HIGHWAY USE AND HIGHWAY COSTS

A Report

of the

JOINT STATE GOVERNMENT COMMISSION

to the

GENERAL ASSEMBLY

of the

COMMONWEALTH OF PENNSYLVANIA

SESSION OF 1953

The Joint State Government Commission was created by Act of 1937, July 1, P. L. 2460, as amended 1939, June 26, P. L. 1084; 1943, March 8, P. L. 13, as a continuing agency for the development of facts and recommendations on all phases of government for the use of the General Assembly.

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LETTER OF TRANSMITTAL

To the Members of the General Assembly of the Commonwealth of Pennsylvania:

The Joint State Government Commission presents herewith a report on the use of the Commonwealth's highways and the costs attributable to vehicles of different types. The study was undertaken by the Commission under authority of the Act of 1939, June 26, P. L. 1084, Section 2(e), upon the suggestion of The Honorable John S. Fine, Governor of Pennsylvania, that the effects of trucks upon highways be ascertained.

The investigations and analyses were made under the immediate supervision of the Commission's Executive Committee. The cost approach directed by the Executive Committee differs from past allocations of highway expenditures in that actual, rather than hypothetical, costs and all, rather than selected, areas of costs are considered. Though the relative cost positions of different vehicles have been established, cost differentials have not been calculated.

The Commission acknowledges the cooperation of the U. S. Bureau of Public Roads and the Commonwealth's departments of Highways and Revenue, who furnished certain data, and of the Pennsylvania State Police, who assisted in the conduct of weight and use surveys.

This report, which outlines cost relationships, will be followed by a technical supplement presenting basic engineering relationships.

BAKER ROYER, *Chairman*

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RECOMMENDATIONS

The Joint State Government Commission recommends:

I. In principle, that the weight, dimensions, and performance of commercial vehicles be limited only by reference to vehicle characteristics which generate highway and bridge requirements and highway and bridge costs.

Specifically, that there be no increase in Pennsylvania's statutory single-axle and tandem-axle weight limits of 20,000 pounds and 36,000 pounds, respectively, but that permissible gross weight, if present axle-weight limits are retained, be determined by reference to the formula:

$$36{,}000 + 750(D - 4)$$

Where: D = distance between first and last axles in any axle group.

II. In principle, that for registration purposes vehicles be classified by reference to cost-generating characteristics.

Specifically, that the chassis-weight basis of the present commercial vehicle classification system be abolished, and that classification of such vehicles be based upon axle weight and associated characteristics.

III. In principle, that registration fees be equal to costs generated.

Specifically, that the registration fees payable by commercial vehicles be arranged to reflect the *relative* highway and bridge costs generated by vehicles, and that the minimum vehicle registration fee be $10.00 and the maximum $300.00.

IV. In principle, that penalties be adequate to effectively discourage violations of weight limits and to cover increases in highway and bridge costs generated by excess weights.

Specifically, that penalties be $100.00 for violation of gross-weight limits and $25.00 for violation of axle-weight limits, plus $2.00 for each 100 pounds or part thereof by which either weight exceeds the maximum permitted, and that no statutory axle-weight tolerance be permitted.

Section I

THE HIGHWAY AND THE MOTOR VEHICLE

Since 1903, when the first motor vehicle registration act was passed in Pennsylvania,[1] the General Assembly has frequently directed its attention to the changing problems of highway transport.

Since the passage of the first registration statute, enactments of the General Assembly have dealt with such matters as (1) classification and registration fees related to changes in vehicle characteristics; (2) regulatory measures concerning the operation of vehicles; (3) establishment and extension of the state highway system and state aid to local road systems; and (4) introduction of the motor fuel tax and changes in rates to facilitate the financing of an increasingly costly highway system to accommodate an increasing number of vehicles.[2]

The introduction of the gasoline tax went a long way toward financing the hard-surfaced roads required by motor vehicles. However, the yield of the tax, along with the proceeds of other highway-user charges, gave rise to revenue diversion for purposes other than highway construction and highway maintenance. The diversion problem was met by an amendment to the Constitution of Pennsylvania which provides:

> All proceeds from gasoline and other motor fuel excise taxes, motor vehicle registration fees and license taxes, operators' license fees and other excise taxes imposed on products used in motor transportation after providing therefrom for (a) cost of administration and collection, (b) payment of obligations incurred in the construction and reconstruction of public highways and bridges shall be appropriated by the General Assembly to agencies of the State or political subdivisions thereof; and used solely for construction, reconstruction, maintenance and repair of and safety on public highways and bridges and air navigation facilities and costs and expenses incident thereto, and for the payment of obligations incurred for such purposes, and shall not be diverted by transfer or otherwise to any other purpose, except that loans may be made by the State from the proceeds of such taxes and fees for a single period not exceeding eight months, but no such loan shall be made within the period of one year from any preceding loan, and every loan made in any fiscal year shall be repayable within one month after the beginning of the next fiscal year.[3]

Past and present policies with respect to regulation, registration, financing, and diversion of highway-user tax revenue reflect the marked changes in the *volume* and *composition* of highway traffic.

In 1920, 598,473 motor vehicles were registered in Pennsylvania. Of the total registration, 48,329, or 8.1 percent, represented commercial vehicles and buses. In 1950, 3,213,155 motor vehicles were registered in the Commonwealth. Of the total registration, 497,233 or 15.5 percent, represented commercial vehicles and buses. Changes in numbers of vehicles and types of vehicles registered in Pennsylvania have resulted in increasingly diversified use of highways.[4]

The increasing diversification in the composition of highway traffic and the magnitude of aggregate highway expenditures, taken in conjunction with the fact that *vehicles* are commonly *privately* owned and operated whereas most *highways* are *publicly* owned and maintained, have

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[1] 1903, April 23, P. L. 268.

[2] For details of highway taxation and vehicle classification in Pennsylvania, see Appendix A.

[3] Constitution of the Commonwealth of Pennsylvania, Article IX, Section 18 (amendment of November 6, 1945).

[4] For vehicle registrations in Pennsylvania, 1906 to 1952, see Appendix B.

given rise to the problems of (1) determining the highway costs attributable to vehicles in different *classes,* and (2) developing a legislatively prescribed formula for assessing attributable costs against users in different *classes.*

The highway costs attributable to a *class* of highway users are equivalent to the *public costs* which must be incurred if the *vehicles of that class,* under statutory conditions regarding safety and convenience, are to be permitted on the public highways. Given the conditions regarding safety and convenience, when a specified *private vehicle* uses the *public roads, public costs* vary with (1) the distance which the vehicle travels over the public roads, and (2) certain vehicle characteristics.

In new construction and reconstruction, heavier axle loads require roads of increased carrying capacity. Again, wider vehicles require wider lanes. Increases in carrying capacity and width of lanes, together with changes in alignments and grades (among other factors), increase public costs. In connection with existing facilities, changes in vehicle characteristics also occasion changes in costs. Inasmuch as vehicle characteristics and their associated effects upon public highways change, public costs attributable to these vehicles vary over time.

Once costs attributable to different *classes* of highway users have been ascertained, a legislatively determined formula is required if costs are to be assessed against users. The payments of users take the form of registration fees, motor fuel taxes, and use or gross receipts taxes.[5] These levies, taken singly or in combination, can be employed with a view of allocating to each *class* of highway users the *public costs generated by the members of the class.* Again, these levies can be employed with a view of allocating costs by imposing a charge upon each *class* of highway users calculated to equal the *estimated value of the service which the members of the class derive* from the use of the highway.

If public costs attributable to different classes of highway users are to be assessed against the members of the different classes, adequate cost and highway-user payment data are required. If public costs are to be allocated on the basis of estimated value of the service which different classes of users derive from the use of the highway, adequate estimates of the values of service, as well as adequate cost and highway-user payment data, must be developed.

Governments, as a rule, control the supply of highway facilities and set the charges for their use. It has often been demonstrated that resources tend to be best utilized when prices charged for facilities and services are permitted to approximate costs of facilities and services. The value-of-service approach does not tend to equate cost and price, and hence cannot be expected to promote efficient utilization of resources.

Under the *value-of-service* approach, *total highway-user charges* may be *equal* to, *smaller,* or *larger* than *total highway costs.* If total charges equal total costs, highway users as a group pay their way. If total charges are *less than costs,* highway users as a group are *subsidized;* if the *reverse* is true, highway users as a group *subsidize* some other group in the community. It should be noted, however, that, *in all cases,* some highway users may *subsidize* others, because there obtains no necessary relationship between value of highway service received and highway costs generated.

Under the *cost-of-service* approach, total highway-user charges *equal* total highway costs, and highway users, individually and as a group, *pay their way.*

In the past, value-of-service and cost-of-service approaches to highway expenditure allocation have been attempted but have failed to produce generally acceptable results. Among the "value-

[5] For an outline of a highway use tax statute, see Appendix C.

of-service" approaches are the private-operating-expense method, the gross-ton-mile method, the space-time method and the differential-benefit method, all of which have failed to establish relationships between vehicle characteristics and value received and between vehicle characteristics and costs generated by these characteristics. The most commonly attempted "cost-of-service" approach, the joint-and-differential-cost method, has, in the past, established *some* relationships between vehicle characteristics and public costs in the area of new construction only. In the subsequent section of this report, there is presented a framework for analysis, in terms of vehicle characteristics, of *actual* public costs on account of *new construction, reconstruction,* and *existing facilities.*

Section II

VEHICLE CHARACTERISTICS AND HIGHWAY COSTS

A. Costs of Highway Transport

Highway transportation generates both *private* and *public* costs. *Private* costs—purchase price of vehicle, operating expenses, time in transit, inconvenience—are met directly by vehicle owners and operators. In Pennsylvania, public costs—for highway construction, reconstruction, maintenance, and administration—of the state highway system are currently recouped by means of highway-user charges; public costs arising in connection with local roads and streets are financed, in the main, out of local taxes and transfers from the Commonwealth's Motor License Fund.

Outstanding characteristics of change in the period from 1920 to 1950 have been: (1) steady increases in the numbers of all types of vehicles; (2) steady increases in diversification of vehicles and vehicle use, as evidenced by increases in weight and dimensions, changes in weight distribution, and increases in speeds and miles traveled. Increases in weight and dimensions and changes in weight distributions result from improved vehicle design and construction, which facilitate increased load-carrying capacities in relation to vehicle chassis weights.

It should be noted that changes in traffic volume and traffic composition have their first impact upon *private,* rather than *public,* costs.

Changes in private costs to highway users are generated by changes in both highway utilization and vehicle characteristics. For example, increases in transit times for specific vehicles are occasioned by increases in numbers of similar vehicles and by changes in numbers and characteristics of dissimilar vehicles. Other private costs, such as insurance charges, are similarly affected.

Changes in private costs eventuate into demands for new highway facilities designed to accommodate the traffic. When new highway facilities are built, private costs are converted into public costs. Commonly, conversion of private costs into public costs tends to minimize total costs of highway transport.

B. Vehicle Characteristics and Public Costs

Public costs incurred in connection with public highways consist of: (1) costs of new construction and reconstruction; (2) costs, generated by use, of preserving, within practical limits, the carrying capacity of existing roads; and (3) administrative costs.

The first two of these costs vary significantly with both: (1) vehicle characteristics, and (2) number of miles traveled by vehicles with specified characteristics. The available evidence suggests that administrative costs do not vary significantly with vehicle characteristics.

The most important vehicle characteristics which determine public costs are numbers and weights of axles, dimensions, and performance. Numbers and weights of axles affect primarily the *unit cost* of surface and base, and vehicle dimensions and performance (braking power and speed) affect primarily the width of the roadway, alignment, gradients, and structures. Generally, increases in dimensions and decreases in performance are associated with increases in numbers of axles and axle weights. In addition to the above characteristics, axle spacing for any given gross weight affects bridge costs.

1. *Weight*

The total gross weight of a vehicle does not affect the *cost* of highway surface or base. A specified gross weight can be distributed among a number of axles in many ways, producing different highway requirements, and the distribution, rather than the gross weight, is of importance in highway design and performance. Examples of distributions of a specific weight (45,000 pounds) over three axles of a truck-tractor semitrailer combination are as follows:

Weight Distribution	*Front Axle*	*Drive Axle*	*Trail Axle*
1	6,000	20,000	19,000
2	8,000	19,000	18,000
3	10,000	18,000	17,000

The first distribution will require greater supporting capacity than the second, and the second greater capacity than the third. Similarily, the useful life of a highway will be shorter under distribution 1 than under distribution 2, and again, shorter under distribution 2 than under distribution 3.

Axle weight determines both highway requirements and highway costs. The unit cost of surface and base will tend to decrease as the gross weight is increasingly evenly distributed over the axles.

2. *Dimensions and Performance*

The effects of vehicle dimensions and performance upon traffic streams are illustrated by the following statement of the U. S. Bureau of Public Roads:

> In level terrain 1 truck is equivalent, in a [highway] capacity sense, to two passenger cars on a multi-lane highway and to 2½ passenger cars on a two-lane highway; in rolling terrain one truck on a multi-lane highway is equivalent to four passenger cars, and on a two-lane highway to five passenger cars.[1]

a. *Height.*—The heights of trucks generally determine clearances which must be provided on highways. These necessary clearances occur "in the portals of truss bridges, in the openings of underpasses, in the height of tunnel bores, in the placement of overhead traffic signs, trolley wires, etc., and in the trimming of over-hanging trees." [2]

b. *Width.*—Clearances required by vehicles of different widths in traffic streams determine the widths of lanes of highways and bridges. "The effect of trucks . . . on the width of pavement required for safety is to increase the traffic lane width 1 foot. . . ." [3]

c. *Length.*—Length of vehicles determines required curvatures and sight distances. Since the rear wheels of a vehicle do not follow the same path as its front wheels when rounding a curve, additional highway surface must be provided to take into account the differences in the paths of travel of these wheels. For longer vehicles, this additional requirement is greater than for shorter vehicles. For combination vehicles, the difference in paths of wheels is less than that of single-unit vehicles of equal length.

The length of vehicles is of importance in determining required sight distances on highways, since a greater time and distance are needed in passing a longer vehicle than in passing a shorter vehicle.

d. *Speed and brake performance.*—The ability of larger and heavier vehicles to maintain speeds while ascending slopes is generally less than that of smaller and lighter vehicles. Consequently, in order to maintain a specified traffic flow for all types of vehicles, grades must be such that the steepness and length of the grade will not impede this flow. If grades are not altered, additional lanes must be provided in order to permit a specified flow of traffic. The brake performance of heavier vehicles also plays a part in the determination of required grades and alignments, since greater distances are required for deceleration of these vehicles.

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[1] *A Factual Discussion of Motortruck Operation, Regulation, and Taxation* (Washington: U. S. Department of Commerce, Bureau of Public Roads, 1951), p. 25.

[2] *A Factual Discussion of Motortruck Operation, . . .*, p. 19.

[3] *A Factual Discussion of Motortruck Operation, . . .*, p. 20.

C. Vehicle Characteristics and Their Effects Upon Highways

Highways are designed for a given total number of vehicle passages, a given vehicle and axle-weight distribution per unit of time, and a specified speed.[4] If the vehicle and weight distribution changes, the life of the highway, in terms of the number of vehicle passages, also changes. If changes in the distribution are occasioned by increases in axle weights, the life span of the highway, in terms of total number of vehicle passages, is reduced. The reduced life span, accompanied by the same total cost, results in increased costs per passage and per vehicle. Under such conditions, unit costs are greater than those originally anticipated and greater than those which would have obtained had the different distribution been utilized for design and construction. Historically, most changes of this type have been to heavier weights and increased numbers of these heavier weights.

The reduction in the total number of vehicles is generally viewed as a shortening of the life of the highway facility, without regard to the increased unit costs involved. From a policy point of view, it is not reduction in number of vehicle passages consequent upon the introduction of heavier weights which is of paramount importance, but increased unit costs which must be charged if total public costs are to be covered.

Vehicles tend to reflect both technological advancement and economic change more readily than do highway systems, since the useful life of passenger cars and trucks is considerably shorter than that of highways and bridges.

In Pennsylvania prior to 1943, the maximum axle weights permitted by statute were 18,000 pounds upon a single axle and 33,000 pounds upon a tandem axle.[5] Since 1943, the maximum weights have been 20,000 pounds upon a single axle and 36,000 pounds upon a tandem, subject, however, to the limitation (among others) that the over-all gross weight of a truck-tractor semi-trailer is not to exceed 45,000 pounds.[6]

As of May, 1952, the Commonwealth owned, operated, and maintained a primary highway system of 14,603 miles and a rural road system of 26,462 miles. Of these, about 1,875 miles of primary highway and 2,305 miles of rural roads have been constructed or reconstructed since 1943.

In other words, but a small part of the Pennsylvania state highway system has been constructed or reconstructed to accommodate the increase in axle weight from 18,000 to 20,000 pounds. There can be no question that increased unit costs attach to axle weights above the weights for which most Pennsylvania roads were designed. However, it should be noted that some of the older roads are, in effect, "posted" because of limited bridge capacity.[7]

1. *Existing Highways*

Increases in axle weights increase highway damage more than proportionately.

The highway-damage differentials associated with weight differentials have been repeatedly observed on actual roads since 1920 when the Bates Test was made in Illinois.[8] The most recent of these observations were made in connection with the Maryland Road Test. Certain of the findings of the Maryland Road Test relative to highway damage produced by different axle weights and axle-weight combinations are reproduced in the chart on the following page.

The *dotted* lines on the chart show the lineal feet of cracking per slab (vertical axis) produced

[4] A brief presentation of the factors involved in highway design appears in Appendix D.

[5] 1931, June 22, P. L. 751.

[6] 1943, May 26, P. L. 618.

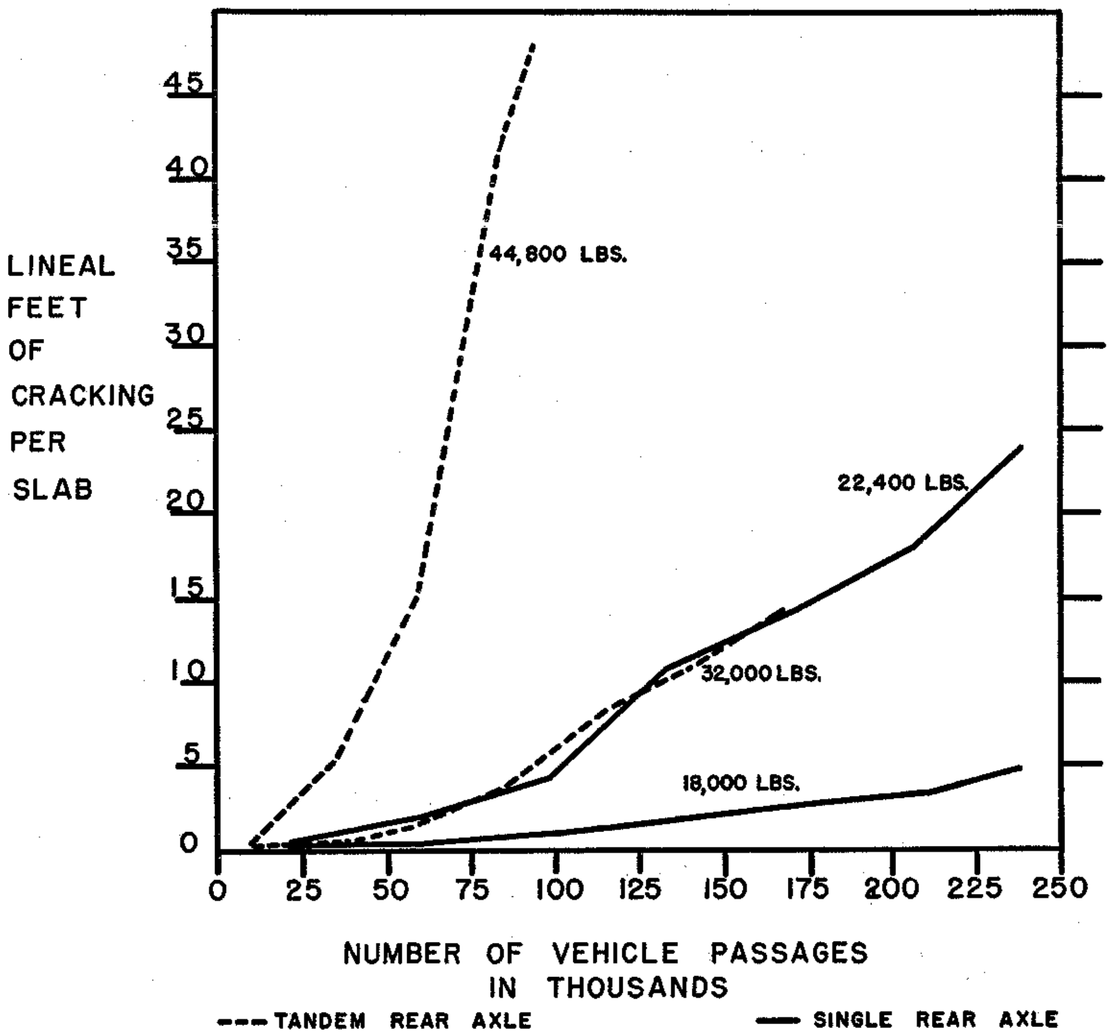
[7] For details, see Appendix E.

[8] For details, see Technical Supplement.

Chart I

MARYLAND ROAD TEST

DETERIORATION OF CONCRETE PAVEMENT IN LINEAL FEET OF CRACKING PER SLAB AND NUMBER AND REAR AXLE LOAD OF VEHICLE PASSAGES



by varying numbers of passages of vehicles (horizontal axis) equipped with *tandem* axles weighing 32,000 pounds and 44,800 pounds, respectively. The *solid* lines present comparable information for *single* axles weighing 18,000 pounds and 22,400 pounds, respectively.

At the conclusion of the road test, the following were among the comparisons noted:

Effects of single-axle loads—

(a) Based on all types of subgrade the results show: (1) the 22,400-lb. single-axle loads caused 6.4 times as much cracking (1,269 versus 196 lineal feet) as the 18,000-lb. single-axle loads after 238,000 truck applications . . . ; (2) 58 per cent of the slabs in the lane subjected to 22,400-lb. loads and only 26 percent of the slabs in the lane subjected to 18,000-lb. loads contained cracks which have been analyzed as constituting structural failures due to the application of the test axle-loads . . . ; and (3) the pavement at 50 percent of the joints in the lane subjected to 22,400-lb. loads and at only 18 percent of the joints in the lane subjected to 18,000-lb. loads was markedly depressed and cracked.

(b) Based on plastic-type subgrades (A-6 silty-clay soils) only, the results reveal that the 22,400-lb. single-axle loads caused 7 times as much cracking (28 versus 4 ft. per 12- by 40-ft. slab) as the 18,000-lb. single-axle load after 238,000 truck applications. . . . The unit quantity, lineal feet of cracking per slab, was used in comparing behavior of various sections directly without the need of considering the total number of slabs involved.[9]

Effects of tandem-axle loads—

(a) Based on all types of subgrade the results show: (1) the 44,800-lb. tandem-axle loads caused 12.3 times as much cracking (3,704 versus 302 lineal ft.) as the 32,000-lb. tandem-axle loads . . . ; (2) 96 percent of the slabs in the lane subjected to 44,800-lb. and only 27 percent of the slabs in the lane subjected to 32,000-lb. loads contained cracks which have been analyzed as constituting structural failures due to the application of the test axle-loads . . . ; (3) the pavement at 93 percent of the joints in the lane subjected to 44,800-lb. loads, and at only 18 percent of the joints in the lane subjected to 32,000-lb. loads was markedly depressed and cracked; and (4) longitudinal cracking, which is associated with lack of support along the free edge of the pavement brought about by excessive pumping, occurred in major extent only in the lane subjected to 44,800-lb. tandem-axle loads. . . .

(b) Based on plastic-type subgrades only (A-6 silty clay soils), the results reveal that the 44,800-lb. tandem-axle loads caused 12.5 times as much cracking (50 versus 4 ft. per 12- by 40-ft. slab) as the 32,000-lb. tandem-axle loads.[10]

Damage generated by different axle weights varies with type of highway. For a specific highway, the relation between (1) highway-damage differentials and axle-weight differentials and (2) highway-cost differentials and axle-weight differentials is such that cost differentials tend to increase less rapidly than highway-damage differentials.

2. *New Construction*

Construction costs and construction-cost differentials attributable to vehicles with different weight and dimension characteristics may be calculated by means of the incremental method.

a. *Essentials of the Incremental Method.*—Briefly, the incremental method of allocating, among vehicles exhibiting different characteristics, the costs of *actual,* rather than *hypothetical,* projects, calls for the following procedure:

(1) For each project of a construction program, the cost of the project is estimated on the assumption that *all* vehicles in the anticipated traffic stream have the characteristics of a "basic vehicle" (approximately those of a standard passenger car). Required highway thicknesses, widths of lanes, number of lanes, and gradients and alignments are determined, and cost of the project is calculated and allocated among all vehicles.

(2) A second series of project costs is esti-

[9] *Road Test One-MD,* Highway Research Board Special Report 4 (Washington, D. C.: National Academy of Sciences—National Research Council, 1952), p. 7.

[10] *Road Test One-MD,* Highway Research Board . . . , pp. 7, 8.

mated for the traffic stream, taking into account the group of vehicles which possess characteristics generating costs greater than those of basic vehicles, but it is assumed that all these vehicles have characteristics generating costs of the next order above those attributable to basic vehicles. Additional project costs are ascertained in this manner and are allocated to all vehicles which differ from basic vehicles.

Successive series of project costs are estimated for the traffic stream, each time taking into account the group of vehicles which possess characteristics generating greater costs and assuming that all these vehicles have characteristics generating costs of the next order above costs allocated in previous determinations. The cost attributable to a class of vehicles is the sum of that class's shares of costs from successive determinations into which the group entered.

b. *An Application of the Incremental Method.*—Differences between load factors generated by vehicle characteristics and costs generated by vehicle characteristics may be illustrated with reference to factors and costs arising in the construction of a new highway. An illustration of this type, based on highway designs developed for this report by the staff of the Joint State Government Commission and on costs determined by the Pennsylvania Department of Highways, is shown in Table 1. This illustration is not typical of a complete construction program or the highway system as a whole because:

(1) Costs of successive, flexible roads are used in this illustration; in actual practice, selection between different types of rigid highways and flexible highways is made.

(2) Costs shown are for the surface, base, and sub-base of the highway, and do not include costs of required grades and curvatures.

(3) Costs shown do not include prorated overhead costs, which differ for a project according to the traffic distribution for which the project is designed.

(4) The traffic distribution used contains axle weights from 2,000 to 40,000 pounds. This distribution would not be expected to occur—since the maximum single-axle load in Pennsylvania is 20,000 pounds—but does serve to show the general nature of costs associated with very heavy axles.

(5) The project considered is but one project of many in Pennsylvania's construction program; it is not representative of the entire program.

(6) The example is not illustrative of reconstruction costs.

(7) Vehicles incur costs for preserving carrying-capacities of existing highways and on account of the performance of administrative functions. These costs are not here considered.

(8) Construction costs used may not be representative of current costs.

Table 1 illustrates the results of the application of the incremental method to a highway which was designed to: (1) carry an average daily traffic of 14,120 axles and a total of approximately 129,000,000 axle passages; (2) permit passage of these axles at a constant rate (the design speed of the highway).

Differential costs arise because of the variations in axle weights (and associated vehicle characteristics).

Column 1 of the table shows axle-weight groups; column 2 shows the number of axles of specified weights in the estimated average daily traffic. Column 3 presents the axle-weight-group shares of total project cost, and column 4 shows the comparable shares of additional highway strength requirement factors. Column 5 shows the additional cost per axle within weight groups, and column 6, the highway strength requirement factor per axle.

The table should be read as follows: Of the 14,120 axles, 11,030 (col. 2) weigh 2,000 pounds

Table 1

SAMPLE DETERMINATION OF INCREMENTAL COSTS OF HIGHWAY SURFACE AND HIGHWAY STRENGTH REQUIREMENT FACTORS

Axle-Weight Group	*Number of Axles of Specified Weight in Estimated Average Daily Traffic*	*Axle-Weight-Group Share of Total Project Cost*	*Axle-Weight-Group Share of Additional Highway Strength Requirement Factor*	*Additional Cost per Axle Within Weight Groups*	*Highway Strength Requirement Factor per Axle*
(1)	(2)	(3)	(4)	(5)	(6)
2,000 pounds and under ..	11,030	$362,552.80	689.4	$32.87	0.063
2,001- 5,000	31	1,736.00	3.9	56.00	0.125
5,001-10,000	188	13,685.40	188.0	72.79	1.000
10,001-15,000	593	48,176.30	2,372.0	81.24	4.000
15,001-18,000	249	21,386.30	3,984.0	85.89	16.000
18,001-20,000	188	17,127.90	6,016.0	91.11	32.000
20,001-22,400	249	24,117.10	15,936.0	96.86	64.000
22,401-30,000	404	48,084.20	413,696.0	119.02	1,024.000
30,001-40,000	1,188	176,682.00	38,928,384.0	148.72	32,768.000
TOTAL	14,120	$713,548.00			

or less (col. 1), and $362,552.80 of the total cost of $713,548.00 (col. 3) is attributable to these axles, representing a cost per axle of $32.87 (col. 5). Similarly, 31 axles weigh from 2,001 to 5,000 pounds, and a cost of $1,736 is attributable to these axles, representing a cost per axle of $56.[11]

The axle-weight groups shown in Table 1 reflect significant—from a cost point of view—vehicle characteristics. If axle costs are to be translated into vehicle costs, the shares of project cost attributable to the total numbers of axles in the weight groups must be multiplied by the ratios of (1) the number of axles associated with vehicles for which costs are to be determined to (2) total numbers of axles in these weight groups.

Columns 4 and 6 of the table show the axle-weight-group shares of additional highway strength requirement factors and the highway strength requirement factors per axle. Comparison of columns 5 and 6 illustrates strikingly that incremental costs of highway surfaces rise much less rapidly than do highway strength requirements.

D. VEHICLE CHARACTERISTICS AND VEHICLE CLASSIFICATION

The analysis so far developed has indicated that the vehicle characteristics primarily responsible for the generation of public cost differentials are:

1. Numbers and weights of axles
2. Vehicle dimensions and performance
3. Miles traveled.

Registration and fee systems which are to recover public costs generated by vehicles exhibiting different characteristics must be related to these factors.

[11] For determination of these amounts, see Appendix F.

Section III

VEHICLE CLASSIFICATION, REGISTRATION, AND REGULATION IN PENNSYLVANIA AND SELECTED STATES

Vehicle classification, registration fees, and regulation may be evaluated with reference to the relationships between highway costs and vehicle characteristics and use outlined in Section II.

A. Vehicle Classification and Registration Fees

In Pennsylvania, passenger cars constitute one vehicle classification.

Buses are classified according to seating capacity and other commercial vehicles on the basis of *chassis weight,* and *registration fees increase as seating capacity or chassis weight increases.* Whatever the historical justification for *chassis weight and seating capacity as measures of magnitude of annual registration fees,* today they bear no *necessary* relationship to highway costs generated.

If registration fees are to: (1) take into account highway damage caused by vehicles and highway requirements of vehicles and (2) be utilized to recoup differential costs, the fees must be based upon vehicle characteristics which *directly* or *indirectly* reflect axle weight and number of axles, dimensions and performance, and miles traveled.

Though it is not possible at this time to specify, for the *state highway system as a whole,* the incremental costs generated by commercial vehicles with different characteristics, it is feasible to evaluate the *relative* magnitude of registration fees charged, from point of view of the *relative* costs generated.

Table 2 shows the relative positions, with respect to vehicle registration fees, chassis weights, and costs generated, of motor vehicles in Pennsylvania.

Examination of the table (columns 2 and 4) shows that the position of vehicles with respect to magnitude of fee payable does not correspond to the position of vehicles with respect to relative costs generated. For example, an R classification two-axle truck (col. 1) ranks 8th (col. 2) in magnitude of registration fee payable, but has a position of 4½ (col. 4) with respect to cost generated. (Since vehicle cost positions 3, 4, 5, and 6 are the same, they are all designated 4½.) Again, a YZ classification three-axle truck ranks 37th in magnitude of registration fee payable, but 34th in relative cost generated. Examination of columns 3 and 4 shows that the position of vehicles with respect to chassis weight does not correspond to their position with respect to relative costs generated.

Registration classifications may be made by reference to vehicle characteristics, either directly or indirectly. Examples of indirect use of vehicle characteristics are provided by the classification and registration systems of many states. Table 3 facilitates evaluation of the commercial vehicle classification and registration systems employed in selected states.

Table 2

RELATIVE POSITIONS, WITH RESPECT TO VEHICLE REGISTRATION FEES, CHASSIS WEIGHTS, AND COSTS GENERATED, OF MOTOR VEHICLES IN PENNSYLVANIA*

Registration Classification and Vehicle Type		*Position with Respect to:*		
		Registration Fee System	*Chassis Weight*	*Costs Generated*
(1)		(2)	(3)	(4)
A	One-axle trailer	1½	1½	1½
A	Two-axle trailer	1½	1½	4½
B	Two-axle trailer	3	3½	4½
B	One-axle trailer	4½	3½	1½
	Passenger car	4½	**	4½
C	One-axle trailer	6½	7½	8
C	Two-axle trailer	6½	7½	9
R	Two-axle truck	8	5	4½
D	One-axle trailer	9½	13	15½
D	Two-axle trailer	9½	13	17
S	Two-axle truck	11	7½	7
E	One-axle trailer	12½	18	15½
E	Two-axle trailer	12½	18	23
T	Two-axle truck	14	13	12
RZ	Three-axle truck	15½	7½	12
AZ	Three-axle trailer	15½	10	12
U	Two-axle truck	18½	18	18½
F	One-axle trailer	18½	23	20½
F	Two-axle trailer	18½	23	27½
BZ	Three-axle trailer	18½	13	12
SZ	Three-axle truck	21½	13	12
CZ	Three-axle trailer	21½	18	18½
TZ	Three-axle truck	23½	18	22
DZ	Three-axle trailer	23½	23	25½
V	Two-axle truck	25	23	25½
G	One-axle trailer	27	26½	20½
G	Two-axle trailer	27	26½	27½
EZ	Three-axle trailer	27	28	30
FZ	Three-axle trailer	29	31	32½
W	Two-axle truck	30	29½	32½
UZ	Three-axle truck	31	23	24
GZ	Three-axle trailer	32	34½	35
Y	Two-axle truck	33	32½	37
VZ	Three-axle truck	34	29½	30
Z	Two-axle truck	35	34½	38
WZ	Three-axle truck	36	32½	30
YZ	Three-axle truck	37	36	34
ZZ	Three-axle truck	38	37	36

* Excludes motorcycles, commercial motor vehicles equipped with solid rubber or cushion rubber tires, electrically propelled vehicles, and buses.

** Registration fee not determined by chassis weight.

Table 3

PRINCIPAL DETERMINANTS OF REGISTRATION AND CLASSIFICATION OF COMMERCIAL VEHICLES IN SELECTED STATES

State	Empty Weight	Gross Weight	
	Maximum Gross Weight Determined by Axle Factor	*Maximum Gross Weight Determined by Axle Factor*	*Maximum Gross Weight NOT Determined by Axle Factor*
(1)	(2)	(3)	(4)
California	X	..	..
Delaware	..	X	..
Illinois [a]	..	..	X
Indiana	..	..	X
Maryland [b]	X	..	..
New Jersey [a]	..	..	X
New York [c]	..	X	..
Ohio [a]	X	..	..
West Virginia [d]	..	X	..

[a] Reduced fees for farm vehicles.

[b] Separate fee schedules for private and public freight vehicles (among others).

[c] Reduced fees for farm vehicles; graduated highway use tax.

[d] Additional graduated fees for carriers of property.

Three of the nine states shown in the table (Illinois, Indiana, and New Jersey) do not relate commercial vehicle classification and registration to vehicle characteristics which generate highway costs; six of the states (California, Delaware, Maryland, New York, Ohio, and West Virginia) relate vehicle classification and registration indirectly to cost-generating vehicle characteristics. Some states use more indirect methods than do others. For example, in Ohio, vehicle characteristics fix maximum gross weight, which is correlated with empty vehicle weight, which in turn is the basis of the registration fee. In Delaware, vehicle characteristics fix maximum gross weight, the basis of the registration fee. In the state of New York, registration fee is based on user-declared gross weight, which may not exceed a statutorily defined maximum fixed by reference to axle combinations.

Although many states use roundabout methods when relating vehicle classification and registration to cost-generating vehicle characteristics, the relationships *can* be established in a *direct* manner.

The levels of costs of providing and maintaining highways change over time. Consequently, vehicle fees, regardless of base, do not reflect highway costs unless properly adjusted from time to time. In Pennsylvania, the latest major change in registration fees for commercial vehicles was made in 1943, effective for the registration year beginning April 1, 1944.[1] However, between 1944 and mid-1952, the index of highway construction costs increased approximately 49 percent.[2]

[1] 1943, P. L. 618.

[2] Highway Price Index—Composite Standard Mile (U. S. Bureau of Public Roads): 1944, 115.5; 1952 (2nd quarter), 171.8.

B. Vehicle Regulation

Traditionally, changes in highway design represent gradual adaptations to changes in vehicle design. Vehicle regulations reflect the difference between use-potential of vehicles and capacities of highway systems as traditionally conceived.

Below are shown the single-axle weight limits recommended by the American Association of State Highway Officials and the limits established by the statutes of ten selected states.

Recommended by American Assn. of State Highway Officials	18,000
California	18,000
Delaware	20,000
Illinois	18,000
Indiana	18,000
Maryland	22,400
New Jersey	22,400
New York	22,400
Ohio	19,000
Pennsylvania	20,000
West Virginia	18,000

Examination of the table shows that the single-axle weight limit recommended by the American Association of State Highway Officials is 18,000 pounds, and that the statutory limits in selected states range from 18,000 pounds to 22,400 pounds.

Regarding the limits of 18,000 pounds and 22,400 pounds, the following may be noted:

1. The limit of 18,000 pounds was established some thirty years ago, and for many years roads were built by reference to this standard. Consequently, at the present time, large parts of many highway systems, including Pennsylvania's, consist of roads which were designed for a single-axle limit of 18,000 pounds.

2. "The 22,400-pound limit has its origin in nothing more substantial than the fact that many years ago 14 inches was the maximum width of solid-rubber tires produced. At that time a load of 800 pounds per inch of width was recommended by the tire manufacturers as the maximum economic tire loading. This 800-pound-per-inch limit, finding its way into many State laws as a limit of unit loading, the resulting total of 11,200 pounds for the 14-inch width of the largest tire produced became the actual limit of wheel loading in many States before wheel or axle-load limits were specifically prescribed." [3]

There is no question that from an engineering point of view it is feasible to build highways capable of carrying heavy weights—at a price. Similarly, there is no question that many highways can carry single-axle loads in excess of those for which they were designed—at a price. The price of constructing roads for heavier axle loads is higher than for lighter loads. Further, the price of operating heavy loads over highways designed for light loads is considerably in excess of the price of operating heavy loads on roads designed for them. Of Pennsylvania's highways, 90 percent were constructed when the single-axle load limit was 18,000 pounds or less, and but 10 percent have been constructed or reconstructed since the single-axle load limit was increased to 20,000 pounds.

Weight restrictions for single axles and tandem axles, together with restrictions on other vehicle characteristics, as provided by Pennsylvania statutes and as recommended by the American Association of State Highway Officials, are shown in Table 4.

Examination of Table 4, column 2, shows that Pennsylvania limits are 20,000 pounds on a single axle and, in effect, 36,000 pounds on a tandem axle, while the axle weights recommended by the American Association of State Highway Officials are 18,000 pounds for a single axle and 32,000 pounds for a tandem axle. In both cases, maximum width is 96 inches, and maximum height is 12 feet, 6 inches (except that in Pennsylvania automobile transporters are permitted 13 feet, 6 inches). Maximum lengths of single-unit trucks are the same in both Pennsylvania statutes

[3] *A Factual Discussion of Motortruck Operation* . . ., p. 33.

Table 4

COMMERCIAL VEHICLE SIZE AND AXLE-WEIGHT LIMITS IN PENNSYLVANIA STATUTE AND LIMITS RECOMMENDED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS *

	Limits in Pennsylvania Statute **	*Limits Recommended by A.A.S.H.O.*
(1)	(2)	(3)
Maximum width	96 inches	96 inches
Maximum height	12½ feet, except automobile transporters permitted 13½ feet	12½ feet
Maximum length:		
Single truck	35 feet	35 feet
Truck-tractor—semitrailer	45 feet	50 feet
Other combinations	50 feet	60 feet
Bus	40 feet	40 feet
Maximum load per inch of tire width	800 pounds	no restriction
Minimum axle spacing, tandem axles	36 inches	no restriction
Maximum gross weight on any one axle	20,000 pounds [a]	18,000 pounds
Maximum gross weight, tandem axles	36,000 pounds [b]	32,000 pounds [c]

* Limitations on gross vehicle weight not included.
** 1929, May 1, P. L. 905, as amended.
[a] Limit of 8,000 pounds for first axle of truck, truck-tractor, or trailer having three axles.
[b] No more than 18,000 pounds on each of the axles.
[c] Determined from maximum loads recommended for axle groups.

and the recommendations of the American Association of State Highway Officials, while maximum lengths of combinations are less in Pennsylvania than those recommended by the American Association of State Highway Officials. Certain maxima contained in Pennsylvania law are not subjects of A.A.S.H.O. recommendations.

Gross weights are not contained in Table 4, since methods used for establishment of these weights in Pennsylvania are different from those used by the American Association of State Highway Officials. In Pennsylvania, the maximum gross weight of all truck-tractor, semitrailer combination vehicles is 45,000 pounds, regardless of number or spacing of axles. For single-unit truck and full trailer combinations, the gross weights in Pennsylvania are 56,000 pounds for combinations having a total of four axles and 62,000 pounds for combinations having a total of five or six axles. The recommendations concerning gross weight of the American Association of State Highway Officials are such that permitted gross weights vary according to axle spacing (but within maximum axle loadings), in order that the effect of the distribution of total weight over axle spacing—of critical importance in bridge design and performance—be taken into account.[4]

[4] For a table showing vehicle gross-weight limits in Pennsylvania and limits recommended by the American Association of State Highway Officials, see Appendix G.

Since statutory gross weight limits in Pennsylvania are not related to axle spacings, no necessary relationships exist between these gross weights and bridge costs. Gross weight, no matter how determined, does not enter into highway (as distinguished from bridge) requirements and costs.

Recommended and statutory gross- and axle-weight limits (for a combination vehicle consisting of a two-axle truck-tractor and a tandem-axle semitrailer) are shown in Table 5.

Examination of the table shows that the higher gross weights shown are not always associated with higher axle weights. Since highway costs are related to axle weights, the higher gross weights do not *necessarily* generate higher public costs.

Gross-weight limits contained in Pennsylvania statutes and those recommended by the American Association of State Highway Officials, are illustrated for specific types of vehicles having generally representative axle spacings in Chart II.

Table 5

STATUTORY GROSS- AND AXLE-WEIGHT LIMITS IN SELECTED STATES AND LIMITS RECOMMENDED BY AMERICAN ASSOCIATON OF STATE HIGHWAY OFFICIALS

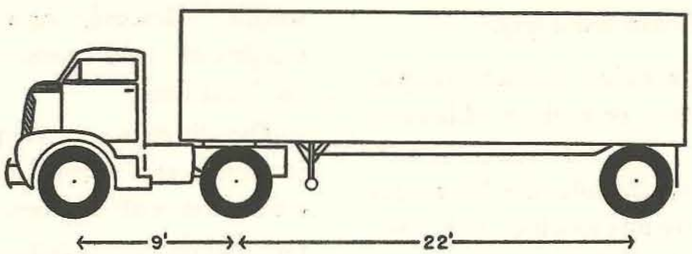
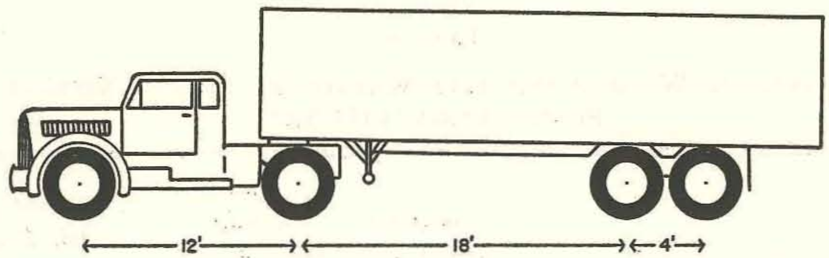
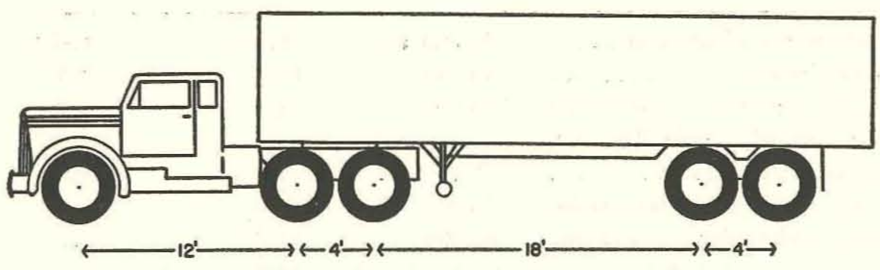
State	*Gross-Weight Limit * (Pounds)*	*Difference: Limit of State and Recommendation of AASHO (Pounds)*	*Single-Axle Weight Limit (Pounds)*	*Tandem-Axle Weight Limit (Pounds)*
(1)	(2)	(3)	(4)	(5)
Recommended by American Association of State Highway Officials	55,980	....	18,000	32,000
California	62,900	+ 6,920	18,000	32,000
Delaware	55,980	....	20,000	36,000
Illinois	59,000	+ 3,020	18,000	32,000
Indiana	68,000	+12,020	18,000	32,000
Maryland	62,900	+ 6,920	22,400	36,000
New Jersey	60,000	+ 4,020	22,400	32,000
New York	55,500	— 480	22,400	36,000
Ohio	65,200	+ 9,220	19,000	31,500
Pennsylvania	45,000	—10,980	20,000	36,000
West Virginia	55,980	....	18,000	32,000

* For combination of two-axle truck-tractor and tandem-axle semitrailer; axle spacings of 12 feet, 18 feet, 4 feet.

Chart II

SAMPLE COMPARISONS OF GROSS WEIGHT LIMITS: PENNSYLVANIA STATUTE AND RECOMMENDATIONS OF THE AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS

TRUCK-TRACTOR SEMITRAILER COMBINATIONS

PENNSYLVANIA STATUTORY GROSS WEIGHT LIMIT (POUNDS)		A.A.S.H.O. RECOMMENDED GROSS WEIGHT LIMIT (POUNDS)
45,000		53,490
45,000		55,980
45,000		59,220

C. Illegal Weights

Penalties for violations of gross-weight and axle-weight limits in Pennsylvania are as follows:

(1) Weight exceeding by more than 5 percent but not by more than 10 percent the maximum allowed—fine of $25 (in default of payment thereof, imprisonment for not more than five days).

(2) Weight exceeding by more than 10 percent the maximum allowed—fine of $50 (in default of payment thereof, imprisonment for not more than ten days).[5]

Violations of statutory weight limitations generate costs of enforcement as well as additional highway costs.

For any specific penalty schedule, the differences between (1) vehicle carrying-capacities and maximum permitted weights and (2) weight restrictions in Pennsylvania and other states are reflected in the relative frequency with which legal-weight violations occur.

[5] 1951, P. L. 1368.

Table 6 shows the frequencies of gross-weight and axle-weight violations in Pennsylvania for commercial vehicles with different characteristics.

The table shows that the four-or-more-axle semitrailer combination is more frequently operated in violation of Pennsylvania's gross-weight limit than is any other type of vehicle listed: 51 percent of these vehicles were of illegal gross weight. However, only 3 percent of the axle weights of these combinations were in excess of the legal limit.

The difference in frequencies of gross-weight violations and axle-weight violations observed in connection with this type of vehicle is due to the fact that the actual carrying-capacity of the vehicle is considerably in excess of its legal gross capacity, but not of its legal axle capacities.

Table 6

Excess Gross Weights and Axle Weights by Type of Vehicle: Pennsylvania, 1951-52 *

Type of Vehicle	*Maximum Gross-Weight Limits*	*Trucks Exceeding Gross-Weight Limits (Percent)*	*Percent of Axle Loads Exceeding 20,000 Pounds*
(1)	(2)	(3)	(4)
Two-axle trucks (dual tires)	30,000 lbs.	1.0%	1.6%
Three-axle trucks	40,000	10.4	0.5
Three-axle semitrailer combination	45,000	8.3	4.7
Four-or-more-axle semitrailer combination	45,000	51.0	3.0
Four-axle truck-trailer combination	56,000	34.4	...
Five-axle truck-trailer combination.	62,000	33.3	...

* Survey conducted by Pennsylvania Department of Highways, 1951 and 1952.

APPENDICES

Appendix A

HIGHWAY TAXATION AND VEHICLE CLASSIFICATION IN PENNSYLVANIA

Since the passage of the first motor vehicle registration act in Pennsylvania in 1903, the field of highway user charges and taxes has broadened to include motor vehicle registration fees, fuels taxes, and gross receipts taxes on certain classes of motor carriers. Diversification in types of motor vehicles has been accompanied by changes in registration categories and registration fee schedules. In addition, changes in types of motor fuel have been followed by statutes providing for the taxation of all fuels commonly used for the propulsion of motor vehicles.

Motor Vehicle Registration and Classification

In 1903, the first motor vehicle registration statute provided for a registration fee of two dollars and a license fee of three dollars payable to the prothonotary.[1]

In 1909, administration of the registration and licensing of motor vehicles was made the responsibility of the Commonwealth, and the following graduated schedule of fees related to the rated horsepower of vehicles was established:[2]

Less than 20 horsepower	—$ 5.00
20-50 horsepower	— 10.00
Over 50 horsepower	— 15.00
Motorcycle	— 2.00

As vehicles, vehicle equipment and vehicle use became increasingly more diversified, registration statutes began to deal with such matters as types of tires utilized, the distinction between passenger automobiles, commercial vehicles and motor buses, gross weight, chassis weight, and motive power used.

In 1913, registration classifications for motor vehicles equipped with pneumatic tires were based upon rated horsepower, while registration classifications for motor vehicles equipped with solid tires and fees of trailers and traction engines were based upon the gross weights of the vehicle.[3] The following is the motor vehicle schedule of 1913:

Motor Vehicles

Pneumatic Tires

Less than 20 hp	—$ 5.00
20-35 hp	— 10.00
35-50 hp	— 15.00
Over 50 hp	— 20.00

Solid Tires

Gross Weight

Less than 4000 lbs.	—$ 5.00
4000-5000	— 10.00
5000-10,000	— 15.00
10,000-15,000	— 20.00
15,000-24,000	— 25.00

[1] 1903, P. L. 268.
[2] 1909, P. L. 265.
[3] 1913, P. L. 672.

In 1919 (P. L. 678), a further revision of the registration classification system provided for a distinction between motor vehicles and commercial motor vehicles and required registration of the former on the basis of horsepower and of the latter on the basis of chassis weight.

Motorcycle	—$3.00
Bicycle with motor attached	— 2.00
Motor vehicles (no metal tires)	— .40 per hp; minimum, $10.

In addition, the 1919 statute provided: "The fees for the registration of commercial motor vehicles, the chassis of which weigh less than 2,000 pounds, shall be on the basis of horsepower."

Commercial Vehicles (chassis weight 2,000 pounds and over)

Class.	Chassis Weight.	Fee.
AA	2,000- 3,000 lbs.	$20.00
A	3,000- 4,500	25.00
B	4,500- 6,000	30.00
C	6,000- 7,000	50.00
D	7,000- 8,000	75.00
E	8,000-10,000	100.00
F	10,000 lbs. and over	150.00

Trailers

Chassis Weight.	Fee.
Under 500 lbs.	0
500- 750 lbs.	$2.00
750-1,000	5.00
1,000-2,000	10.00
2,000 lbs. or over	15.00

In addition, the law provided:

"The fee for the registration of any motor vehicle equipped with metal tires shall be double the regular fee for such vehicle."

In 1921, registration classifications were broadened to include categories for electrically operated vehicles, and in 1923 classifications for omnibuses were added.

Classifications and fees were again changed in 1923 (P. L. 718) for commercial motor vehicles and semitrailers, and a fee schedule was inserted for omnibuses. The changed and new fees were as follows:

Commercial Motor Vehicles

Class	Chassis Weight	Pneumatic Tires	Solid Rubber
A	Less than 2,000 lbs.	$15.00	$18.75
B	2,000-3,000 lbs.	24.00	30.00
C	3,000-4,000	32.00	40.00
D	4,000-5,000	40.00	50.00

Commercial Motor Vehicles—*Continued*

Class	Chassis Weight	Pneumatic Tires	Solid Rubber
E	5,000-6,000 lbs.	$56.00	$70.00
F	6,000-7,500	80.00	100.00
G	7,500-9,000	100.00	125.00
H	Over 9,000 lbs.	140.00	200.00

Electric Motor Vehicles

Class	Gross Weight	Fee
A	Under 5,000 lbs.	$15.00
B	" 7,000	24.00
C	" 11,000	32.00
D	" 15,000	40.00
E	" 18,000	56.00
F	" 22,000	80.00
G	" 25,000	100.00
H	" 26,000	140.00

Tractors and semi-trailers to be registered separately.

Trailer or Semi-Trailer

Chassis Weight	Fee
Less than 500 lbs.	$2.00
500-1,000 lbs.	5.00
1,000-2,000	10.00
2,000-3,000	15.00
3,000-4,000	20.00
4,000-5,000	30.00
5,000 lbs. and over	50.00

Omnibuses

	Pneumatic Tires	Solid Rubber Tires
5 passengers or less	$20	$25.00
5-26 passengers	$2/seat over 5	2.50
More than 26 passengers	$5/seat over 26	6.25
		$250—53 or more passengers used exclusively in 1st, 2nd, & 3rd class cities.

In 1927 (P. L. 886) the classifications "A-H" were designated "R-Z."

In 1929, the vehicle code provided fee schedules for motorcycles and motor bicycles, motor vehicles (passenger cars), commercial motor vehicles and truck tractors with pneumatic tires, commercial motor vehicles and truck tractors with solid rubber or cushion rubber tires, electrically operated commercial motor vehicles and truck tractors, trailers and semitrailers, motor buses and motor omnibuses with solid tires, and metal-tired vehicles. Commercial motor vehicle registration was based upon chassis weight, and motor bus and motor omnibus registration was based upon seating capacity.

The Vehicle Code of 1929 (P. L. 905) contained the following fee schedule:

"Section 701. Motorcycles and Motor-Bicycles.—

"The fee for the annual registration of a motorcycle shall be three ($3) dollars, and for the annual registration of a bicycle with a motor attached two ($2) dollars.

"Section 702. Motor Vehicles.—The fee for annual registration of motor vehicles, except as provided in this act, shall be at the rate of forty (40) cents for each horsepower, or fractional part thereof: Provided, That the minimum fee payable for such annual registration shall be ten ($10) dollars.

"Section 703. Commercial Motor Vehicles and Truck Tractors with Pneumatic Tires.—Commercial motor vehicles and truck tractors with pneumatic tires, other than those electrically operated, shall be divided into nine (9) classes, and the fee for annual registration of such vehicles in each of the respective classes, based on the gross chassis weight, as given and certified to by the manufacturer, shall be as follows:

Class.	Chassis Weight in Pounds.	Fee.
R	Less than 2000	$16.50
S	2000 and over but less than 3000	26.00
T	3000 and over but less than 4000	35.00
U	4000 and over but less than 5000	45.00
V	5000 and over but less than 6000	63.00
W	6000 and over but less than 7500	90.00
Y	7500 and over but less than 9000	110.00
Z	9000 and over but less than 12,000	155.00
ZZ	12,000 and over	225.00

"Section 704. Commercial Motor Vehicles and Truck Tractors with Solid Rubber or Cushion Rubber Tires.—Commercial motor vehicles and truck tractors with solid rubber or cushion rubber tires, approved by the Secretary of Highways of this Commonwealth, other than those electrically operated, shall be divided into nine (9) classes, and the fee for the annual registration of such vehicles in each of the respective classes, based on the gross chassis weight as given and certified to by the manufacturer shall be as follows:

Class.	Chassis Weight in Pounds. (Solid Rubber Tires)	Fee.
R	Less than 2000	$28.00
S	2000 and over but less than 3000	45.00
T	3000 and over but less than 4000	60.00
U	4000 and over but less than 5000	75.00
V	5000 and over but less than 6000	105.00
W	6000 and over but less than 7500	150.00
Y	7500 and over but less than 9000	190.00
Z	9000 and over but less than 12,000	300.00
ZZ	12,000 and over	350.00

Class.	Chassis Weight in Pounds. (Cushion Rubber Tires)	Fee.
R	Less than 2000	$25.00
S	2000 and over but less than 3000	35.00
T	3000 and over but less than 4000	50.00
U	4000 and over but less than 5000	60.00
V	5000 and over but less than 6000	85.00
W	6000 and over but less than 7500	125.00
Y	7500 and over but less than 9000	150.00
Z	9000 and over but less than 12,000	200.00
ZZ	12,000 and over	275.00

"Section 705. Electrically Operated Commercial Motor Vehicles and Truck Tractors.—Electrically operated commercial motor vehicles and truck tractors shall be divided into eight (8) classes, and the fee for annual registration of such vehicles in each of the respective classes, based on the gross maximum weight of chassis, battery, body, and load, as given and certified to by the manufacturer, shall be as follows:

Class.	Weight of Chassis, Battery, Body and Load in Pounds.	Fee.
R	Less than 5001	$16.50
S	5001 and over but less than 7001	26.00
T	7001 and over but less than 11001	35.00
U	11001 and over but less than 15001	45.00
V	15001 and over but less than 18001	63.00
W	18001 and over but less than 22001	90.00
Y	22001 and over but less than 25001	110.00
Z	25001 and over but less than 26000	155.00

"Section 706. Trailers and Semi-Trailers.—Trailers and semi-trailers, whether equipped with pneumatic, cushion rubber, or solid rubber tires, shall be divided into seven (7) classes, and the fee for annual registration of such vehicles in each of the respective classes, based on the gross weight of chassis as given and certified to by the manufacturer, shall be as follows:

Class.	Chassis Weight in Pounds.	Fee.
A	Less than 1000	$5.00
B	1000 and over but less than 2000	8.00
C	2000 and over but less than 3000	15.00
D	3000 and over but less than 4000	25.00
E	4000 and over but less than 5000	30.00
F	5000 and over but less than 6000	45.00
G	6000 and over	75.00

"Section 707. Motor Buses and Motor Omnibuses with Pneumatic Tires.—

"The fee for annual registration of each motor bus, and motor omnibus with pneumatic tires, shall be according to seating capacity and the following classes:

Class.	Seating Capacity.	Fee.
A	Five (5) passenger or less	$25.00
B	More than five (5) passengers and less than eight (8) passengers	$30.00
C	More than seven (7) passengers and not more than twenty-six (26) passengers	$40.00 plus $4.00 for each seat over seven seats
D	In excess of twenty-six (26) passengers	$40.00 plus $4.00 for each seat over seven seats to and including twenty-six seats plus $10.00 for each seat over twenty-six

"Section 708. Motor Buses and Motor Omnibuses with Solid Rubber Tires.—

"The fee for annual registration of each motor bus, and motor omnibus with solid rubber or cushion rubber tires, shall be according to seating capacity and the following classes:

Class.	Seating Capacity.	Fee.
A	Five (5) passengers or less	$37.50
B	More than five (5) passengers and less than eight (8) passengers	$45.00
C	More than seven (7) passengers and not more than twenty-six (26) passengers	$50.00 plus $5.00 for each seat over seven seats

Class.	Seating Capacity.	Fee.
D	In excess of twenty-six (26) passengers (except as otherwise provided in Class E)	$50.00 plus $5.00 for each seat over seven seats to and including 26 seats plus $12.50 for each seat over twenty-six
E	In excess of fifty-three (53) passengers when operated exclusively in cities	$400.00

"Section 709. Metal Tires.—The fee for annual registration of any motor vehicle, trailer or semi-trailer equipped with metal tires, shall be double the regular fee of a similar vehicle equipped with solid rubber tires."

The registration classifications contained in the vehicle code of 1929 have been continued with minor modifications to the present time.

Separate rates for four- and six-wheeled commercial vehicles and truck tractors were provided in 1931 (P. L. 751). The fees were as follows:

Commercial Motor Vehicles and Truck Tractors—Four-Wheeled

Class	*Chassis Weight (in pounds)*	*Pneumatic Tires*	*Solid Rubber Tires*	*Cushion Rubber Tires*
R	Less than 2000	$16.50	$28.00	$25.00
S	2000-3000	26.00	45.00	35.00
T	3000-4000	35.00	60.00	50.00
U	4000-5000	45.00	75.00	60.00
V	5000-6000	63.00	105.00	85.00
W	6000-7500	90.00	150.00	125.00
Y	7500-9000	110.00	190.00	150.00
Z	9000 and over	155.00	300.00	200.00

Commercial Motor Vehicles and Truck Tractors—Six-Wheeled
(3 Axles)

Class	*Chassis Weight (in pounds)*	*Pneumatic Tires*	*Solid Rubber Tires*	*Cushion Rubber Tires*
RZ	2000- 3000	$40.00	$65.00	$55.00
SZ	3000- 4000	50.00	75.00	65.00
TZ	4000- 5000	60.00	90.00	70.00
UZ	5000- 6000	90.00	150.00	125.00
VZ	6000- 7500	155.00	275.00	200.00
WZ	7500- 9000	175.00	300.00	225.00
YZ	9000-12000	200.00	325.00	250.00
ZZ	12000 and over	225.00	350.00	275.00

Electrically Operated Commercial Motor Vehicles and Truck Tractors—
Four-Wheeled

Class	*Weight of Chassis, Battery, Body and Load in Pounds*	*Fee*
R	Less than 5001	$16.50
S	5001- 7001	26.00
T	7001-11001	35.00
U	11001-15001	45.00
V	15001-18001	63.00
W	18001-22001	90.00
Y	22001-25001	110.00
Z	25001-26000	155.00

Six-Wheeled (3 Axles)

RZ	Less than 12001	$40.00
SZ	12001-14001	50.00
TZ	14001-16001	60.00
UZ	16001-22001	90.00
VZ	22001-26001	155.00
WZ	26001-30001	175.00
YZ	30001-34001	200.00
ZZ	34001-36000	225.00

Trailers and Semi-Trailers—The fee for annual registration of trailers and semi-trailers is based on the combined weight of chassis and body, if so constructed, or the gross weight of the trailer or semi-trailer exclusive of the load to be transported.

Two-Wheeled *Semi-Trailer*

			Tire Equipment	
Class.	Weight in Pounds.	Pneumatic.	Cushion.	Solid.
A	Less than 1000	$5.00	$6.00	$8.00
B	1000-2000	8.00	10.00	15.00
C	2000-3000	15.00	20.00	25.00
D	3000-4000	25.00	30.00	35.00
E	4000-5000	30.00	40.00	50.00
F	5000-6000	45.00	60.00	75.00
G	6000 and over	75.00	85.00	100.00

Four-Wheeled (2 Axles) *Trailer or Semi-Trailer*

			Tire Equipment	
Class.	Weight in Pounds.	Pneumatic.	Cushion.	Solid.
A	Less than 1000	$5.00	$6.00	$8.00
B	1000-2000	8.00	10.00	15.00
C	2000-3000	15.00	20.00	25.00
D	3000-4000	25.00	30.00	35.00
E	4000-5000	30.00	40.00	50.00
F	5000-6000	45.00	60.00	75.00
G	6000 and over	75.00	85.00	100.00

Six-Wheeled (3 Axles) *Trailer*

			Tire Equipment	
Class.	Weight in Pounds.	Pneumatic.	Cushion.	Solid.
AZ	Less than 3000	$40.00	$45.00	$50.00
BZ	3000-4000	45.00	50.00	60.00
CZ	4000-5000	50.00	60.00	70.00
DZ	5000-6000	60.00	75.00	90.00
EZ	6000-7000	75.00	100.00	125.00
FZ	7000-9000	85.00	110.00	135.00
GZ	9000 and over	100.00	125.00	150.00

Motor Buses and Motor Omnibuses with Pneumatic Tires

Class.	Seating Capacity.	Fee.
A	5 passengers or less	$25.00
B	More than 5 passengers and less than 8	30.00
C	More than 7 passengers and not more than 26 passengers	40.00 plus $4 for each seat over 7 seats.
D	In excess of 26 passengers	40.00 plus $4 for each seat over 7 seats to and including 26 seats, plus $10 for each seat over 26.
E	In excess of 53 passengers, when operated exclusively in cities	300.00

In 1937 (P. L. 2329) the classification "Commercial Motorcycle" was added, and the registration fee fixed at $5.

An act in 1943 (P. L. 3) made the annual registration for motor vehicles (noncommercial) $10, eliminating the reference to horsepower. Act No. 270 of the same Session (P. L. 618) changed certain fees to be as follows:

Commercial Motor Vehicles and Truck Tractors—Four-Wheeled

Class.	Chassis Weight (in pounds).	Pneumatic Tires.	Solid Rubber Tires.	Cushion Rubber Tires.
R	Less than 2000	$16.50	$28.00	$25.00
S	2000-3000	26.00	45.00	35.00
T	3000-4000	35.00	60.00	50.00
U	4000-5000	45.00	75.00	60.00
V	5000-6000	70.00	120.00	92.00
W	6000-7500	96.00	160.00	124.00
Y	7500-9000	120.00	204.00	156.00
Z	9000 and over	175.00	315.00	228.00

Six-Wheeled (3 Axles)

RZ	2000- 3000	40.00	65.00	55.00
SZ	3000- 4000	50.00	75.00	65.00
TZ	4000- 5000	60.00	90.00	70.00
UZ	5000- 6000	98.00	158.00	133.00
VZ	6000- 7500	168.00	288.00	213.00
WZ	7500- 9000	186.00	311.00	236.00
YZ	9000-12000	215.00	340.00	265.00
ZZ	12000 and over	250.00	375.00	300.00

In 1949 (P. L. 1412), the classification "Commercial Motorcycle" was removed, and the fee for all motorcycles, including bicycles with motor attached, was raised to $4. A fee ($12) was inserted for "trailers designed for living quarters" by the same act.

Act No. 399 of the 1951 Session (P. L. 1557) raised the fee for two-wheeled semi-trailers with pneumatic tires, Class B (1000 to 2000 pounds), from $8 to $10.

At the present time, vehicles are classified as motorcycles, passenger motor vehicles, commercial motor vehicles, trailers and semitrailers, and motor buses and motor omnibuses. Registration classifications and fees of commercial motor vehicles are dependent upon the tire equipment and the method of propulsion (electric or internal combustion), while classification of motor buses and motor omnibuses is dependent upon tire equipment and seating capacity. The present registration fee schedules provided in The Vehicle Code[4] are as follows:

Motorcycles—"The fee for the annual registration of a motorcycle as defined in this act shall be four ($4) dollars."

Motor Vehicles—"The fee for annual registration of motor vehicles, except as provided in this act, shall be ten ($10) dollars."

[4] 1929, P. L. 905, as amended.

Commercial Motor Vehicles and Truck Tractors—

Four-Wheeled

Class	Chassis Weight (in pounds)	Pneumatic Tires	Solid Rubber Tires	Cushion Rubber Tires
R	Less than 2000	$16.50	$28.00	$25.00
S	2000-3000	26.00	45.00	35.00
T	3000-4000	35.00	60.00	50.00
U	4000-5000	45.00	75.00	60.00
V	5000-6000	70.00	120.00	92.00
W	6000-7500	96.00	160.00	124.00
Y	7500-9000	120.00	204.00	156.00
Z	9000 and over	175.00	315.00	228.00

Six-Wheeled (3 Axles)

Class	Chassis Weight (in pounds)	Pneumatic Tires	Solid Rubber Tires	Cushion Rubber Tires
RZ	2000- 3000	40.00	65.00	55.00
SZ	3000- 4000	50.00	75.00	65.00
TZ	4000- 5000	60.00	90.00	70.00
UZ	5000- 6000	98.00	158.00	133.00
VZ	6000- 7500	168.00	288.00	213.00
WZ	7500- 9000	186.00	311.00	236.00
YZ	9000-12000	215.00	340.00	265.00
ZZ	12000 and over	250.00	375.00	300.00

Electrically Operated Commercial Motor Vehicles and Truck Tractors—

Four-Wheeled

Class	Weight of Chassis, Battery, Body and Load in Pounds	Fee
R	Less than 5001	$16.50
S	5001- 7001	26.00
T	7001-11001	35.00
U	11001-15001	45.00
V	15001-18001	63.00
W	18001-22001	90.00
Y	22001-25001	110.00
Z	25001-26000	155.00

Six-Wheeled (3 Axles)

Class	Weight of Chassis, Battery, Body and Load in Pounds	Fee
RZ	Less than 12001	$40.00
SZ	12001-14001	50.00
TZ	14001-16001	60.00
UZ	16001-22001	90.00
VZ	22001-26001	155.00
WZ	26001-30001	175.00
YZ	30001-34001	200.00
ZZ	34001-36000	225.00

Class	Chassis Weight in Pounds	Tire Equipment Pneumatic	Cushion	Solid
Two-Wheeled Semitrailer—				
A	Less than 1,000	$5.00	$6.00	$8.00
B	1,000-2,000	10.00	10.00	15.00
C	2,000-3,000	15.00	20.00	25.00
D	3,000-4,000	25.00	30.00	35.00
E	4,000-5,000	30.00	40.00	50.00
F	5,000-6,000	45.00	60.00	75.00
G	6,000 and over	75.00	85.00	100.00
Four-Wheeled (2 axles) Trailer or Semitrailer—				
A	Less than 1,000	5.00	6.00	8.00
B	1,000-2,000	8.00	10.00	15.00
C	2,000-3,000	15.00	20.00	25.00
D	3,000-4,000	25.00	30.00	35.00
E	4,000-5,000	30.00	40.00	50.00
F	5,000-6,000	45.00	60.00	75.00
G	6,000 and over	75.00	85.00	100.00
Six-Wheeled (3 axles) Trailer—				
AZ	Less than 3,000	40.00	45.00	50.00
BZ	3,000-4,000	45.00	50.00	60.00
CZ	4,000-5,000	50.00	60.00	70.00
DZ	5,000-6,000	60.00	75.00	90.00
EZ	6,000-7,000	75.00	100.00	125.00
FZ	7,000-9,000	85.00	110.00	135.00
GZ	9,000 and over	100.00	125.00	150.00

Trailers Designed for Living Quarters—"The fee for annual registration of trailers designed and used exclusively for living quarters shall be twelve ($12) dollars."

Motor Buses and Motor Omnibuses with Pneumatic Tires—

Class	*Seating Capacity*	*Fee*
A	5 passengers or less	$25.00
B	More than 5 passengers and less than 8	30.00
C	More than 7 passengers and not more than 26 passengers	40.00 plus $4.00 for each seat over 7 seats.
D	In excess of 26 passengers	40.00 plus $4.00 for each seat over 7 seats to and including 26 seats, plus $10.00 for each seat over 26.
E	In excess of 53 passengers, when operated exclusively in cities	300.00

Motor Buses and Motor Omnibuses with Solid Rubber Tires—

Class	*Seating Capacity*	*Fee*
A	5 passengers or less	$37.50
B	More than 5 passengers and less than 8	45.00
C	More than 7 passengers and not more than 26 passengers	50.00 plus $5.00 for each seat over 7 seats.
D	In excess of 26 passengers (except as otherwise provided in Class E)	50.00 plus $5.00 for each seat over 7 seats to and including 26 seats plus $12.50 for each seat over 26.
E	In excess of 53 passengers when operated exclusively in cities	400.00

Metal Tires—"The fee for annual registration of any motor vehicle, trailer or semi-trailer equipped with metal tires, shall be double the regular fee of a similar vehicle equipped with solid rubber tires."

Fuels Taxes

Pennsylvania's first liquid fuels tax act (1921, P. L. 1021) established a rate of taxation of one cent per gallon. By 1931 (P. L. 149), the rate of tax had risen to three cents per gallon. In 1949 (P. L. 893), the present rate of five cents per gallon was established. Until 1947, liquid fuel tax statutes dealt with but gasoline. By 1947, however, Diesel oil had begun to assume an important role in highway transportation, and the Act of 1947, P. L. 1199, provided for the taxation of such fuels used for the propulsion of vehicles on the highways of the Commonwealth. The rate of the Diesel fuel tax was changed in 1949 to its current level of five cents per gallon. An agricultural refund of one-half of the tax paid on liquid fuels consumed for agricultural purposes in the Commonwealth was provided by the Act of 1949, P. L. 1880.

A summary history of the Pennsylvania Liquid Fuels Tax appears in Table A-1.

Gross Receipts Taxes

A tax on the gross receipts of motor carriers engaged in the business of carrying passengers or property for hire over the highways of the Commonwealth was enacted in 1931 (P. L. 694). The rate of the tax was eight mills per dollar of the total gross receipts of intrastate carriers and eight mills per dollar upon the ratio of the gross receipts of interstate carriers of the miles operated in Pennsylvania to the total miles operated. The statute permitted deductions on account of excise taxes paid to any city in the Commonwealth for use of its highways and on account of registration fees paid to the Commonwealth. The Act of 1951, P. L. 1761, removed these deductions.

Table A-1

SUMMARY HISTORY OF THE PENNSYLVANIA LIQUID FUELS TAX

Act	*Principal Change from Prior Act*	*Rate **
1921, P. L. 1021	....	$.01 per gal.
1923, P. L. 834	New act; rate changed; tax on all liquid fuels	a—.01 b—.01
1923, P. L. 969	"Liquid fuels" defined; excludes kerosene and fuel oil	Same
1925, P. L. 671	Emergency tax continued until June 30, 1927; part of tax paid into Motor License Fund	Same
1925, P. L. 695	Clarified tax disposition	Same
1926, P. L. 27	Certain highway employees authorized to aid in collection of tax	Same
1926, P. L. 28	"Liquid Fuel Permits" required of dealers; additional reports	Same
1927, P. L. 201	Rate of permanent tax changed; emergency tax continued two years	a—.02 b—.01
1927, P. L. 287	Re-enacted permanent and emergency taxes; provision for collection of delinquent tax	Same
1927, P. L. 294	"Liquid fuels" redefined	Same
1929, P. L. 343	Tax to be collected by Department of Revenue (Fiscal Code)	Same
1929, P. L. 1037	New act; rate	a—.04 until July 1, 1930; then .03
1929, P. L. 1537	"Liquid fuels" redefined	Same
1931, P. L. 149	New act; rate; tax imposed on distributors instead of each dealer	a—.03
1931, P. L. 298	"Liquid fuels" redefined	Same
1931, P. L. 299	Tax rate required to be shown separately on signs	Same
1933, P. L. 11	Tax rate required to be shown separately from price	Same
1933, P. L. 206	Permit may be revoked after hearing; appeals to Dauphin County Court	Same
1933, P. L. 837	Fines to be credited to the Motor License Fund	Same
1933, P. L. 917	U. S. and Commonwealth of Pa. bonds may be substituted for surety bonds	Same
1933, P. L. 1474	Liquid Fuels Tax lien to be determined by specific acts and not by Fiscal Code	Same
1935, P. L. 412	Additional emergency tax enacted	a—.03 b—.01
1937, P. L. 248	Emergency tax continued until May 31, 1939	Same
1937, P. L. 1703	Change in discount allowed distributors	Same
1937, P. L. 2774	Specifies that distributors are liable to Commonwealth for payment of tax, but tax to be borne by consumers	Same

Table A-1 *(Continued)*

Act	*Principal Change from Prior Act*	*Rate* *
1939, P. L. 55	Emergency tax continued until May 31, 1941	Same
1939, P. L. 634	Purposes for which county may use tax broadened	Same
1941, P. L. 60	Emergency tax continued two years	Same
1943, P. L. 616	Emergency tax continued two years	Same
1945, P. L. 803	County Liquid Fuels Tax Fund established in each county with provisions for disposition of money from it	Same
1945, P. L. 1102	Additional tax continued two years; additional tax to be deposited in the Motor License Fund and specific appropriations given to political subdivisions for highway purposes	Same
1947, P. L. 393	Additional tax continued two years; appropriations from Motor License Fund raised	Same
1947, P. L. 618	Basis of distribution of funds from County Fund changed	Same
1947, P. L. 881	Certain extensions of time regarding redeterminations and appeals	Same
1947, P. L. 1196	County may add to its L.F.T. Fund from other sources for certain purposes	Same
1947, P. L. 1199	Fuel Use Tax Act; certain exemptions; tax paid by user	a—.04 (Fuel Use Tax)
1947, P. L. 1243	"Liquid fuel" redefined	Same
1949, P. L. 315	Rate of additional tax; additional tax continued two years. Extra tax to be put into Motor License Fund	a—.03 b—.02
1949, P. L. 893	Fuel Use Tax rate changed; additional tax imposed	a—.03 b—.02 (Fuel Use Tax)
1949, P. L. 1632	"Highway" redefined in Fuel Use Tax law	Same
1949, P. L. 1880	Tax to be refunded (one-half the amount of the tax paid less $1.50 filing fee) for agricultural use	Same
1951, P. L. 483	Additional Fuel Use Tax continued until May 31, 1953	Same
1951, P. L. 485	Additional Liquid Fuels Tax continued until May 31, 1953; entire additional tax placed in Motor License Fund with special appropriations removed	Same
1951, P. L. 1548	Posting of signs by retail dealers further regulated	Same
1951, P. L. 1965	New Fuel Use Tax Act repealing 1947, P. L. 1199; tax imposed on dealer-user	Same
1951, P. L. 2028	Refunds for exempted uses under the liquid fuel tax made on annual instead of quarterly basis	Same

* a—Permanent Tax.

b—Emergency or Additional Tax.

Appendix B

VEHICLE REGISTRATIONS IN PENNSYLVANIA: 1906 TO 1952, INCLUSIVE

Year	*Passenger Cars*	*Commercial Motor Vehicles*	*Motor Buses and Omnibuses*	*Motor-cycles*	*Total (Except Trailers and Tractors)*	*Trailers and Tractors*	*Total—All Registrations*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1906	10,954 [a]		.....	.....	10,954	.....	10,954
1907	14,054 [a]		.....	.....	14,054	.....	14,054
1908	20,094 [a]		.....	.....	20,094	.....	20,094
1909	34,531 [a]		.....	.....	34,531	.....	34,531
1910	33,346 [a]		.....	3,854	37,200	.....	37,200
1911	43,282 [a]		.....	4,826	48,108	.....	48,108
1912	58,221 [a]		.....	7,298	65,519	.....	65,519
1913	78,907 [a]		.....	10,677	89,584	.....	89,584
1914	104,950	6,329	.....	14,335	125,614	1,332	126,946
1915	152,365	8,384	.....	17,245	177,994	2,385	180,379
1916	218,846	11,732	.....	21,439	252,017	3,197	255,214
1917	306,001	19,152	.....	24,567	349,720	3,681	353,401
1918	363,001	31,185	.....	26,621	420,807	4,387	425,194
1919	441,224	40,893	.....	25,760	507,877	4,861	512,738
1920	521,835	48,329	.....	23,981	594,145	4,328	598,473
1921	632,541	57,048	.....	21,111	710,700	5,071	715,771
1922	763,916	65,821	.....	19,316	849,053	5,675	854,728
1923	988,346	76,278	[b]	19,817	1,084,441	5,819	1,090,260
1924	1,043,691	178,122	6,733	17,540	1,246,086	6,844	1,252,930
1925	1,162,824	193,159	6,769	16,122	1,378,874	7,338	1,386,212
1926	1,276,519	206,321	8,034	14,609	1,505,483	8,280	1,513,763
1927	1,365,826	217,937	8,464	14,267	1,606,494	8,804	1,615,298
1928	1,428,514	225,299	8,405	13,807	1,676,025	9,177	1,685,202
1929	1,524,799	241,442	8,682	13,670	1,788,593	9,848	1,798,441
1930	1,540,016	240,903	8,460	13,223	1,802,602	10,311	1,812,913
1931	1,527,316	239,506	8,020	12,423	1,787,265	11,212	1,798,477
1932	1,455,027	239,283	6,527	11,307	1,712,144	13,049	1,725,193
1933	1,419,484	240,222	5,910	11,541	1,677,157	15,430	1,692,587
1934	1,476,120	253,370	5,705	12,071	1,747,266	19,983	1,767,249
1935	1,523,249	258,898	5,621	11,731	1,799,499	25,724	1,825,223
1936	1,635,138	277,110	5,868	11,914	1,930,030	30,392	1,960,422
1937	1,755,633	283,625	6,062	12,195	2,057,515	34,244	2,091,759
1938	1,746,780	273,059	5,451	11,441	2,036,731	34,107	2,070,838

Appendix B *(Concluded)*

Year	*Passenger Cars*	*Commercial Motor Vehicles*	*Motor Buses and Omnibuses*	*Motor-cycles*	*Total (Except Trailers and Tractors)*	*Trailers and Tractors*	*Total—All Registrations*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1939	1,846,402	301,155	5,671	11,856	2,165,084	40,675	2,205,759
1940	1,915,454	297,395	5,900	11,445	2,230,194	43,651	2,273,845
1941	2,029,120	300,779	6,614	12,275	2,348,788	48,126	2,396,914
1942	1,895,056	281,529	7,846	13,353	2,197,784	47,312	2,245,096
1943	1,724,348	273,229	8,281	10,706	2,016,564	46,590	2,063,154
1944	1,643,154	276,072	8,309	11,782	1,939,317	52,220	1,991,537
1945	1,731,430	304,972	8,993	13,849	2,059,244	63,410	2,122,654
1946	1,874,688	364,173	10,517	20,352	2,269,730	83,792	2,353,522
1947	2,024,119	407,591	12,114	26,375	2,470,199	95,215	2,565,414
1948	2,171,622	439,876	12,728	32,549	2,656,775	103,572	2,760,347
1949	2,344,192	452,867	12,338	30,736	2,840,133	106,705	2,946,838
1950	2,575,219	484,549	12,684	27,451	3,099,903	113,252	3,213,155
1951	2,700,386	502,255	12,700	26,481	3,241,822	120,654	3,362,476
1952	2,784,561	507,881	12,550	25,562	3,330,554	126,210	3,456,764

[a] Combined Passenger and Commercial Vehicles.

[b] Omnibuses were registered as Commercial Motor Vehicles prior to 1924.

SOURCE: Monthly Report, March, 1953, Department of Revenue, Bureau of Motor Vehicles.

Appendix C

THE NEW YORK STATE HIGHWAY USE TAX

A highway use tax, based on weights of vehicles and miles traveled, is imposed upon certain commercial vehicles under a 1951 enactment (as amended) of the legislature of the State of New York.*

The tax is imposed upon all vehicles having a maximum stated gross weight of more than 18,000 pounds, except vehicles owned by farmers and used excusively to transport agricultural commodities raised or consumed on farms, vehicles owned and operated by Federal, state, or municipal governments, and vehicles operated under contract as rural mail carriers (among others).

The tax is based upon the maximum gross weight of the vehicle as stated by the user, subject to audit and approval of the State Tax Commission, except for those times during which the vehicle carries no load, when the tax liability is computed on the basis of the actual unladen weight. At a weight of 18,000 pounds, the rate is six mills per mile traveled. The rate increases by one mill per 2,000 pounds per mile to 26,000 pounds, by one-half mill per 2,000 pounds per mile between 26,000 and 42,000 pounds, and by one mill per 2,000 pounds per mile in excess of 42,000 pounds.

A highway use permit must be obtained from the State Tax Commission for each vehicle. A fee of $5.00 must accompany each application. With the permit is issued a plate to be placed on the vehicle; permit and plate are effective until revoked or suspended, and are not transferable either to another motor vehicle or another person. However, if, under a lease, the lessee is to operate or does operate the vehicle for less than thirty days, he may operate the vehicle under the permit obtained by the owner.

Regulations of the State Tax Commission require that both unladen weight and maximum gross weight be painted on the vehicle.

A return must be filed by the twentieth of each month, covering the preceding calendar month, for each vehicle for which a permit has been issued, whether or not the vehicle has operated in the state and whether or not the miles traveled are taxable. The tax is due when the return is filed. Permission may be obtained to report on a quarterly, rather than a monthly, basis if it appears that the amount of tax due monthly is less than $10.00.

Highway use permits may be revoked or suspended for nonpayment of the tax or for other violations of the law; unless the Commission specifies otherwise, revocation or suspension of one permit of a user automatically revokes or suspends all his permits. Cash penalties for nonpayment of tax are provided, and violations are made crimes punishable by fines and/or imprisonment. The statute also provides that unpaid tax shall constitute a lien on the vehicle, which may be satisfied by sale of the vehicle. Decisions of the Commission are appealable.

The number of active permits (as of September 10, 1952) totaled 226,742, held by 32,841 carriers. Collections from the tax approximate $750,000 per month. No data concerning utilization and tax payments by size of units are presently available.

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* Laws 1951, Chapter 74, Tax Law, Article 21, as amended.

Appendix D

HIGHWAY DESIGN

If adequate strength is to be assured, the structural design of a highway presupposes an analysis of all forces which are likely to act on the highway. The following brief presentation deals with the factors which enter into such an analysis.

The highway structure consists of two parts:

(1) the pavement, which provides a smooth surface for the movement of motor vehicles and transmits and distributes the wheel loads to

(2) the subgrade soil, which is the supporting medium underlying the pavement.

In general, pavements may be classified as either rigid or flexible, and design differs according to the type selected. A rigid pavement acts as a beam or slab which, when properly supported, will resist heavy loads because of its flexural (bending) strength. Rigid pavements are subject to cracking under relatively small deformations. Rigid pavements usually consist of slabs of Portland cement concrete laid over natural soil or a special subgrade course of graded aggregate (gravel or crushed stone), which is regarded as the top layer of the subgrade because its functions are to provide drainage and to add supporting strength to the natural subgrade.

A flexible pavement acts as a mat which provides a smooth running surface but will readily deform under loads unless sufficiently supported by base courses of aggregate. Flexible pavements generally consist of two to three inches of asphaltic, cemented aggregates called macadam or bituminous concrete, and several layers of graded aggregate (base and subbase courses) which provide necessary load supporting strength. Asphaltic concrete is much like Portland cement concrete in that it consists of filler material—in this case crushed stone aggregate—bound together by a cement.

The subgrade soil which supports the pavement may be either natural soil found in place, or, if the supporting characteristics of the natural soil are found to be inadequate, special subgrade soil brought to the site. In either case, the strength and stability of the subgrade is usually improved by certain construction operations and by provision of adequate drainage facilities.

Generally, engineering design is based upon the analysis of forces caused by external loads on the structure, the evaluation of properties of the constituent materials that will effect the resisting strength of the structure, and finally the selection of a structure which has the properties required to resist all applied loads. In highway design, the structure must resist loads without excessive deformation and consequent failure. The capacity of the highway to meet this requirement under specified loadings depends chiefly on two factors:

(1) supporting capacity of the subgrade soil; and

(2) strength of the pavement.

Supporting Capacity of the Subgrade Soil—

The stability or supporting capacity of subgrade soil is dependent upon resistance to deformation which the soil particles exhibit under load.

Resistance to deformation depends upon:

(1) *frictional resistance,* or the resistance to sliding produced by interlocking of the soil particles; and

(2) *cohesive resistance,* or the resistance afforded by the mutual attraction of the soil particles in the presence of moisture.

Soils may be classified according to the type of resistance characterizing them:

(1) frictional (coarse-grained materials such as sand and gravel);

(2) cohesive (fine-grained materials such as clay); and

(3) cohesive-frictional (materials such as sand-clay mixtures).

The resistance of each of the above types of soils is affected by two other important soil properties: moisture content and density. These two properties are dependent upon each other. Under any given compactive pressure, the maximum obtainable density of a soil occurs at a particular moisture content, called optimum moisture content. With increase in compaction (pressure), maximum density is obtained at lower optimum moisture contents. Since the support strength of soils increases as the density increases, it is desirable to compact the subgrade soil to the maximum obtainable density.

Although the moisture content of the subgrade soil usually can be controlled during construction to obtain maximum density, it is difficult to predict and impossible to control the moisture content of the soil when the highway is in use. The amount of rainfall runoff seeping downward through the soil can be partially controlled by drainage facilities, but other factors, such as the capillary rise of moisture from the water table and the rise of the water table elevation, are not subject to such control. Nevertheless, it is necessary to estimate the maximum moisture content which might reasonably be expected to prevail in the subgrade, since the density—and hence the strength—of the subgrade will vary with the moisture content. The highway structure must be designed for the weakest anticipated subgrade support.

The differences in the types of resistances (cohesive and/or frictional) observed in different soils cause variation in the reactions of soils to loads. This variation has given rise to several theories which attempt to account for the subgrade reaction of different types of soil. These theories offer a basis for calculating, for certain common subgrade soils, the forces resulting from applied loads. Chief among these theories are the elastic theory, the liquid theory, and the plastic theory. Before examining each in turn, it will be convenient to state here the simplifying assumptions common to all three:

(1) all particles of the soil are similar in kind and dimension;

(2) the soil has the same properties in all directions; and

(3) the soil is of limitless length, width, and depth under the surface tested.

Elastic Theory

In summary, according to this theory, soils tend to recover or rebound to their original position after loading. Results from computations based upon this theory agree rather well with experimental observation made on pavements supported by subgrades in which clay or cohesive type soils predominate. However, calculations for pressures under edges or corners of concrete slabs indicate large pressures which are at variance with actual observations.

Liquid Theory

In summary, this theory is that the tendency of a soil to recover to its initial level is dependent upon and proportional to the loadings tending to displace it. That is, the upward pressure of the subgrade soil is assumed to be proportional to the downward displacement of the slab. The liquid theory is so named because the assumed proportional relationship between pressure and deflection is known to exist in the case of a flat plate floating on a liquid. If the soil is a granular, frictional-type soil, results of computations agree rather well with actual field observation. The liquid theory further lends itself to an evaluation of the subgrade stresses under a corner or edge of a concrete slab when the load is located in the interior of the slab.

Plastic Theory

In summary, this theory stipulates that under certain conditions of applied pressure and moisture content, soils will be reshaped and will not tend to move back to their original position. Analyses based upon the plastic theory seem to agree with certain field observations for cohesive clay subgrades, but the theory appears to be descriptive of the behavior of flexible rather than rigid highways.

These theories of subgrade behavior are used in analyzing stresses in the subgrade under specific loading conditions. In addition, it is necessary to obtain actual values of the strength or ability of the subgrade soil to resist predicted stresses under the anticipated moisture conditions. These values are usually obtained by strength tests. The two most important and most widely used of these tests are the plate bearing test and the California Bearing Ratio test.

Plate bearing tests are carried out on the subgrade soil in place to determine its supporting capacity. The test involves the incremental loading of a circular steel plate of standard size[1] placed directly on the subgrade soil, and the measurement of the displacement of the soil as the load is increased. The results are reported in pounds per square inch stress per inch of displacement, which is called the Modulus of Subgrade Reaction.

The California Bearing Ratio (CBR) test is dissimilar from the plate bearing test in that it is usually carried out in the laboratory[2] on a sample of subgrade soil prepared to the anticipated density and moisture content. The test is made with a standard size piston of three-square-inch area so loaded that it penetrates the soil sample at a constant rate of 0.05 inches per minute. Results of the test are

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[1] Usually thirty-inch diameter.

[2] It can also be carried out in the field, or six-inch undisturbed tube samples can be taken in the field and evaluated in the laboratory.

expressed as the percentage of the standard load value for 0.1 inch penetration, based on the strength of graded crushed stone.

Once the supporting capacity of the soil under the anticipated conditions of moisture, density, and loading has been established, it is possible to design a pavement of sufficient thickness or strength to distribute anticipated axle loads to the subgrade at a bearing pressure which will not exceed the strength of the soil.

Strength of Pavement

The most important factor in determining the required strength of the pavement is the magnitude of the stresses (forces) caused by axle loads. The stresses caused by vehicular traffic are not only the result of the downward force or weight of the vehicles, but also of their movement. The stresses caused by the acceleration (or deceleration) of the wheels on the pavement are called impact effects, and depend on the velocity of the vehicle, its tire equipment, its unsprung weight, and the condition of the road surface. Slow-moving traffic on rough roads causes large impact effects. Thus, the wheel loads or axle loads must be increased by a multiplying, impact factor that may vary from 1.2 to 1.7 in order to arrive at the total loading effect that will determine the highway pavement strength required.

Another important consideration in determining the stresses in the pavement that will effect its required strength is the location of the wheel loads on the pavement surface. When loads are placed at the corner or along the edge of a concrete slab, higher stresses develop because there is less support offered, and crumbled edges and cracked corners may result. Load-transfer devices at the ends of the slab give the corners some added support, and aid in keeping the corner stresses down, while thickened-edge pavement cross-sections are often utilized to give extra strength to the higher-stressed edge areas.

Still another factor which adds complexity to rigid pavement design is the effect of changes in temperature on the slab. It is well known that solid masses expand and contract with increase and decrease, respectively, in temperature. Concrete slabs will contract and expand with daily and seasonal variations in temperature. The effect of forces due to temperature changes are especially important in two cases: the lengthening and shortening of the slab with seasonal temperature variation, and curling or distortion of the slab caused by differences in temperatures between the top and the bottom of the slab. In the first case, forces develop because the slab is prevented by frictional resistance from sliding along the subgrade as its size changes. These stresses can be kept within safe limits by the proper jointing of the pavement ends. In the second case, curling, significant increases in stresses may occur when corners or edges of the pavement (lifted away from the subgrade) are weighted. These forces are critical.

In the highway structure, the magnitude of the stresses generated by wheel and axle loads varies with the distance below the surface: from high stresses at the surface, where loads are concentrated in the small area of tire contact, to low stresses distributed over a large area of subgrade. The design of flexible pavements facilitates distribution of loads to the subgrade through several layers of materials. As in design of rigid highways, the stress transmitted through the highway structure to the subgrade must not exceed the strength of each successive layer of materials in the structure.

Appendix E

POSTING OF BRIDGES AND EFFECT UPON UTILIZATION OF PENNSYLVANIA HIGHWAYS

Table E-1

POSTING OF BRIDGES AND EFFECT UPON UTILIZATION OF PENNSYLVANIA PRIMARY SYSTEM HIGHWAYS, BY COUNTY

County	*Number of Posted Bridges*				*Highway Mileage for Which Bridge Postings Restrict Weight*		
	Total	*Under 10,000-Pound Load Limit*	*10,000 to 20,000-Pound Load Limit*	*20,000 to 30,000-Pound Load Limit*	*Total*	*Fully Restricted*	*Partially Restricted*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TOTAL	350	14	68	268	489.9	45.8	444.1
Adams	6	..	..	6	11.5	....	11.5
Allegheny	9	1	5	3	4.7	....	4.7
Armstrong	9	..	..	9	12.9	7.8	5.1
Beaver	4	1	2	1	8.7	1.1	7.6
Berks	4	..	..	4	14.4	....	14.4
Blair	1	..	..	1	.1	....	.1
Bucks	11	..	4	7	10.1	2.6	7.5
Butler	4	..	1	3	13.1	....	13.1
Carbon	4	..	..	4	5.0	....	5.0
Chester	13	..	4	9	13.2	....	13.2
Clarion	3	..	3	..	5.9	....	5.9
Columbia	3	..	2	1	2.7	....	2.7
Crawford	2	..	..	2	2.9	....	2.9
Cumberland	8	..	..	8	10.6	....	10.6
Dauphin	4	..	..	4	9.3	.9	8.4
Delaware	5	..	3	2	6.7	....	6.7
Fayette	4	..	3	1	6.7	....	6.7
Forest	5	..	1	4	19.0	....	19.0
Franklin	6	..	1	5	13.2	1.3	11.9
Huntingdon	8	2	1	5	4.5	....	4.5
Indiana	17	..	5	12	23.9	3.9	20.0
Jefferson	10	1	4	5	10.0	.7	9.3
Juniata	62	1	1	60	45.8	.6	45.2
Lackawanna	1	..	1	..	4.7	..	4.7
Lancaster	5	..	..	5	9.9	....	9.9
Lawrence	1	1	..	..	.5	..	.5
Lebanon	43	..	1	42	68.8	11.2	57.6
Lehigh	8	..	2	6	11.8	....	11.8
Luzerne	5	3	..	2	13.9	.1	13.8
Lycoming	1	..	1	..	4.8	..	4.8

Table E-1 *(Concluded)*

County	Number of Posted Bridges				Highway Mileage for Which Bridge Postings Restrict Weight		
	Total	Under 10,000-Pound Load Limit	10,000 to 20,000-Pound Load Limit	20,000 to 30,000-Pound Load Limit	Total	Fully Restricted	Partially Restricted
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mercer	9	..	3	6	18.8	.4	18.4
Monroe	1	1	..	..	.6	..	.6
Montgomery	12	..	2	10	6.4	.1	6.3
Northampton	5	2	2	1	7.8	....	7.8
Northumberland	6	..	5	1	7.9	.8	7.1
Perry	21	..	..	21	32.5	8.4	24.1
Philadelphia	4	..	3	1	5.4	....	5.4
Schuylkill	2	..	..	2	7.0	....	7.0
Venango	1	..	..	1	.4	....	.4
Warren	5	..	1	4	15.4	3.6	11.8
Washington	9	..	3	6	7.2	.4	6.8
Wayne	1	..	..	1	.8	....	.8
Westmoreland	3	..	2	1	3.2	....	3.2
Wyoming	1	..	..	1	.7	....	.7
York	4	1	2	1	6.5	1.9	4.6

Table E-2

POSTING OF BRIDGES AND EFFECT UPON UTILIZATION OF PENNSYLVANIA SECONDARY SYSTEM HIGHWAYS, BY COUNTY

County	Number of Posted Bridges				Highway Mileage for Which Bridge Postings Restrict Weight		
	Total	Under 10,000-Pound Load Limit	10,000 to 20,000-Pound Load Limit	20,000 to 30,000-Pound Load Limit	Total	Fully Restricted	Partially Restricted
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TOTAL	2,997	976	1,101	920	6,246.3	1,214.8	5,031.5
Adams	55	21	9	25	94.6	5.4	89.2
Allegheny	35	9	26	..	30.8	1.8	29.0
Armstrong	49	2	16	31	83.7	11.6	72.1
Beaver	26	23	..	3	31.9	1.7	30.2
Bedford	78	49	19	10	78.5	28.8	49.7
Berks	50	14	21	15	105.4	1.1	104.3
Blair	9	4	4	1	10.1	.5	9.6
Bradford	179	86	60	33	467.3	136.5	330.8
Bucks	68	9	18	41	110.4	15.1	95.3
Butler	43	2	11	30	111.4	7.5	103.9
Cambria	17	6	6	5	8.3	.5	7.8
Cameron	5	1	3	1	53.0	26.5	26.5
Carbon	4	..	..	4	13.6	....	13.6
Centre	26	5	12	9	180.8	90.4	90.4
Chester	128	9	29	90	163.9	16.4	147.5
Clarion	36	8	19	9	90.4	7.9	82.5
Clearfield	27	1	13	13	174.6	87.3	87.3
Clinton	14	2	10	2	107.8	53.9	53.9
Columbia	50	27	15	8	78.4	9.9	68.5
Crawford	133	38	62	33	235.1	21.9	213.2
Cumberland	45	11	8	26	75.8	6.0	69.8
Dauphin	30	10	5	15	56.0	1.1	54.9
Delaware	12	1	5	6	14.0	....	14.0
Elk	7	1	5	1	31.4	15.7	15.7
Erie	83	29	36	18	141.1	20.9	120.2
Fayette	30	8	11	11	47.3	1.9	45.4
Forest	8	3	3	2	30.1	2.2	27.9
Franklin	23	8	8	7	55.0	3.6	51.4
Fulton	16	6	7	3	9.1	1.7	7.4

Table E-2 *(Concluded)*

County	Number of Posted Bridges				Highway Mileage for Which Bridge Postings Restrict Weight		
	Total	Under 10,000-Pound Load Limit	10,000 to 20,000-Pound Load Limit	20,000 to 30,000-Pound Load Limit	Total	Fully Restricted	Partially Restricted
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Greene	92	46	29	17	180.5	19.2	161.3
Huntingdon	55	17	28	10	33.0	3.8	29.2
Indiana	43	1	12	30	86.7	12.2	74.5
Jefferson	36	1	19	16	86.8	2.7	84.1
Juniata	24	9	3	12	55.8	4.9	50.9
Lackawanna	23	7	11	5	50.7	8.4	42.3
Lancaster	75	25	24	26	128.5	7.4	121.1
Lawrence	31	9	15	7	64.8	5.1	59.7
Lebanon	10	1	3	6	32.4	....	32.4
Lehigh	20	..	9	11	33.2	4.5	28.7
Luzerne	18	9	7	2	39.1	1.7	37.4
Lycoming	44	11	18	15	124.0	9.3	114.7
McKean	8	3	5	..	59.4	29.7	29.7
Mercer	94	18	53	23	162.3	24.1	138.2
Mifflin	14	6	4	4	66.2	33.1	33.1
Monroe	17	4	9	4	22.8	3.9	18.9
Montgomery	71	5	11	55	90.0	3.7	86.3
Montour	17	4	10	3	24.0	....	24.0
Northampton	16	2	4	10	24.0	1.1	22.9
Northumberland	33	6	19	8	67.8	6.6	61.2
Perry	34	13	10	11	90.9	21.6	69.3
Pike	20	14	5	1	73.0	6.4	66.6
Potter	62	30	27	5	339.6	169.8	169.8
Schuylkill	11	1	4	6	22.2	....	22.2
Snyder	35	17	16	2	53.7	7.5	46.2
Somerset	74	39	26	9	61.0	13.9	47.1
Sullivan	31	9	20	2	64.0	5.2	58.8
Susquehanna	117	40	51	26	256.3	40.7	215.6
Tioga	161	75	67	19	284.8	72.4	212.4
Union	24	8	12	4	42.8	3.5	39.3
Venango	28	13	8	7	92.6	12.6	80.0
Warren	50	13	26	11	125.5	17.9	107.6
Washington	109	55	28	26	172.2	33.6	138.6
Wayne	52	18	22	12	128.3	26.5	101.8
Westmoreland	37	9	17	11	67.4	.5	66.9
Wyoming	29	18	7	4	75.6	15.4	60.2
York	96	27	21	48	174.6	8.1	166.5

Appendix F

SAMPLE DETERMINATION OF INCREMENTAL COSTS AND HIGHWAY SURFACE REQUIREMENT FACTOR ATTRIBUTABLE TO AXLES BY WEIGHT GROUP*

Axle Weight Group	*Numbers of Axles of Specified Weight in Estimated Average Daily Traffic*	*Numbers of Axles in Weight Group and All Higher Weight Groups*	*Estimated Project Cost for Axle Weights Including but not Exceeding Specified Weight Group*	*Additional Project Cost Attributable to Increase in Weight Shown in Col. 1 on Account of Number of Axles Shown in Col. 3*	*Additional Cost per Axle Within Weight Group (Col. 5 ÷ Col. 3)*	*Cost per Axle for Each Weight Group (Cumulative Col. 6)*	*Axle-Weight Group Share of Total Project Cost (Col. 7 × Col. 2)*	*Estimated Project Highway Strength Requirement Factor for Axle Weights Including but not Exceeding Specified Weight Group*	*Highway Strength Requirement Factor per Axle*	*Axle-Weight Group Share of Additional Highway Strength Requirement Factor (Col. 10 × Col. 2)*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
2,000 pounds and under	11,030	14,120	$464,120	$464,120	$32.87	$32.87	$362,552.80	882.5	.0625 [a]	689.4
2,001 to 5,000 ..	31	3,090	535,584	71,464	23.13	56.00	1,736.00	1,075.6	.1250 [a]	3.9
5,001 to 10,000 ..	188	3,059	586,967	51,383	16.79	72.79	13,685.40	3,742.3	1.0000 [b]	188.0
10,001 to 15,000 ..	593	2,871	611,219	24,252	8.45	81.24	48,176.30	12,365.3	4.0000 [b]	2,372.0
15,001 to 18,000 ..	249	2,278	621,805	10,586	4.65	85.89	21,386.30	39,701.3	16.0000 [b]	3,984.0
18,001 to 20,000 ..	188	2,029	632,391	10,586	5.22	91.11	17,127.90	72,165.3	32.0000 [b]	6,016.0
20,001 to 22,400 ..	249	1,841	642,976	10,585	5.75	96.86	24,117.10	131,077.3	64.0000 [a]	15,936.0
22,401 to 30,000 ..	404	1,592	678,262	35,286	22.16	119.02	48,084.20	1,659,397.3	1,024.0000 [a]	413,696.0
30,001 to 40,000 ..	1,188	1,188	713,548	35,286	29.70	148.72	176,682.00	39,371,269.3	32,768.0000 [a]	38,928,384.0
TOTAL	14,120				$148.72		$713,548.00			39,371,269.3

* Based on highway designs prepared by staff of Joint State Government Commission (see Technical Supplement) and cost estimates of Pennsylvania Department of Highways. This example is not representative, since: (a) it applies to but one type of surface (flexible); (b) load distribution is not typical; (c) highway cross-section costs, but not gradient and curvature costs, are considered; (d) costs of other types of construction, reconstruction, highway deterioration, and administration are not reflected.

[a] Theoretical extrapolations of highway test data.

[b] Based on highway test data.

Appendix G

COMMERCIAL VEHICLE GROSS WEIGHT LIMITS IN PENNSYLVANIA STATUTE AND LIMITS RECOMMENDED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS

GROSS WEIGHT LIMITS CONTAINED IN PENNSYLVANIA STATUTE *

(1)	(2)
Two-axle truck or truck-tractor	30,000 pounds
Three-axle truck or truck-tractor	40,000
One-axle semitrailer	18,000
Two-axle trailer or semitrailer	26,000
Three-axle trailer	36,000
All combinations—truck-tractor and semitrailer	45,000
Four-axle truck and full trailer	56,000
Five-axle or six-axle truck and full trailer	62,000

* 1929, May 1, P. L. 905, as amended.

MAXIMUM LOADS RECOMMENDED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS

Distance in Feet between the Extremes of Any Group of Axles	*Maximum Load in Pounds Carried on Any Group of Axles*	*Distance in Feet between the Extremes of Any Group of Axles*	*Maximum Load in Pounds Carried on Any Group of Axles*
(1)	(2)	(1)	(2)
4 ft.	32,000 lbs.	31 ft.	53,490 lbs.
5	32,000	32	54,330
6	32,000	33	55,160
7	32,000	34	55,980
8	32,610	35	56,800
9	33,580	36	57,610
10	34,550	37	58,420
11	35,510	38	59,220
12	36,470	39	60,010
13	37,420	40	60,800
14	38,360	41	61,580
15	39,300	42	62,360
16	40,230	43	63,130
17	41,160	44	63,890
18	42,080	45	64,650
19	42,990	46	65,400
20	43,900	47	66,150
21	44,800	48	66,890
22	45,700	49	67,620
23	46,590	50	68,350
24	47,470	51	69,070
25	48,350	52	69,790
26	49,220	53	70,500
27	50,090	54	71,200
28	50,950	55	71,900
29	51,800	56	72,590
30	52,650	57	73,280