Some Statistical Evaluations of Truck Weight Characteristics in Mississippi

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The number of trucks needed to be weighed was determined so that the mean weight of each axle and vehicle for each vehicle type would have an error not greater than ±5 percent on 95 percent confidence limit. This was done separately for empty and loaded vehicles. Analyses of mean weights for the periods of weight stations operations (6 a.m.-2 p.m.; 2 p.m.-10 p.m.; 10 p.m.-6 a.m.; and 8 a.m.-4 p.m.) disclosed that the period 2 p.m.-10 p.m. produced mean weights which were not significantly different from the mean weights of 24-hr operations and, therefore, could be substituted for the 24-hr operations provided the mean weights were desired. It was found that there were several statistical populations (or universes) of mean weight characteristics which were significantly different. Individual stations were identified in relation to these populations, thus indicating the stations where reliable mean weights could be obtained and correctly interpreted. An IBM-650 computer was used for statistical computations which basically consisted of (a) mean, (b) standard deviation, (c) standard error of the mean, (d) sample sizes for ± 5 percent error on 95 percent confidence limit, (e) t test of significance of differences between means, and (f) analysis of variance tests.

●TRUCK WEIGHING by state highway departments for highway planning and research has been in effect for the last 25 years or so. The principal objectives have been the determination of mean axle and vehicle weights; the frequency distribution of weights by weight groups; the weight characteristics of the heaviest type vehicles; the frequency of application of heavy loads to the pavements; and the extent of overloading as determined by the individual state laws and as recommended by the American Association of State Highway Officials.

Concerning truck weighing, there is no unanimity of opinion or standardization of practices among the states, and no objective criteria have been developed to determine whether the data are adequate or inadequate for each purpose for which they are used. However, as experience was being gained, the tendency appeared among the states to curtail the weight sampling by reducing the number of stations or the hours of operations or both.

In 1959, Mississippi decided to undertake statistical analyses of its truck weight data. The primary purpose was to investigate the possibilities that mean weights, of quality similar to those obtained by procedures currently in use, could be obtained by simplified methods. More specifically, it was hoped that the studies would show the possibility that an administratively convenient 8-hr daylight period of truck weighing operations would provide the data needed for trend studies, mean axle weights, and mean vehicle weights, with substantially the same degree of accuracy as obtained by the procedures used in 1958 and 1959. Experience and observations led to the belief that this improvement might be possible, and, if so, savings would be effected. Also, it was thought that the inconvenience to the driving public might be reduced and safety fostered because Mississippi felt that the night weighing operations were potentially more dangerous than those of the daylight hours. It was hoped that schedules of truck weighing could be developed to provide the results which would be representative of axle and vehicle mean weights of both daylight and night operations by daytime sampling only. It was realized, however, that other data such as frequency of occurrence of very heavy axles and vehicles and their load distribution characteristics are equally or even more important for the solution of engineering problems.

When the studies were first conceived in Mississippi, the general qualitative appraisal and exploration were only of secondary importance. It was as a byproduct that additional information on the characteristics of some of the truck weight data was disclosed. But it is chiefly these incidental disclosures and the methods used in obtaining them that may be of interest and application outside of Mississippi.

Historically, from the very beginning of truck weighing operations in Mississippi, the location of weighing stations and periods of weighing have been more or less decided on judgment formed from the general knowledge of local traffic characteristics. Truck weight sampling practices have been varied. In the late 1930's, weighing stations were operated during each season of the year on all road systems under the state's jurisdiction. Provision was made in the schedules for 24-hr sampling on both weekdays and weekends. Following the 1930's, the collection of weight data was continued in the summer months at 15 locations, with sampling periods varying from 8 hours in some years to 24 hours in others. A few new locations were added in urban areas and on the state's secondary system during the summer of 1956.

During 1958 and 1959, weight data were collected for 24-hr periods at 42 locations, 18 of which were on the primary system, 7 in urban areas, and 17 on the secondary system. At each location there were three 8-hr operations — from 6 a.m. to 2 p.m., from 2 p.m. to 10 p.m., and from 10 p.m. to 6 a.m. — all during the summer months. The data from these operations provided the material for the studies presented in this paper.

Each study of qualitative appraisal was so designed as to reveal by probability measures the existence of a significant situation or provide the knowledge, if possible, which would lead toward a conclusion that a more efficient and desirable procedure than the one in operation could be developed.

The vehicle and axle weights for any given vehicle type obtained at any station constitute a sample of a larger population of all vehicles of the type passing that station. To aid in designing more efficient samples for future operations, it was necessary to decide whether the population of vehicle and axle weights for a given vehicle type passing one station was sufficiently similar to that of other stations as to be combined into one composite population. The assumption was made that the weight distributions obeyed the well-known Gaussian law. A statistical test, the F test, provided information on whether or not the spread of the underlying normal distribution as measured by the standard deviations obtained at one station differed significantly, in the statistical sense, from the spread obtained at the other stations. The 18 rural stations on the primary state highways were used for this purpose.

The analyses were made by vehicle types for 1959, using data for loaded and empty vehicles.

The vehicle types for which sufficient data were available for analysis are as follows:

Type	Description
13	2-axle motortruck with dual tires on rear axles
14	3-axle motortruck
21	2-axle tractor, 1-axle semitrailer
22	2-axle tractor, 2-axle semitrailer
24	3-axle tractor, 2-axle semitrailer

Following the general statistical practices, the mean values were not computed for a count of less than 5 vehicles. The standard deviation and the variance were not computed for a count of less than 10. The sample size was not computed for a count of less than 30. The standard theoretical distribution values used for determination of significance are for the 95 percent confidence limit. If the computed values are equal to or less than the theoretical values, it is considered that the station mean weights could come from a single statistical population. This test was used only for screening purposes, and the more detailed testing was performed later.

The particular expression of the F test used for this purpose is given, using the following definitions:

A = individual weight;
ΣA_1 = total of weights at station 1;
ΣA = total of weights at all stations;
N_1 = number of weights at station 1;
N = total number of weights;
n_w = degrees of freedom, within stations;
n_b = degrees of freedom, between stations;
S_w = squares, within stations;
S_b = squares, between stations;
V_w = variance, within stations;
V_b = variance, between stations; and
m = last weight.

Within Stations

$$S_w = \left(\Sigma A_1^2 - \frac{(\Sigma A_1)^2}{N_1}\right) + \left(\Sigma A_2^2 - \frac{(\Sigma A_2)^2}{N_2}\right) + \ldots + \left(\Sigma A_m^2 - \frac{(\Sigma A_m)^2}{N_m}\right)$$

$$V_w = \frac{S_w}{n_w}$$

in which

n_w = total number of weights at all stations minus the number of stations or degrees of freedom within stations.

Between Stations

$$S_b = \frac{(\Sigma A_1)^2}{N_1} + \frac{(\Sigma A_2)^2}{N_2} + \ldots + \frac{(\Sigma A_m)^2}{N_m} - \frac{(\Sigma A)^2}{N}$$

$$V_b = \frac{S_b}{n_b}$$

in which

n_b = number of stations or degrees of freedom between stations.

$$F = \frac{\text{Larger variance}}{\text{Smaller variance}}$$

The larger variance could be either V_w or V_b.

Table 1 shows that, for total vehicle weights, the 2-axle tractors with 2-axle semitrailers (type 22) had the computed F-value of 6.20 as compared with the limiting theoretical value of 1.96. From this it was concluded that the distribution between stations as measured by the average value at each station did differ significantly from the distribution of values

TABLE 1
F TEST OF SIGNIFICANCE OF DIFFERENCES WITHIN AND BETWEEN MEAN WEIGHTS OF LOADED VEHICLES AT RURAL STATIONS

Vehicle Type	Axle	F: Computed	F: Theoretical
13	1	2.14	1.96
13	2	1.91	1.96
Total 13		1.89	1.96
14	1	1.21	2.13
14	2	1.60	2.13
14	3	1.02	2.13
Total 14		1.67	2.13
21	1	2.29	1.92
21	2	2.74	1.92
21	3	4.24	1.92
Total 21		3.65	1.92
22	1	3.55	1.96
22	2	4.12	1.96
22	3	6.61	1.96
22	4	4.58	1.96
Total 22		6.20	1.96
24	1	1.39	2.71
24	2	1.75	2.71
24	3	3.78	2.71
24	4	2.64	2.71
24	5	2.78	2.71
Total 24		2,65	2.71

TABLE 2

COMPARISON OF NUMBER OF LOADED VEHICLES WEIGHED AND NUMBER OF LOADED VEHICLES NEEDED IN SAMPLE, RURAL

Vehicle Type	Axle	No of Vehicles Counted	Mean Weight (lb)	Sample Size No of Vehicles
13	1	1,521	4,634	120
13	2	1,521	10,519	218
13	Total	1,521	15,154	143
14	1	117	6,494	174
14	2	117	14,179	126
14	3	117	12,328	160
14	Total	117	32,897	81
21	1	792	5,483	131
21	2	792	13,536	92
21	3	792	13,577	144
21	Total	792	32,597	77
22	1	2,814	7,710	101
22	2	2,814	15,220	60
22	3	2,814	13,235	109
22	4	2,814	13,624	104
22	Total	2,814	49,788	57
24	1	93	8,355	77
24	2	93	11,353	148
24	3	93	12,181	86
24	4	93	12,582	92
24	5	93	13,384	86
24	Total	93	57,859	46

TABLE 3

COMPARISON OF NUMBER OF EMPTY VEHICLES WEIGHED AND NUMBER OF EMPTY VEHICLES NEEDED IN SAMPLE, RURAL

Vehicle Type	Axle	No of Vehicles Weighed	Mean Weight (lb)	Sample Size No of Vehicles
13	1	1,020	3,933	89
13	2	1,020	5,139	224
13	Total	1,020	9,073	115
14	1	93	5,460	796
14	2	93	6,227	135
14	3	93	4,936	412
14	Total	93	16,624	267
21	1	555	4,938	115
21	2	555	6,523	146
21	3	555	5,805	258
21	Total	555	17,268	121
22	1	1,291	6,379	92
22	2	1,291	7,232	98
22	3	1,291	5,091	163
22	4	1,291	5,302	154
22	Total	1,291	23,993	74
24	1	28	7,953	166
24	2	28	6,435	146
24	3	28	6,203	115
24	4	28	4,932	117
24	5	28	5,139	103
24	Total	28	30,664	80

around each station mean, and therefore it would not be expected that they came from a single population. Similarly, the F-values computed for the individual axle weights for this type of truck combination lead to the same conclusion. The same test when applied to 2-axle trucks with dual rear tires (type 13) and 3-axle motortrucks (type 14) indicated that the weights for these vehicles could come from single respective populations, or that the means for these vehicle types could come from single populations as indicated by the computed F-values which are smaller than the limiting theoretical values.

Under the existing procedures, trucks of all types are being weighed at all stations. It is considered impractical to designate only the particular types of vehicles to be weighed at some stations and not at other stations (as could be erroneously inferred from the data in Table 1). The discrepancy between the computed and the theoretical values for the 2-axle tractors with the 2-axle semitrailers (type 22) was so great that it was felt that similar results could be expected from empty vehicles and also at urban stations where greater dispersions of weights are usually found.

Despite the observed population heterogeneity, random sampling could be applied, and mean values describing the heterogeneous population computed. But for greater efficiency, more homogeneous populations were identified, as is explained later. Inasmuch as random sample sizes from a heterogeneous population would be expected to be larger for the same degree of reliability of the mean than from homogeneous populations, it was decided to determine the sample sizes for the heterogeneous population first. It was reasoned that such samples would provide the necessary data whether or not means would be found later to isolate homogeneous populations.

In these studies the sample size design criterion was set at ± 5 percent standard error of the mean on the 95 percent confidence limit. In other words, the probability would be 19 to 1 in favor that the estimates of mean values yielded by many samples of the specified size would not differ from the true mean by more than twice the corresponding standard errors, in this case by not more than ± 5 percent of the means.

Defining the population as all units weighed, the number of units in the sample according to the design specification was computed from the formula:

$$N = \frac{(1.96)^2 V}{(5\% M)^2}$$

in which

1.96 = T value for sample size between 30 and infinity with a confidence limit of 95 percent;
V = population variance; and
M = population mean weight.

The number of units in the populations and the corresponding number of units needed in the sample as required by the design are given in Table 2. The dispersions or spread of axle weights are larger than vehicle weights. Therefore, the minimum number of vehicles to be selected for the sample is determined by the largest of the indicated minimum number of axles of the vehicle type. For example, for the 2-axle trucks (type 13), the number of units needed to be weighed is 218 as determined by the second axle and not 143 as shown for the total vehicle weight. Thus a random selection of 218 trucks (type 13) would produce mean axle weights and a mean vehicle weight which would be representative of the 1, 521 such vehicles actually weighed. This illustrates the point that considerable saving of effort can be accrued if the mean weights only were to be considered. Similar observation applies to 2-axle tractor, 1-axle trailer combinations (type 21), where 144 such vehicles would have provided the representative mean weights instead of 792 actually weighed. The most striking observation is about the 2-axle tractor, 2-axle semitrailer combination (type 22), of which 2, 814 vehicles were weighed and only 109 vehicles, randomly selected, were needed to produce reliable mean weights.

The data in Table 2 also lead to the observation that the loading practices vary so widely for some vehicle types that the total number of units in the population (the number actually weighed) was not sufficient to produce reliable means. Thus for the 3-axle trucks (type 14), the minimum needed to assure reliability should be 174, whereas only 117 were actually weighed. Similarly, the 93 units actually weighed of the 3-axle trucks with 2-axle semitrailers (type 24) were not sufficient, as 148 would be needed to assure the mean weights to be within ±5 percent error on the 95 percent confidence limit.

The 14 and 24 vehicle types are of the heaviest in the single-unit trucks and combinations, respectively. They are also the rarest in frequency of appearance.

TABLE 4a

SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS, ALSO BETWEEN VARIANCES, OF 8 AM TO 4 PM PERIOD COMPARED WITH 24 HOURS — 1959

				Axle										Total Vehicle	
				1		2		3		4		5			
System	Type	Vehicle Loading	Value[a]	F	t	F	t	F	t	F	t	F	t	F	t
Rural	13	Loaded	T												
			C												
		Empty	T												
			C												
	21	Loaded	T												
			C												
		Empty	T												
			C												
	22	Loaded	T	1.08			1.96		1.96						
			C	1.12			2 38		2.92						
		Empty	T			1.08	1.96	1 08		1.08				1.08	
			C			1.17	2.36	1.21		1.20				1.20	
Urban	13	Loaded	T												
			C												
		Empty	T												
			C												
	14	Empty	T												
			C												
	21	Loaded	T												
			C												
		Empty	T												
			C												
	22	Loaded	T												
			C												
		Empty	T												
			C												

[a]T = theoretical and C = computed.

Note: Blank spaces indicate that computed values are smaller than theoretical values, thus the differences are "not significant."

TABLE 4c

SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS, ALSO BETWEEN VARIANCES, OF 2 PM TO 10 PM PERIOD COMPARED WITH 24 HOURS — 1959

				Axle										Total Vehicle	
				1		2		3		4		5			
System	Type	Vehicle Loading	Value[a]	F	t	F	t	F	t	F	t	F	t	F	t
Rural	13	Loaded	T												
			C												
		Empty	T												
			C												
	21	Loaded	T												
			C												
		Empty	T												
			C												
	22	Loaded	T								1 96				
			C								2.11				
		Empty	T						1.96	1.13				1.13	
			C						2 73	1.22				1 14	
Urban	13	Loaded	T												
			C												
		Empty	T												
			C												
	14	Empty	T												
			C												
	21	Loaded	T												
			C												
		Empty	T												
			C												
	22	Loaded	T												
			C												
		Empty	T			1.25		1.25						1.25	
			C			1.48		1 33						1.40	

[a]T = theoretical and C = computed.
Note Blank spaces indicate that computed values are smaller than theoretical values, thus the differences are "not significant "

TABLE 4b

SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS, ALSO BETWEEN VARIANCES, OF 6 AM TO 2 PM PERIOD COMPARED WITH 24 HOURS — 1959

				Axle										Total Vehicle	
				1		2		3		4		5			
System	Type	Vehicle Loading	Value[a]	F	t	F	t	F	t	F	t	F	t	F	t
Rural	13	Loaded	T												
			C												
		Empty	T		1.96										
			C		2.17										
	21	Loaded	T												
			C												
		Empty	T												
			C												
	22	Loaded	T	1.08			1.96		1.96		1.96				1.96
			C	1.10			3.38		4.45		2.64				3.31
		Empty	T						1.96						
			C						2.28						
Urban	13	Loaded	T												
			C												
		Empty	T												
			C												
	14	Empty	T		2.40										
			C		2 44										
	21	Loaded	T		1.99										
			C		3.03										
		Empty	T			1.46	2.00		2.00						2.00
			C			1.58	2.40		2.55						2.50
	22	Loaded	T	1.19	1.97		1.97		1.97		1.97				1.98
			C	1.32	2.98		4.90		7.14		6.36				6.50
		Empty	T			1.30		1.30							
			C			1.63		1.40							

[a]T = theoretical and C = computed.
Note: Blank spaces indicate that computed values are smaller than theoretical values, thus the differences are "not significant."

Studies by individual stations produced results generally in agreement with the data in Table 2.

Empty vehicles were analyzed in the same manner. The results for all stations are given in Table 3.

Table 3 indicates that the number of empty units that should be weighed is also considerably less than actually weighed for types 13, 21, and 22. Types 14 and 24 samples should have been larger than actually weighed to satisfy the desired accuracy.

It was the practice to weigh all the heavy vehicles passing by the weighing parties. The mean weights of the heavy vehicles, as they have been obtained for years, were less accurate than ±5 percent error on the 95 percent confidence limit. Therefore, to reduce the error of the mean, the weighing of trucks on more frequent schedules, increasing the number of weighing stations, or development of new procedures would be necessary to obtain samples as large as indicated in Table 2. However, the mean

TABLE 5a

ARRAY OF COMPUTED t-VALUES FOR SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS 2-AXLE MOTORTRUCK, DUAL REAR TIRES (TYPE 13), LOADED—RURAL, 1959

Axle 1			Axle 2			Vehicle		
Sta. No.	Computed Value	Theoretical Value	Sta. No.	Computed Value	Theoretical Value	Sta. No.	Computed Value	Theoretical Value
8 AM-4 PM Period, Each Station Compared to Same Period at all Stations								
7	0.034	2.000	56	0.00	2.06	56	0.00	2.06
45	0.044	2.014	10	0.02	2.01	37	0.10	2.05
56	0.050	2.056	37	0.10	2.05	19	0.19	2.03
37	0.102	2.052	50	0.16	1.99	32	0.25	2.10
27	0.115	2.021	32	0.21	2.10	29	0.25	1.99
32	0.205	2.101	29	0.22	1.99	53	0.34	2.00
2	0.224	1.994	1	0.46	2.03	16	0.35	2.02
16	0.632	2.021	19	0.59	2.03	50	0.44	1.99
51	0.924	2.021	16	0.60	2.02	1	0.63	2.03
1	1.026	2.000	7	1.02	2.00	22	0.74	2.00
50	1.033	1.994	53	1.09	2.00	10	0.82	2.01
29	1.511	1.994	27	1.18	2.02	7	0.87	2.00
53	1.621	2.000	2	1.34	1.99	2	0.96	1.99
22	1.702	2.000	22	1.35	2.00	27	1.00	2.02
34	1.716	1.984	45	1.69	2.01	45	1.41	2.01
19	1.940	2.030	51	1.94	2.02	51	1.93	2.02
42	2.194	2.014	42	2.14	2.01	42	2.54	2.01
10	3.678	2.008	34	2.89	1.98	34	3.03	1.98
8 AM-4 PM Period, Each Station Compared to 24-Hr Period at all Stations								
2	0.01	1.99	56	0.00	2.06	56	0.00	2.06
56	0.05	2.06	37	0.10	2.05	29	0.01	1.99
37	0.10	2.05	32	0.21	2.10	53	0.13	2.00
32	0.21	2.10	10	0.24	2.01	37	0.15	2.05
27	0.28	2.02	1	0.25	2.03	16	0.20	2.02
45	0.30	2.01	16	0.37	2.02	32	0.21	2.10
7	0.31	2.00	50	0.49	1.99	19	0.29	2.03
16	0.43	2.02	29	0.59	1.99	1	0.49	2.03
50	0.77	1.99	7	0.69	2.00	10	0.65	2.01
51	1.16	2.02	19	0.74	2.03	50	0.66	1.99
1	1.29	2.03	53	0.75	2.00	7	0.67	2.00
34	1.38	1.98	27	0.94	2.02	2	0.76	1.99
53	1.41	2.00	2	0.99	1.99	27	0.85	2.02
29	1.81	1.99	45	1.33	2.01	22	0.92	2.00
22	1.97	2.00	22	1.65	2.00	45	1.19	2.01
42	1.98	2.01	51	1.72	2.02	51	1.79	2.02
19	2.14	2.03	42	2.40	2.01	42	2.71	2.01
10	3.96	2.01	34	3.26	1.98	34	3.27	1.98

weights obtained by existing procedures, such as they were with respect to accuracy, have been used by the engineers and the administrators. So, at least judging by this criterion of usefulness, these mean weights were considered satisfactory. With this thought in mind, the exploration was made into the possibility of further reduction of sample sizes, instead of indicated theoretical increase, so that the accuracy of the mean weights from still smaller samples would not be significantly different from those actually obtained.

This approach is possible in theory when the concept of chance variations is considered. Because the mean values of two samples of different or equal sizes, taken from the same population, are likely to produce different results, it can be determined whether or not these differences could be due to chance variations among the units which compose the means. If within certain measures, as expressed by confidence limits, these differences can be attributed to chance, then it can be concluded that either one of the samples is representative when they are of equal size, or that the smaller sample is representative of the population or of a larger sample. These determinations were made by means of the t tests of significance of differences between means and the F tests of significances of differences between variances, using the equations:

$$t = \frac{M_1 - M}{SE}$$

and

$$F = \frac{V_1}{V_2}$$

TABLE 5b

ARRAY OF COMPUTED t-VALUES FOR SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS
2-AXLE TRACTOR, 1-AXLE SEMITRAILER (TYPE 21), LOADED—RURAL, 1959

Axle 1			Axle 2			Axle 3			Vehicle		
Sta No.	Computed Value	Theoretical Value	Sta No.	Computed Value	Theoretical Value	Sta. No	Computed Value	Theoretical Value	Sta No	Computed Value	Theoretical Value
8 AM-4 PM Period, Each Station Compared to Same Period at all Stations											
10	0 00	2.12	53	0 00	2 06	37	0 00	2 20	37	0.00	2.20
53	0 00	2.06	37	0 00	2.20	37	0 00	2.20	37	0.00	2.20
32	0.04	2.15	37	0 00	2 20	29	0 04	2.09	32	0 00	2.15
19	0 04	2 09	32	0.04	2.15	53	0.05	2 06	53	0.05	2 06
51	0 04	2 09	2	0.04	2.11	51	0 08	2 09	29	0 08	2.09
37	0.06	2 20	51	0.04	2 09	32	0 11	2 15	51	0.08	2.09
37	0.06	2.20	7	0.12	2.12	7	0.12	2 12	16	0 09	2 07
7	0.08	2 12	29	0.13	2 09	16	0 14	2 07	45	0 10	2 06
29	0.13	2 09	16	0 14	2.07	19	0.17	2 09	2	0 12	2 11
16	0.23	2.07	45	0 20	2.06	22	0 36	2 03	7	0.16	2 12
50	0 92	2 02	19	0 21	2 09	10	0 43	2 12	19	0 17	2 09
45	1 05	2 06	10	0 35	2 12	56	1 09	2.02	10	0 35	2 12
2	1 12	2.11	27	0 50	2 03	50	1.68	2.02	22	1 06	2.03
27	1 34	2 03	22	0.68	2 03	45	2 30	2 06	50	1 49	2.02
34	2 13	2 02	50	1.02	2 02	2	2 60	2 11	34	2 06	2 02
22	2.66	2 03	56	1.41	2.02	34	2 75	2 02	56	2.26	2 02
56	2 67	2.02	34	1 69	2.02	27	3.67	2 03	27	2 89	2.03
8 AM-4 PM Period, Each Station Compared to 24-Hr Period at all Stations											
10	0 00	2.12	53	0 00	2.06	53	0 00	2.06	53	0 00	2.06
32	0.04	2 15	37	0.00	2 20	37	0.00	2 20	37	0.00	2.20
19	0 04	2 09	37	0.00	2.20	37	0 00	2 20	37	0 00	2.20
53	0 05	2 06	2	0 00	2.11	51	0.04	2 09	32	0 00	2 15
7	0.08	2 12	51	0 04	2 09	29	0.04	2 09	51	0 04	2 09
51	0 08	2.09	32	0.07	2.15	22	0.07	2.03	16	0 05	2.07
37	0 10	2.20	16	0.09	2 07	32	0 11	2.15	2	0.08	2.11
37	0.10	2 20	7	0.12	2 12	7	0 12	2.12	29	0.08	2.09
29	0.13	2.09	45	0.15	2.06	16	0.14	2 07	45	0 10	2 06
16	0 23	2.07	22	0.15	2.03	19	0 21	2 09	7	0.12	2 12
50	0.65	2.02	29	0.17	2.09	10	0 39	2 12	19	0.21	2 09
45	1.05	2 06	19	0.25	2 09	56	1.45	2 02	10	0 35	2 12
2	1.12	2.11	10	0.31	2.12	50	1.89	2.02	22	0 73	2 03
27	1 15	2.03	27	1 10	2 03	45	2.25	2.06	50	1.73	2.02
56	2 45	2.02	50	1 39	2 02	2	2.52	2.11	34	2.38	2.02
34	2.52	2 02	56	2.09	2 02	34	3 02	2.02	56	2.72	2.02
22	2.91	2.03	34	2.16	2 02	27	3 99	2 03	27	3 28	2 03

in which

M_1 = mean of the larger sample,
M = mean of the smaller sample,
SE = standard error of the mean of the smaller sample,
V_1 = larger variance, and
V_2 = smaller variance.

In Tables 4a, 4b, and 4c, the comparisons between the mean weights for different types of vehicles are shown for rural and urban stations. Mississippi was particularly interested in the three 8-hr periods: 8 a.m. to 4 p.m., 6 a.m. to 2 p.m., and 2 p.m. to 10 p.m. Thus the comparisons in Tables 4a, 4b, and 4c were made between these individual 8-hr periods and the 24-hr period. Only the results of the tests showing significance of the differences are given. Blank spaces mean that the computed values of F or t were smaller than the theoretical values and therefore the differences were considered to be statistically not significant. In Table 4c, only 2-axle tractors with 2-axle semitrailers (type 22) showed slight significance for the mean empty vehicle weight and some significance of certain mean axle weights in both rural and urban areas. Vehicles of types other than those given in the tables were not sufficient in numbers to make computations.

These tests indicated that, for all practical purposes, desired information concerning the mean vehicle and axle weights could have been obtained from the data obtained during the 8-hr period, 2 p.m. to 10 p.m., which would have been representative of the 24-hr weighing operations. However, this period would require operations after dark and, therefore, was considered unsatisfactory by Mississippi.

TABLE 5c

ARRAY OF COMPUTED t-VALUES FOR SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS
2-AXLE TRACTOR, 2-AXLE SEMITRAILER (TYPE 22), LOADED – RURAL, 1959

Axle 1			Axle 2			Axle 3			Axle 4			Vehicle		
Sta No	Computed Value	Theoretical Value	Sta No	Computed Value	Theoretical Value	Sta No	Computed Value	Theoretical Value	Sta No	Computed Value	Theoretical Value	Sta No	Computed Value	Theoretical Value
8 AM-4 PM Period, Each Station Compared to Same Period at all Stations														
42	0 04	2 15	32	0 08	2 09	42	0 00	2 15	32	0 04	2 09	50	0 01	2 01
32	0 17	2 09	42	0 11	2 15	32	0 08	2 09	1	0 07	2 15	16	0 03	1 99
19	0 28	2 03	1	0 11	2 15	1	0 18	2 15	42	0 11	2 15	32	0 04	2 09
16	0 40	1 99	45	0 46	1 99	50	0 36	2 01	53	0 36	1 98	42	0 07	2 15
37	0 74	2 02	53	0 49	1 98	16	0 70	1 99	16	0 42	1 99	1	0 14	2 15
10	0 76	2 03	2	0 68	1 99	7	1 03	2 01	50	0 55	2 01	53	1 09	1 98
1	0 94	2 15	50	0 95	2 01	45	1 91	1 99	2	0 61	1 99	2	1 83	1 99
27	0 96	1 99	29	1 06	2 04	37	1 97	2 02	22	0 84	1 99	7	2 02	2 01
2	1 04	1 99	16	1 23	1 99	29	2 08	2 04	7	1 20	2 01	34	2 10	1 99
53	1 05	1 98	19	1 28	2 03	51	2 32	2 01	29	1 51	2 04	29	2 12	2 04
34	1 25	1 99	22	1 35	1 99	34	2 33	1 99	34	2 19	1 99	37	2 18	2 02
50	1 30	2 01	10	1 87	2 03	53	2 70	1 98	37	2 48	2 02	45	2 38	1 99
7	1 36	2 01	34	1 99	1 99	2	2 95	1 99	10	2 52	2 03	10	2 48	2 03
45	1 42	1 99	37	2 22	2 02	22	3 15	1 99	45	2 85	1 99	22	2 65	1 99
51	2 63	2 01	7	2 96	2 01	19	3 33	2 03	19	2 96	2 03	19	2 69	2 03
56	3 05	2 00	56	3 05	2 00	27	4 07	1 99	56	3 04	2 00	51	3 87	2 01
29	3 24	2 04	27	3 29	1 99	10	2 70	2 03	27	3 35	1 99	27	4 33	1 99
22	3 34	1 99	51	3 96	2 01	56	5 12	2 00	51	3 41	2 01	56	5 08	2 00
8 AM-4 PM Period, Each Station Compared to 24-Hr Period at all Stations														
42	0 00	2 15	42	0 07	2 15	42	0 00	2 15	32	0 04	2 09	42	0 04	2 15
32	0 17	2 09	32	0 08	2 09	32	0 13	2 09	42	0 07	2 15	32	0 08	2 09
37	0 46	2 02	1	0 14	2 15	1	0 14	2 15	1	0 07	2 15	1	0 14	2 15
27	0 50	1 99	22	0 47	1 99	7	0 18	2 01	53	0 08	1 98	50	0 40	2 01
19	0 52	2 03	16	0 52	1 99	50	0 99	2 01	50	0 27	2 01	53	0 41	1 98
2	0 69	1 99	29	0 69	2 04	37	1 47	2 02	22	0 37	1 99	16	0 54	1 99
16	0 81	1 99	19	0 86	2 03	16	1 56	1 99	16	0 78	1 99	7	1 52	2 01
34	0 87	1 99	2	1 24	1 99	34	1 56	1 99	7	0 88	2 01	34	1 56	1 99
10	0 97	2 03	53	1 27	1 98	53	1 57	1 98	2	0 93	1 99	29	1 81	2 04
1	0 97	2 15	34	1 38	1 99	29	1 61	2 04	29	1 29	2 04	37	1 85	2 02
45	1 06	1 99	45	1 38	1 99	22	1 93	1 99	34	1 85	1 99	22	1 85	1 99
53	1 48	1 98	50	1 43	2 01	10	2 23	2 03	37	2 27	2 02	10	2 19	2 03
7	1 62	2 01	10	1 44	2 03	19	2 82	2 03	10	2 31	2 03	2	2 31	1 99
50	1 63	2 01	37	1 86	2 02	45	2 92	1 99	19	2 74	2 03	19	2 35	2 03
51	2 41	2 01	7	2 34	2 01	51	2 99	2 01	45	3 30	1 99	45	3 10	1 99
56	2 69	2 00	56	3 82	2 00	2	3 62	1 99	56	3 42	2 00	51	4 27	2 01
29	3 51	2 04	27	4 03	1 99	27	4.89	1 99	51	3 69	2 01	27	4 96	1 99
22	3 87	1 99	51	4 44	2 01	56	6 20	2 00	27	3 71	1 99	56	5 78	2 00

The 8 a.m. to 4 p.m. period (Table 4a) shows some significance for total weights of empty vehicles (type 22), for some of the axle loads empty, and for total weights of loaded vehicles of the same type at weight stations on rural roads. In urban areas during that period, there was no significance for either test for any vehicle type or any axle during the 8 a.m. to 4 p.m. period. The 6 a.m. to 2 p.m. period (Table 4b) is the least representative, having the largest number of instances of significant differences.

TABLE 6a

ARRAY OF COMPUTED F-VALUES FOR SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS 2-AXLE MOTORTRUCK, DUAL REAR TIRES (TYPE 13), LOADED—RURAL, 1959

Axle 1			Axle 2			Vehicle		
Sta. No.	Computed Value	Theoretical Value	Sta. No.	Computed Value	Theoretical Value	Sta. No.	Computed Value	Theoretical Value
8 AM-4 PM Period Each Station Compared to Same Period at all Stations								
34	1.01	1.25	1	1.01	1.59	50	1.01	1.32
42	1.01	1.49	50	1.02	1.32	27	1.04	1.55
56	1.06	1.71	22	1.04	1.39	7	1.08	1.37
16	1.07	1.53	16	1.05	1.53	22	1.09	1.39
50	1.09	1.32	37	1.07	1.69	16	1.09	1.53
7	1.14	1.37	42	1.10	1.49	34	1.09	1.25
29	1.16	1.32	27	1.10	1.55	1	1.10	1.59
19	1.18	1.59	34	1.14	1.25	2	1.11	1.32
22	1.18	1.39	2	1.14	1.32	56	1.11	1.71
37	1.28	1.69	56	1.16	1.71	42	1.13	1.49
45	1.31	1.45	7	1.16	1.37	51	1.13	1.53
10	1.36	1.39	51	1.16	1.53	53	1.15	1.37
27	1.36	1.55	53	1.17	1.37	37	1.18	1.69
51	1.37	1.53	29	1.25	1.32	10	1.20	1.39
53	1.53	1.37	10	1.27	1.39	29	1.32	1.32
2	1.63	1.32	32	1.53	1.96	32	1.54	1.96
1	2.07	1.59	45	1.88	1.45	45	1.69	1.45
32	2.32	1.96	19	2.09	1.59	19	1.76	1.59
8 AM-4 PM Period Each Station Compared to 24-Hr Period at all Stations								
50	1.04	1.32	1	1.01	1.59	27	1.01	1.55
34	1.06	1.25	50	1.02	1.32	50	1.04	1.32
42	1.06	1.49	22	1.04	1.39	22	1.05	1.39
56	1.11	1.71	16	1.05	1.53	16	1.05	1.53
16	1.12	1.53	37	1.07	1.69	34	1.05	1.25
7	1.20	1.37	42	1.10	1.49	56	1.07	1.71
29	1.22	1.32	27	1.10	1.55	2	1.08	1.32
19	1.24	1.59	34	1.14	1.25	51	1.09	1.53
22	1.24	1.39	2	1.14	1.32	7	1.12	1.37
27	1.30	1.55	56	1.16	1.71	1	1.13	1.59
37	1.35	1.69	7	1.16	1.37	10	1.16	1.39
45	1.37	1.45	51	1.17	1.53	42	1.17	1.49
10	1.43	1.39	53	1.17	1.37	53	1.19	1.37
51	1.44	1.53	29	1.25	1.32	37	1.22	1.69
53	1.46	1.37	10	1.27	1.39	29	1.37	1.32
2	1.55	1.32	32	1.53	1.96	32	1.60	1.96
1	2.16	1.59	45	1.87	1.45	19	1.70	1.59
32	2.43	1.96	19	2.09	1.59	45	1.74	1.45

Historically speaking, in all states, the truck weighing stations were almost universally selected intuitively rather than on the basis of the representative characteristics of mean weights obtained. In Mississippi the weighing stations were located at what was believed to be "representative" locations. As a part of this study, it was decided to evaluate this "representativeness" by measuring the extent of variations or similarities that exist among the weights obtained at individual stations and their collective means for the respective truck types.

The measures of significance of these variations were the t and F tests. If both tests showed no significance (that is, if the computed values are smaller than the theoretical values), the interpretation then is that the station data could be representative of the mean of all 18 stations. The results are given in Tables 5a, 5b, 5c, and Tables 6a, 6b, and 6c for the respective measures. The stations are arrayed in ascending order of computed values with the theoretical values for the 5 percent confidence level given side by side.

The primary interest of Mississippi was in the characteristics of the 8 a.m. to 4 p.m. period as they were related to the total 24-hr period. From the arrays of t and F tests, Tables 5a, 5b, and 5c, and 6a, 6b, 6c series, it was found that, for loaded vehicles of types 13, 21, and 22 in the predominant instances, no significance was indicated for the variances of weights at stations 1, 7, 10, 27, 29, 32, 34, 37, 42, 51, and 53. That is, each one of these 11 stations for practical purposes could be considered representative of the means of the 18 stations. The results of this study indicated the possibility of reducing the number of stations.

TABLE 6b

ARRAY OF COMPUTED F-VALUES FOR SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS
2-AXLE TRACTOR, 1-AXLE SEMITRAILER (TYPE 21), LOADED — RURAL, 1959

Axle 1			Axle 2			Axle 3			Vehicle		
Sta. No.	Computed Value	Theoretical Value	Sta. No.	Computed Value	Theoretical Value	Sta. No.	Computed Value	Theoretical Value	Sta. No	Computed Value	Theoretical Value
8 AM-4 PM Period, Each Station Compared to Same Period at all Stations											
7	1.01	2.07	10	1.04	2.07	34	1.02	1.51	34	1.01	1.51
32	1.02	2.21	34	1.06	1.51	19	1 02	1.92	19	1.10	1.92
29	1.08	1.92	51	1.12	1.92	10	1.04	2.07	51	1.16	1.92
50	1.10	1.53	19	1.18	1.92	51	1.21	1.92	22	1.21	1.59
22	1.12	1 59	7	1.19	2 07	32	1.22	2.21	10	1.26	2.07
10	1.14	2.07	37	1.19	2.54	29	1.26	1.92	29	1.28	1.92
19	1.14	1.92	53	1.21	1 73	7	1.31	2.07	37	1.28	2.54
53	1.17	1.73	2	1.36	2.01	37	1.33	2.54	7	1.30	2.07
45	1.23	1.71	22	1.43	1 59	22	1.38	1.59	32	1.37	2.21
2	1 36	2.01	50	1.66	1.53	53	1.39	1.73	53	1.47	1.73
56	1 38	1.53	27	1.72	1.57	27	1.48	1.57	27	1.66	1.57
16	1.41	1.81	16	1.86	1.81	45	1.56	1.71	45	1.70	1.71
27	1.62	1.57	45	1.91	1.71	50	1.64	1.53	50	1.81	1.53
51	1.63	1.92	29	1.93	1.92	16	1.71	1.81	16	2.03	1.81
34	2.25	1.51	56	2.00	1.53	56	1.73	1.53	56	2.05	1.53
37	5.42	2.54	32	2.17	2.21	2	2.69	2.01	2	2.43	2.01
8 AM-4 PM Period, Each Station Compared to 24-Hr Period at all Stations											
32	1.00	2.21	51	1.04	1.92	32	1.11	2.21	22	1 10	1.59
7	1.03	2.07	7	1.10	2.07	34	1.12	1.51	34	1.11	1.51
29	1.07	1.92	10	1.12	2.07	19	1.12	1.92	7	1.17	2.07
50	1.08	1.53	53	1.13	1.73	10	1.14	2.07	19	1.22	1.92
22	1.10	1.59	34	1.14	1.51	7	1.20	2.07	51	1.28	1.92
19	1.12	1 92	19	1.27	1.92	53	1.27	1.73	53	1.33	1.73
53	1.15	1.73	2	1.27	2.01	22	1.27	1.59	10	1.39	2.07
10	1.16	2.07	37	1.28	2.54	51	1.32	1.92	29	1.41	1.92
56	1.40	1.53	22	1.33	1.59	27	1.36	1.57	37	1.41	2.54
16	1.43	1.81	27	1.61	1.57	29	1.38	1 92	27	1.50	1 57
51	1.61	1.92	16	1.73	1.81	37	1.46	2.54	32	1.51	2.21
27	1.64	1 57	45	1.77	1.71	16	1.56	1.81	45	1.54	1.71
34	2.22	1.51	50	1.78	1.53	56	1.58	1.53	16	1.84	1.81
2	2.78	2.01	56	1.86	1.53	50	1.79	1.53	56	1.86	1.53
45	4.77	1.71	29	2.07	1.92	45	5.49	1.71	50	2.00	1.53
37	5.35	2.54	32	2.33	2.21	2	9.17	2.01	2	2.20	2.01

Such arrays can be useful for identification of stations with relation to populations of similar characteristics, particularly within and among the administrative road systems. An important observation is that of the 11 stations previously mentioned, all but one are located on primary state highways. The 7 stations for which the F-values indicated significance of differences of variances and, therefore, could not be identi-

TABLE 6c

ARRAY OF COMPUTED F-VALUES FOR SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS
2-AXLE TRACTOR, 2-AXLE SEMITRAILER (TYPE 22), LOADED—RURAL, 1959

Axle 1			Axle 2			Axle 3			Axle 4			Vehicle		
Sta No	Computed Value	Theoretical Value	Sta No	Computed Value	Theoretical Value	Sta No	Computed Value	Theoretical Value	Sta No	Computed Value	Theoretical Value	Sta No	Computed Value	Theoretical Value
8 AM-4 PM Period Each Station Compared to Same Period at all Stations														
53	1 01	1 25	10	1 01	1 59	16	1 02	1 28	50	1 00	1 44	16	1 01	1 28
34	1 02	1 28	16	1 04	1 28	50	1 05	1 44	16	1 03	1 28	34	1 09	1 28
2	1 05	1 32	53	1 08	1 25	27	1 06	1 28	51	1 06	1 46	51	1 11	1 46
19	1 06	1 57	19	1 10	1 57	19	1 07	1 57	19	1 07	1 57	19	1 13	1 57
37	1 07	1 53	32	1 10	1 92	1	1 10	2 21	29	1 07	1 64	2	1 18	1 32
56	1 08	1 35	27	1 14	1 28	51	1 14	1 46	27	1 08	1 28	32	1 19	1 92
42	1 10	2 21	51	1 15	1 46	34	1 16	1 28	2	1 11	1 32	53	1 19	1 25
16	1 15	1 28	50	1 20	1 44	29	1 17	1 64	1	1 17	2 21	50	1 21	1 44
50	1 21	1 44	34	1 22	1 28	10	1 24	1 59	34	1 17	1 28	29	1 22	1 64
7	1 24	1 45	29	1 24	1 64	37	1 31	1 53	32	1 18	1 92	27	1 22	1 28
45	1 25	1 28	2	1 31	1 32	45	1 31	1 28	53	1 21	1 25	7	1 35	1 45
10	1 36	1 59	7	1 43	1 45	32	1 38	1 92	10	1 24	1 59	37	1 40	1 53
29	1 36	1 64	22	1 44	1 28	2	1 40	1 32	37	1 29	1 53	1	1 41	2 21
27	1 42	1 28	56	1 52	1 35	53	1 51	1 25	7	1 35	1 45	10	1 47	1 59
32	1 51	1 92	42	1 58	2 21	42	1 73	2 21	45	1 36	1 28	45	1 47	1 28
22	1 62	1 28	37	1 61	1 53	7	1 74	1 45	56	1 36	1 35	42	1 55	2 21
51	1 84	1 46	45	1 63	1 28	22	1 86	1 28	22	1 46	1 28	22	1 77	1 28
1	10 43	2 21	1	2 47	2 21	56	2 03	1 35	42	1 55	2 21	56	1 92	1 35
8 AM-4 PM Period Each Station Compared to 24-Hr Period at all Stations														
16	1 02	1 28	10	1 02	1 59	16	1 03	1 28	51	1 01	1 46	16	1 06	1 28
42	1 02	2 21	16	1 03	1 28	1	1 05	2 21	50	1 05	1 44	53	1 13	1 25
37	1 05	1 53	53	1 07	1 25	51	1 09	1 46	16	1 09	1 28	34	1 14	1 28
56	1 05	1 35	32	1 10	1 92	50	1 11	1 44	29	1 12	1 64	51	1 16	1 46
50	1 08	1 44	19	1 11	1 57	19	1 12	1 57	19	1 13	1 57	27	1 16	1 28
53	1 11	1 25	27	1 13	1 28	27	1 12	1 28	27	1 13	1 28	19	1 18	1 57
34	1 15	1 28	51	1 15	1 46	34	1 22	1 28	53	1 15	1 25	2	1 24	1 32
2	1 18	1 32	50	1 21	1 44	29	1 24	1 64	2	1 17	1 32	32	1 25	1 92
19	1 19	1 57	34	1 23	1 28	45	1 25	1 28	1	1 23	2 21	50	1 27	1 44
29	1 21	1 64	29	1 25	1 64	10	1 31	1 59	34	1 23	1.28	29	1 29	1 64
27	1 26	1 28	2	1 32	1 32	37	1 38	1 53	32	1 24	1 92	7	1 29	1 45
32	1 35	1 92	7	1 42	1 45	53	1 43	1 25	7	1 28	1 45	1	1 34	2 21
7	1 40	1 45	22	1 43	1 28	32	1 46	1 92	56	1 29	1 35	45	1 40	1 28
45	1 41	1 28	56	1 51	1 35	2	1 47	1 32	45	1 30	1 28	37	1 47	1 53
22	1 44	1 28	42	1 59	2 21	7	1 66	1 46	10	1 30	1 59	10	1 55	1 59
10	1 52	1 59	37	1 62	1 53	22	1 76	1 28	37	1 35	1 53	42	1 62	2 21
51	2 07	1 46	45	1 62	1 28	42	1 82	2.21	22	1 39	1 28	22	1 68	1 28
1	9 27	2 21	1	2 45	2 21	56	1 93	1 35	42	1 64	2 21	56	1 83	1 35

TABLE 7a

SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS, ALSO BETWEEN VARIANCES, OF THE 8 AM TO 4 PM PERIODS OF 11 SELECTED STATIONS, RURAL, COMPARED TO THE 24 HOURS OF THE TOTAL 18 STATIONS

				Axle										Total Vehicle	
				1		2		3		4		5			
Year	Type	Vehicle Loading	Value[a]	F	t	F	t	F	t	F	t	F	t	F	t
1958	13	Loaded	T			1.08	1.96							1.08	1.96
			C			1.16	2.57							1.09	2.14
1959	13	Loaded	T												
			C												
1958	21	Loaded	T		1.97	1.13	1.97		1.97						1.97
			C		2.58	1.14	3.42		2.34						2.36
1959	21	Loaded	T	1.22	1.98	1.22		1.22						1.22	
			C	1.44	3.63	1.32		1.26[b]						1.28	
1958	22	Loaded	T					1.13		1.13				1.13	
			C					1.18		1.25				1.22	
1959	22	Loaded	T	1.13		1.13			1.97					1.13	
			C	1.26		1.15[b]			2.00[b]					1.17[b]	

[a]T = theoretical and C = computed.
[b]Between 0.05 and 0.01 level of significance.
Note: Blank spaces indicate that computed values are smaller than theoretical values, thus the differences are "not significant."

TABLE 7b

SIGNIFICANCE OF DIFFERENCES BETWEEN MEAN WEIGHTS, ALSO BETWEEN VARIANCES, OF THE 24-HR PERIODS OF 11 SELECTED STATIONS, RURAL, COMPARED TO THE 24 HOURS OF THE TOTAL 18 STATIONS

				Axle										Total	
				1		2		3		4		5		Vehicle	
Year	Type	Vehicle Loading	Value[a]	F	t	F	t	F	t	F	t	F	t	F	t
1958	13	Loaded	T												
			C												
1959	13	Loaded	T												
			C												
1958	21	Loaded	T				1.96		1.96						1.96
			C				2.35		2.05						2.10
1959	21	Loaded	T												
			C												
1958	22	Loaded	T	1.00	1.96	1.00		1.00	1.96	1.00				1.00	
			C	1.01	2.24	1.02		1.08	2.44	1.10				1.07	
1959	22	Loaded	T		1.96										
			C		2.51[b]										

[a]T = theoretical and C = computed.
[b]On 0.01 level of significance, table value t = 2.58.
Note: Blank spaces indicate that computed values are smaller than theoretical values, thus the differences are "not significant."

fied with the population of the 18 rural stations, all are located on the roads of the Interstate System. Station No. 51, however, showed no significance on F test but showed appreciable and consistent significance on t test. Table 5c and its inclusion in the population of stations on primary system other than Interstate would require additional investigation.

Although of no immediate importance because there was no intent to reduce the number of stations in Mississippi, the arrays gave promise as a methodology when sampling by populations is considered. As a further step in the possible application of these findings, a study was made of the 11 selected stations, comparing them with the total population of 18 stations. These analyses were made for the years 1959 and 1958.

The manner of presentation in Tables 7a and 7b is similar to that used in Tables 4a, 4b, and 4c. In Table 7a, most of the mean weights obtained at the selected stations for the period 8 a.m. to 4 p.m. did not differ significantly from the corresponding mean weights at 18 stations; others were borderline cases of significance on the 5 percent level. Axle 2 of vehicle type 21 in 1958 and axle 1 in 1959 show very significant difference on t test. As would be expected, better agreement was found in a comparison of 24-hr periods for the 11 selected stations with the total population of 18 stations, as given in Table 7b. The larger difference was significant on the 5 percent level but still nonsignificant on the 1 percent level for t values.

Inasmuch as the t test is sensitive to the precision of the mean — that is, the standard error of the mean — its practical implication sometimes is not self-apparent. When neither the t nor F test indicates significance, no further investigation may be needed for such uses as comparisons in trend studies, as the observed difference could be ascribed to chance variations. But when interest is evidenced in absolute numerical values, then these values should be observed from the point of view of their practical application. For instance, in Table 7a for axle 1, vehicle type 21, in 1959, $t = 3.63$, indicating that the difference between the mean weights was very significant and that the likelihood of such a difference being due to chance alone was highly improbable. On further investigation it was found that the standard error of the 11 station mean of 5,344 lb was quite precise, only 56 lb, and that the difference between the means was only 139 lb or 2.5 percent of the 18 station mean of 5,483 lb. This difference would not be considered too important by Mississippi for many practical uses.

CONCLUSIONS

The application of statistical method in the analysis of truck weights resulted in the decision by Mississippi to reduce, on a trial basis for one year, the truck weighing operations by limiting them to the 8 a.m. to 4 p.m. period. In addition, certain analytical methodologies have been successfully tried which might find further application in future search for other needed information. Certain areas where additional research is needed are delineated as the result of findings of this study.

1. Considering only the mean weights, it was found that for the vehicle types for which data were available in sufficient quantities it is possible to reduce the number of vehicles weighed and/or stations operated and to select an 8-hr period of weight station operations which would give mean weights representative of a 24-hr period during the summer months. Of the periods available for study, the period from 2 p.m. to 10 p.m. produced the best results, but the period from 8 a.m. to 4 p.m., although not quite so good, was considered satisfactory and was decided on for use in Mississippi because the increased accuracy obtained using the 2 p.m. to 10 p.m. period was not sufficient to justify the operating inconvenience. Any 8-hr operation can be expected to produce less accurate mean weight data than will a 24-hr operation for heavy, comparatively rare vehicles, and less accurate data for other characteristics such as numbers or frequencies of vehicles or axles loaded over the legal or recommended limits because these vehicles are encountered infrequently. Estimating the proportion of empty and loaded vehicles in the total traffic volume can be regarded as a separate problem which needs its own solution.

2. It was found that by using techniques of statistical analyses, weight stations can be identified by statistical populations and grouped accordingly, which affords the basis in developing maximum efficiency for obtaining meaningful average weights. In Mississippi it was indicated that 11 selected rural stations would provide representative mean weight data that had been previously obtained at 18 stations. However, for reasons peculiar to every individual station, it was decided to continue the weighing operations at all 18 rural stations. Because of this decision, it is expected that larger samples will be obtained than the indicated minimums for the types of vehicles which were investigated.

3. The study indicated that the samples of very heavy loads were too small to draw accurate conclusions. Because all heavy trucks were already weighed in accordance with the current practices to increase the sample of extremely heavy vehicles and those loaded above the recommended limits, it would be necessary to increase the number of stations or expand the schedules of operations, or find new means of obtaining the weight data.

4. The sampling procedures developed in Mississippi are designed for errors of estimate of ± 5 percent on 95 percent confidence limit. It should be kept in mind, however, that for some purposes such as establishment of trends in mean weights, greater accuracy may be needed.

5. To develop optimum truck weighing procedures, in addition to the observations already made in Mississippi, some methods, yet unknown, need to be developed and measures provided for the other important elements discussed in this paper. For the benefit of future truck weighing studies, the nature of data needed to resolve problems arising from requirements of highway design and administration of highway transportation should be more precisely defined. Whether the frequency of occurrence of critical weights for design purposes, the extent of overloading above legal or specified limits for enforcement, or data on average and maximum weights for economic studies are needed, the tolerance limits for the accuracy of estimates should be established so that optimum sampling procedures can be properly designed.