HOT MIX COMPONENT-RECORDATION EVALUATION

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In Cooperation With The
Testing Laboratory Section
Testing and Research Division

Research Project 68-C-12
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This study was conducted in cooperation with the Workman-Richardson Asphalt Company, Jackson, Michigan. The Company was under paving contract with the State for MDSH Project MB23091-003, which required approximately 9,000 tons of Bituminous Aggregate 4.11. The Testing Laboratory Section assisted in recording ingredient weight dial measurements and provided advice and consultation during data collection and analysis.

The purpose of this study was to evaluate the performance of the automatic batching and recording system installed at the plant. The basis for evaluation in this report is a comparison of component weights as recorded manually from dials, and the same weights as printed automatically. The two measurements were made independently; one by the conventional mechanical lever system, the other by means of SR-4 strain-gage tensile load cells supporting the weight hoppers. In addition, comparisons were made among truck net-load weights as calculated from accumulated dial readings, printed on tickets, and as measured by platform scales. Ingredient weights were taken visually from the aggregate and asphalt dials for about 20 percent of the total production.

System General Description:

The control system consists of a solid-state digital logic system which controls a proportioning system and printer. Input to this system consists of an analog signal from load cells on the aggregate weight hopper and the asphalt weight tank.

Four load cells were installed on both the asphalt weight tank and the aggregate weight hopper by removing the existing supporting clevises and inserting the cells. Two men installed all eight cells in approximately four hours. The existing mechanical scales remained undisturbed and fully functional but were not a portion of the control system.

The tension load cells (Baldwin-Lima T3PI) are precision calibrated to 1/10 percent and temperature compensated. The rated capacity of the load cells is 3,000 lb for those installed on the aggregate hopper and 500 lb for those on the asphalt tank. Sensings for both control and printout were taken from these load cells.

The load cells provide a d-c voltage proportional to the input weight when provided with a reference voltage. The voltage is amplified, integrated, then changed to a frequency proportional to the weight. The frequency (cycles per second) is counted during a reference period of time (sec) to display the system weight (cycles).

Presets, controlling the cut-off point of the materials, were accomplished by comparing thumbwheel switches with the count in the display weight counter.

The system provided presets for five ingredients (No. 1 stone, No. 2 stone, dust, sand, asphalt), and two proportioning formulas (formulas A and B), with compensation to anticipated cut-off of the ingredient by the weight of product in the air between the valve and the tank, (called Mid-Air Compensation).

On the moving-carriage printer (Monroe 600) the system prints the net weight of each of the five ingredients, the net aggregate and the asphalt weights, and corresponding tare weights, the net batch weight, and the net truck weight. In addition, the system prints the date, time (from an internal digital clock), truck code, and the day's accumulated batch weights for one customer.

The system also controls times for dry mixing, wet mixing, and dumping of the mixed batch into the truck.

Weighing can be done either automatically or manually.

Another feature is the checking of each ingredient for over and under weight.

Analysis

To indicate system performance, various frequency distributions of weight measurements are illustrated. As a measure of accuracy, the average of certain distributions can be compared with the target or mix design weight. The spread or variation of the weight measurements can be interpreted as a measure of precision of consistency. Comparisons between weighing methods can also be made.

Another type of frequency distribution utilized was for differences between measurements of the same weight as indicated by the dial and as recorded by the printer. Here the average difference is a measure of how well the two systems agree. The range and degree of concentration of the differences is an indication of the relative reliability of the two methods.

Several possible sources of error in dial measurements should be borne in mind. These errors might add a significant component to the dispersion of the differences in the dial-printer comparisons. The sources would include the mechanical system itself and, more likely, the error to the observer reading and recording the dial measurements.

As a practical consideration, however, the weight distributions for the components, sub-totals, and totals appear generally well-behaved and within reasonable limits. The dial and printer measurements demonstrate satisfactory agreement regardless of the source of bias or variation. Thus, it seems that useful information can be gained from the data by studying the various frequency distributions.

A problem arises when an attempt is made to compare stone or sand measurements with a target value. Changes that were made in order to balance the stone-sand proportions were not always noted or otherwise brought to our attention. Thus, in order to compare weights with a specific target or intended weight, the data had to be examined to detect shifts and only the corresponding weights are included. These changes were not always apparent. An oversight in this selection would create a misleading increase in the dispersion of the frequency distribution.

Ticket Misprints

There are several types of printing errors appearing on the tickets. They may not have been caused by the printer but were evident on the ticket. Neither occurred very frequently, nor did they seem to be very serious. These errors or misprints should be mentioned, however, since an inspector would have to be cautioned and instructed how to deal with them in the event they can't be eliminated.

One that occurred most often was a missed first or third digit of the net asphalt weight (Fig. 1, Lines 2 and 3). If the third (units) digit was skipped no harm resulted as the batch weight appeared to be correct. If the first (hundreds) digit was skipped, however, the batch weight would reflect only the sum of the net aggregate weight and the asphalt weight as printed. This resulting batch weight was about 260 lb low in these cases. This deficiency was carried on, of course, to total truck weight, daily totals, etc.

Workman - Richardson Asphalt Co.

TELEPHONE 787-4200 — ASPHALT PAVING · GRADING · SAND & GRAVEL — № 7076

801 LEWIS STREET JACKSON, MICHIGAN 49203

SOLD TO: MDSH PROJECT NO. MB 23091-003

Job No.

P. O. No.

Asphalt Mix Type

MDSH-M99 From CRAWFORD RD

JOB # 1117

Load No.

DATE	TIME
8 23	7 00

Weighed By

Rcv'd. By

Agg. 1	Agg. 2	Agg. 3	Agg. 4	TARE Agg. Zero	NET Aggregate	Asphalt	TARE Asph. Zero	NET Asphalt	Batch Weight	
	2.235	105	2.384	24	4.716	(28)	13	288	5.004*	-1-
	2.081	105	2.526	19	4.730	289	16	(28)	5.019* O.K.	-2-
	2.089	100	2.469	35	4.734	291	13	(28)	4.762* LOW	-3-
?{ 2	(209)	103	2.493	29	4.731	291	13	292	5.005*	-4-
327	2.090	107	2.517	41	5.219	290	9	294	5.513*	-5-
										-6-
										-7-
										-8-
										-9-
										-10-

TRUCK NO	CUMULATIVE DAY WEIGHT	NET LOAD WEIGHT
33	146.046	25.303

Figure 1. Possible ticket misprints, (each line is authentic but selected from various tickets for illustration).

Regarding the latter case, examination of dial measurements indicated that the specified amount of asphalt had actually been included in the mix. Therefore, the quality of mix was not affected, but of course payment would be.

A missed digit sometimes occurs when the first aggregate weight is printed (Fig. 1, Line 4). The number printed here also does not represent the actual weight. Checking the net aggregate and batch weight dial readings in these cases revealed that the proper amount seems to have been included.

Occasionally the sequence of weights may be printed out of order and/or weights and accumulated totals will appear unrealistic. Effects may carry over to the next load. Correct amounts should be determined and noted on the ticket before production is continued.

In one case, only aggregate was dumped into the pug-mill and forgotten. When the next truck arrived after a period of time a new batch was started. As a result, the batch dumped consisted of a normal batch plus the aggregate for another. This apparently went unnoticed.

DISCUSSION

In general the individual component weight averages seem to agree very well with the mix design target value and the dispersion seemed to be within acceptable tolerances. As mentioned previously, however, proportion changes occurred frequently for stone and sand. Thus, it was difficult to determine the target weight with which to compare measured values for these ingredients. For this reason most of the data were used in difference distribution comparisons between dial and printer (Fig. 2).

It will be noted that these two distributions are close to being mirror images of one another. The reason for this is probably due to the way the dial was read. In many instances it was difficult to determine from the dial when the addition of the stone terminated. As a consequence, if the stone was erroneously read high or low then, because the final accumulated aggregate weight could be more precisely determined, the sand would be correspondingly low or high.

Distributions of weights for a group of measurements where the mix design apparently remained constant are illustrated in Figures 3 and 4. It can be seen that the stone is overweight on the average of 15 lb for the printer results and 24 lb for the dial readings with respect to the target weights. This bias apparently is causing the overweight condition for net aggregate and batch weights.

The sand weights on the average agree almost perfectly. The variation is quite limited; approximately 90 percent of the measurements fall within the specification limits. This would seem to be evidence that the system is capable of accurate and consistent production.

The distributions of mineral filler and asphalt weights exhibit very good agreement between dial and printer data. More individual weight measurements are included in these distributions since the design weight did not change. Because of the large amount of data, the average and the extent of variation must be close to stable and therefore reliable. The dispersion of each is remarkably small and should cause little concern.

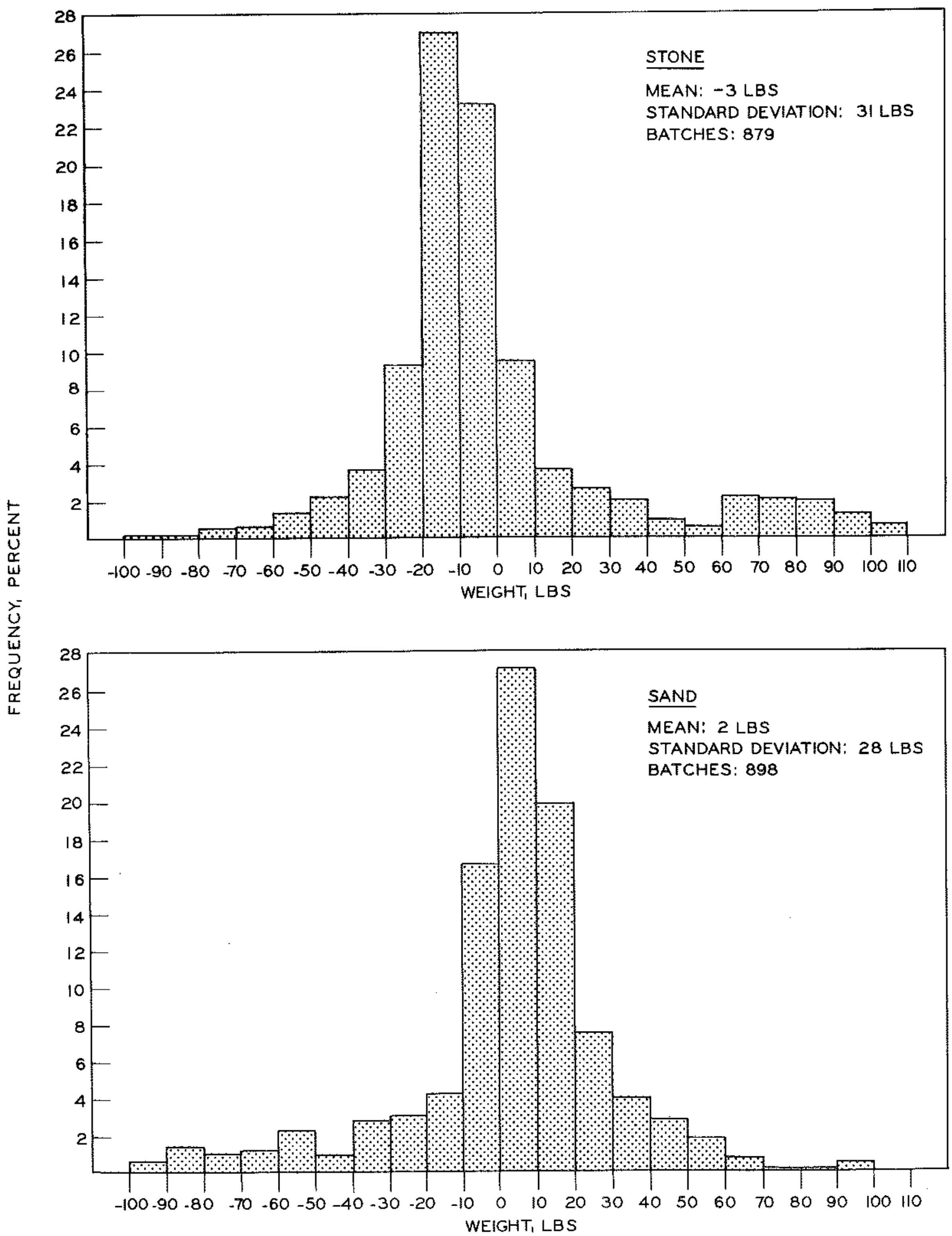


Figure 2. Frequency distributions for the difference between printer and dial aggregate weight measurements.

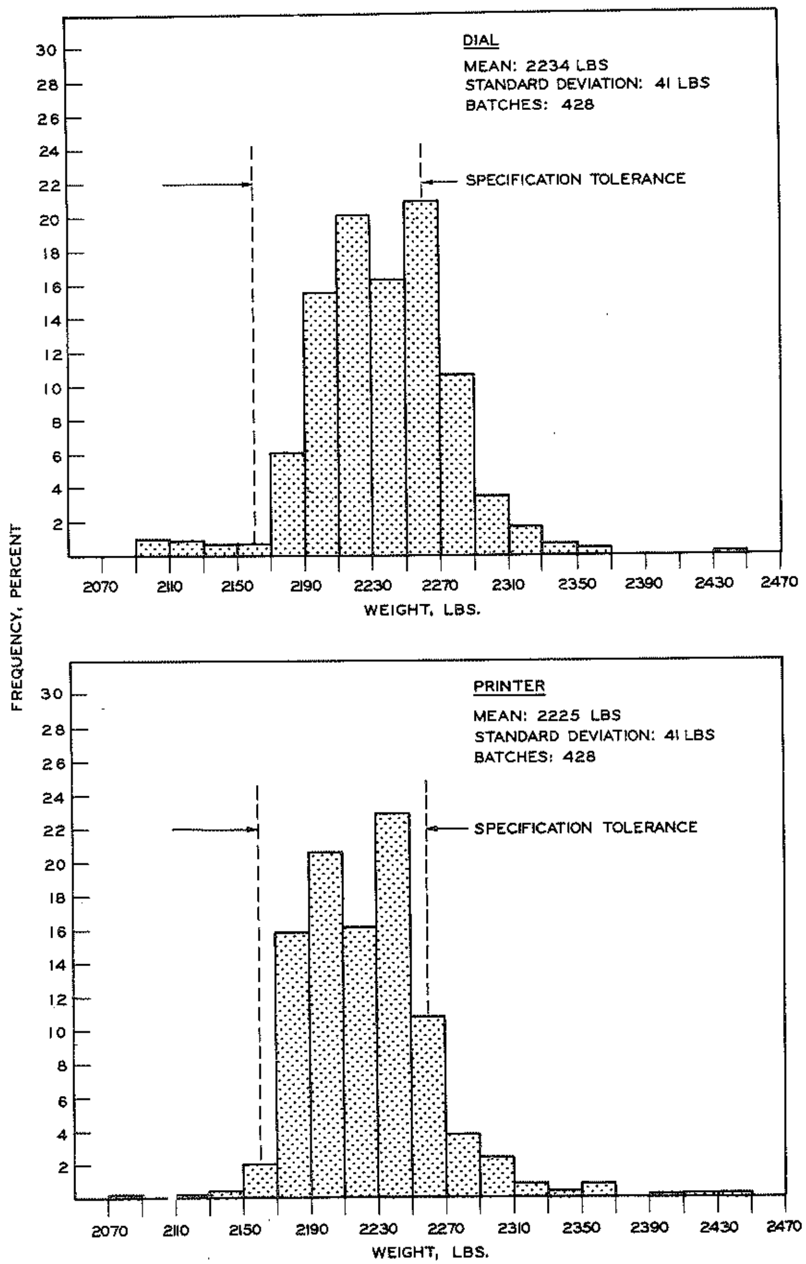


Figure 3. Net stone weight distributions. (Design wt. 2,210 lb).

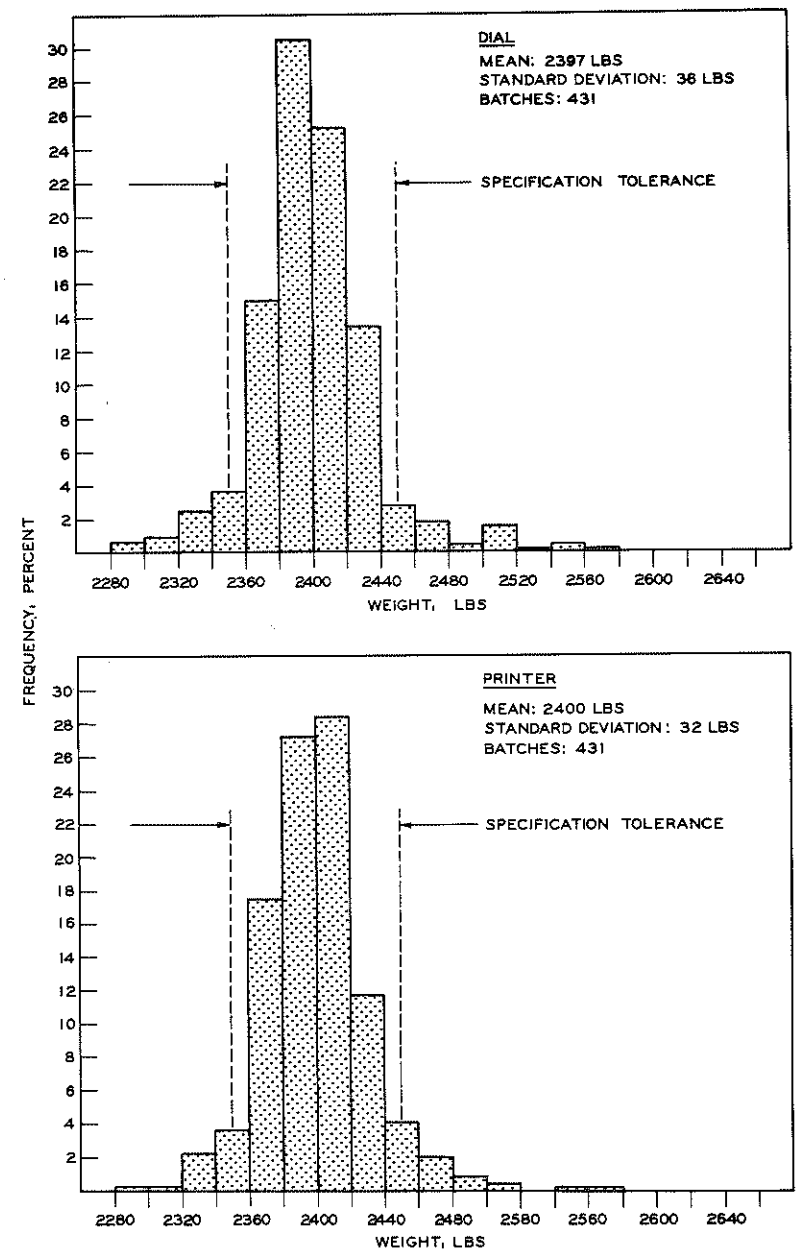


Figure 4. Net sand weight distributions. (Design wt. 4,710 lb).

Not surprisingly, the mineral filler weights are well within the 100 $\pm$ 50 lb specification limits (Fig. 5). Supposedly, the wide tolerance is due to limitations of the conventional weighing systems. Using the sensitive electronic load-cells, however, small component weights can be measured more precisely.

If mineral filler is a sufficiently critical component it now may be desirable to narrow the specification limits. If not critical it may be advantageous to suppress the printing of mineral filler weights as a separate component, as this may free the system to perform some other more useful function. Net mineral filler weight could be obtained on a spot-check basis by subtracting the coarse and fine aggregate net weights from the net aggregate if and when desired.

Average asphalt weight appears to agree very well with the design weight; the variation of the measurements is quite small (Fig. 6). Approximately 90 percent of the values fall within the specification limits.

Net aggregate and batch weight distributions are slightly biased (15 to 20 lb) which is due to the excess stone (Fig. 7 and 8). By subtracting this bias it can be seen that the averages would agree almost exactly with design weights. The variation is not extensive enough to cause a significant proportion of batches (less than 5 percent) to fall outside specification tolerances.

The frequency distribution for the difference between the printed net aggregate total and the sum of the three individual printed weights is illustrated in Figure 9. The average is close to zero, which is desirable, but the variation is somewhat disconcerting. About 40 percent of the differences show a discrepancy greater than $\pm$ 20 lb. Since the system does not add the individual weights to arrive at a net aggregate weight it would only be by chance that they would agree exactly. The differences are undoubtedly due to variations in the load cell signal from which the weight is determined.

The question arises then, which measurements (net aggregate or individual component) are to be used for quality assurance purposes? One appears to be redundant. This question is important since it is the net aggregate weight which is added to net asphalt weight to give the batch weight which is the basis for payment.

Since the specifications apply to individual ingredient weights, it appears that those individual weights should be used as the basis for judging conformance. Bearing these facts in mind it may be that printing a net aggregate figure is unnecessary.

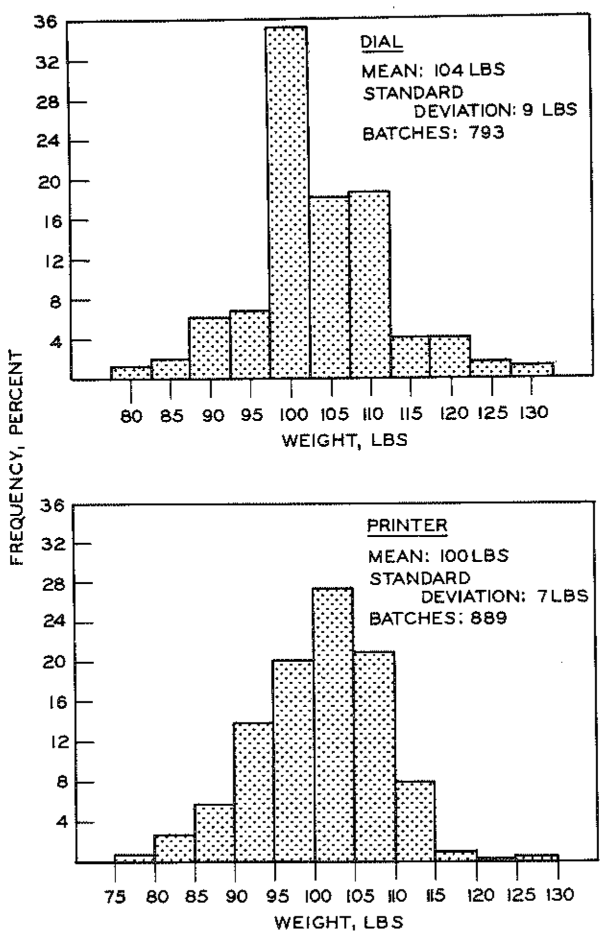


Figure 5. Mineral filler weight distributions (Design wt. 100 lb).

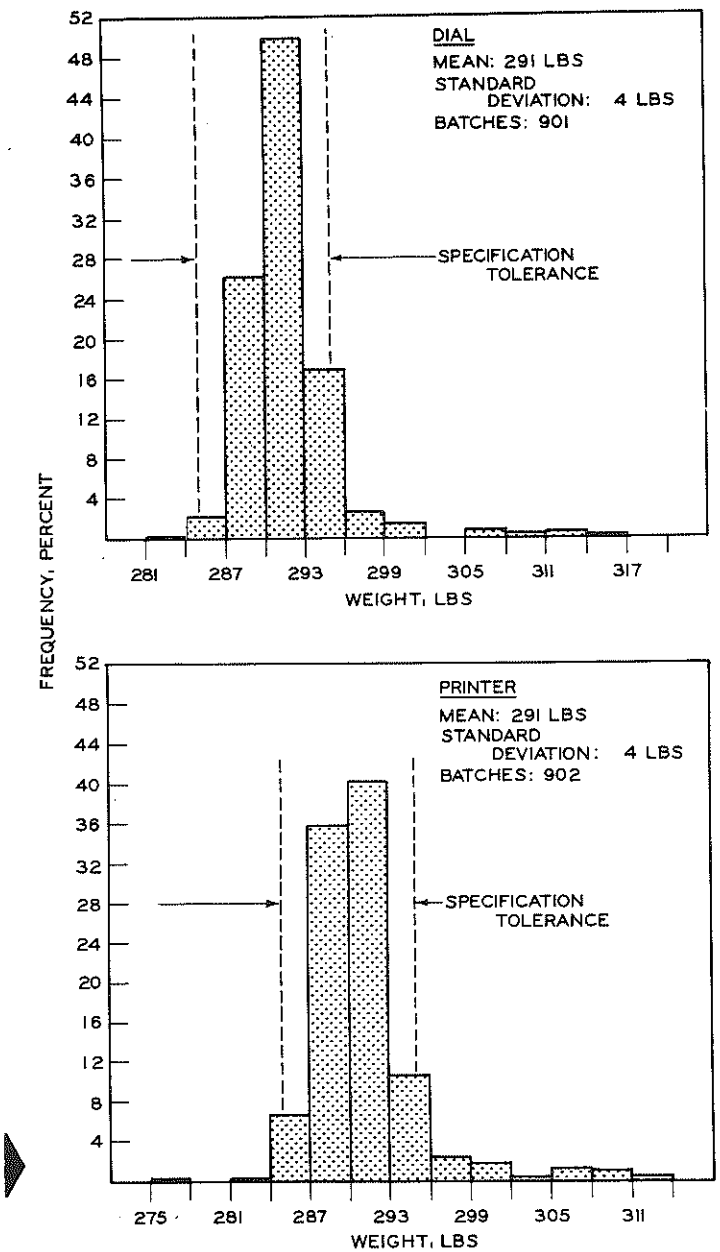


Figure 6. Asphalt weight distributions. (Design wt. 290 lb).

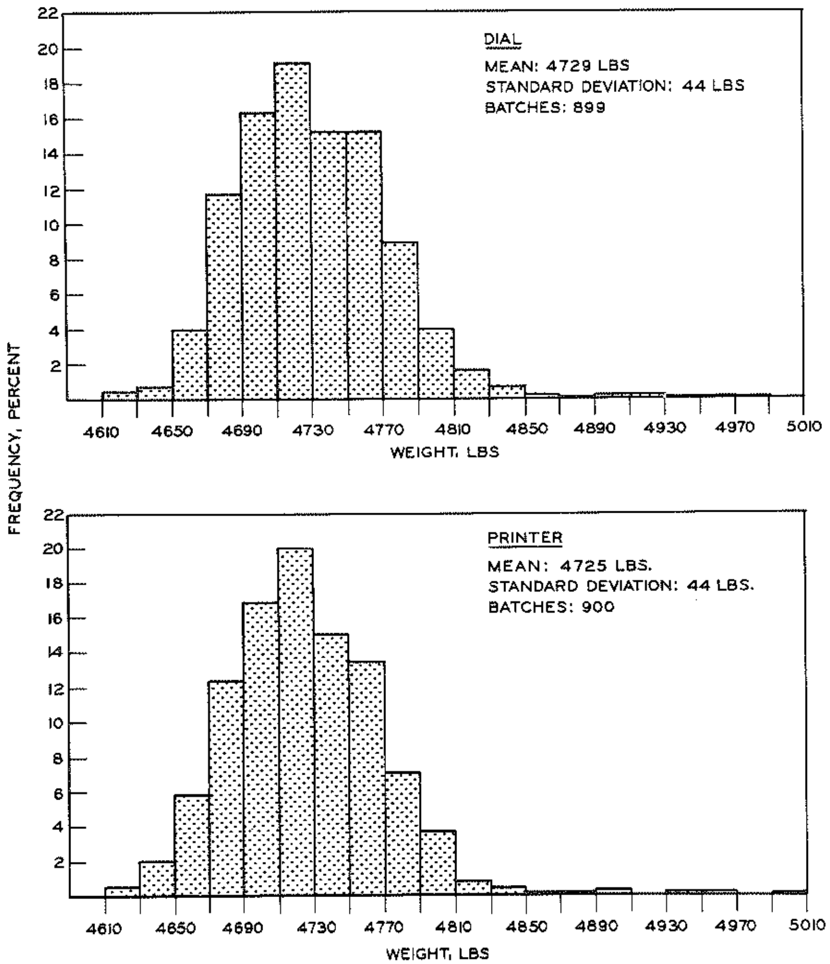


Figure 7. Net aggregate weight distributions. (Design wt. 4,710 lb).

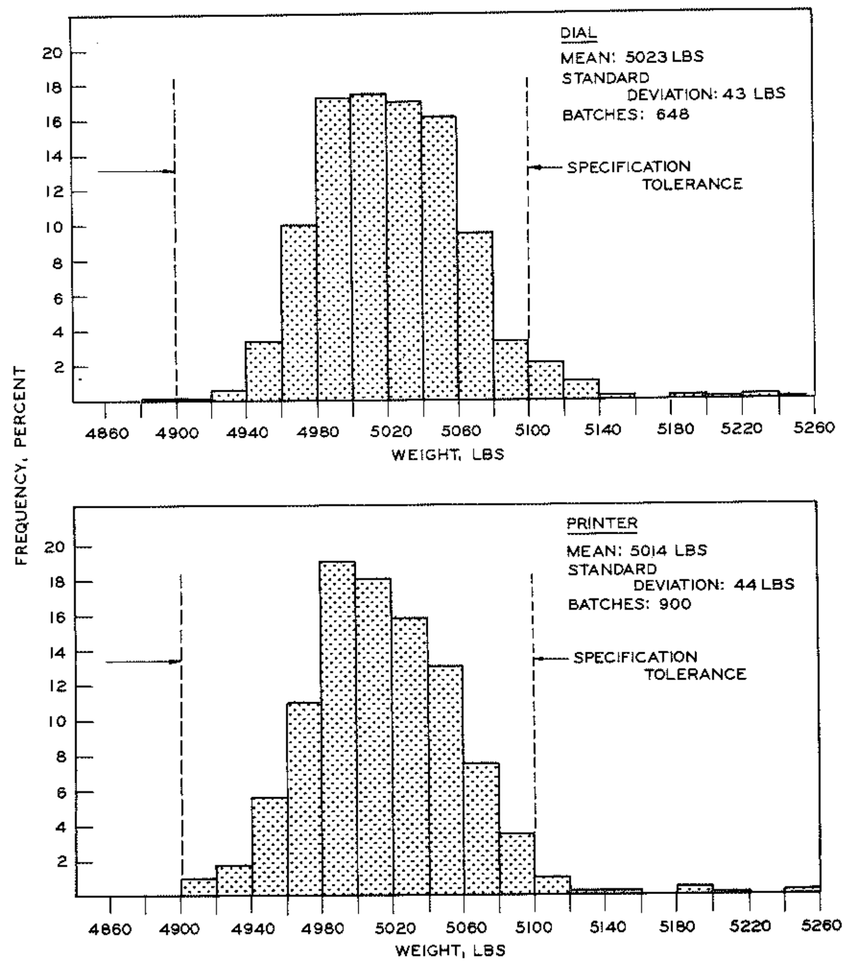


Figure 8. Batch weight distributions. (Design wt. 5,000 lb).

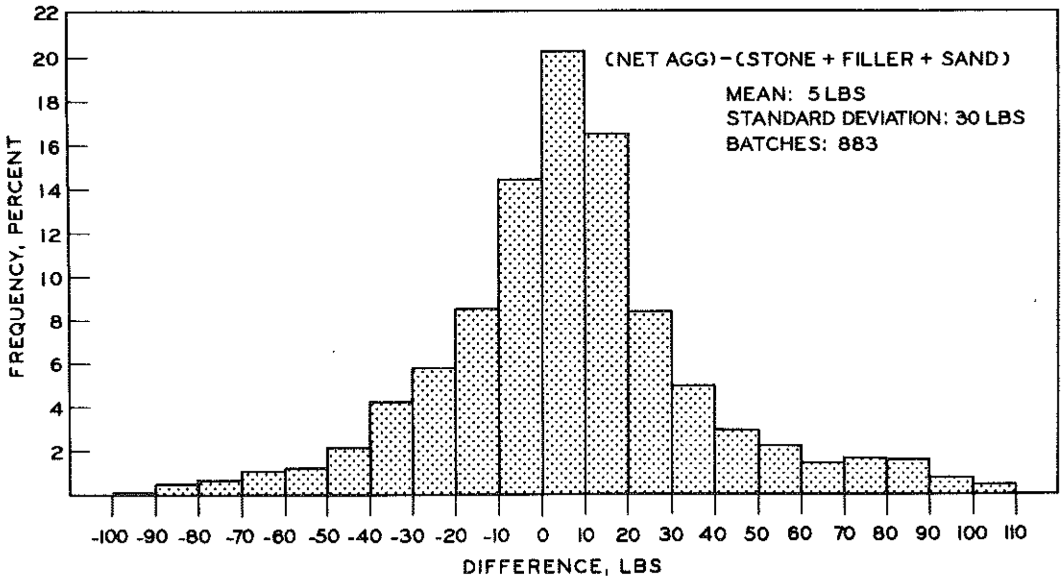


Figure 9. Frequency distribution for the difference between net aggregate weight and the sum of the component weights.

Net Load

To compare truck net-load weights as measured by the three methods (platform, dial, and printer) distributions of paired differences were computed for each combination (Fig. 10). These distributions do not show which method is most accurate, merely how they compare.

It appears the platform scale was reading slightly high in comparison with the accumulated dial, and higher yet when compared with the printer. The dial-printer difference is predictable from the 6 lb average difference in batch weights. This difference multiplied by five or six batches per truck would account for the average 34 lb net load difference. As a percent of the net-load weight the platform minus printer average difference (69 lb) is admittedly very small, amounting to only between 0.23 and 0.28 percent. This bias, when accumulated over many loads, may or may not be critical. The percentage is even less for the platform minus dial average difference.

Quality Assurance

Depending on the ultimate quality assurance procedures developed to deal with the printer data, the Department may not need as much detail as is now required. A less sophistocated system would then be possible since certain arithmetic would not need to be performed.

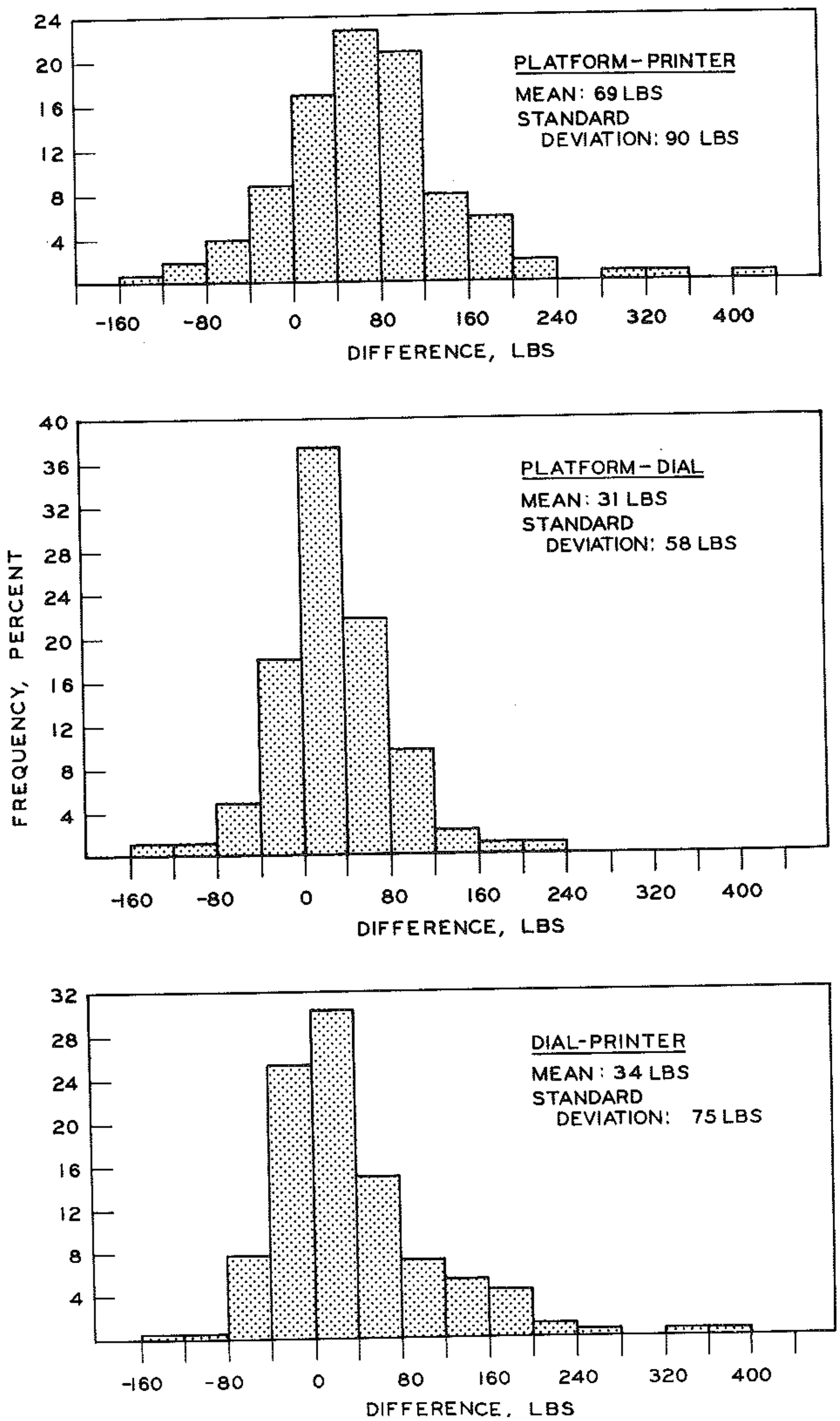


Figure 10. Truck net load difference distributions.

For example, if all the weights were processed after completion of a project to determine the degree of conformance and make final payment adjustments, only load identification, necessary zero-weights, and cumulative ingredient weights would be necessary. A simple computer program could handle the computation of net-weights, sub-totals, batch weights, etc. It would seem that the ticket data will have to be processed by computer in any event.

A contractor, of course, might desire additional detail to allow a more sophisticated looking ticket for other customers. It would be a simple task to provide the option for accumulated or net weights in a computer program.

Under normal production an inspector could not evaluate the printed data for each batch for quality control purposes. He could operate on a spot-check basis, looking for gross departures from specified weights. The limits could be established for either accumulated totals or net weights.

For better day-by-day quality control, however, an inspector could analyze several tickets in depth in order to determine conformance to proportions. Ticket sampling would be done periodically throughout the day. Compared with the present methods of taking a small scoop of mix from trucks at random and running an extraction test this would be an immense improvement. There would be less time delay in determining proportions and, moreover, a much larger and hence more representative sample would give a more reliable estimate of current production quality. A scheme could be developed that would call for sequential analysis of tickets should routine inspection indicate the need. Production would have to be slowed at this point but little time would be lost by making a check test.

Provisions will have to be made for rejected or diverted loads. These quantities would not be included when computing final pay quantities.

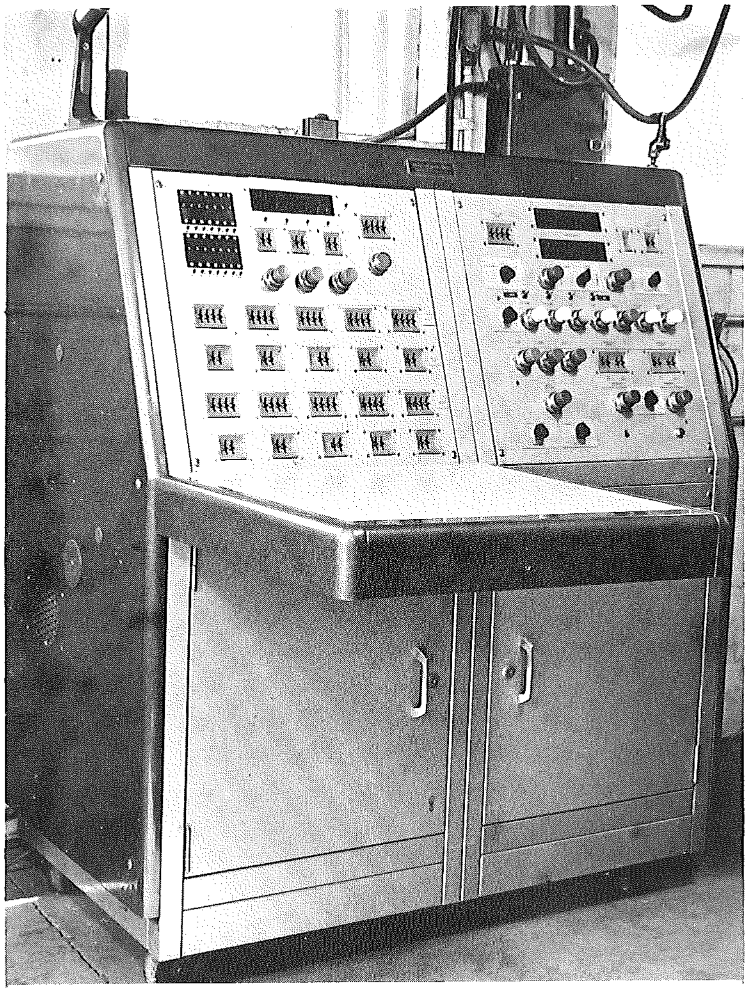
Remarks

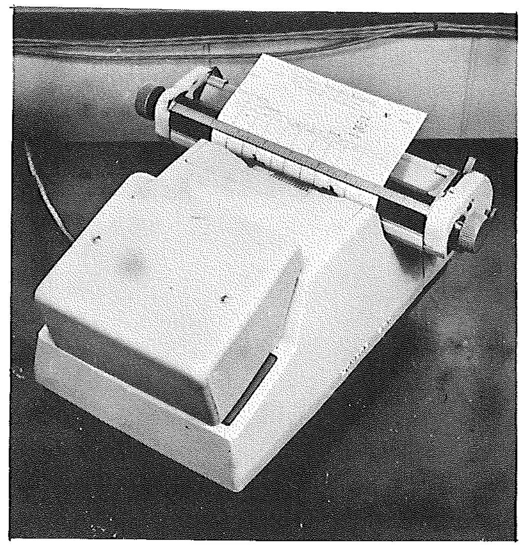
Based on the data gathered in this study, the system in general appears to be capable of consistent and acceptable production. More precise estimates of system reliability were impossible to obtain from the method of operation prescribed for this study. Repeated measurements of the same weights and periodic calibration checks would have been desirable to gain more refined estimates of any error but were beyond the scope of this project. In addition, time did not permit an effective study of background information regarding similar systems and procedures.

One assignable source of error seems to be variation in the signal from the load cell which is sensed for weight determinations. Over the long run, however, the differences average to about zero and do not appear to significantly affect the distribution of batch weights since most batches are within specifications. It may be enough, however, to cause a component weight to be out of specification.

There seems to be a tendency to include on the average a slight excess of the first aggregate or stone in this case. This is evident in the frequency distributions of stone for both dial and printer data.

Finally, it is recommended that the mix design be printed on each ticket. This would not only be of value in any future data analysis study but would also promote better quality control by providing a constant reference for the inspector and increase operator motivation toward quality.





Printer

Control console

Left and right panels of console