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16. ABSTRACT

Synopsis

The distribution of wheel loads on certain city streets and county roads is evaluated and a comparison is made with wheel loads found on state highways. The need for this study has long been the subject of discussion among engineers designing local roads with the use of wheel load criteria derived from trucks using the state highways.

It was found that trucks using local roads generally have lighter axle loads on a cumulative basis then trucks traveling on state highways. Truck constants were derived from the axle load data collected for this study. These truck constants exhibit a substantial reduction when compared with the state-wide truck constants for state highways.

Sample designs are presented showing reductions in design thickness. A method for calculating truck constants is presented. Instructions to help with selection and operation of loadometer sites are also included in the appendix.

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STRUCTURAL DESIGN OF CITY AND COUNTY ROADS

66-46

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M & R 33222

Prepared in Cooperation with the U.S. Department of Commerce, Bureau of Public Roads October 1966

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FOREWORD

This paper examines the need for separate sets of constants to express the effect of wheel loads on city and county pavements and discusses other factors in the design of the structural section.

The need for this information has been the subject of many conferences between state and local highway officials. It was reasoned that if the character of traffic was different for these lighter traveled city and county roads than for state highways, then quite possibly these local highways were being overdesigned when state highway constants were used in the pavement design formula. State highway constants are being used for all such designs as they are the only constants available.

The study was initiated by the City and County Projects Engineer, with the data collection phase assigned to Urban Planning and the analysis and reporting phase to the Materials and Research Laboratory.

This investigation is sponsored by the Bureau of Public Roads. The data collection or "Loadometer Survey" phase of the study is included under Part I, Item III - 21 of Project HPR-1(2). The data analysis and design modification phase is included in Part II of the work program as Item 4-29 of Section D.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

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SYNOPSIS

The distribution of wheel loads on certain city streets and county roads is evaluated and a comparison is made with wheel loads found on state highways. The need for this study has long been the subject of discussion among engineers designing local roads with the use of wheel load criteria derived from trucks using the state highways.

It was found that trucks using local roads generally have lighter axle loads on a cumulative basis than trucks traveling on state highways. Truck constants were derived from the axle load data collected for this study. These truck constants exhibit a substantial reduction when compared with the state-wide truck constants for state highways.

Sample designs are presented showing reductions in design thickness. A method for calculating truck constants is presented. Instructions to help with selection and operation of loadometer sites are also included in the appendix.

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INTRODUCTION

Structural section design for flexible pavements in California is based on an empirical formula which considers three variables. One variable takes into account the strength of the pavement structure, another represents the effect of the supporting soil, while the third variable deals with the destructive effect of traffic.

The destructive potential of traffic is expressed in terms of the number of passages of a 5,000 pound wheel load (EWL) which is equivalent, in destructive effect, to the actual wheel loads.

To facilitate conversion of the various wheel loads occurring in mixed traffic to the common denominator of equivalent 5,000 pound wheel loads, use is made of certain constants. These constants are commonly termed truck constants or EWL constants. They are derived from statistical distributions of truck axle loads and are calculated separately for each group of trucks categorized according to number of axles.

The truck constant for a given truck classification represents the number of 5,000 pound wheel loads which would be generated in one year by the passage of one truck per day in one direction. As an example, a truck constant of 2,000 for 5-axle trucks would mean that 365 passages of a typical 5-axle truck would be equal in destructive effect to 2,000 passages of a 5,000 pound wheel load.

This EWL constant, when multiplied by the average daily truck traffic in both directions for that particular truck classification, gives the total yearly equivalent 5,000 pound wheel loads for that class of truck.

This research project, "Design of the Structural Section of City and County Roads", analyzes the distribution of axle loads for trucks traveling on local roads. It is primarily concerned with the selection of truck constants representative of this distribution.

The urgency of this study was made necessary by the passage of the Collier-Unruh Local Transportation Development Act. This law provided funds to cities and counties for the construction of select system roads and streets. It specified that the design and construction of these roads would be according to certain minimum engineering standards. These standards were to be administered by the Division of Highways and designs were to be subject to approval by the Division. Since the Division of Highways engineers would accept without question, designs based upon State level criteria, most city

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and county engineers found themselves designing roads using the State's method.

Federal aid secondary roads also came under State influence with regard to structural design standards. Designs for these roads, therefore, were often placed in the same situation as the select system facilities. However, the majority of these roads carry traffic of a character equivalent to state highways.

In 1963, a revised thickness design formula was introduced by the Division of Highways. The revisions were based largely on data from the AASHO Road Test. In addition, safety factors were added and the design life was increased from the previous 10-year period to one of 20 years. The combined effect increased design thicknesses for flexible pavement structural sections. Experience had dictated that such heavier sections were needed on state highways.

Cities and counties using the new formula for road design, however, began to find that under certain circumstances its' use resulted in considerable "overdesign" of their facilities.

The problem, presented by representatives of cities and counties to the Division of Highways for solution, was the rectification of a design procedure which currently provides uneconomical pavement thicknesses for local roads.

The solution to the problem is divided into several parts. These parts are:

(1) Adjustment of design safety factors

(2) Adjustment of design period or life

(3) Derivation of new truck constants

It is the third portion of the solution to which this study is directed. The effect of eliminating the safety factors and reducing the design life from 20 to 10 years for the lighter traveled city and county roads is shown in Table 9.

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CONCLUSIONS

Substantial differences in frequency distributions of axle loads were found to exist between state highways and local roads. These differences contributed to reductions in truck constants calculated for local road traffic.

The current state-wide constants and the constants derived from data collected in this study are shown below.

Truck Category	Current State-wide Constants	Constants from Study
2-axle (6-tire)	280	200
3-axle	930	690
4-axle	1320	1070
5-axle	3190	1700
6-axle	1950	1050

A reduction in total EWL's amounting to 39% was found when the truck constants from this study were applied to truck traffic distributions similar to these occurring in the study.

Use of the truck constants from the study in computing the Traffic Index (T.I.) for typical local road traffic resulted in a 7% reduction in the T.I.

When the reduced T.I. is applied to a typical design situation, the thickness reductions vary from 6% to 11% for all layers of the structural section.

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RECOMMENDATIONS

When Test Method No. Calif. 301 is used to design* pavements for city and county roads, the following truck constants are applicable:

(1) Optimum design of city streets or county roads should be attained by using truck constants calculated and projected from a traffic and loadometer survey of the facility.

(2) For those local roads or streets described in this report as Commercial, Collector, Farm-to-Market, or Connector; the following truck constants are recommended for use:

Truck Category	Constants
2-axle (6-tire)	200
3-axle	690
4-axle	1070
5-axle	1700
6-axle	1050

*Notes:

(1) Gravel equivalent factors for asphalt concrete should be estimated from the graph or calculated from the formula in Figure 3.

(2) Traffic indices should be calculated to the nearest 0.1.

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DISCUSSION

Mr. C. T. Ledden, City and County Projects Engineer, initiated discussion and correspondence covering the use of the Division of Highways flexible pavement design formula for local roads. This ultimately resulted in a research project with City and County Projects Department designated as the responsible agency. Research work and report writing were to be the responsibility of the Materials and Research Department. The loadometer survey and the processing of the raw data were assigned to the Urban Planning Department.

Loadometer Survey

The process of site selection began when a committee of city, county, and state representatives met in Sacramento to discuss the impending study. It was decided that twenty-five sites located on Select System roads would be used. Local agencies were to suggest suitable locations and the State would then select the twenty-five stations from those proposed.

To assist the local agencies in loadometer site selection, Urban Planning personnel assembled the paper: "Comments on Truck Weighing Procedure at Locations not Equipped with Loadometer Pits or Pit Scales". These comments appear in this report as Appendix A.

Random selection of loadometer sites was thought to be desirable; however, the limited number of locations submitted and the fact that some of these were unsuitable precluded random selection.

Site selection was then accomplished using engineering judgment as the determining factor. The final twenty-five locations are shown in Table 1. Of these locations, nine are primarily commercial roads, one is a collector road, twelve are farm-to-market roads, and three are connector roads.

Commercial roads are defined as arterials serving areas which are primarily commercial in nature. This does not include the so-called "downtown" facility. Collector road is used in the sense of a road providing for traffic movement between the local streets in residential areas and major arterials. Farm-to-market roads provide for the movement of traffic through agricultural areas to major arterials or to the state primary system. The term "connector road" is used in the sense of a road connecting two areas of relatively high population density. An example might be a road connecting two towns.

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The apparatus used to weigh axles consisted of a portable frame in which were mounted four small scales or "Loadometers". The scales were so arranged that the entire axle could be weighed. The combination of frame and loadometers is termed a "T" scale (Figure 4).

Loadometer data was gathered for eight hours at each location. At fifteen locations, both directions of traffic were sampled. This was not feasible at the other ten locations. In every case, a classified traffic count of all traffic passing the loadometer station was taken concurrent with the loadometer data. Count data is presented in Table 2 for each station and is summarized according to road type.

Data collection began early in August, 1965, and was finished in September, 1965. Loadometer stations were operated between the hours of 7 to 12 A.M. and 1 to 4 P.M.

Data was obtained by weighing trucks sampled from passing traffic. Trucks were pulled out of the traffic into a waiting line, and as one truck left the line, the next truck to come down the road was directed to enter the waiting line. This procedure assured random sampling of the trucks traveling the highway.

Data collected by the survey crew at the weigh site included:

(1) Axle weights.
(2) General class of commodity carried.
(3) Origin and destination.
(4) Body type.
(5) Vehicle type.
(6) Operation (ICC, off highway, etc.)
(7) Direction of travel.
(8) Date.
(9) Time of day.

Classified count data which was recorded concurrently included:

(1) Number of vehicles (by axle category).
(2) Date.
(3) Time.
(4) Direction of travel.

Sample forms for recording loadometer data and classified count data are shown in Appendix A, Figures A-1 and A-2, respectively.

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Processing of Raw Data

The field data sheets were coded by Urban Planning personnel and punched onto cards for completion by electronic data processing. Use was made of existing programs written for the tabulation of axle loads for the annual loadometer survey taken at fixed locations throughout the State.

Processed data, from the computer, contained the following items:

(1) Summary of classified traffic count data and accompanying codes.
(2) Tabulation of commodities carried and their codes.
(3) Tabulation showing frequency distribution of axle weights according to truck category (Loadometer W-4 frequencies - See Figure 1 for example).
(4) Tabulation showing frequency distribution of axle weights according to truck category and the probable distribution resulting from modification with the classified count data (Tables W-4 - See Figure 2 for example).

This material was turned over to the Materials and Research Department for analysis.

Analysis of Processed Data

All data gathered from the 25 stations was examined to ascertain its relevancy. Several stations showed that trucks carrying seasonal produce were included. Amounts of this type of traffic were not excessive and were thought to represent an average situation.

One station (Contra Costa Co.), located on a connector road, had a large number of empty 3-axle trucks. These were dump trucks returning to a rock quarry. This sample constituted 10 percent of the total number of 3-axle trucks weighed. However, the 3-axle constants for all three road types show a maximum difference of only 14 percent. In addition, the 3-axle constant from a study made by the City of Fresno, is very close to that for the connector roads. In view of the above, it was felt that this station warranted inclusion and should not be modified.

Empty 5-axle trucks from two stations (Contra Costa Co. and San Bernardino Co.), constituted 10 percent of the total number of 5-axle trucks weighed. This was partially compensated by the interception of a number of 5-axle trucks

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hauling materials to a construction site in San Bernardino. Without this compensating traffic, it might have been necessary to modify data for 5-axle trucks.

No other stations revealed concentrations of certain types of loads which might bias the study. For this reason, data from all 25 stations was considered acceptable for this study.

Only eight 6-axle trucks were weighed in the study and although a truck constant is developed for these trucks, its' accuracy could be subject to question. However, the EWL Constant developed appears reasonable when compared to the State EWL Constant.

Calculations

Initial steps in the treatment of the loadometer data involved calculation of the equivalent 5,000 pound wheel loads (EWL) generated by one passage of an average axle in each weight interval. The method of calculation is shown in Table 4.

Single axle weight intervals and the corresponding EWL/axle repetitions are shown below. The calculations are based on the formula $EWL = \left(\frac{W}{5}\right)^{4.2}$ (Ref. 1, p. 9-10).

Axle Weight Intervals (kips)	Equivalent Number of Repetitions of 5,000 Pound Wheel Load
0.0 to 3.0	0.0012
3.0 " 6.9	0.052
7.0 " 7.9	0.291
8.0 " 11.9	0.981
12.0 " 15.9	4.05
16.0 " 18.0	9.30
18.1 " 20.0	15.0
20.1 " 21.9	22.6
22.0 " 23.9	32.8
24.0 " 25.9	46.6
26.0 " 29.9	75.1
30.0 " 34.9	141

A summation was made of the number of axles falling within the above axle weight intervals and was then further categorized as follows:

(1) 2-axle (6-tire) trucks
(2) 3-axle trucks
(3) 4-axle trucks
(4) 5-axle trucks
(5) 6-axle trucks

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This summation was modified by applying a probable number factor (PNF) to the trucks weighed at each station.

$$PNF = \frac{\Sigma \text{ axles counted at a given station}}{\Sigma \text{ axles weighed at a given station}}$$

This factor was calculated separately for each class of trucks categorized by axles as above. Application of the factor weights the final calculation of truck constants in accordance with the actual truck traffic past the stations included in the calculations. Use of the factor is based on the assumption that the axles weighed constitute a representative sample of the axles counted.

In making the summations, one-way loadometer data was doubled to give the one-way sites equal weight in the study. Examination of commodity data, origin and destination data and consideration of the sites treated in this manner indicate that this treatment is approximately correct.

Equivalent wheel loads were calculated for each truck category according to axle weight interval by multiplying the probable numbers of trucks by the EWL/axle for that weight interval. The EWL's for each truck category were then totaled.

Typical equivalent wheel loads per axle for each axle class of truck were calculated by dividing the total equivalent wheel loads for each truck category by the number of trucks in that category.

Truck constants were obtained by expanding the typical EWL/axle for each truck category into the number of equivalent 5,000 pound axle repetitions generated by the passage of one truck of that category per day, in one direction, for 365 days. A detailed method for calculation of truck constants is given in Appendix B.

Tandem axles were not treated separately except during weighing and recording. For calculations, one passage of a tandem axle was treated as two passages of a single axle carrying one-half the load carried by the tandem axles.

RESULTS

All-Station Constants

Truck constants were calculated using the data from all 25 stations. The constants are shown below compared with the current state-wide constants.

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Truck Category	All-Station Constants from Study	Current State-wide Constants	All-Station Constants as a % of State-wide
2-axle (6-tire)	200	280	71%
3-axle	690	930	74%
4-axle	1070	1320	81%
5-axle	1700	3190	53%
6-axle	1050	1950	54%

The reductions in constants are significant and vary from a 47% reduction in the case of 5-axle trucks to a 19% reduction in the case of the 4-axle trucks. The overall reduction in equivalent wheel loads for use in the design formula can be shown by multiplying the truck category distribution (as a percent of total trucks counted) by both sets of constants.

The result, as shown below, amounts to an average overall reduction of 39%.

Truck Category	Percent in Each Category		All-Station Constants from Study		
2-axle (6-tire)	63	x	200	=	12,600
3-axle	14	x	690	=	9,660
4-axle	4	x	1070	=	4,280
5-axle	19	x	1700	=	32,300
6-axle	--	x	1050	=	----
			Total		58,840

Truck Category	Percent in Each Category		Current State-wide Constants		
2-axle (6-tire)	63	x	280	=	17,640
3-axle	14	x	930	=	13,020
4-axle	4	x	1320	=	5,280
5-axle	19	x	3190	=	60,610
6-axle	--	x	1950	=	----
			Total		96,550

$$\text{Reduction in EWL} = 100 \left(\frac{96{,}550 - 58{,}840}{96{,}550} \right) = 39\%$$

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Application of the two sets of constants to a hypothetical traffic situation wherein the truck distribution is similar to that found in the study shows the reduction in T.I.. Table 5 shows this type of calculation for a road with a 6.0 T.I. according to the state-wide constants. As shown in the table, the T.I. becomes 5.6 when calculated with the all-station constants from this study. This amounts to a 7 percent reduction in T.I.

Comparison of the two sets of constants in terms of thickness design appears in Table 6. Here the design of a structural section has been calculated and the thicknesses of the various layers tabulated. Contrary to standard design procedure, the thicknesses in this example have not been rounded off to the nearest 0.05'. They show, therefore, the theoretical thickness reduction possible with the separate set of constants.

Values for T.I. in Table 6 have been calculated to the nearest 0.1 and values for the asphalt concrete gravel equivalent factor have been determined graphically from Figure 3. This allows the designer to take the greatest advantage of the design method in attaining economy. The table shows a reduction of 11 percent in thickness of asphalt concrete and reductions of 6 percent in the base and subbase layers. The overall thickness reduction is 7 percent. It should be noted that the greatest reduction occurs in the most expensive material.

Since the reduction in truck constant varies for each truck category, thickness reduction for any given situation depends upon the prevailing distribution of truck traffic. For this reason, the references to thickness reduction made in this report are only representative of one situation. Savings in thickness for other situations may vary from 5 percent to 15 percent for the various layers.

Constants for Various Road Types

As was mentioned earlier, the stations in the study were grouped into four road types. The road types are shown below with the percentage of the total traffic found in each road type.

Road Type	Percentage of Total Trucks
Commercial	48.4%
Collector	0.8%
Farm-to-market	27.6%
Connector	23.2%

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Since only one station fell into the category of a collector road and since a small percentage of the total truck traffic was counted there, this road type was not considered separately.

Traffic distributions were determined and truck constants calculated for the three principal road types in the study. Distribution of the truck traffic on these roads is shown in Table 7. Table 8 shows the constants calculated for these roads.

The 2-axle (6-tire) truck constants show substantial differences between farm-to-market roads and connector roads. Farm-to-market roads, which carry one-fourth of the total 2-axle traffic (Table 3), have the highest constant. The differences in total equivalent wheel load caused by the variation of these constants both above and below the all-station constant is neglegible. This is true because the EWL per repetition is small for these vehicles.

The constants for the 3-axle trucks are very similar for all road types. Four-axle truck constants are very similar with the exception of the constant for connector roads. Since 4-axle trucks constituted only one percent of the connector road truck traffic, this constant of 420 is somewhat in doubt and would not be suitable for use without further data. A small number of these lightly loaded 4-axle trucks was counted and hence had little effect on the all-station constant for this vehicle.

More than one-half of the total number of 5-axle trucks counted were found on the connector roads where the 5-axle constant was the lowest. Substantial difference was found to exist between the 5-axle truck constant for connector roads and that for farm-to-market roads.

Six-axle truck constants, while calculated for these road types, are based on a very small number of weight determinations and are not considered to be accurate.

Use of the farm-to-market constants with the typical truck distribution found on this road type raises the T.I. slightly more than 3 percent when compared with the all-station constants. The slight increase in thickness required for the increase in T.I. should not alter the expected service life an appreciable amount.

Considering the fact that maintenance of these roads is more convenient because of lighter traffic and since design R-value is predicated upon the worst condition; there would seem to be no good reason to favor the farm-to-market constants over

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the all-station constants. Another factor in favor of using the all-station constants appears in the apparent transition to lighter axle loads which occurs as an area changes from a rural to an urban or suburban character.

A slight savings, depending upon the character of the traffic, could perhaps be effected by using the connector road constants for structural design of that road type. The reduction in T.I., when these constants are applied to the typical connector road traffic distribution, amounts to slightly more than 3 percent. It should be considered, however, that a change in land use of the area or a build-up of commercial establishments along the road would alter the average axle loads in an upward direction. No 6-axle trucks were weighed on connector roads and since the 4-axle constant for this road type is doubtful, it is felt that the all-station constants should be favored for use with this road type.

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TABLE 1

LOCATIONS OF LOADOMETER STATIONS

Station	Location
A-1	Riverside Co., 62nd Ave. 1 mi. w/o S.S.R. 86
A-2	San Bernardino Co., Hesperia Rd. at Sequoia St.
A-3	Orange Co., Westminster Ave. approx. 1050' e/o Los Angeles Co. line
A-4	Ventura Co., Tierra Rejada Rd. at west city limits of Simi
A-5	Kings Co., 12th Ave. between Flint Ave. and Fargo Ave.
A-6	Fresno Co., Belmont Ave. e/o Clovis Ave.
A-7	Merced Co., Lander Ave. at the town of Stevinson
A-8	Monterey Co., Greenfield-Arroyo Seco Rd. w/o Central Ave.
A-9	San Mateo Co., Pescadero Rd. at the town of Pescadero
A-0	Contra Costa Co., Ygnacio Valley Rd. at Via Monte
B-1	Marin Co., Petaluma - Pt. Reyes Rd. w/o San Geronimo Rd.
B-2	Napa Co., Silverado Trail s/o Yountville Rd.
B-3	Solano Co., Lewis Rd. s/o Midway
B-4	Placer Co., Auburn-Folsom Rd. 2 mi. s/o Auburn
B-5	El Dorado Co., Mt. Aukum Rd. 1 mi. s/o Somerset
C-1	City of San Bernardino, E. St. n/o Athol St.
C-2	City of Pomona, Holt Ave. e/o East End Ave.
C-3	City of Santa Ana, South Main St. n/o Mcfadden St.

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TABLE 1 (Contd)

Station	Location
C-4	City of Ventura, Telegraph Rd. e/o Mills Rd.
C-5	City of Delano, County Line Rd. e/o U.S. 99
C-6	City of Visalia, Tulare Ave. e/o Divisadero St.
C-7	City of Merced, G St. n/o 18th St.
C-8	City of Santa Clara, Scott Ave. between Walsh Ave. and Kifer Rd.
C-9	City of Walnut Creek, Rudgear Rd. at Camel Lane
C-0	City of Fremont, Fremont Blvd. s/o Bidwell Drive

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TABLE 2

EIGHT HOUR CLASSIFIED

TRUCK COUNT

Station	Road** Type	2-axle (6-tire)	3-axle	4-axle	5-axle	6-axle	Totals
A-1	3	2	---	---	---	---	2
A-2	4	26	5	1	142	---	174
A-3*	4	66	4	1	8	---	79
A-4	3	144	14	6	20	---	184
A-5	3	42	9	6	18	---	75
A-6	3	67	5	4	11	---	87
A-7	3	50	14	11	59	1	135
A-8	3	10	39	3	1	---	53
A-9	3	15	---	---	---	---	15
A-0*	4	163	88	5	128	---	384
B-1	3	33	10	3	18	2	66
B-2	3	36	5	---	2	2	45
B-3	3	14	1	2	15	---	32
B-4	3	20	17	1	13	---	51
B-5	3	9	2	---	2	---	14
C-1*	1	133	10	7	4	---	154
C-2*	1	235	19	8	5	1	268
C-3*	1	226	41	18	4	---	289
C-4*	1	81	23	4	1	---	109
C-5	1	26	9	5	21	2	63

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TABLE 2 (Contd)

Station	Road** Type	2-axle (6-tire)	3-axle	4-axle	5-axle	6-axle	Totals
C-6	1	35	3	3	6	---	47
C-7*	1	67	23	3	4	---	97
C-8*	1	88	18	5	5	---	116
C-9*	2	19	2	1	---	---	22
C-0*	1	128	27	10	22	---	187
Total		1735	388	107	509	8	2747

* Counts were taken in one direction only

** 1-Commercial, 2-Collector, 3-Farm-to-market, 4-Connector

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TABLE 3

EIGHT HOUR CLASSIFIED TRUCK COUNT FOR

VARIOUS ROAD TYPES

Truck Category	2-axle (6-tire)	3-axle	4-axle	5-axle	6-axle	Total
Commercial Streets	1019	173	63	72	3	1330
Connector Roads	255	97	7	278	0	637
Farm-to-market Roads	442	116	36	159	5	758
Collector Streets	19	2	1	0	0	22
Total, All-Stations	1735	388	107	509	8	2747

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TABLE 4

CALCULATION OF EQUIVALENT

WHEEL LOADS PER AXLE REPETITION

L_1 = Minimum axle load L_2 = Maximum axle load

$\frac{L_1 + L_2}{2}$ = average axle load $\frac{L_1 + L_2}{4}$ = average wheel load (W)

EWL/Repetition = $\left(\frac{W}{5}\right)^{4.2} = \left(\frac{L_1 + L_2}{20}\right)^{4.2}$

Single Axle Weight Intervals L_1 L_2	$L_1 + L_2$	$\frac{L_1 + L_2}{2}$	$\left(\frac{L_1 + L_2}{20}\right)^{4.2}$
0.0 - 3.0	*	2.00	0.0012
3.0 - 6.9	9.9	4.95	0.052
7.0 - 7.9	14.9	7.45	0.291
8.0 - 11.9	19.9	9.95	0.981
12.0 - 15.9	27.9	13.95	4.05
16.0 - 18.0	34.0	17.00	9.30
18.1 - 20.0	38.1	19.05	15.0
20.1 - 21.9	42.0	21.00	22.6
22.0 - 23.9	45.9	22.95	32.8
24.0 - 25.9	49.9	24.95	46.6
26.0 - 29.9	55.9	27.95	75.1
30.0 - 34.9	64.9	32.45	141.

*$L_1 + L_2$ for the 0.0 to 3.0 kip interval was assumed to be 4.0

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TABLE 5

COMPARISON OF TWO SETS

OF TRUCK CONSTANTS IN TERMS

OF TRAFFIC INDEX

Truck Category	Design Period Truck Traffic	State-wide Truck Constant	EWL
		A	
2-axle (6-tire)	243	280	68,040
3-axle	54	930	50,220
4-axle	15	1320	19,800
5-axle	73	3190	232,870
6-axle	--	1950	---
			370,930
		B	
		All-Station Truck Constant	
2-axle (6-tire)	243	200	48,600
3-axle	54	690	37,160
4-axle	15	1070	16,050
5-axle	73	1700	124,100
6-axle	--	1050	---
			255,910

$$T.I. = 6.7 \left(\frac{EWL}{10^6}\right)^{.119}$$

$T.I._A$ = 6.0 Using State-wide EWL Constants

$T.I._B$ = 5.6 Using EWL Constants developed in this study

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TABLE 6

COMPARISON OF TWO SETS OF

TRUCK CONSTANTS IN

TERMS OF

THICKNESS DESIGN

Constants	Current State-wide	All-Station From Study	
Total EWL	370,930	225,910	
Traffic Index	6.0	5.6	
G_f* (AC)	2.32	2.40	
Thicknesses**			% Thickness Reduction
Asphalt Concrete	.18'	.16'	11%
Aggregate Base	.49'	.46'	6%
Aggregate Sub-base	.77'	.72'	6%
Total	1.44'	1.34'	7%

*Gravel equivalent factor (G_f) from Figure 3

**Calculations based on: Base R-value = 78
Subbase R-value = 50
Basement Soil = 10

Thicknesses calculated to nearest 0.01' using the relationship:

$$T = \frac{0.0032(T.I.)(100-R)}{G_f}$$

Values for G_f are found in Test Method No. Calif. 301 where the use of this equation is outlined.

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TABLE 7

PERCENTAGE DISTRIBUTION OF TRUCKS

ACCORDING TO AXLE CLASSIFICATION

SHOWN FOR EACH ROAD TYPE

Truck Category	All-Stations	Commercial	Farm to Market	Connector
2-axle (6-tire)	63.2%	76.7%	58.3%	40.1%
3-axle	14.2%	13.0%	15.3%	15.2%
4-axle	3.8%	4.7%	4.7%	1.1%
5-axle	18.5%	5.4%	21.0%	43.6%
6-axle	0.3%	0.2%	0.7%	0.0%
Total	100.0%	100.0%	100.0%	100.0%

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TABLE 8

TRUCK CONSTANTS FOR VARIOUS ROAD TYPES

COMPARED WITH CURRENT AND ALL-STATION CONSTANTS

Truck Category	Commercial	Connector	Farm to Market	All-Station	Current State-wide
2-axle (6-tire)	200	110	360	200	280
3-axle	700	730	630	690	930
4-axle	1130	420	1380	1070	1320
5-axle	1830	1230	2330	1700	3190
6-axle	820	--	1250	1050	1950

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TABLE 9

COMPARISON OF DESIGN THICKNESSES
IN TERMS OF CHANGES IN
TRUCK CONSTANTS, SAFETY FACTOR, AND DESIGN LIFE

Constants	Current State-wide	Current State-wide	Current State-wide	All-Station From Study
Design Life	20-year	10-year	10-year	10-year
Use of Safety Factor	Yes	Yes	No	No
Total EWL	741,860	370,930	370,930	225,910
Traffic Index	6.5	6.0	6.0	5.6
G_f* (AC)	2.23	2.32	2.32	2.40
Thicknesses** (Inches)				
Asphalt Concrete	.28'	.25'	.18'	.16'
Aggregate Base	.53'	.49'	.49'	.46'
Aggregate Subbase	.67'	.61'	.77'	.72'
Total	1.48'	1.35'	1.44'	1.34'

*Gravel equivalent factor (G_f) from Figure 3.

**Calculations based on: Base R-value = 78
Subbase R-value = 50
Basement Soil = 10

To indicate the true change in thickness, thicknesses are not rounded off but are calculated to the nearest 0.01' using the relationship

$$T = \frac{0.0032\,(T.I.)(100-R)}{G_f}$$

Values for G_f are found in Test Method No. Calif. 301 where the use of this equation is outlined.

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LOADOMETER W4 FREQUENCIES ALL AXLES

CAT	YR	TB	WEIGHT		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
4	C5	3	UNDER	03000	2375	99	56	5		1		3			3				2		
4	C5	3	03000	06999	173	53	574	119		73	32	160	5		8	152	6		129		
4	C5	3	07000	07999			46	35		16	3	27			1	18	1		54		
4	C5	3	08000	11999			93	51		25	21	56	1		3	32	6		40		
4	C5	3	12000	15999			52	23		14	7	143				27	5		16		
4	C5	3	16000	18000			18	11		4		27			1	33			32		
4	C5	3	18001	20000			6	1		2		4				3			5		
4	C5	3	20001	21999				1											2		
4	C5	3	22000	23999			1														
4	C5	3	24000	25999							1										
4	C5	3	26000	29999																	
4	C5	3	30000	34999																	
					2548	152	846	246		135	64	420	6		16	265	18		280		

FIGURE I

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TABLE W-4 (OTHER URBAN)--- NUMBER OF AXLE LOADS OF VARIOUS MAGNITUDES OF LOADED AND EMPTY TRUCKS AND TRUCK COMBINATIONS OF EACH TYPE WEIGHED, THE PROBABLE NUMBER OF SUCH LOADS, AND THE EIGHTEEN KIP AXLE EQUIVALENTS OF EACH GENERAL TYPE AND OF ALL TYPES COUNTED AT 10 STATIONS FROM AUG. 10 TO SEP. 1, 1965, COMPARED TO CORRESPONDING DATA FOR 19XX

SINGLE AXLES

AXLE LOADS IN POUNDS AND 18 KIP AXLE EQUIVALENCY ITEMS	TRACTOR - SEMITRAILER COMBINATIONS										TRUCK AND TRAILER COMBINATIONS									
	3 - AXLE		4 - AXLE		5 - AXLE		6 - AXLE OR MORE		TRACTOR-SEMI-TRAILER TOTAL PROBABLE NOS.		3 - AXLE		4 - AXLE		5 - AXLE		6 - AXLE OR MORE		TRUCK-TRAILER TOTAL PROBABLE NOS.	
	CUR	PRI	CUR	PRI	CUR	PRI	CUR	PRI	CUR	PRI	CUR	PRI	CUR	PRI	CUR	PRI	CUR	PRI	CUR	PRI
UNDER 3000											1								6	
3000- 6999	105		29		4				216		2		3						21	
7000- 7999	29		8		5				67				1						3	
8000-11999	50		13		12				119						1				10	
12000-15999	14		3		1				28						2				20	
1 16000 18000	5		3						13											
18001-20000			1						2											
20001-21999	1								2											
22000-23999																				
24000-25999			1						2											
26000-29999																				
30000-34999																				
UNKNOWN																				
TOTAL SINGLE AXLES WEIGHED	204		58		22						3		4		3					
TOTAL SINGLE AXLES COUNTED	288		122		39				449		18		12		30				60	

1/CALIF LEGAL LIMIT. SINGLE AXLE 18000 POUNDS

FIGURE 2

RELATIONSHIP BETWEEN GRAVEL EQUIVALENT FACTOR FOR ASPHALT CONCRETE AND TRAFFIC INDEX

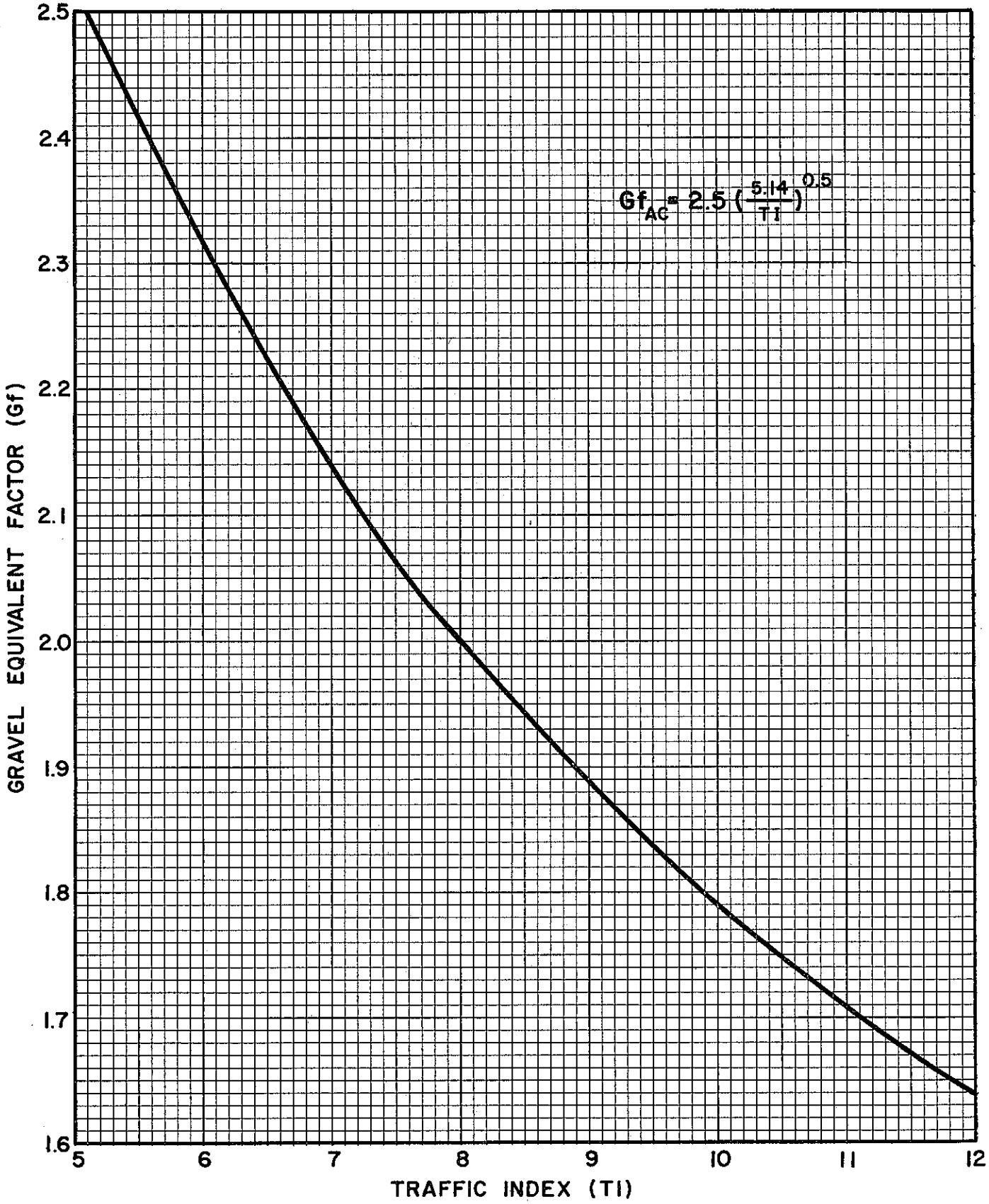

FIGURE 3

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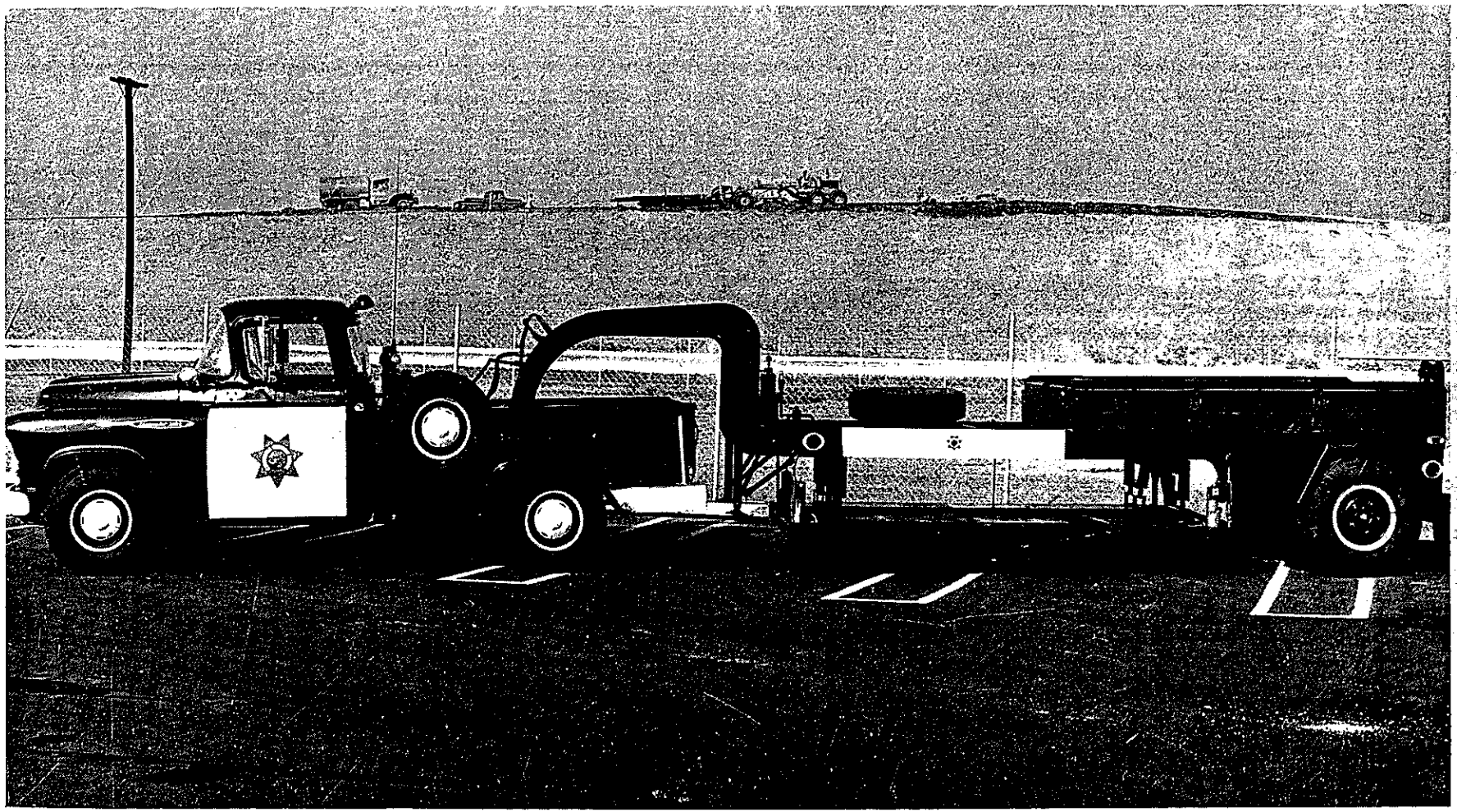

T-SCALE SUSPENDED BENEATH TRAILER READY FOR TRANSPORT
(NOTE LOADOMETERS AT EACH CORNER OF SCALE)

FIGURE 4

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APPENDIX A

Comments on Truck Weighing Procedure at Locations not Equipped with Loadometer Pits or Pit Scales

Basic Considerations

In the conduct of a truck weight study, it is necessary to determine the exact nature of the data needed, the amount of data to collect, the number of locations to operate, and the selection of these sites.

Nature of the Data

It is essential to know before the field work begins the questions that the study is to answer. Typical questions to be considered before a form can be designed for use in the field are:

(a) Is the sole purpose of the data to develop E.W.L. factors?

(b) In addition to axle weights, is it desirable to know about commodity movements, origin and destinations of vehicle, and trip length?

(c) If other information is desirable, what type of questions should be asked to obtain it?

Once the scope of the data required is known, then questions may be formulated and placed in a logical manner on an interview schedule so that the data collection process will yield the type of answers required by the study.

Amount of Data to Collect

The decision as to the amount of data to collect is determined by the degree of accuracy required for an estimate of the item to be sampled and by the cost of obtaining this estimate. Once a policy decision has been made as to the amount of data to collect, then the number and type of locations can be determined. Probably a minimum of five (5) locations would be necessary to estimate E.W.L. factors for a given county.

If the area under study has seasonal variations in types of trucks and axle loadings, it may be desirable to conduct the weighing several times during the year.

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Site Selections

The proper selection of sites for weighing is extremely important if an adequate sample is to be gathered safely. The selection should not be attempted without the guidance of someone experienced in this type of survey.

A list of items to be considered for the selection of a non-permanent site follows:

1. Site should be away from traveled way.
2. Site must be on a hard, level surface, preferably paved.
3. Site, if paved, must be able to withstand loaded trucks without pavement damage.
4. There must be a minimum distance of 75 feet of level surface on each side of the scale.
5. Site must not be on or adjacent to a grade.
6. The site must be visible in both directions for a safe distance.
7. Good approaches to the site are essential.
8. Driveways, roads, places of business must not be obstructed by waiting vehicles.
9. Traffic congestion must not be caused by the site location.
10. The site should be located so that a typical sample of vehicles can be obtained for that type of road.
11. Traffic past a site should be sufficient to yield an adequate sample.
12. Site must be one which can be operated in safety both for the survey personnel and for the vehicle operator.
13. Extreme care must be taken in the selection of any site in a built-up area such as a site located on a city street.

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Safety

There is a considerable element of danger in weighing trucks both to the survey crew and the motorist.

Some items to be considered as means to reducing the hazards are:

1. Have site well signed.
2. Use flagmen.
3. Do not stop vehicles on traveled way.
4. Do not let vehicles project into traveled way.
5. Have adequate storage space off of traveled way for waiting vehicles.
6. Bypass vehicles when storage capacity is full.
7. Weigh vehicles in one direction only.
8. When directing a vehicle to the scales, use utmost caution and do so only when it is safe.
9. Have an easy return to traveled way.
10. Crewmen should not crawl under vehicles.
11. Crewmen should not go between units of a truck combination.
12. Crewmen should watch for unsafe loads which might fall during weighing.
13. Crewmen should watch for projections from vehicles which can cause serious injury.
14. Crewmen should watch for defective tires which might blow out if subjected to sudden strain.

Scale Setup

There are three basic scale setups not requiring pits:

1. Two loadometers with ramps.
2. Four loadometers with ramps.
3. California Highway Patrol "T Scale."

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The last two are the preferred methods. The only difference between method 2 and method 3 is that in method 3 the loadometers are mounted as a unit in a steel frame. This platform can be dropped on a flat surface in a matter of minutes and the weighing operation can begin. Whereas, in method 2 the loadometers must be spaced and adjusted for distance between the treads.

Crew Size

A six-man crew on light volume roads collecting only basic information should be adequate. The size, however, could vary from a minimum of 4 to 10 or 12 depending upon special requirements.

A typical six-man crew would have:

1 recorder
2 scalemen
1 traffic classifier
2 flagmen

Operation

A site is normally occupied during daylight hours.

A classified count is taken of all vehicles traveling in the direction of weighing during the time the station is in operation.

Vehicles are directed to the scales and each axle is weighed. Any other pertinent information is obtained by the recorder at this time.

Public Relations

The vehicle driver should be approached in a pleasant, courteous manner and asked the pertinent information. The operation should be efficient and businesslike. Delays create poor relationships with the public.

All officials who have jurisdiction for an area in which a site is located should be contacted in advance so that they are aware of the survey and its purpose.

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Explanation of Interview
Schedule for the Loadometer Survey

OPERATION: Recorder will observe vehicle license and by use of the following criteria will circle the appropriate code.

1. Circle 1 if the vehicle license is not W, X, Y, or Z.

2. Circle 2 if the vehicle license is W, X, Y, or Z and has an ICC number on the door.

3. Circle 3 if vehicle license is W, X, Y, or Z and does not have an ICC number.

VEHICLE TYPE: Refer to "Key to Vehicle Type Designation" and write designation. Do not use boxes. Example of these designations are:

1. 3 3 axle single unit vehicle

2. $\frac{a}{3}$ $\frac{b}{3}$
   a = 3 axle truck
   b = 3 axle full trailer

3. $\frac{a}{2}$ $\frac{b}{S1}$ $\frac{c}{2}$
   a = 2 axle tractor
   b = 1 axle semi-trailer
   c = 2 axle full trailer

4. $\frac{a}{3}$ $\frac{b}{S2}$
   a = 3 axle tractor
   b = 2 axle semi-trailer

BODY TYPE: Write body type. Examples are: flatbed, livestock, log, box, dump, hopper, tank.

Do not use boxes.

COMMODITY: Enter specific commodity. For example rough rice or milled rice. Avoid general freight classification if possible.

Do not use boxes.

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ORIGIN - DESTINATION: If used enter terminal points.

AXLE WEIGHTS: Enter loadometer reading for each axle in the upper boxes and sum to get axle weight.

TAPE READING: If used enter accumulative readings.

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STATE OF CALIFORNIA
TRUCK WEIGHT STUDY

RECORDER _____ STATION NO. _____

DATE _____ DIRECTION _____

HOUR BEGINNING _____

OPERATION: PVT [1] ICC [2] OFH [3]

VEHICLE TYPE _____ [ ][ ] [ ][ ]

BODY TYPE _____ [ ][ ]

COMMODITY _____ [ ][ ][ ][ ][ ]

ORIGIN		DESTINATION	
CITY	STATE	CITY	STATE
	CALIF [ ]		CALIF [ ]
[ ][ ]	[ ][ ][ ][ ]	[ ][ ]	[ ][ ][ ][ ]

AXLE WEIGHT - HUNDREDS OF POUNDS

A	B	C	D	E	F	G
[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]
[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]

TAPE READING-CUMULATIVE FEET TO 1/10

B	C	D	E	F	G
[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]	[ ][ ][ ]

FIGURE A-1

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FORM M-27

STATE OF CALIFORNIA—DEPARTMENT OF PUBLIC WORKS

82529 7-53 15M SPO

DIVISION OF HIGHWAYS—TRAFFIC CENSUS

Day..... Date.....

Weather.....

Station Description.....

Signed.....

No..... Town..... Leg.....

Signed.....

TYPE		A.M. HOURS 6-7	7-8	8-9	9-10	A.M. 10-11	11-12	P.M. 12-1	1-2
PASSENGER AUTOMOBILES (CALIFORNIA REGISTRATION)	20								
	40								
	60								
	80								
	100								
	120								
	140								
	160								
	180								
	200								
SUBTOTAL									
FOREIGN PASSENGER CARS									
BUSSES									
FREIGHT VEHICLES	PICKUPS								
	2 AXLES								
	3 AXLES								
	4 AXLES								
	5 AXLES								
	6 OR MORE AXLES								
	TOTAL								

TYPE		P.M. HOURS 2-3	3-4	4-5	5-6	6-7	7-8	P.M. 8-9	9-10	TOTAL
PASSENGER AUTOMOBILES (CALIFORNIA REGISTRATION)	20									20
	40									40
	60									60
	80									80
	100									100
	120									120
	140									140
	160									160
	180									180
	200									200
SUBTOTAL										
FOREIGN PASSENGER CARS										
BUSSES										
FREIGHT VEHICLES	PICKUPS									
	2 AXLES									
	3 AXLES									
	4 AXLES									
	5 AXLES									
	6 OR MORE AXLES									
	TOTAL									

FIGURE A-2

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KEY TO COMMERCIAL VEHICLE TYPE DESIGNATION

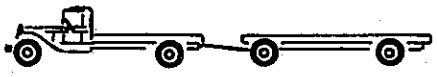
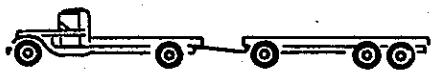
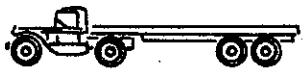
	2		3
	2-2		3-2
	2-3		3-3
	2-S-1		3-S-1
	2-S-2		3-S-2
	2-S-1-2		3-S-1-2
	2-S-2-3		3-S-2-3

FIGURE A-3

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APPENDIX B

METHOD FOR CALCULATING EQUIVALENT WHEEL LOADS, TRUCK CONSTANTS, AND TRAFFIC INDICES

SCOPE

This method describes the procedure for transforming traffic count data into descriptive numbers which are used in calculating the structural thickness of pavement.

DEFINITIONS

Traffic Index (TI) - a number representing the weight and volume of truck traffic on a given section of highway.

Equivalent Wheel Load (EWL) - the number of repetitions of a 5,000 pound wheel load which would have the same damaging effect as the truck axle or axles being considered.

Average Daily Truck Traffic (ADTT) - the number of trucks passing a given point on a highway, in both directions, in any 24-hour period.

Truck Constant - (EWL Constant) - a number expressing the total EWL generated by the passage of an average truck of a particular type, once a day, in one direction, for a period of one year.

PROCEDURE FOR CALCULATING TRAFFIC INDEX

For structural thickness design purposes, the average daily truck traffic must be converted into a traffic index. Initially, we must convert all axle loads[1] to an equivalent number of 5,000 pound wheel loads by using the equation:

$$\text{EWL/Repetition} = \left(\frac{W}{5}\right)^{4.2} \qquad (1)$$

Where: EWL = equivalent 5,000 pound wheel loads for one repetition of a particular average wheel load

W = Average wheel load in kips

The graphical solution to this equation is presented in Figure B-1 along with an example showing that one 5,000 pound wheel load would have a constant EWL of 1.0.

[1] Treat a tandem unit as two single axles each carrying one-half the tandem unit load.

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To determine total EWL, multiply the repetitions of the axle load by the EWL per repetition.

To convert the total EWL to a traffic index, use the following equation:

$$TI = 6.7 \left(\frac{EWL}{10^6}\right)^{0.119} \qquad (2)$$

This equation is solved graphically in Figure B-2.

In order to convert mixed truck traffic to equivalent 5,000 pound wheel loads, it is necessary to have a sampling of the truck traffic, using the highway, by axle weights and by number of axles. This information, for a state-wide count, is made available each year by the Traffic Department in its W-4 tables. Convert the number of axles in a given weight category to the equivalent 5,000 pound wheel loads by using equation (1).

In practice, the calculations for TI are made by using truck constants for trucks in the following categories: 2, 3, 4, 5, and 6 axle trucks. These constants are derived as follows:

1) Obtain loadometer data - axle weight for all trucks listed by truck category - and a classified traffic count.

2) Separate the axle weights in each truck category into axle weight intervals as shown in Table B-1.

3) Calculate the average wheel load for each weight interval and convert to average EWL/repetition by the relationship $EWL = \left(\frac{W}{5}\right)^{4.2}$ (Table B-2). This average EWL/repetition is then multiplied by the number of axles in each weight interval. This yields a total EWL for each truck category in each weight interval for the period encompassed by the loadometer survey.

4) The EWL's in each truck category are then summed up.

5) Knowing, then, the total EWL's and the total number of axles for each truck category, the average EWL/axle can be calculated for each category.

6) The truck constant for each truck category is then obtained by multiplying the average EWL/axle by 365 days and by the number of axles on one truck in that category. The result is divided by two in order to reduce to a uni-directional constant.

Constants have been calculated by the Division of Highways from the State-wide traffic count and are listed in Table B-4. The State-wide constants should only be used in cases where more accurate truck traffic data is not available.

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7) To calculate annual EWL, the truck constants for each truck category are multiplied by the average daily truck traffic and the anticipated increase factor. The resulting totals for each truck category are summed up to obtain the total average annual EWL's in one direction.

8) For use in the thickness design equation, the total annual EWL's are multiplied by the number of years in the design period and are then converted to Traffic Index (TI) by the relationship shown in Equation (2).

To clarify the preceding explanation, the following hypothetical example is shown:

Given: Loadometer traffic count data as indicated in Table B-1. Average daily traffic as given in Table B-3.

Required: To determine the truck constants for the truck traffic and establish a traffic index for the section of highway involved for a twenty year design life.

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SOLUTION:

TABLE B-1

LOADOMETER TRAFFIC COUNT DATA
(BOTH DIRECTIONS)

Axle Weight Intervals (Kips)	No. Axles Weighed				
Single Axles	2-axle (6-tire) Trucks	3-axle Trucks	4-axle Trucks	5-Axle Trucks	6-axle Trucks
Under 3.0	11,561	22	43	52	9
3.0 - 6.9	1,092	1,186	187	2,169	57
7.0 - 7.9	438	384	27	710	25
8.0 - 11.9	952	810	59	1,300	90
12.0 - 15.9	433	464	19	888	24
16.0 - 17.9	41	108	10	910	7
18.0 - 18.0	2	8		75	
Tandem Axles[1]					
Under 6.0		4	18	22	6
6.0 - 11.9		282	446	1,794	100
12.0 - 17.9		262	236	882	52
18.0 - 23.9		178	162	536	74
24.0 - 29.9		130	154	1,672	98
30.0 - 31.9		82	66	1,058	6
32.0 - 32.0		6	4	62	4
Total Number Axles	14,519	3,926	1,431	12,130	552

[1]Treat a tandem unit as two single axles, each carrying one-half the tandem unit load. For this reason the tabulated figures are actually twice the number of tandem axles counted.

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TABLE B-2

CALCULATIONS FOR TRUCK CONSTANTS

Axle Weight Intervals (Kips)	EWL per[1] Repetition	2-axle 6-tire Trucks	3-axle Trucks	4-axle Trucks	5-axle Trucks	6-axle Trucks
Single axles						
Under 3.0	0.006	69[2]	0	0	0	0
3.0 - 6.9	0.055	60	65	10	119	3
7.0 - 7.9	0.299	131	115	8	212	7
8.0 - 11.9	1.00	952	810	59	1,300	90
12.0 - 15.9	4.11	1,780	1,907	78	3,650	99
16.0 - 17.9	9.28	380	1,002	93	8,445	65
18.0 - 18.0	11.7	23	94	0	878	0
Tandem Axles						
Under 6.0	0.006[3]		0	0	0	0
6.0 - 11.9	0.035		10	16	63	4
12.0 - 17.9	0.299		78	71	264	16
18.0 - 23.9	1.23		219	199	659	91
24.0 - 29.9	3.53		459	544	5,902	346
30.0 - 31.9	6.30		517	416	6,665	38
32.0 - 32.0	7.20		43	29	446	29
Total EWL's		3,395	5,319	1,523	28,603	788
Total No. Axles[4]		14,519	3,926	1,431	12,130	552
Average EWL/Axle[5]		0.234	1.355	1.064	2.358	1.428
Truck Constants[6]		85	740	775	2,150	1,565

[1]Calculated from equation (1) or obtained from Fig. B-1. Use average wheel load. (Ave. wheel load = Ave. axle load ÷ 2)

[2]EWL/Axle multiplied by number of axles. (No. of axles from Table B-1)

[3]These constants calculated for one-half of the average tandem axle load.

[4]From Table B-1.

[5]Total EWL's divided by Total No. of Axles.

[6]EWL/Axle x 365 days x No. Axles on each truck ÷ by 2 directions.

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TABLE B-3

CALCULATION OF ANNUAL EWL

Truck Category	Average Daily[1] Truck Traffic	x	Truck[2] Constants	x	Anticipated[3] Increase Factor	=	EWL By Truck Category
2-axle (6-tire)	337		85		2.30	=	65,900
3-axle	182		740		1.90	=	255,900
4-axle	93		775		1.75	=	126,100
5-axle	276		2,150		2.10	=	1,246,100
6-axle	40		1,565		1.50	=	93,900
			Total Average Annual EWL's			=	1,787,900

Computing the total design EWL for 20 years:

$$EWL_{20\ yr.} = 1{,}787{,}900 \times 20 = 35{,}800{,}000^{4}$$

Traffic Index (TI) is calculated from the EWL by the use of equation (2) or from Fig. B-2.

$$TI = 6.7 \left(\frac{EWL}{10^6}\right)^{0.119}$$

$$= 6.7 \left(\frac{35{,}800{,}000}{10^6}\right)^{0.119}$$

$$= 6.7 \ (35.8)^{0.119}$$

$$= 6.7 \times 1.53$$

$$= 10.25 \text{ use a TI of } 10.5$$

This value of 10.5 for Traffic Index can now be used in the pavement structural thickness design equation, as explained in Test Method No. Calif. 301.

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[1]Two directional count.

[2]These constants are for this example only and are not to be used in any actual calculations. Use the constants given near the end of this Test Method if applicable.

[3]This factor converts average daily truck traffic from the present count to the anticipated average count for the mid-year of the design period.

[4]Three significant figures are adequate for the accuracy of the method and data.

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SPECIAL CASES Where a one-directional count is given, such as is the case for an on or off ramp, the truck constants should be doubled. The truck constants are based on a two-directional count. Notes: For cases where reliable traffic data is not available or traffic conditions can be considered average for a state-wide count, the EWL Truck Constants given in Table B-4 can be used in place of computing Truck Constants.

TABLE B-4

EWL CONSTANTS

No. of Axles	Constants
2	280
3	930
4	1320
5	3190
6	1950

Table B-5 gives typical traffic index values for different types of traffic.

TABLE B-5
TYPICAL TRAFFIC INDICES FOR VARIOUS CLASSES OF HIGHWAYS

Class of Road	Traffic Index Range
Heavy Industrial	11 and above
Heavy Truck Traffic	10 - 11
Average Highways	7 - 10
Shoulders and Frontage Roads	4.5 - 7.5
Residential Streets	2 - 6

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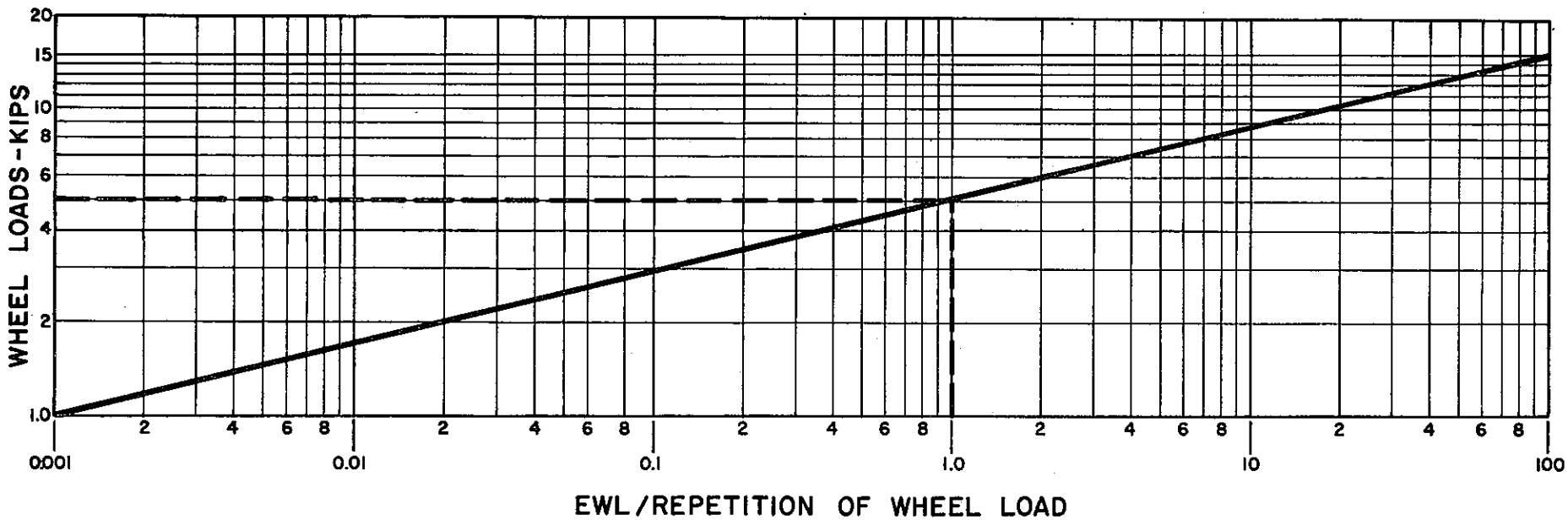
CONVERSION CHART
AVERAGE WHEEL LOAD TO EQUIVALENT 5,000 LB. WHEEL LOADS



SOLUTION OF: $EWL = \left(\frac{W}{5}\right)^{4.2}$

FIGURE B-1

CONVERSION CHART
EWL to TI

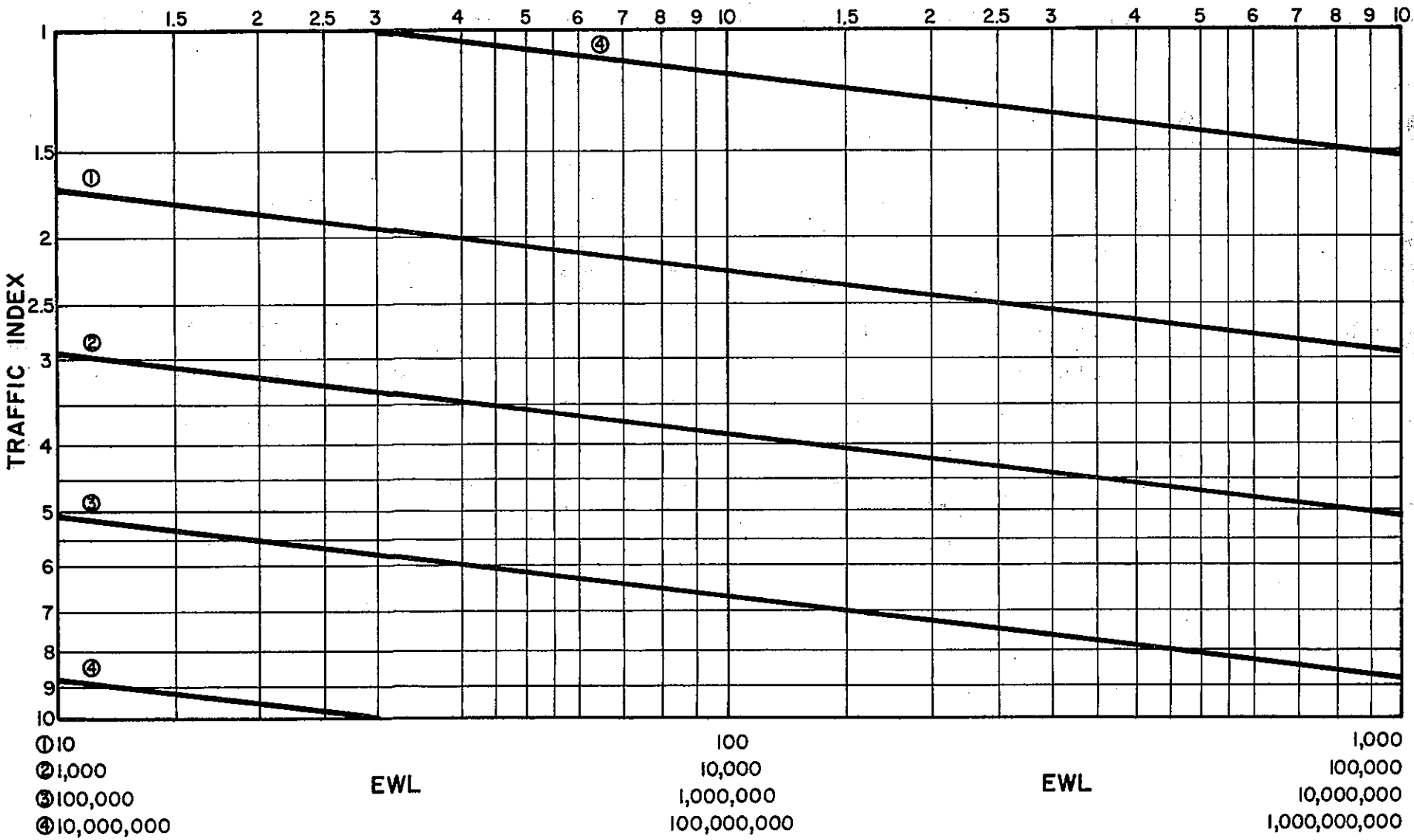


FIGURE B-2

Solution of $TI = 6.7 \left(\frac{EWL}{10^6}\right)^{.119}$

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