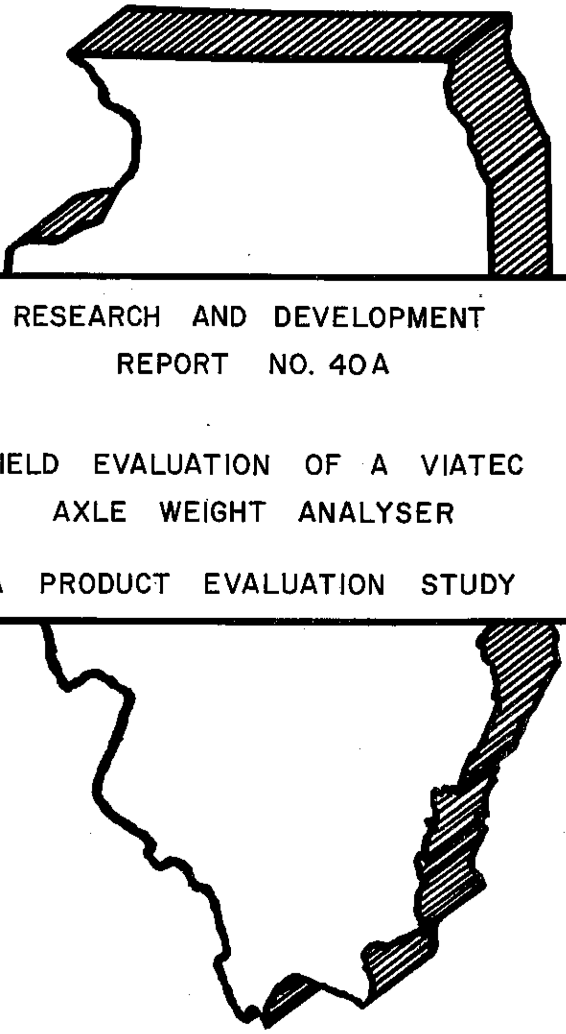
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS



RESEARCH AND DEVELOPMENT REPORT NO. 40A

FIELD EVALUATION OF A VIATEC AXLE WEIGHT ANALYSER

A PRODUCT EVALUATION STUDY

SPRINGFIELD, ILLINOIS 62706 — MARCH 1972

State of Illinois
DEPARTMENT OF TRANSPORTATION
Division of Highways
Bureau of Research and Development

FIELD EVALUATION OF A VIATEC AXLE WEIGHT ANALYSER

(A PORTABLE WEIGH-IN-MOTION CLASSIFIER)

by

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A Product Evaluation Study
by the
Illinois Division of Highways

March 1972

ABSTRACT

A portable axle weight classifier manufactured under the trade name of Viatec Axle Weight Analyser was evaluated in the field to determine its utility as a practical device for highway usage. The Analyser is designed to classify axles of vehicles traveling at regular highway speeds into incremental 4,000-lb weight groups ranging to over 40,000 lbs. The field test included the weights of 1,876 axles (409 trucks) in the regular traffic stream which were classified by the Analyser and weighed at a truck weigh station. The classifier placed 56 percent of the axles in correct weight groups. The system operated most inefficiently below the 8,000-lb axle weight level where 66 percent of the axles were classified incorrectly. On a cumulative basis, total axle weight for the period of weighing (15 hours) was indicated 22 percent high by the Analyser, and computed cumulative 18,000-lb single-axle equivalencies were indicated 53 percent high. The Analyser does not recognize single and tandem axles separately, not permitting unmanned usage if estimates of 18,000-lb axle equivalencies are desired.

A considerable amount of additional testing of the Analyser would be necessary before a determination could be made regarding the feasibility of developing factors that could be applied to the Analyser data to provide reasonable estimates of static weights and 18,000-lb single-axle equivalencies.

ACKNOWLEDGEMENTS

Special thanks are extended to George Reiter and Associates, agents for Plessey Electronics Corporation, manufacturers and distributors of the Tellurometer Viatec Axle Weight Analyser, for obtaining and assisting in the installation of the scale used during this evaluation. Also, thanks are extended to the personnel of the Carlock weigh station who interrupted their normal routine to collect additional weight data for this evaluation. The cooperation of the State Police of District Six (Pontiac) who control the operations of this weigh station is also gratefully acknowledged. The assistance of Illinois Division of Highways personnel of District 3 who provided traffic protection during the installation and removal of the portable scale system is appreciated.

FIELD EVALUATION OF A VIATEC AXLE WEIGHT ANALYSER

INTRODUCTION

The weighing of truck axles to gather data for highway planning, research, and pavement and bridge design, and for law enforcement, is an expensive endeavor. Conventional pit scales provide very accurate static weighings but require a substantial capital investment and are costly to maintain and man. Conventional portable scales are less costly, but generally less accurate and also expensive to man. Neither type provides any information on the magnitudes of the dynamic loadings applied to pavements and bridges. The use of either type disrupts the smooth flow of traffic and becomes totally impractical in very high volume multilane situations.

Any axle weighing system capable of overcoming the many disadvantages of the existing systems is obviously of great interest in the highway and vehicle weight enforcement fields.

The Viatec Axle Weight Analyser, Model WA1, manufactured and distributed by the Tellurometer Division of the Plessey Electronics Corporation, has appeared to have potential for filling some of the needs left unfulfilled by conventional scales, and perhaps by other available scales for weighing in motion. The most important in this latter group is probably that which has been developed by Clyde E. Lee of the University of Texas(1).[1/]

The Axle Weight Analyser has two basic parts: an axle sensor and a weight classifier. Power is supplied by a 12-volt automotive battery. The sensor, a large capacitor which has a rubber-air dielectric, is placed on the roadway surface

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[1/] Numerals in parentheses and underscored refer to the list of references at the conclusion of the report.

across one wheelpath of the pavement. Compression of the dielectric by loading changes the capacitance in proportion to the magnitude of the load. The change is converted to a voltage pulse by the classifier and then classified into one of eleven 4,000-lb weight groups extending upward to over 40,000 lb. The classifier, which is connected to the sensor by cable, can be located up to 50 ft. from the sensor. Weight data are accumulated on digital counters.

According to the manufacturer, the Model WA1 Viatec Axle Weight Analyser should be expected to classify axle weights within the 4,000-lb group boundaries with an instrumental accuracy of ± 5 percent within an instrument temperature range of 32F to 140F. The manufacturer points out that the dynamic load measurements made by the Analyser may differ appreciably from static load measurements, and suggests that variations of up to 15 percent can be considered to be normal. A belief is expressed that when thousands of measurements are made, errors will tend to cancel to the benefit of overall accuracy.

The Analyser is precalibrated at the manufacturing plant prior to delivery.

A field evaluation of the Viatec Axle Weight Analyser reported by Bryden and Monda for the New York State Department of Transportation (2) has been encouraging.

ILLINOIS EVALUATIVE STUDY

In response to a request from the Illinois Division of Highways, an Axle Weight Analyser was made available by the Tellurometer Division of Plessey Electronics Corporation for field testing in Illinois.

This field evaluation covered a single installation near a truck weigh station over a three-day period in October 1971. The location was such that trucks that were part of normal traffic were classified into the 4,000-lb groups at their operating speeds by the analyser before entering the weigh station to be weighed statically. The classification data generated by the analyser and the weight data by the static scales were compared and were analyzed to evaluate the accuracy of the Analyser and its potential for use by the Illinois Division of Highways.

Installation

The Analyser was installed on the inside wheelpath of the westbound driving lane of I-74 at overhead structure 604. This site is located approximately one mile east of the westbound truck weigh station, in McLean County, near Carlock, Illinois. The site location was selected because of its close proximity to the weigh station.

The scale system was installed during a 1-hour period beginning at 10:00 a.m. on October 13, 1971. After traffic protection was established, the driving lane where the sensor pad was to be placed was closed. A mop-grade bitumen (25 penetration grade) was placed in a heat kettle for melting. The heating interval for the bitumen was the most lengthy process of the entire installation operation, with the bitumen requiring approximately 45 minutes to become liquid. During the heating interval, the preparation of the sensor was completed. The physical dimensions of the sensor pad are 1'-7" x 6'-0" x 1/4". The outer cover of the sensor is polychloroprene rubber with a double two-inch-wide perforated metal strip attached around its outer perimeter. A second perforated strip is attached to the first by pop-rivets which permit rapid removal of the pad from the pavement. The bottom side of the sensor pad was thoroughly covered with an application of silicone grease. This is applied to prevent the sensor from adhering to the pavement surface so easy removal can be achieved. Photographs illustrating the installation and removal of the scale sensor are in Appendix A.

The next installation step was to saw-cut a 1/2 x 1/2-inch slot across the bituminous shoulder surface to accommodate the cable between the sensor and classifier.

The pavement surface was marked off at the location where the sensor was to be placed. The concrete was saturated with alcohol and the alcohol ignited to burn away foreign matter from the surface of the pavement. After burning, a thin coating of the hot bitumen was applied thoroughly to the area where the sensor was to be placed. After troweling the hot bitumen to a smooth consistency, the sensor was placed immediately thereon with the silicone grease side down. Minor repositioning of the sensor to obtain the correct wheelpath alignment was accomplished and then additional hot bitumen was poured over the perforated metal strips around the outer perimeter of the pad. Again, while still hot, the bitumen was troweled to provide a smooth transition between sensor and pavement surface. The final step was to connect the sensor to the classifier, placing the cable in the slot across the shoulder. A double fold of clothesline rope was placed in the slot atop the cable, and the remaining hot bitumen poured into the slot to seal the cable therein. With this, the installation was completed, requiring approximately one hour total time. (With the aid of a conventional bitumen heat kettle the installation time could be easily reduced to thirty minutes or less.) Connection of the battery to the classifier completed the system, making it ready to accumulate weight classification data.

The removal of the sensor at the conclusion of weighing required about 15 minutes. The initial step was to chisel the heads off the pop rivets along the second perforated metal strip. The second metal strip was pulled with pliers from the bitumen, and the other perforated strip attached to the sensor. The pad was then lifted from the pavement surface without difficulty. The rope in the cable slot was lifted out with pliers and the cable was removed. Photographs illustrating the removal are in Appendix A.

Data Acquisition

The Viatec Axle Weight Analyser was operated in combination with the platform scales of the existing truck weighing station during the following periods:

October 13, 1971	12:00 m to 4:00 p.m.
October 14, 1971	8:00 a.m. to 12:00 m 1:00 p.m. to 4:00 p.m.
October 15, 1971	8:00 a.m. to 12:00 m

All trucks traveling the westbound pavement passed over the Analyser sensor and were then weighed at the weigh station.

To assure satisfactory matching of the weights of individual axles classified by the analyser and weighed at the weighing station a mile distant, three sources of information were used. An observer on the overhead structure near the Analyser recorded the type of truck approaching the analyser, the number of axles, the firm name, and the time, and also gave the truck an identifying sequential number beginning with the numeral one assigned to the first truck weighed at the start of the operating period. A man at the recording classifier identified each truck passing over the sensor with a sequential number beginning again with the numeral one assigned to the first truck to pass. This individual also read and recorded the number of axles assigned to the various weight groups by the classifier and returned the counters to zero position after each truck weighing. A man at the weighing station recorded the same information as the observer on the overhead structure. The attendant at the weighing station who made the weighing was provided with the sequential number assigned to each vehicle for recording on the permanent tape on which had been printed the weight of each axle and the total weight of each vehicle weighed, along with the date and time of weighing. These tapes were made available to the study forces.

Samples of the form sheets on which were recorded the truck identification data and the axle classification data are included as Appendix B.

The Analyser was kept in operation through a total period of 120 hours to gain information regarding its general service performance capabilities.

Data Evaluation

During the 15-hour primary weighing period, 409 trucks and a total of 1,876 axles were recorded and weighed at the weighing station. The same number of trucks but 9 fewer axles were registered at the Viatec Analyser. The reason why the 9 axles did not actuate the sensor-recorder system is not known. The distribution of the vehicles and axles weighed, according to vehicle type (single unit, truck-tractor semitrailer, etc.) and axle configuration is shown in Table 1. The various vehicle types and axle configurations are illustrated in Figure 1.

The distribution of vehicles and axles in the survey sample by vehicle body type is shown in Table 2.

The accuracy of the classification of axles into the various weight groups by the Analyser is shown in Table 3. While the Analyser classifies all axles into 4,000-lb weight groups up to 40,000 lbs, and places all axles weighing 40,000 lbs or more into a single group, no axle weight in the survey exceeded the 20,000 to 23,999 group. It will be noted in the Table that the overall yield of axles classified correctly was a disappointing 56.2 percent. The system operated most inefficiently below the 8,000-lb axle weight level. The overall average of somewhat over 70 percent for correct classification in the weight groups exceeding 8,000 lbs is much better than the average for correct classification below 8,000 lbs, but immediately places an apparent constraint on uses for the equipment.

A cataloging that was made of the amount of cargo being carried in the vehicles of the survey with reference to apparent capacity showed an approximate 60:40 ratio

TABLE 1

DISTRIBUTION OF VEHICLE TYPES AND AXLE CONFIGURATIONS IN SURVEY SAMPLE

Vehicle[1/] Type	Number of Vehicles	Percent of Total Vehicles	Number of Axles	Percent of Total Axles
2D	27	6.6	54	2.9
2D-3	1	0.3	5	0.3
3D	8	1.9	24	1.3
2S-1	16	3.9	48	2.6
2S-2	40	9.8	160	8.5
2S-3	1	0.3	5	0.3
2S-1-2	2	0.5	10	0.5
3S-1	3	0.7	12	0.6
3S-2	308	75.3	1,540	82.0
3S-3	3	0.7	18	1.0
Total	409	100	1,876	100

[1/] Common code - see Figure 1

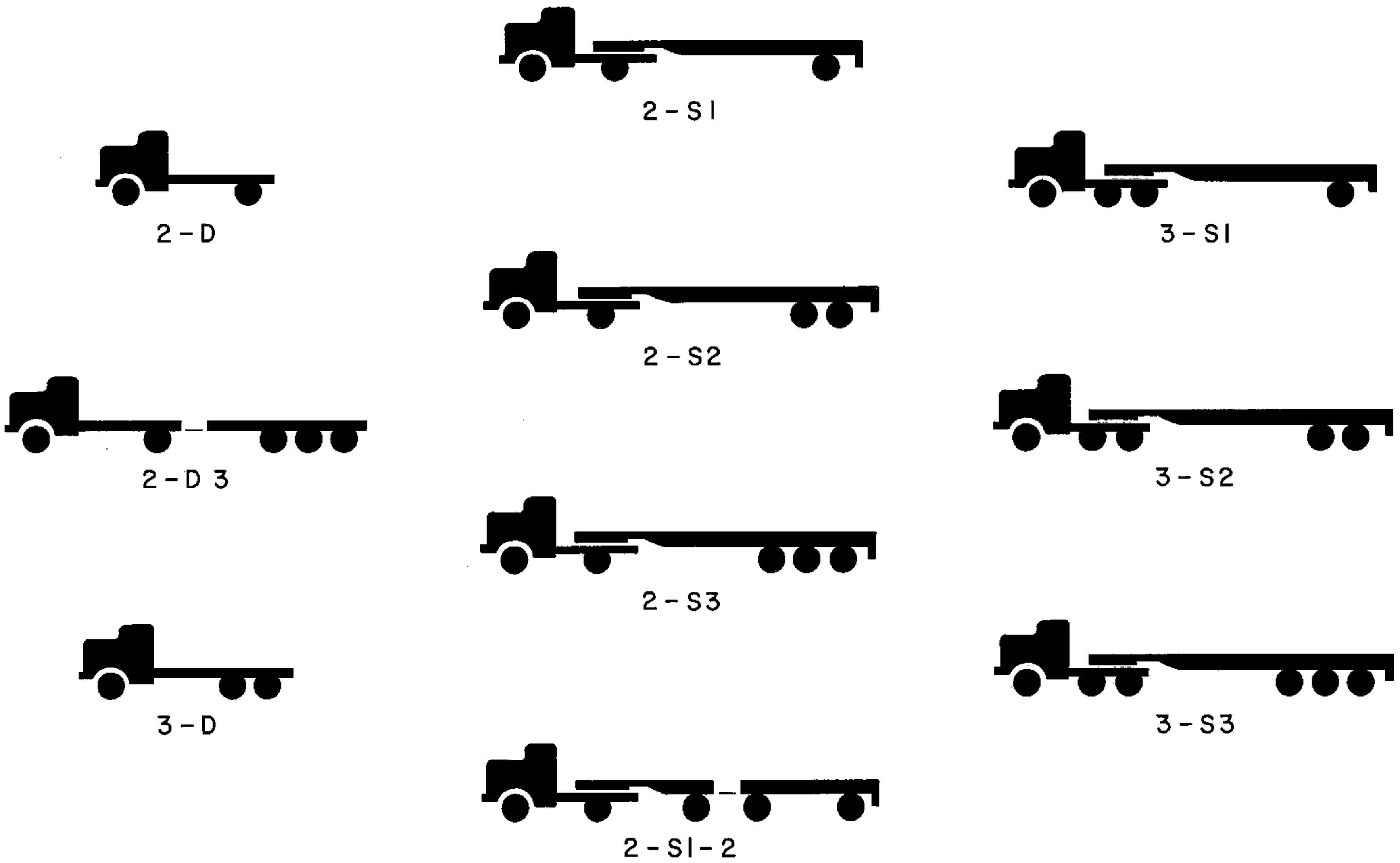


Figure 1. Illustration of Vehicle Types

TABLE 2

DISTRIBUTION OF VEHICLES AND AXLES IN SURVEY SAMPLE BY VEHICLE BODY TYPE

Body Type	Number of Vehicles	Percent of Vehicles	Number of Axles	Percent of Axles
Standard cargo	257	62.8	1,154	61.5
Flat bed - Low boy	56	13.7	272	14.5
Tanker	46	11.2	233	12.4
Stock - Stake	19	4.6	82	4.4
Grain box	16	3.9	75	4.0
Motor car carrier	8	2.0	33	1.8
Miscellaneous	7	1.8	27	1.4
Total	409	100	1,876	100

TABLE 3

Weight Group	Number of Axles Classified	Axles Classified Correctly		Axles Classified Incorrectly	
		Number	Percent	Number	Percent
400 to 3,999	125	7	5.6	118	94.4
4,000 to 7,999	688(2)[1/]	269	39.1	419	60.9
8,000 to 11,999	566(3)	406	71.7	160	28.3
12,000 to 15,999	425(3)	318	74.8	107	25.2
16,000 to 19,999	62(1)	49	79.0	13	21.0
20,000 to 23,999	1	1	100.0	0	0.0
Total	1,867(9)	1,050	56.2	817	43.8

[1/] Numbers in parentheses indicate numbers of axles weighed at weighing station but not recorded by Analyser.

between vehicles essentially loaded and vehicles essentially empty. Axles of the empty vehicles were seen to predominate in the less-than-8,000-lb weight group and were strongly represented among those that were misclassified.

The reason for the very low degree of classification accuracy in the less-than-8,000-lb weight group is not clear.

Table 4 is presented to show the dispersal of axle weight classifications from the true weight group classification. A strong tendency toward the classification of axles one weight group too high will be seen. Smaller numbers of axles were classified two and three groups too high. The tendency toward classifying axles in groups higher than indicated by the static weighings is probably due at least partly to the dynamic nature of the loads imparted to the Analyser by the moving vehicles. A recent report of a National Cooperative Highway Research Program project (3) indicates that dynamic forces at the tire-pavement interface may on occasion be in excess of twice the force imposed statically by the same tire load. The number of axles classified one group too low will be seen not to be great, with only a few being classified two groups too low. The information in Table 4 is presented in another manner in Figure 2, again showing the tendency for the misclassified axles to be placed in a higher rather than a lower group.

Table 5 has been prepared to provide further information on the accuracy of the system in locating the true classification of axle weights. It will be seen that a fairly strong tendency exists for the misclassifications to be "near misses." For example, 135 axles in the 4,000 to 7,999-lb group weighing within 1,000 lbs of the upper limit of the group were classified in the next higher group. Again, in this table, the tendency for axles to be misclassified into higher groups rather than lower groups is evident.

TABLE 4

DISPERSAL OF AXLE WEIGHT CLASSIFICATIONS FROM TRUE WEIGHT GROUPS

True Weight Group (lbs)	Number of Axles Classified		Incorrectly Recorded Classifications									
			One Group Too High		Two Groups Too High		Three Groups Too High		One Group Too Low		Two Groups Too Low	
	Correct	Incorrect	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
400 to 3,999	7	118	4	3.3	107	90.8	7	5.9	0	0.0	0	0.0
4,000 to 7,999	269	419	349	83.3	70	16.7	0	0.0	0	0.0	0	0.0
8,000 to 11,999	406	160	127	79.4	8	5.0	0	0.0	25	15.6	0	0.0
12,000 to 15,999	318	107	85	79.4	0	0.0	0	0.0	18	16.8	4	3.8
16,000 to 19,999	49	13	2	15.4	0	0.0	0	0.0	10	76.9	1	7.7
20,000 to 23,999	1	0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	1,050	817	567	69.4	185	22.6	7	0.9	53	6.5	5	0.6

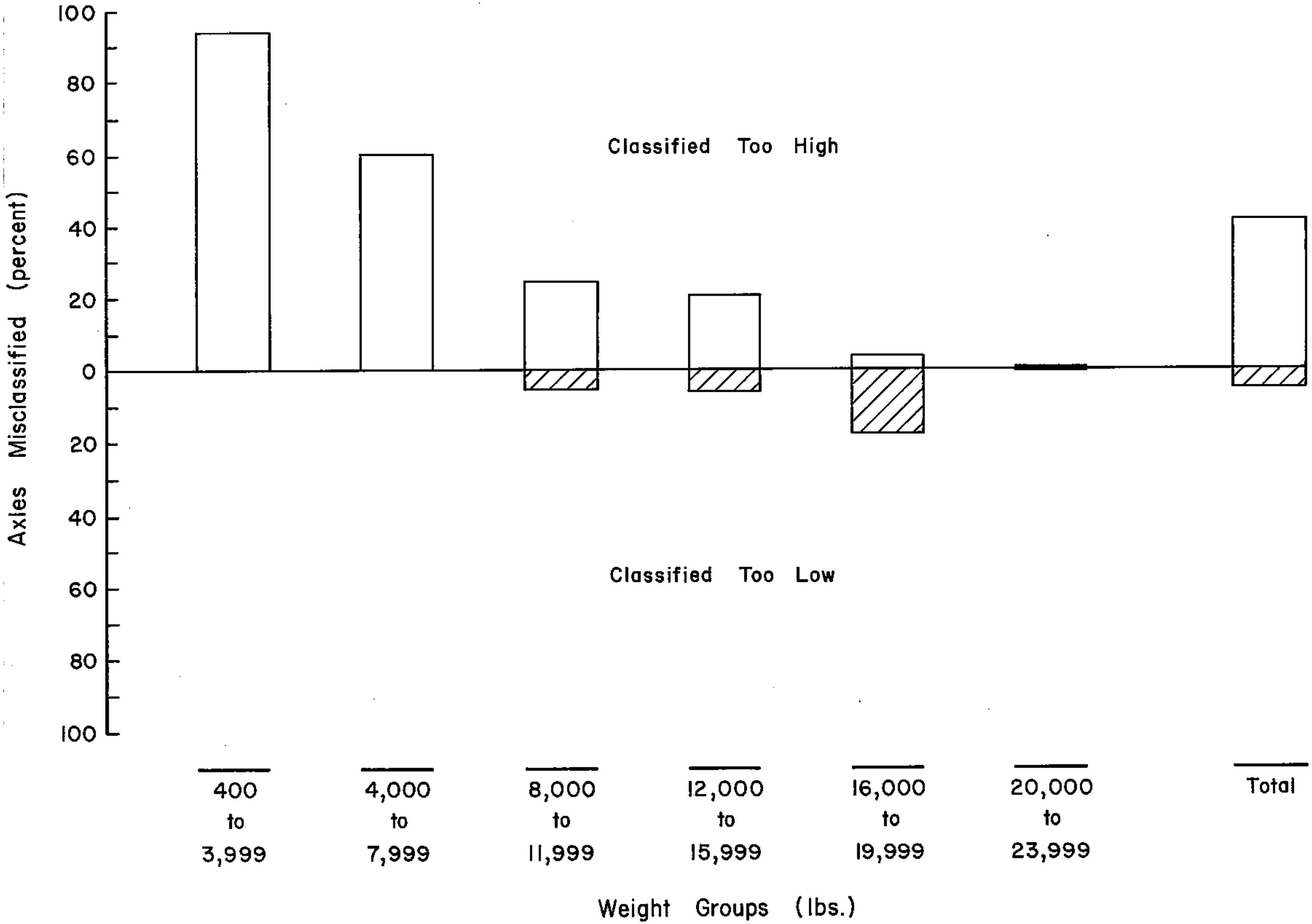


Figure 2. Dispersal of Axle Weight Classifications from True Weight Groups

TABLE 5

DISTRIBUTION OF AXLES INTO 1,000-LB WEIGHT INCREMENTS FOR MISASSIGNED AXLES

True Weight Group (lbs)	True Weight Subgroup (lbs)	Recorded Classification				
		One Group Too High	Two Groups Too High	Three Groups Too High	One Group Too Low	Two Groups Too Low
400 to 3,999	999 or less	2	-	-	-	-
	1,000 to 1,999	2	-	-	-	-
	2,000 to 2,999	-	13	2	-	-
	3,000 to 3,999	-	94	5	-	-
4,000 to 7,999	4,000 to 4,999	48	8	-	-	-
	5,000 to 5,999	67	12	-	-	-
	6,000 to 6,999	99	16	-	-	-
	7,000 to 7,999	135	34	-	-	-
8,000 to 11,999	8,000 to 8,999	3	-	-	15	-
	9,000 to 9,999	25	1	-	7	-
	10,000 to 10,999	42	3	2	2	-
	11,000 to 11,999	57	4	-	1	-
12,000 to 15,999	12,000 to 12,999	-	-	-	7	-
	13,000 to 13,999	8	-	-	4	1
	14,000 to 14,999	17	-	-	3	2
	15,000 to 15,999	60	-	-	4	1
16,000 to 19,999	16,000 to 16,999	1	-	-	6	-
	17,000 to 17,999	-	-	-	4	1
	18,000 to 18,999	1	-	-	-	-
	19,000 to 19,999	-	-	-	-	-
20,000 to 23,999	20,000 to 20,999	-	-	-	-	-
	21,000 to 21,999	-	-	-	-	-
	22,000 to 22,999	-	-	-	-	-
	23,000 to 23,999	-	-	-	-	-
Total		567	185	7	53	5

Table 6 was prepared to explore the possibility that certain axles, such as the second axle of a tandem pair, were more susceptible to misclassification than others. It is obvious from the table that the misclassifications are well-distributed among axles and not concentrated at any particular location.

Table 7 has been developed to show the accumulation of axle weights during the weighing period. For the axles grouped by the Analyser, the average weight for the axles in each group is assumed to be the median weight for the group. For example, the average weight for the axles in the 8,000 to 11,999-lb group is assumed to be 10,000 lbs. Actual recorded axle weights were used in computing cumulative axle weights at the weighing station. It will be noted in the table that the cumulative weights as determined by the Analyser for the lower two weight groups were substantially lower than those determined by the weighing station, and substantially higher for all the other weight groups. No great degree of consistency between groups is to be observed. The total of all axle weighings included in the survey was 22.4 percent high by the Analyser.

One of the very important possible uses envisioned for the Viatec Axle Weight Analyser was that of affording a quick and economic means for recording data on which to base estimates of 18-kip single-axle equivalencies representative of mixed traffic loadings on pavements based on AASHO Road Test concepts. This loading information is urgently needed in establishing the performance histories of pavements for the development of structural design criteria and for predicting future pavement life.

The results of 18-kip single-axle equivalency determinations for the 15 hours of field study are shown in Table 8. It will be noted that, as with the cumulative axle weights, the cumulative 18-kip equivalencies as shown by the Analyser were substantially higher (53.1 percent) than shown by the scale weighings, without any consistency between individual weight groups.

TABLE 6

FREQUENCY OF MISCLASSIFICATION ACCORDING TO VEHICLE TYPE AND AXLE LOCATION

Vehicle Type	Axle Number[1]						Total Axles Misclassified	Total Axles Weighed
	1	2	3	4	5	6		
2-D	7/27[2]	18/27					25	54
			Triple Tandem					
2-D3	0/1	0/1	1/1	1/1	1/1		3	5
		Tandem Pair						
3-D	4/8	2/8	7/8				13	24
2-S1	4/16	6/16	11/16				21	48
			Tandem Pair					
2-S2	13/40	16/40	21/40	17/40			67	160
			Triple Tandem					
2-S3	0/1	0/1	0/1	0/1	1/1		1	5
2-S1-2	0/2	2/2	1/2	2/2	2/2		7	10
		Tandem Pair						
3-S1	1/3	1/3	0/3	0/3			2	12
		Tandem Pair		Tandem Pair				
3-S2	99/308	154/308	135/308	152/308	142/308		682	1,540
		Tandem Pair		Triple Tandem				
3-S3	0/3	0/3	1/3	1/3	1/3	2/3	5	18
Total							826	1,876

[1] Number 1 is steering axle; others follow in sequence

[2] Number misclassified/Number weighed

TABLE 7

CUMULATIVE AXLE WEIGHTS - ANALYSER VS. WEIGHING STATION

Weight Group (lbs)	Number of Axles in Weight Group		Cumulative Axle Weights		Excess or Deficiency By Analyser (%)
	By Analyser	By Weighing Station	By Analyser (lbs)	By Weighing Station (lbs)	
400 to 3,999	7	125	14,000	23,680	- 4.8
4,000 to 7,999	308	690	1,848,000	4,562,320	- 59.5
8,000 to 11,999	875	569	8,750,000	5,333,000	+ 64.1
12,000 to 15,999	528	428	7,392,000	5,922,000	+ 24.8
16,000 to 19,999	146	63	2,628,000	1,047,000	+151.0
20,000 to 23,999	3	1	66,000	20,000	+230.0
Total	1,867[1/]	1,876	20,698,000	16,908,000	+ 22.4

[1/] Nine axles not classified

TABLE 8

ENT AXLE LOADINGS - ANALYSER VS. WEIGHING STATION

Tandem Axles				Total		
Number of Axles		18-Kip Equivalencies		18-Kip Equivalencies		Excess or Deficiency By Analyser (%)
Analyser	By Weighing Station	Analyser	By Weighing Station	Analyser	By Weighing Station	
5	105	0.0	0.1	0.0	0.1	-100.0
270	648	1.4	3.2	2.5	4.5	- 44.4
829	527	24.9	15.8	33.1	23.3	+ 42.1
501	413	41.1	33.9	57.4	42.9	+ 33.8
135	58	27.9	12.0	45.2	19.9	+127.1
3	1	1.3	0.4	1.3	0.4	+225.0
1,743[1/]	1,752	96.6	65.4	139.5	91.1	+53.1

In the acquisition of simple axle weight and count data, the Analyser can be left unattended for fairly long periods of time, the only need being to record periodically the summations of axles classified in each weight group. At the present stage of development of the equipment, unmanned usage is not possible for the establishment of 18-kip single-axle equivalencies where single axles and tandem axles must be recognized separately. This can now be done only by manually recording during the entire period of operation single and tandem axles being classified into each weight group. While this is a considerable disadvantage, it is probably outweighed by other advantages of the system over any kind of static weighing system.

DISCUSSION

The Viatec Axle Weight Analyser proved to be simple to install and easy to use. No great technical skill is required for either its installation or its operation. Physically, it withstood 120 hours of impact by fairly heavy traffic without any indication of a breakdown. No trouble was experienced with the electronic components during the same period of time.

Usually, when devices for weighing in motion are being considered, three possible applications come to mind:

(1) to determine static axle weights
(2) to measure dynamic axle weights
(3) to serve as a culling device for selective static weighings

It is self-evident that axles in motion will almost invariably include a dynamic increment of weight (either plus or minus) that will be dependent upon the smoothness of the approach pavement, characteristics of the vehicle suspension system, the speed of the vehicle, and numerous other factors as well. On a statistical basis, it is conceivable that an average dynamic correctional factor or factors could be applied to the weight-in-motion data so that a reasonably reliable estimate of average static weight conditions over an extended period of time could be achieved.

The average difference of 22.4 percent between the static weighings and the Analyser results as shown in Table 7 does not appear unreasonable as a possible average dynamic increment in view of the 20 to 30 percent impact factors now often used in pavement and bridge design. However, the concentration of deficient weights in the lowest Analyser weight groups as compared with excesses in the other groups as also shown in Table 7 suggests that more than impact was probably responsible for the differences. For the series of tests that was conducted, the factory static calibration was accepted, and no information is available to permit further theorizing on the reasons for the differences.

A considerable amount of additional field testing of the Analyser will be necessary before a determination can be made regarding the feasibility of developing factors that can be applied to the Analyser data to provide reasonable estimates of static weights.

The magnitudes of loads applied to road surfaces by axles or wheels of moving vehicles are difficult to measure, and little reliable data are available concerning them. While a far greater knowledge of these loads is very desirable, and a necessity if truly rational methods for the structural design of pavements and bridges are ever to be realized, the needed information has been slow to come. The testing that has been described shows the Viatec Axle Weight Analyser to offer promise as one means for obtaining the needed data in a quick and efficient manner. The information that was obtained, however, is not of sufficient quality or quantity to add any truly authoritative data to the meager amount now on hand.

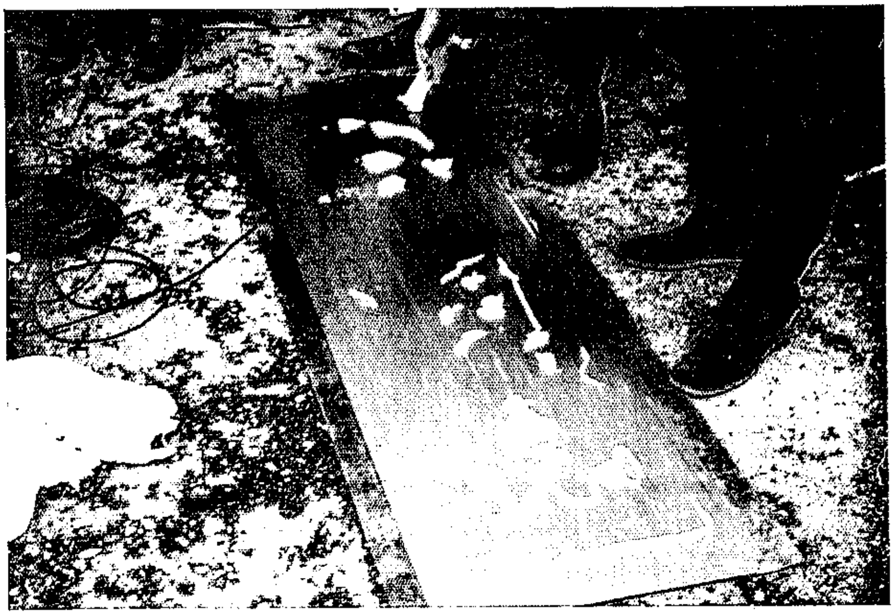
The rather large difference (+53.1 percent) between total 18,000-lb single-axle equivalencies as computed from the Analyser data and the weighing station data is not very encouraging to those agencies who would wish to use the system in conjunction with pavement design procedures employing the axle-equivalency concept as developed at the AASHO Road Test. The need to have a manual recording of axle type (single or tandem) made in conjunction with axle classification by the Analyser if 18-kip single-axle equivalencies are the desired output is a further restrictive feature that must be considered. Perhaps additional electronic components that would somehow identify single and tandem axles separately could be developed to overcome this disadvantage.

The Analyser undoubtedly could be used in its present state of development to reduce static weighings significantly if a desire exists to limit axle weighings to those near or exceeding legal load limits. Again, a classification of single and tandem axles separately would enhance the operation.

APPENDICES

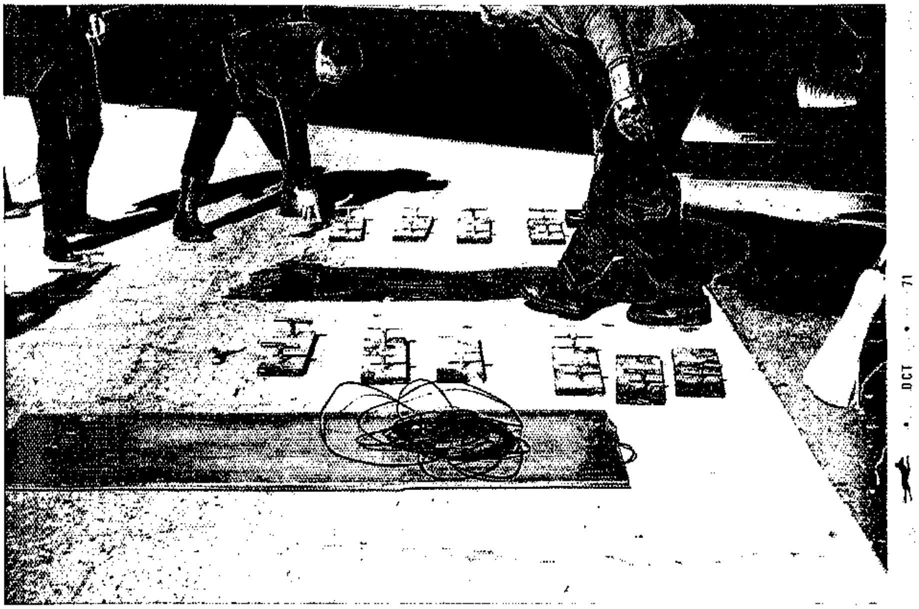
APPENDIX A

(PHOTOGRAPHS OF SCALE SENSOR - INSTALLATION AND REMOVAL)



Silicone grease being applied to bottom side of sensor pad. Perforated metal strips can be observed along both sides of the sensor pad.

Ignition and burnoff of alcohol on pavement surface in location where sensor pad is to be placed.



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Hot bitumen being poured onto pavement surface.

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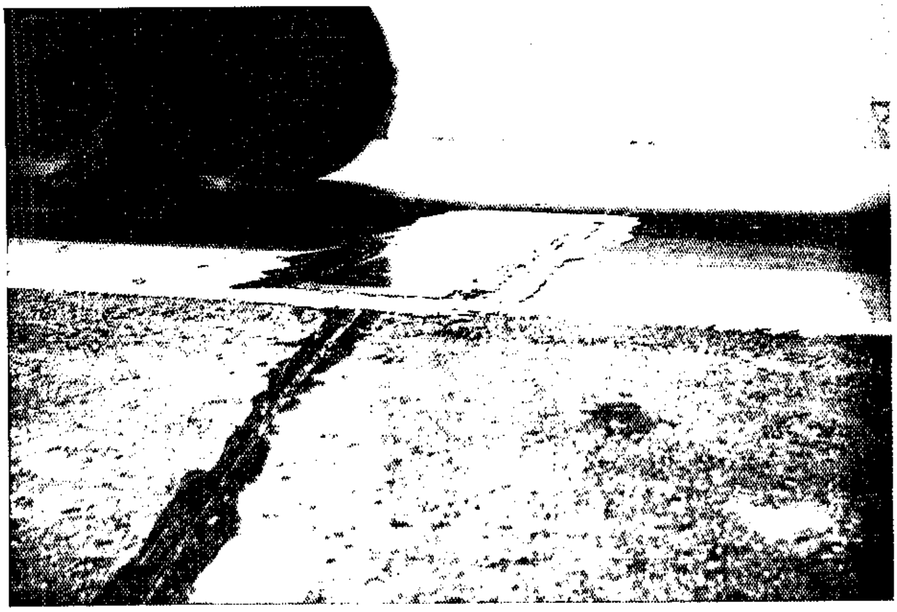
Sensor pad in place with weights during cooling of bitumen.

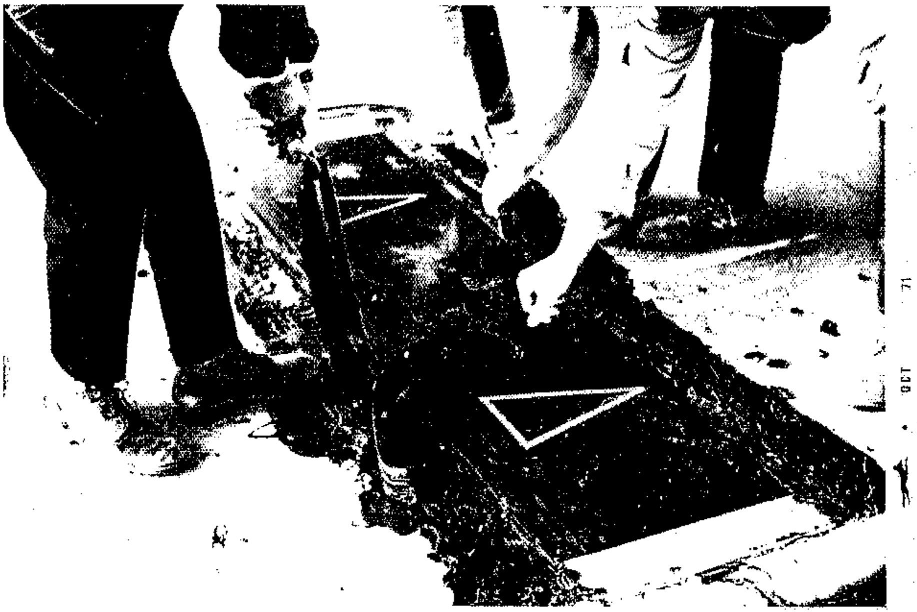
Bitumen being troweled over perforated metal strip to form smooth transition between sensor and pavement surface.

Cable slot being filled with bitumen. Note double fold of clothesline rope atop cable.

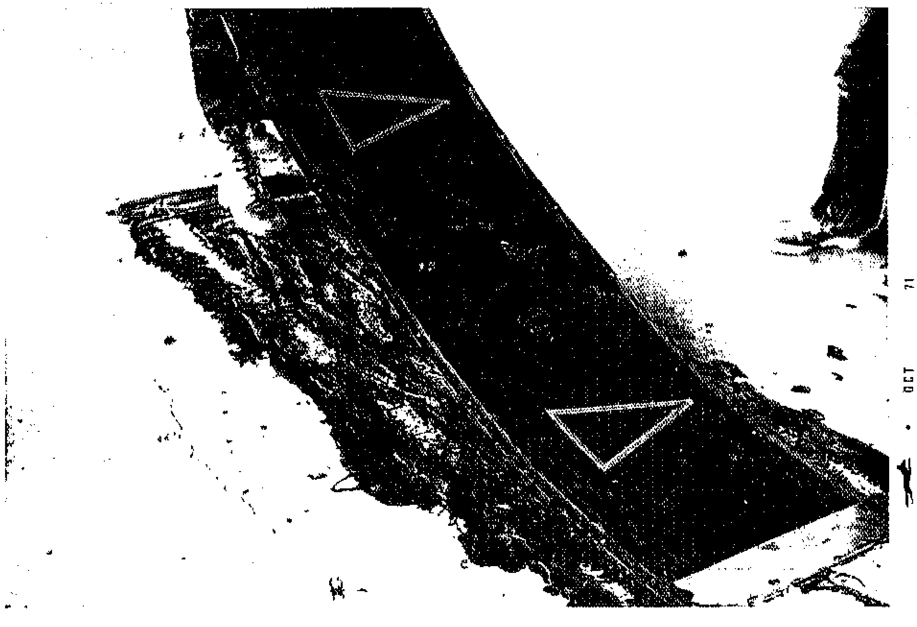
Completed sensor installation. Signs in the foreground are for weigh station entrance approximately one mile from installation. Classifier is situated on pier to the right.



Sensor in place with an immediate axle application forthcoming. Note slot across shoulder where cable is emplaced.



Perforated metal strip being pulled from bitumen on the left, while pop-rivets are being chiseled off on the right during sensor pad removal.



After removal of perforated strips, sensor pad is easily lifted from pavement surface.

APPENDIX B

SAMPLE OF FORMS USED DURING DATA COLLECTION

	0–4	16–20	32–36
F			
P			
S			
	4–8	20–24	36–40
F			
P			
S			
	8–12	24–28	40– +
F			
P			
S			
	12–16	28–32	Axles
F			
P			
S			

	0–4	16–20	32–36
F			
P			
S			
	4–8	20–24	36–40
F			
P			
S			
	8–12	24–28	40– +
F			
P			
S			
	12–16	28–32	Axles
F			
P			
S			

	0–4	16–20	32–36
F			
P			
S			
	4–8	20–24	36–40
F			
P			
S			
	8–12	24–28	40– +
F			
P			
S			
	12–16	28–32	Axles
F			
P			
S			

	0–4	16–20	32–36
F			
P			
S			
	4–8	20–24	36–40
F			
P			
S			
	8–12	24–28	40– +
F			
P			
S			
	12–16	28–32	Axles
F			
P			
S			

Sample of form used to collect data from the classifier.

NUMBER								
TIME								
FIRM								
SPEED								
TYPE BODY								
TOTAL AXLES								
WT. STA.								
TOTAL WT.								
AXLES 1								
2								
3								
4								
5								
6								

SYMBOLS ---- STD.—STANDARD TRAILER GB.—GRAIN BOX FB.—FLAT BED
DB. —DOUBLE TRAILER TB.—TANKER BD. LB.—LOW BOY

NUMBER								
TIME								
FIRM								
SPEED								
TYPE BODY								
TOTAL AXLES								
WT. STA.								
TOTAL WT.								
AXLES 1								
2								
3								
4								
5								
6								

Sample of form used at portable scale and at weigh station.

LIST OF REFERENCES

1. Lee, C. E., "A Portable Electronic Scale for Weighing Vehicles in Motion," Highway Research Board Record No. 127, 1966.

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3. Whittemore, A. P., Wiley, J. R., Schultz, P. C., and Pollock, D. E., "Dynamic Pavement Loads of Heavy Vehicles," National Cooperative Highway Research Program Report No. 105, 1970.