FIELD EVALUATION OF THE OHMART NUCLEAR WEIGHING SYSTEM

F. Copple

Research Laboratory Division
Office of Testing and Research
Research Project R-64 E-32
Research Report No. R-495

Michigan State Highway Department
Lansing, March 1965

FIELD EVALUATION OF THE
OHMART NUCLEAR WEIGHING SYSTEM

This report describes the performance of a weighing system in which nuclear radiation is used for continuous measurement and recording of the weight of soil aggregate during loading into a truck by conveyor belt. This system's greatest advantage is its capability of providing an instantaneous reading of the weight of a material at any time during loading operations. Through direct reading of accumulated weight, trucks can be loaded rapidly to their legal capacity, thereby improving the efficiency of hauling.

On January 17, 1964, representatives of both the Office of Construction and the Office of Testing and Research made an inspection trip to the Ohmart Corporation plant at Cincinnati, Ohio, to investigate the feasibility of using an automatic system for weighing of soil aggregates used in road and bridge construction projects. As a result of this inspection, it was decided to permit use of the automatic weighing system on a trial basis. O. E. Gooding & Co. of Ypsilanti subsequently purchased an Ohmart system.

On May 14, 1964, in response to a request from the Office of Construction, R. L. Greenman directed the Research Laboratory to observe trial runs, analyze results, and make recommendations regarding further use of this weighing system. In cooperation with F. B. Gale of the Office of Construction, the Research Laboratory began observations and data procurement on June 23, 1964, during construction of I 94 shoulders near Jackson (Construction Project 13801C, C14). Weights were obtained at this site using both nuclear and conventional methods.

Operating Principles

The Ohmart nuclear weighing system is based on the principle that gamma radiation passing directly through a medium will be attenuated in direct proportion to the density and thickness of the medium. Fig. 1 shows the nuclear source and the detector tubes arranged in a C-frame with arms extending transversely across and separated by the conveyor belt and any material being carried. A Cesium 137 radioactive source is located in the lower arm and a gamma ray detection cell in the upper one. At any instant, the quantity of gamma rays being measured by the detector cell is influenced by a 3-in. wide volume of material extending across the width of the belt. Thus the weight of material per unit length of belt is indicated by the intensity of gamma radiation reaching the detector cell, and changes in this intensity cause a proportional change in the electrical signal emitted by the detector cell. The electrical signal of the detector cell is combined with a signal from a tachometer on the conveyor to give a continuous cumulative weight value for material passing over the belt.

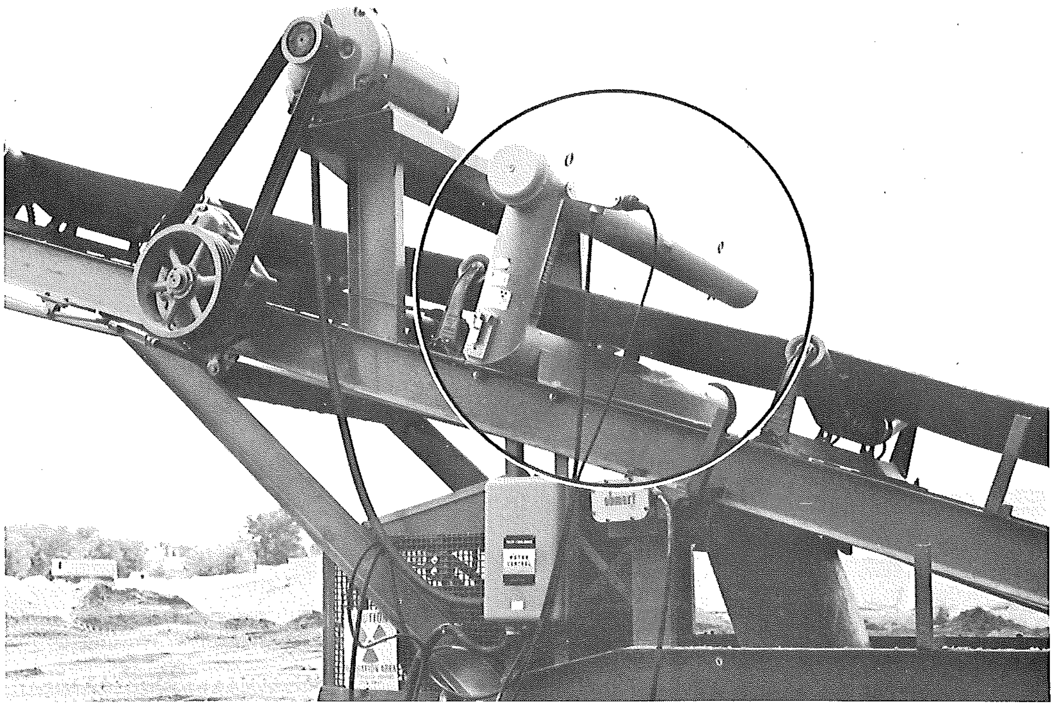


Figure 1. C-frame (circled) housing Cesium 137 radioactive source and detector cell, as mounted on conveyor belt.

Method of Testing

Fig. 2 shows a typical setup of the truck loading and nuclear weighing equipment as used at the Woodworth Pit near Jackson. The equipment was later moved to the Stevick Pit, a few miles away. The recording instruments, together with the Ohmart system operator, were located in the trailer shown in Fig. 3. After being loaded with gravel weighed by the nuclear method, trucks were also weighed on conventional mechanical platform scales (upper right center in Fig. 2). The conventional mechanical scales were used as the standard, although in routine accuracy checks they were occasionally found to be somewhat in error. Both the nuclear and the conventional weight values were recorded by the nuclear weighing

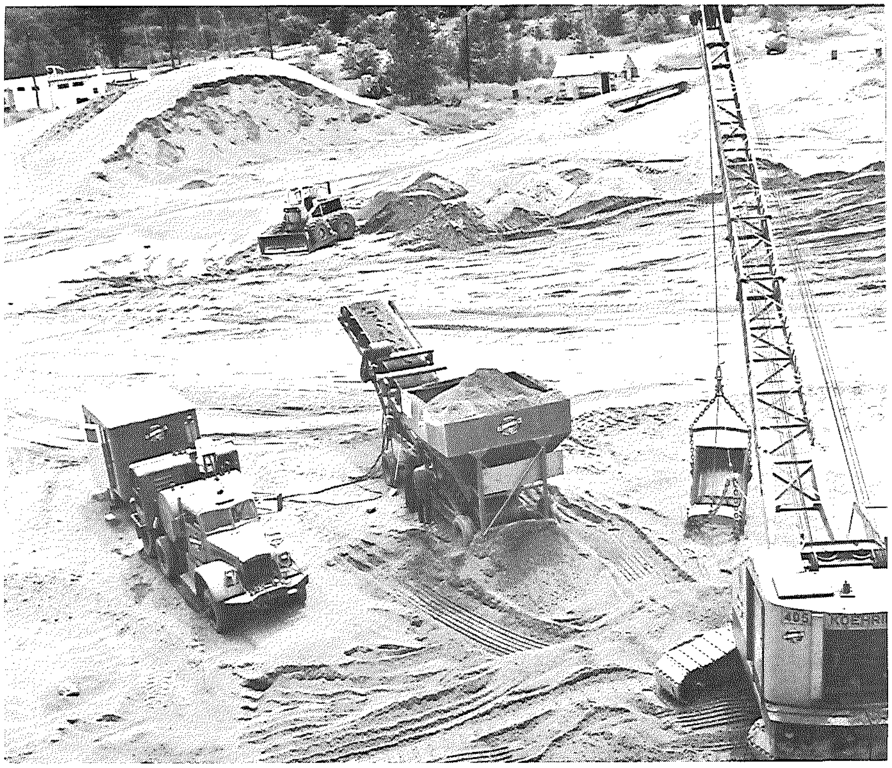


Figure 2 (left). Typical location of truck loading and weighing equipment at Woodworth pit.

Figure 3. Trailer containing recording instruments for Ohmart nuclear weighing system.

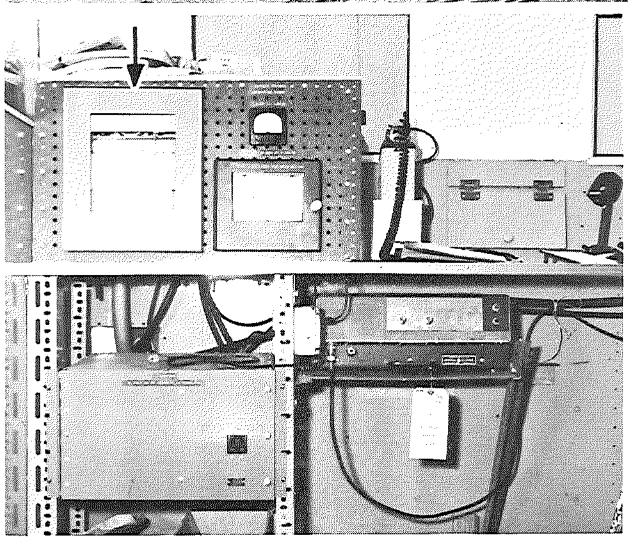
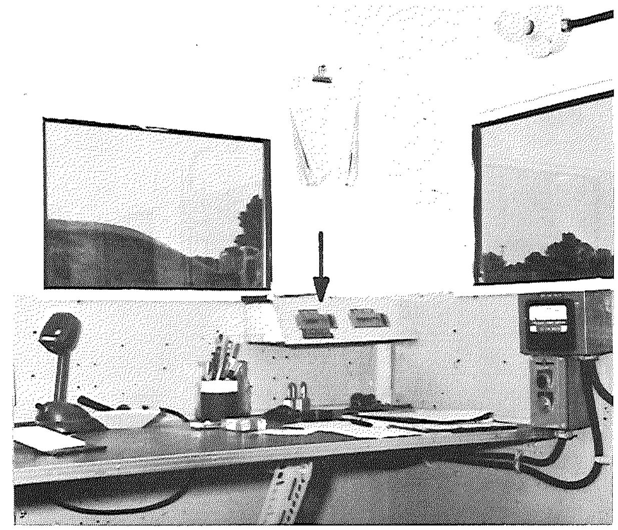


Figure 4 (left). Recording instruments for Ohmart nuclear weighing system; arrow indicates strip chart recorder.

Figure 5 (right). Location of tally counter for cumulative weight of gravel indicated by arrow.



system (conveyor belt) operator. Radio communication was maintained between the operators of the conventional and the nuclear weighing systems. Weights of material as measured by the nuclear system were recorded by both a strip chart recorder (Fig. 4) and a tally counter (Fig. 5) which indicated weight in 50-lb increments.

Two sizes of truck were used for hauling the gravel--one group with a capacity of about 60,000 lb and the other about 30,000 lb. Using the nuclear method, approximately 28,000 tons of gravel were weighed at the Woodworth Pit and about 6,000 tons at the Stevick Pit.

Test Results

Test results are expressed in terms of the differences between conventional and nuclear weight values for individual truckloads of gravel. Each difference is called an error. The dispersion of errors about the mean value is expressed by the common statistical term, standard deviation (σ). Approximately 67 percent of the values of the distribution lie within a distance of one standard deviation, measured plus or minus from the mean, and 95 percent lie within a distance of two standard deviations of the mean.

Fig. 6 shows the frequency distribution of differences between conventional and nuclear weight values for all data obtained during these tests. The mean average error was about 61.7 lb per truckload or 0.27 percent. Errors in nuclear weighing of individual truckloads were usually quite small but occasionally exceeded 1,000 lb. The distribution of errors shows that 67 percent of all trucks weighed should be within about $\pm$ 1/2 ton (σ) of the average error and 95 percent of all trucks should be within about $\pm$ 1 ton (2 σ). It is apparent from these data that the differences between nuclear and conventional weight values are not completely random, but are influenced considerably by adjustments of the equipment. On some days, the differences varied within a small range which was always slightly in favor of the contractor (nuclear scale weight greater than conventional scale weight), and on other days the differences would be within a small range consistently in favor of the Department (nuclear scale weight less than conventional scale weight). However, since only one operator was used on the nuclear system during this study, the degree of operator influence on adjustments of the system could not be determined.

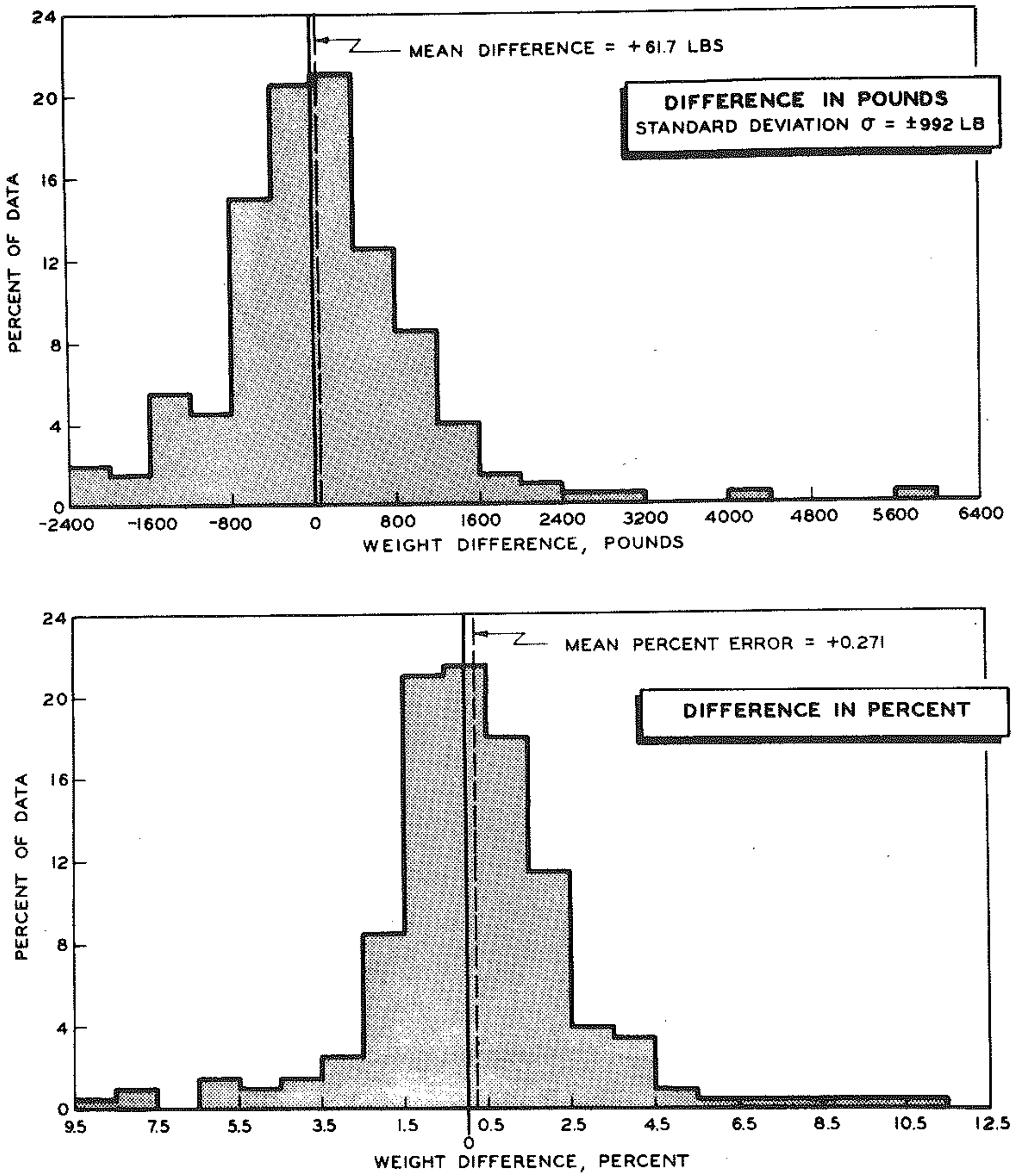


Figure 6. Frequency distributions of differences between conventional and nuclear weights (conventional minus nuclear).

The difference between nuclear and conventional weights appeared to be of the same magnitude regardless of which truck capacity was used (30,000 or 60,000 lb load). This means that the 60,000-lb load measurements would have a smaller error in terms of percentages than would the 30,000-lb load measurements. Fig. 7 shows the distribution of differences for loads of both 30,000 and 60,000 lb.

Because they tended to average out over a day's run, occasional large errors in the weights of single truckloads did not appreciably affect the accumulated weights. Fig. 8 shows the relationship between the average error encountered when measuring by the nuclear method and the number of truckloads weighed. It can be seen from these data that after approximately 100 truckloads of gravel have been weighed by the nuclear method, any large errors should be averaged out and the overall accuracy would be near the average expected from the system. For the nuclear system the average or cumulative accuracy was about 61.7 lb per truckload in favor of the State. No better accuracy can be expected unless the system is calibrated more precisely.

The Ohmart system appeared to be quite trouble-free. The only moving parts are in the recording instruments, and there is no contact between the equipment and the material being weighed. For these reasons there should be no wear. At first, trouble was encountered with the tachometer installation on the conveyor belt, but this should not be a recurring problem. Also, several hours were required for initial calibration of the new Ohmart gage. This extensive a calibration seldom should be required in the future.

After initial calibration by an Ohmart representative, who remained at the site for several days, the operator of the weighing system was required to make only a minor daily adjustment so that the system would record zero with the conveyor belt flowing empty. The Ohmart Corp. representative indicated that an improved method of checking the calibration of the system would soon be available. With this new method, the zero point check would still be used, but the high end of the density scale would also be checked using metal plates on the conveyor belt as a standard, and thus the weighing system's accuracy could be improved. Unfortunately, the standard plates were not available for evaluation during these tests.

Although the Ohmart system often was moved short distances at each gravel source as the stockpiles were consumed, and was moved several miles from one gravel pit to another, the initial calibration appeared to remain stable.

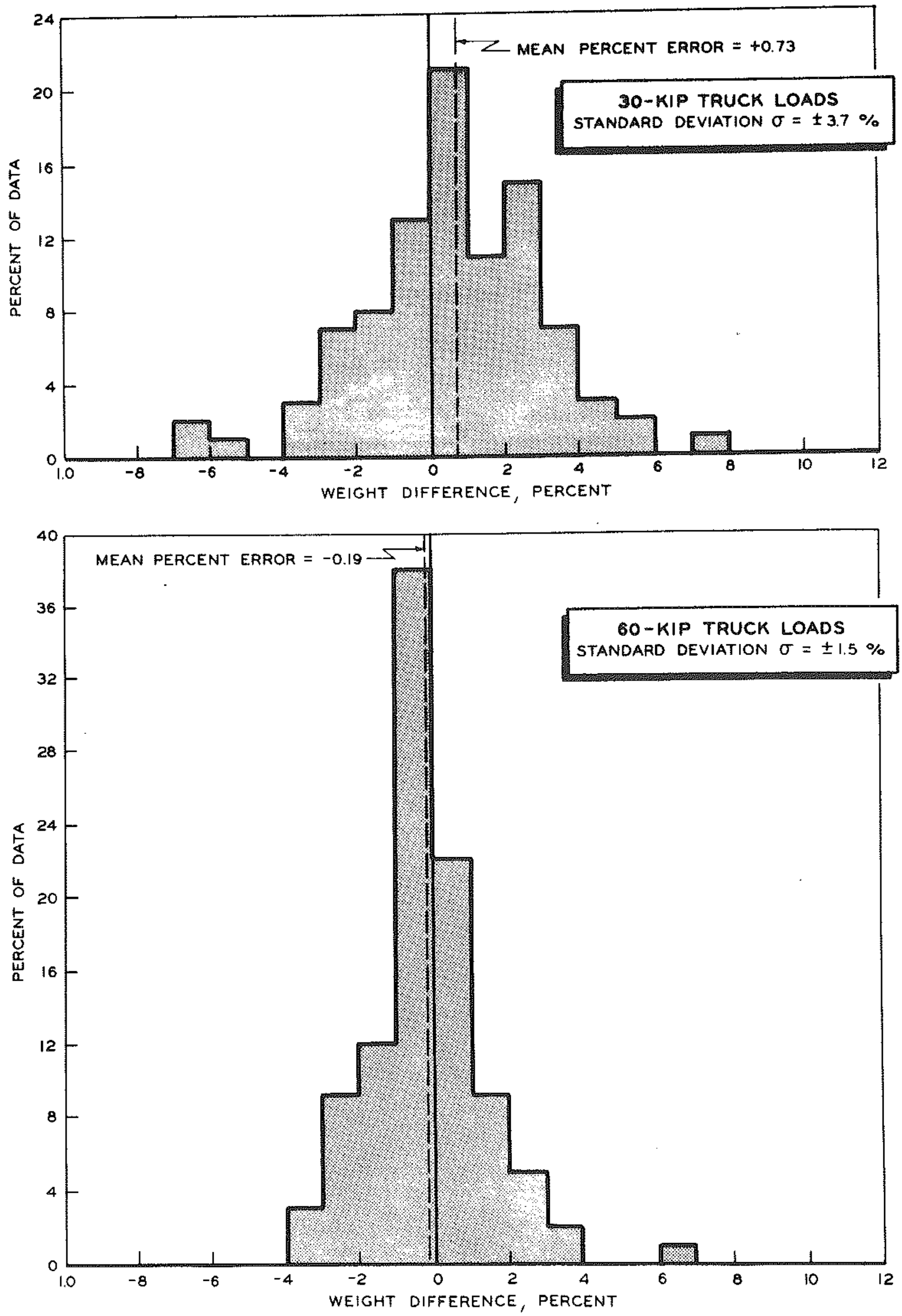


Figure 7. Frequency distributions of differences between conventional and nuclear weights for two truck load capacities (conventional minus nuclear).

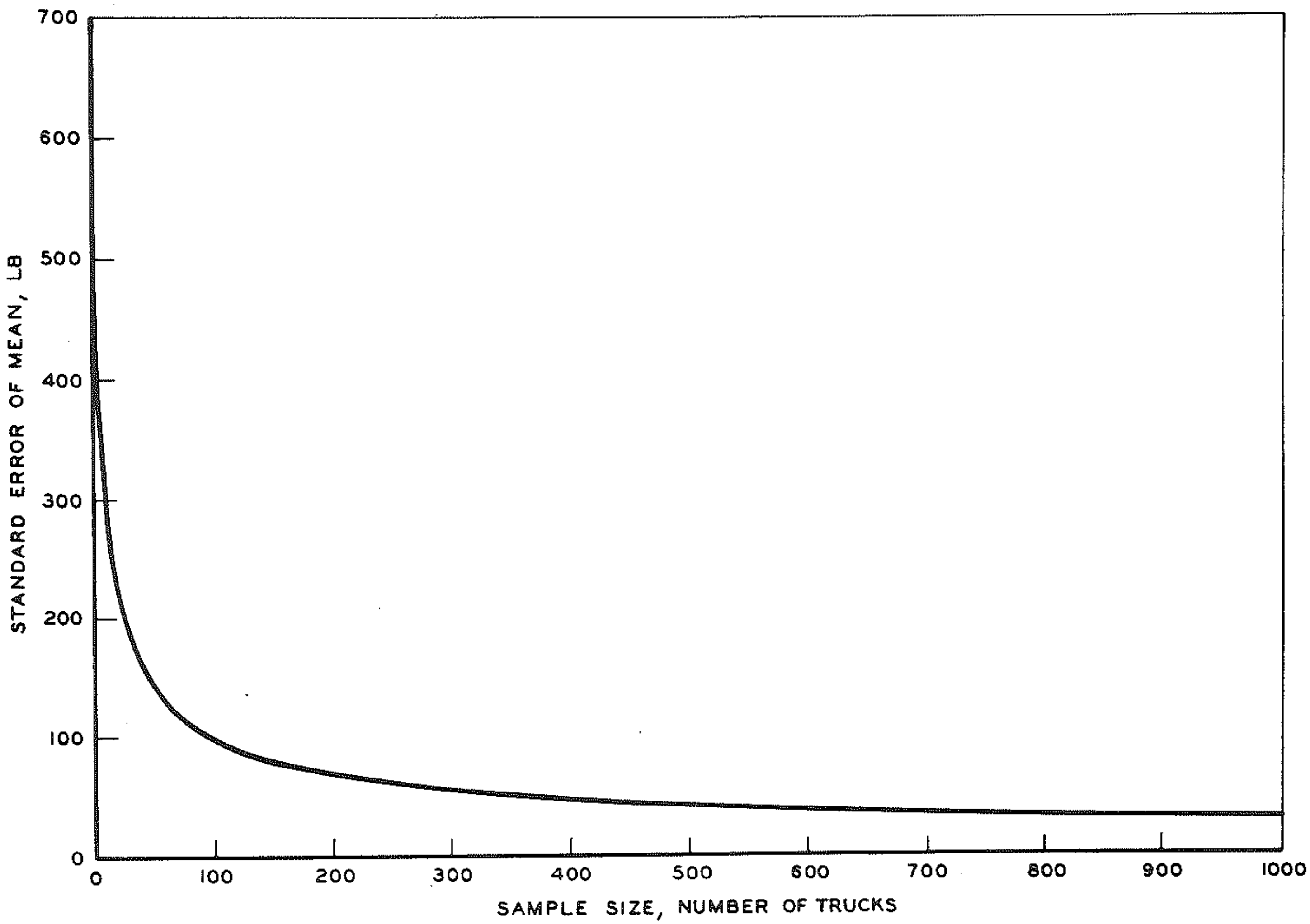


Figure 8. Relationship between number of trucks weighed and average cumulative weighing error.

Conclusions

1. The Ohmart nuclear weighing device is capable of making instantaneous continuous cumulative weight measurements of gravel as it is loaded into trucks by conveyor belt.

2. The average error for the nuclear weighing system tested was about 61.7 lb per truckload in favor of the contractor. In the future, this average could be easily changed by a simple adjustment.

3. The average error in weighing gravel by the nuclear method was not significantly affected by the size of the loads used in these tests. The error, in pounds, was about the same for both the 30,000- and 60,000-lb truckloads.

4. The cumulative accuracy of the weight value, as recorded by the Ohmart nuclear system, is a function of the number of trucks loaded. After about 100 truckloads of gravel, the cumulative error should be within 100-lb per truckload of the expected average error for the system.

5. The Ohmart nuclear system could be used to increase the efficiency of the weighing and recording operation since it could be instrumented to stop the conveyor belt after loading each truck to a desired constant weight such as 30,000 or 60,000 lb.

6. It is recommended that contractors working on Michigan highways be permitted to use the Ohmart nuclear method of weighing gravel provided that:

a. They observe the calibration and operating instructions recommended by the manufacturer.

b. A representative number of gravel trucks be weighed by both nuclear and conventional methods to provide a daily reliability check. Additional experience with the nuclear weighing system may show that this checking procedure is unnecessary.