CONTROL OF HOT MIX PRODUCTION
BY COLD FEED ONLY

Final Report

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ABSTRACT

This report is concerned with an analysis of the gradation control possible with recently improved aggregate cold feed systems. The gradation control for three mix types produced in a screenless batch plant was monitored and statistically compared with this state's historically documented control performance for batch plants with screens. The results indicate that with proper cold feed control a screenless plant operation can produce a more uniform mix than a batch plant with screens. Recommendations are given for improved screenless plant operations.

IMPLEMENTATION STATEMENT

On the basis of study findings determined by this research project, the Department has elected to revise specification requirements regarding plant equipment and permit the use of screenless plant operations on all state projects involving asphaltic concrete construction.

INTRODUCTION

The accelerated trend toward "End Result" specifications necessitates changes in the Department's basic philosophy of control. This is especially true with regard to the number of requirements placed on the contractor so that he may provide the necessary end product. In a number of cases for hot mix production, the Department may have overspecified its requirements for both equipment and materials; yet the contractor was still expected to control his production economically and provide a better, less expensive product. One such recent overspecification was the blanket requirement for screens.

Recent improvements in cold feeders (Figures 1 and 2), such as individual belt feeders for each bin with variable speed feeder drives, have greatly improved the accuracy of the proportioning of the individual aggregates. Adjustments in the proportioning can be made by simply using push buttons (Figure 3); and position indicators, which show whether the desired percentages are being maintained, are in constant view of the plant operator and inspector (Figure 4).

The use of such improved cold feeders favors "screenless" plant operations, whereby total control of the aggregate proportioning is at the cold feed.

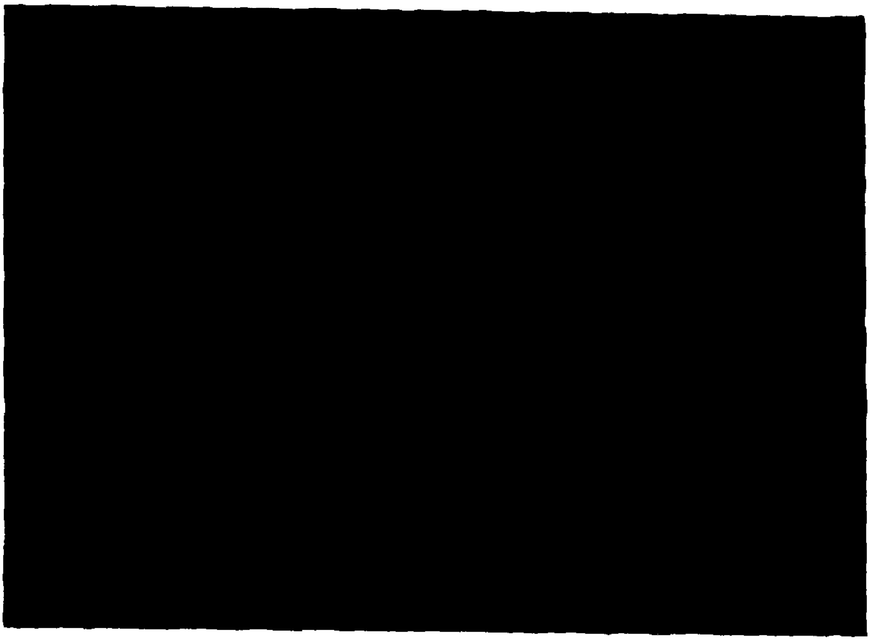

FIGURE 1: OVERALL VIEW OF IMPROVED COLD FEEDER

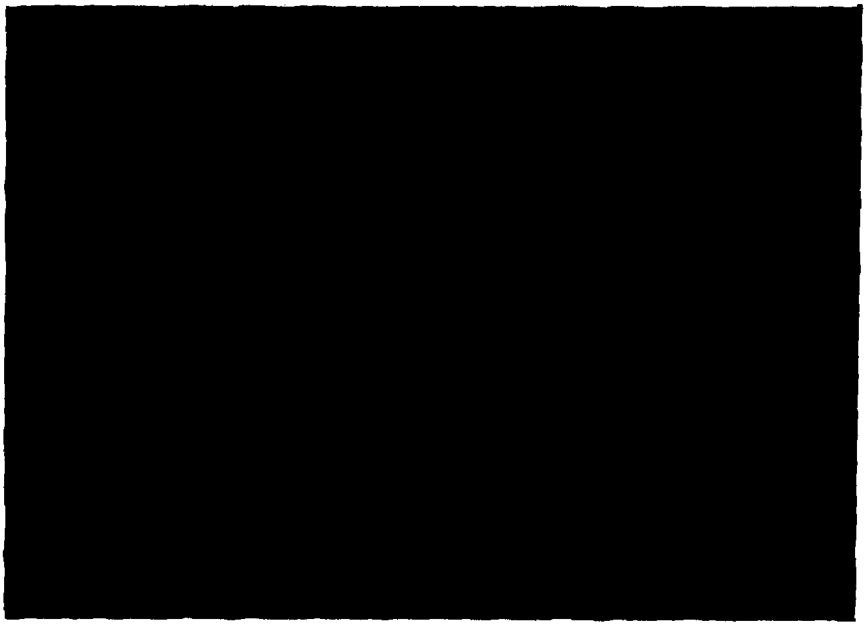

FIGURE 2: INDIVIDUAL BELT FEEDER WITH VARIABLE SPEED DRIVE

FIGURE 3: PUSH BUTTON FEEDER CONTROLS

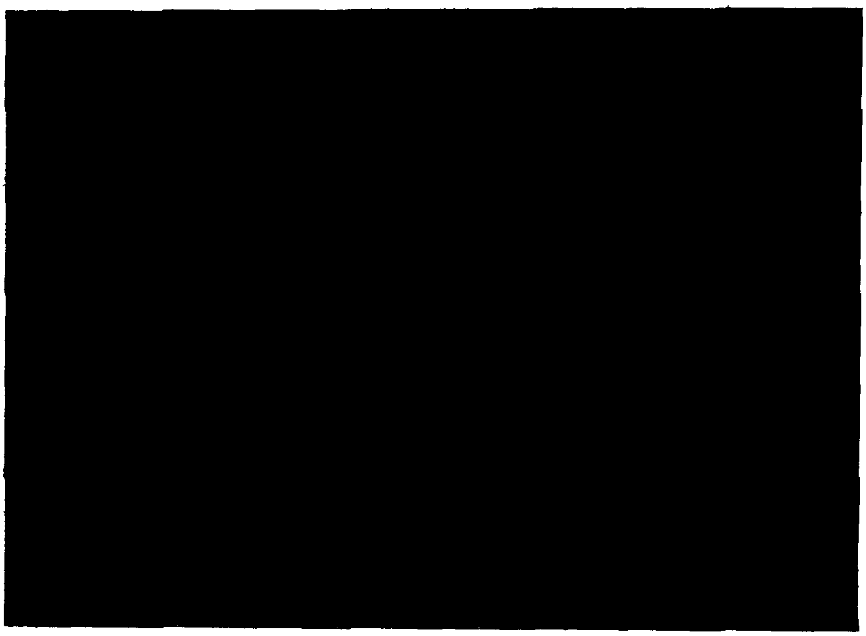

FIGURE 4: POSITION INDICATORS TO MAINTAIN DESIRED PERCENTAGES

PURPOSE OF STUDY

This research was undertaken to study the feasibility of controlling the gradation of bituminous mixtures by "cold feed" only.

SCOPE

The study consisted of comparisons of the gradations of bituminous mixtures produced in a "screenless" batch plant with those historically produced in batch plants with screens. In addition to monitoring the composite cold feed gradation and the corresponding gradation of the bituminous mixture, the gradations of the individual, cold feed materials were checked for uniformity.

METHODOLOGY

From July, 1974 through February, 1975, the Research Section of the Louisiana Department of Transportation and Development monitored the operations of the LeBlanc Brothers batch plant at Schriever, Louisiana. The plant had a cold feed system with the features described previously and was operating under special provisions as a "screenless" plant. Modifications of the batch plant consisted of removing: (1) the screens from the screening unit, with the exception of a scalping screen; and (2) the partitions between the individual hot bins. For this particular state project, 20,000 tons of Type 5B base course, 11,000 tons of Type 1 binder course, and 7,500 tons of Type 1 wearing course were produced.

In addition to the specified, daily, plant centrifuge extractions for both gradation and asphalt content control, additional samples for gradation analysis were taken from the cold feed and from the final bituminous product. These additional cold feed samples, taken for every 250 tons of plant production, were obtained from each individual cold bin feed belt and from the composite cold feed belt. Since the contractor elected to have the wet, fine sand as his first cold bin feed, it was not felt appropriate to collect samples of the blended, composite cold feed while the plant was operating; the wet sand would stick to the feed belt. Thus, when the composite gradation was sampled, the cumulative feed belt running beneath all the cold bins was stopped and all material on a one-foot length of the belt was taken. At the same time the cold feed was sampled, additional samples of the final hot mix product were taken for reflux extraction and subsequent gradation analysis.

In all, 638 samples were analyzed for gradation: 319 individual cold bin samples, 90 composite cold feed samples, 102 plant centrifuge extraction samples, and 127 reflux extraction samples.

RESULTS

The mix gradations for all three mix types are given in Tables 1, 2, and 3. Each table shows, for one particular mix type, the composite cold feed gradation and the extracted mix gradations; ranges, means, and standard deviations are given. It should be pointed out that the poor accuracy (mean value) and poor standard deviation shown in the cold feed samples for the binder course mix (Table 2) can be attributed to this particular mix's coarse aggregate (shell), which is susceptible to bridging in the cold bin, and thus causes temporarily non-uniform feeds. Such temporary variations in the cold bin feed, although seriously affecting the cold feed sample, were dampened out in the plant processing and did not substantially affect the uniformity of the final hot mix product.

The plant extraction gradation data from Tables 1, 2, and 3 are shown in Figures 5, 6, and 7. Figure 5 indicates that, for every sieve size specified for the Type 5B base course, the screenless operation resulted in every individual plant extraction falling within the control limits. Figure 6 indicates that, except for one outlier on the No. 4 sieve (49 percent passing), all extraction gradations fell within the control limits for the Type 1 binder course. Figure 7 shows that all individual plant extractions for the Type 1 wearing course were within the statistically derived control limits. Therefore, no penalties would be imposed for lack of gradation control.

No significant variation in the individual cold bin aggregate gradations was observed for any of the three mixes.

TABLE 1: BASE COURSE GRADATIONS (% PASSING)

	Cold Feed (n=49)			Plant Extractions (n=54)			Lab Reflux Extractions (n=68)		
Screen	Range	Mean	Std.Dev.	Range	Mean	Std.Dev.	Range	Mean	Std.Dev.
1/2	93-98	96.4	1.16	90-99	96.3	1.84	93-98	96.1	1.37
3/8	78-91	85.8	3.72	77-91	86.8	3.42	76-90	85.3	2.94
4	39-60	47.4	5.14	42-58	48.2	4.00	40-58	47.5	4.06
10	28-44	36.8	4.41	31-44	34.6	3.53	29-44	34.8	3.89
40	16-31	25.8	3.78	19-29	22.7	2.52	19-32	23.4	3.18
80	3-20	13.6	3.60	7-15	11.4	1.82	9-17	11.9	1.81
200	2-13	8.1	2.62	4-9	6.6	1.39	4-10	6.9	1.32

TABLE 2: BINDER COURSE GRADATIONS (% PASSING)

	Cold Feed (n=24)			Plant Extractions (n=23)			Lab Reflux Extractions (n=34)		
Screen	Range	Mean	Std.Dev.	Range	Mean	Std.Dev.	Range	Mean	Std.Dev.
3/4	98-100	98.9	0.72	95-100	97.9	1.46	94-100	97.5	1.15
1/2	85-96	90.8	3.43	77-94	87.7	3.63	80-90	85.4	2.67
3/8	71-90	79.5	5.09	65-85	77.5	4.48	68-82	74.6	3.46
4	55-79	65.4	6.25	49-66	58.9	4.32	52-65	57.8	3.38
10	41-71	56.3	7.00	38-53	45.5	3.60	42-52	45.3	2.73
40	22-43	34.4	6.39	19-34	25.1	3.27	20-32	25.6	3.12
80	10-25	16.1	4.63	9-12	10.7	1.25	10-14	11.9	1.15
200	7-18	11.9	3.21	6-9	7.2	1.03	7-10	8.2	1.05

TABLE 3: WEARING COURSE GRADATIONS (% PASSING)

	Cold Feed (n=17)			Plant Extractions (n=25)			Lab Reflux Extractions (n=25)		
Screen	Range	Mean	Std.Dev.	Range	Mean	Std.Dev.	Range	Mean	Std.Dev.
1/2	78-91	86.4	4.16	81-92	86.9	3.01	81-91	86.8	3.19
4	49-59	52.8	4.94	45-56	50.8	2.91	48-58	53.1	3.09
10	35-50	44.3	4.95	36-44	40.1	2.33	36-46	41.5	3.03
40	17-33	26.4	4.48	21-29	24.0	2.27	18-28	23.6	2.45
80	6-16	12.7	3.43	8-14	11.5	1.76	6-14	11.2	2.23
200	4-10	7.9	2.15	5-8	6.9	1.12	2-8	6.5	1.46

FIGURE 5: BASE COURSE GRADATIONS VERSUS CONTROL LIMITS

FIGURE 6: BINDER COURSE GRADATIONS VERSUS CONTROL LIMITS

FIGURE 7: WEARING COURSE GRADATIONS VERSUS CONTROL LIMITS

DISCUSSION OF RESULTS

Figures 5, 6, and 7 noted standard deviations for every sieve size for all three mix types evaluated. Figures 8 and 9 compare these deviations for both the base and wearing course mixes with historical standard deviations (1)* attained from plants with screens; no historical data was available for the particular binder course under study. It is worth noting that for both mix types and for every sieve size, the screenless plant operation had the least standard deviation, which implies a more uniform gradation.

Table 4 shows Louisiana's statistically derived, allowable tolerances (% passing) for the various hot mix sieve sizes. Basically, these tolerances for the individual test result were established from $\pm 3\sigma$ where σ was the standard deviation of actual, screened plant performance data. Figure 10 presents requirements and actual variations for the past 20 years for a Type 1 wearing course. It should be noted from the figure that the third bar in each group of 5 bars has been exactly derived from past actual variations in screened plants (the second bar). It should also be noted that the present variation for screened plants (fourth bar) is merely three times the standard deviations previously shown in Figure 9. The variability indicated by this present screened plant data is surprising since, if anything, the level of control should have improved due to the improvements in equipment and production technology during the past decade. One of the primary reasons for such lack of quality control can be traced to the contractor's failure to monitor his production process through the use of gradation control charts. The prime point, however, to notice from Figure 10 is that the variation experienced during the screenless plant operation (fifth bar) was both less than the variation from screened plants and more in conformance to the present allowable tolerances.

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*Underlined numbers in parentheses refer to list of references.

FIGURE 8: VARIATION IN BASE COURSE GRADATION

FIGURE 9: VARIATION IN WEARING COURSE GRADATION

In previous tables and figures, it was seen that the gradations actually produced (from hot mix extractions) using the screenless plant operation were very acceptable; not only were individual plant extraction gradations within the control limits, but the variations between these extraction results were less than for conventional plants with screens. Figures 11 and 12 illustrate how well a sample from the cold feed belt described the gradation actually produced. Whereas Figure 11 shows that for a large number of samples the cold feed samples were accurate, Figure 12 shows that such cold feed samples were not as precise. That is, more variation was present in these cold feed samples than in the actual mix itself, although the mean values were the same. It is believed that the manner in which the cold feed was stopped to allow for sampling (one bin at a time), coupled with the closeness of the point of sampling to the cold bins themselves, accounted for much of this variation.

Referring again to the accuracy of Figure 11, it should be pointed out that some bias is present; the cold feed samples tend to have a slightly finer gradation. This trend was consistent for all three mix types (see Tables 1, 2, and 3). It is believed that most of this bias was stack loss from the batch plant amounting to essentially one and a half percent on the No. 200 sieve.

TABLE 4

LOUISIANA GRADATION CONTROL LIMITS
% PASSING

U. S. Sieve	Individual	Average of 2 Tests
3/4 inch and larger	± 9	± 6
1/2 inch	±12	± 9
3/8 inch	±10	± 7
No. 4	±10	± 7
No. 10	± 9	± 6
No. 40	± 7	± 5
No. 80	± 5	± 4
No. 200	± 3	± 2

FIGURE 10: VARIATION IN HOT MIXED ASPHALTIC CONCRETE THROUGH THE YEARS

FIGURE 11: ACCURACY OF COLD FEED SAMPLES

FIGURE 12: PRECISION OF COLD FEED SAMPLES

CONCLUSIONS

On the basis of this evaluation, the following conclusions seem warranted and are within the constraints of the material and plant used in the study:

1. Except for one result on one screen size, all 102 plant extraction gradations were within the statistically derived control limits for all screen sizes.

2. The gradation of the mix produced in the screenless batch plant was more uniform than that currently being produced in batch plants with screens.

3. An appropriate cold feed sampling procedure, size, and location must be established before such gradation results can be used for control purposes.

4. Batch plant stack losses are not compensated for in composite cold feed samples for screenless plant operations.

RECOMMENDATIONS

The following recommendations are made in light of both the results of this study and subsequent experience with other cold feed systems:

1. The use of screenless plant operations should be optional with a contractor provided the particular cold feed system employed will control proportioning of aggregates accurately enough to produce a gradation consistent with the job mix formula.

2. Care should be exercised when stockpiling and handling the individual aggregate materials to minimize segregation.

3. The order of aggregate feed onto the composite cold feed belt should be from coarse to fine.

4. Composite cold feed samples should be taken while the plant is operating. Appropriate sampling devices could range from a pan which is fed through the cold feed system on the composite belt to ample-size hand-held catch pans which are passed through the aggregate stream at the end of the conveyor belt.

5. A reconfirmation of all individual feeder belt RPM's should be made whenever any significant deviation in mix gradation occurs; if still warranted, a recheck of individual cold bin gradations should then be made.

6. A vibrating unit should be used for those particular cold bins whose aggregate material tends to either bridge or lump together, thereby causing temporary interruptions in feeds; additionally, a grate should be placed over those cold bins whose aggregate does tend to lump together (some fine sands).

7. An automatic plant shutoff should be provided to operate when any aggregate cold bin becomes empty or when its flow is interrupted.

8. A scalping screen appropriate for the maximum approved aggregate size should be placed over the hot bins.

REFERENCES

1. Shah, S. C., "Quality Control Analysis, Part V - Review of Data Generated by Statistical Specifications on Asphaltic Concrete," Research Report No. 94, Louisiana Department of Highways, December, 1975.