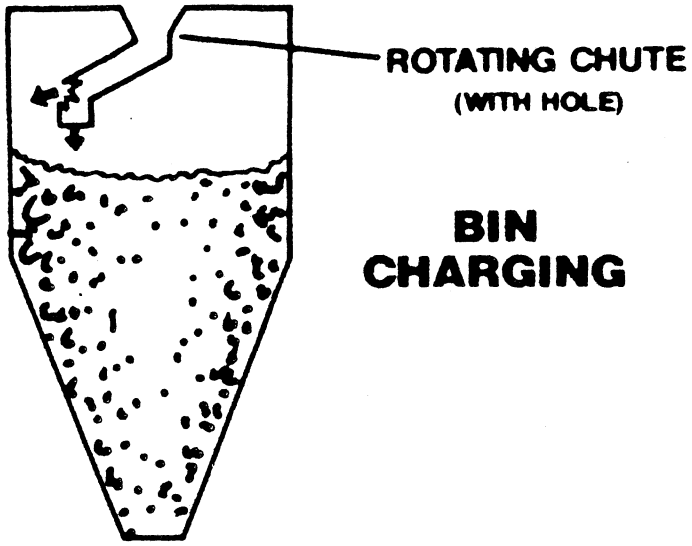

Figure 1. Rotating distribution chute.

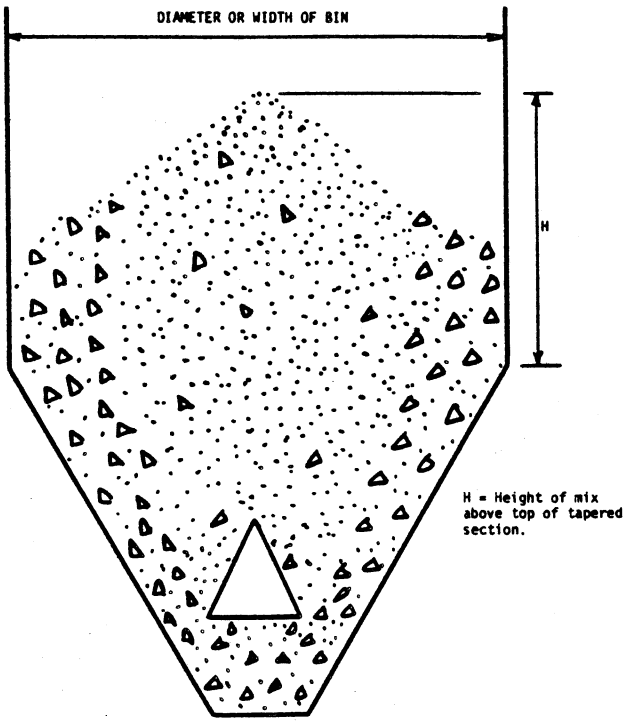

Figure 2. Silo with cone.

it is being emptied, and the gradations are required to agree. A statistical analysis is performed on individual sieves and the results must be within certain tolerances. If the results are satisfactory, the silo is approved unconditionally. If the results indicate no segregation until the last several loads, a conditional approval might be issued under which use of the last several loads is not allowed.

Two equipment manufacturers — Barber Greene* and ASTEC Industries, Inc.[4] — provided information on the causes of mix segregation, including those originating in silos. Many of their suggestions for eliminating segregation were the same as those given by respondents to the survey questionnaire.

To minimize or prevent segregation when transferring the mix from the silo to the truck, consecutive dumps should be made at the front, rear, and middle as shown in Figure 3. In addition to controlling segregation, this practice promotes remixing of the material as it is dumped and goes through the paver.

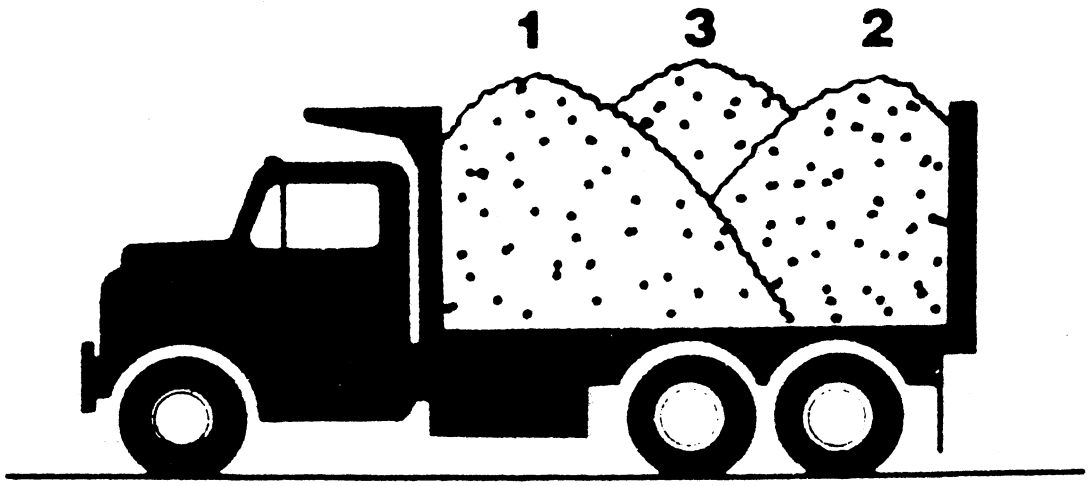

Figure 3. Truck loading sequence.

*James A. Scherocman: personal correspondence September 1981.

To reduce or eliminate segregation during the paving operations, Brock suggests use of the following practices:

1. Do not empty the paver hopper between truck loads of mix.
2. Do not raise paver wings after every truck load of mix is emptied.
3. Raise truck body sufficiently to keep paver hopper full of mix.
4. Increase opening of rear hopper gates on paver.
5. Reduce speed of the conveyor and auger.
6. Reduce paver speed.[4]

To control segregation at any stage, precautions should be taken in the sampling and testing. The acceptability of a mix processed through a surge silo can be determined visually or by performing an extraction and gradation analysis. The gradation analysis cannot, of course, indicate segregation that occurs in the paving process after the sample has been taken or if the sample has been taken so as not to include segregated material. In Virginia there have been several instances where segregation was visible in the pavement but none was revealed by gradation analyses on samples taken from the truck.

FIELD PROJECT

One of the contractors who placed a mix with excessive segregation in Virginia in 1980 was required to modify his equipment and procedures to obtain an acceptable mix before the surge silo could be used in 1981. Upon advise from the silo manufacturer, the contractor made changes to the cold feed, drum-mixer, conveyor, rotating chute at the top of the silo, truck-loading procedure, paver adjustment and operations, and the mix design. A trial section of pavement was placed to determine if the changes eliminated or reduced the segregation to an acceptable level.

The 200-ton (181 Mg) capacity silo was filled with 145 tons (132 Mg) of I-2 mix from the drum-mixer before any mix was removed. Some segregation developed in the center of

the paver hopper; however, when the hopper was kept full the segregation was not noticeable. Before the change was made, slight segregation was evident in the center of the pavement lane. A second paver with better conveyor and auger controls was also tried, and with it the appearance of the mix in the pavement appeared to be improved. After all adjustments were made, the segregation did not appear objectionable; therefore, the system was tentatively approved for use on state work.

When paving started approximately two months later, the operation was observed for possible segregation. Some segregation was observed in the center of the paver hopper and this carried through to the center of the pavement lane. The truck body was raised to keep the hopper full and the segregation in the middle was improved, but the mix then tended to segregate on the sides of the hopper.

The segregation was significantly improved over that noted the previous year and it was not felt to be detrimental; therefore, paving was allowed to continue. It was not possible to conclude which changes contributed the most to the improvements, because they were all made at the same time. Field engineers reported that the segregation tended to reappear after several weeks, possibly because of a lack of attention and adherence to the original changes.

No other cases of segregation believed to be caused by surge silos were reported to the author.

RECOMMENDATION FOR IMPLEMENTATION

It is recommended that the findings of this study be applied to selected field projects. Because segregation is usually a problem only with coarse mixes, paving projects should be selected that involve the production of coarse surface mix through a surge silo. The mix should be sampled at various stages of the production and the paving process to determine the source and magnitude of segregation. When the source of segregation has been identified, appropriate corrections that were identified in the present study should be attempted.

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