

# Economic Cost of Traffic Accidents in Relation to the Highway

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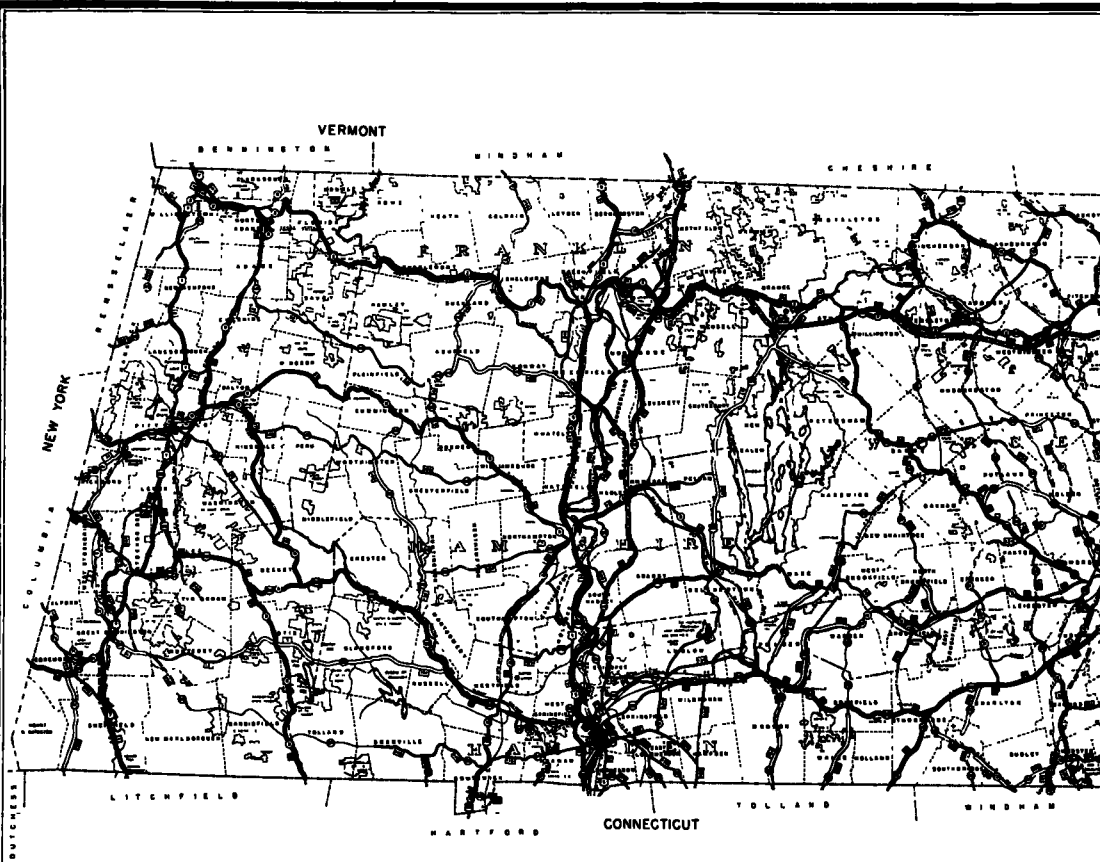
The traffic accident toll in number of persons killed and injured has been publicized so frequently that many people are quite familiar with the figures and can even relate the details of the latest fatal accident. Few persons, however, have an intimate knowledge of where, on a statewide basis, most of the collisions are occurring, what types are most frequent and what would be the odds, as measured in number of accidents per 100 million vehicle-miles, of having an accident on the Massachusetts streets and highways. Prior to the 1954-55 Accident Cost Study in Massachusetts which was conducted by the Massachusetts Department of Public Works and the Registry of Motor Vehicles in cooperation with the U. S. Bureau of Public Roads, the monetary cost of traffic accidents was purely conjectural.

This paper shows what this Accident Cost Study has revealed in terms of accident rates and direct costs of accidents on the six highway systems in Massachusetts and to point out where special attention should be directed in order to stem the tide of rising accident toll at its highest points.

It is reasonable to expect that the conditions which prevail in Massachusetts are typical of those in most other states.

● THE HIGHWAY NETWORK in Massachusetts can be divided into six systems whose total mileage in 1953 was 24,506 mi. This mileage had increased to 26,310 by 1958. The breakdown in mileage and in traffic volumes on each system during 1953—the year on which the Accident Cost Study was based—is as follows:

Highway Systems	Miles (A)	Average Traffic Volumes (B)	Million Vehicle-Miles (AxB) (Vehicles)
<b>Federal-aid primary</b>			
State highways	1,516	2,657,000	4,028
Local systems	452	3,170,000	1,433
<b>Federal-aid secondary</b>			
State highways	438	991,000	434
Local systems	1,748	894,000	1,563
<b>Non-Federal aid</b>			
State highways	155	1,381,000	214
Local systems	20,197	196,000	3,956
<b>Grand Total</b>	<b>24,506</b>	<b>474,000</b>	<b>11,628</b>



# MASSACHUSETTS

MAP SHOWING

**FEDERAL AID PRIMARY SYSTEM**

AND THE

**FEDERAL AID SECONDARY SYSTEM**

PREPARED BY THE

**DEPARTMENT OF PUBLIC WORKS—TRAFFIC DIVISION**

**HIGHWAY PLANNING**






IN CO-OPERATION WITH THE

**U. S. DEPARTMENT OF COMMERCE**

**BUREAU OF PUBLIC ROADS**

1958

**LEGEND**

	STATE HIGHWAY ON FEDERAL AID PRIMARY SYSTEM
	PROPOSED STATE HIGHWAY ON FEDERAL AID PRIMARY SYSTEM
	LOCAL ROAD ON FEDERAL AID PRIMARY SYSTEM
	STATE HIGHWAY ON FEDERAL AID SECONDARY SYSTEM
	LOCAL ROAD ON FEDERAL AID SECONDARY SYSTEM

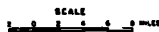
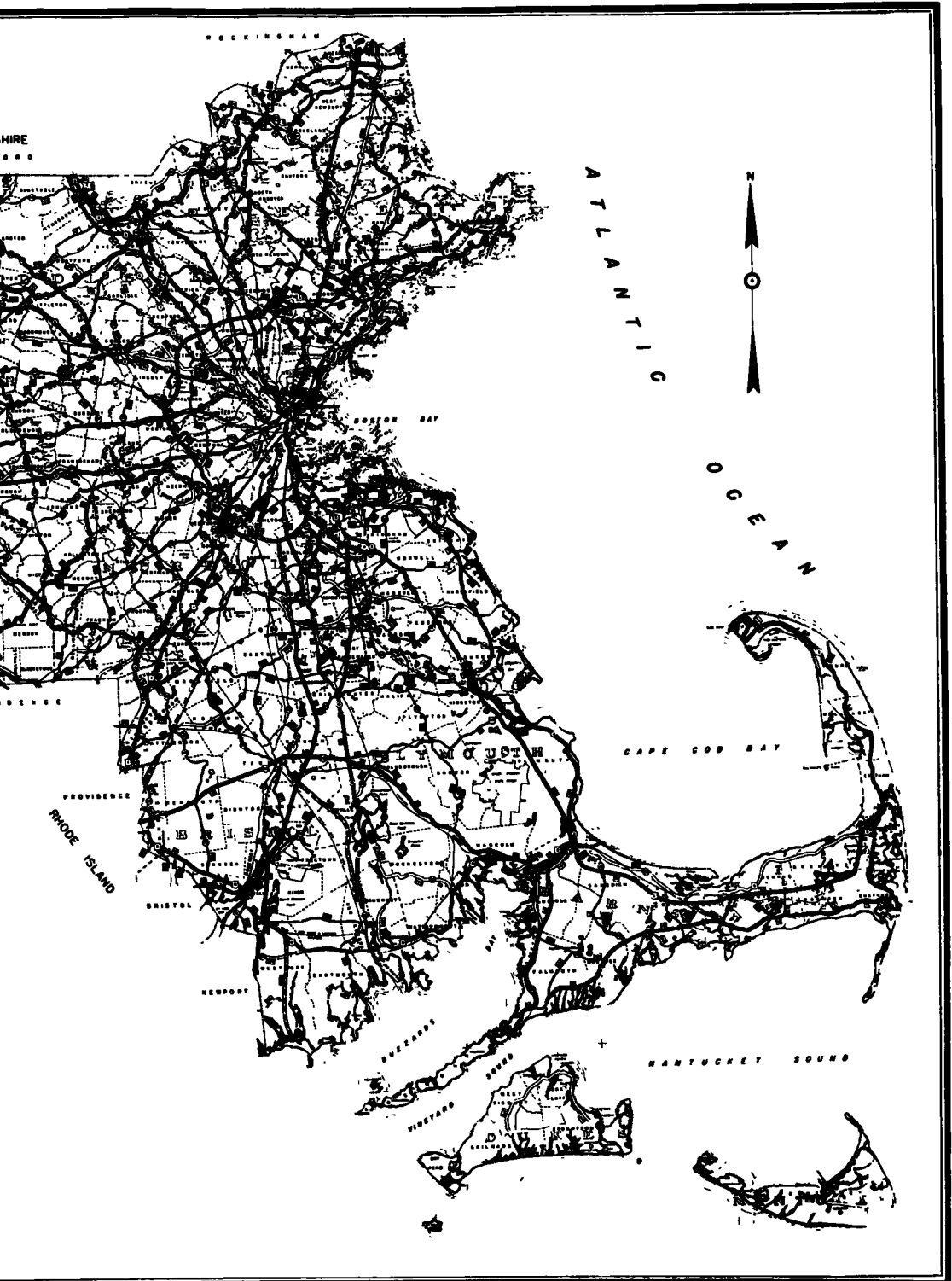


Figure 1



Massachusetts.

It may be of interest to know what the networks of highways in Massachusetts look like and although map space does not permit the inclusion of all roads, Figure 1 does show the extent and alignment of the Federal-aid highways. Massachusetts is probably not unique among the states in having a high percentage of curves in its roads. As shown on the map the number of long straight highways is still low. This is due to the ground contour, the large number of cities and towns, and to connecting roadways which follow alignment established many years ago. The rapidly expanding expressway system in this state will, in the next few years, certainly be effective in increasing the mileage of highways with better alignment.

### GENERAL ACCIDENT EXPERIENCE

As brought out in Dunman's paper (HRB Bull. 208), there were, in 1953, 1,239,000 registered passenger cars and 1,858,000 licensed operators in Massachusetts.

The vehicle-miles driven in passenger cars during 1953 on the Commonwealth's 24,500 mi of highways totaled 11,628,000,000.

In this same year, Accident Cost Study figures show that 131,500 passenger car accidents occurred which resulted in a direct cost of \$50,224,000.

Under the Massachusetts law until June 30, 1953, compulsory reporting to the Registrar of Motor Vehicles included only those cases involving personal injury. On June 30, 1953 the law was revised to include the compulsory reporting of accidents in which any person was killed or injured or in which there was damage in excess of \$100 to any one vehicle or other property. The \$100 limit was raised to \$200 by another revision in the law on June 25, 1956. Registry figures in 1953 show 36,113 personal-injury accidents reported, while in 1954 a total of 67,626 personal-injury and property-damage accidents were reported. The difference between the figures used in this paper and the Registry figures of reported accidents is due to the large number of non-reportable property damage collisions.

### ACCIDENT EXPERIENCE BY HIGHWAY SYSTEMS

Massachusetts, though densely populated in many sections, still has a low proportion of urban areas when compared with rural areas. Approximately 15 percent of the 8,093 sq mi in Massachusetts are classed as urban and 85 percent as rural.

Table 1, the basic accident table, shows that 88 percent of all accidents in the state occur in the urban areas, whose road mileage is 6,480 of the state's 24,506 mi. This point is a most enlightening one when considering density of accidents on the various highway systems. Moreover, in the urban areas, the major trouble occurs in the 39 cities of the Commonwealth where, according to Registry of Motor Vehicle figures in 1953, 67 percent of the total collisions in the state occurred.

Table 1 also furnishes a comparison of the accident experience on the state highway and local road systems. Without, for the moment, considering road mileage and traffic volumes, the 24,562 accidents on the state highways in comparison with the 106,974 accidents on the local road system clearly show where the chief problem in accident reduction lies. The figures in Table 1 substantiate the conclusion that special attention should be focused on the urban areas in the state and on the local road systems, if appreciable reductions in accidents are to be effected.

The Federal-aid systems, both primary and secondary, accounted for 47,681, or 36 percent of the 131,536 accidents. Of the 47,681 accidents, 24,080 occurred on state highways and 23,601 on local roads.

In terms of "severity" of accident the property-damage class far outweighs the other two classes of accidents. Without the facts it is difficult to realize that 97,951 "property damage only" collisions occur in one year and that these comprise 75 percent of all accidents. Local systems account for 80 percent of the property-damage accidents.

TABLE 1  
MOTOR-VEHICLE TRAFFIC ACCIDENTS BY HIGHWAY SYSTEM AND SEVERITY FOR  
PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953

Highway System	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Federal-aid Primary system												
State highways	40	33	73	1,903	2,249	4,152	4,481	8,703	13,184	6,424	10,985	17,409
Local systems	-	49	49	15	5,216	5,231	-	12,081	12,081	15	17,346	17,361
Total	40	82	122	1,918	7,465	9,383	4,481	20,784	25,265	6,439	28,331	34,770
Federal-aid secondary system												
State highways	24	5	29	576	410	986	3,257	2,399	5,656	3,857	2,814	6,671
Local systems	-	20	20	30	1,514	1,544	-	4,676	4,676	30	6,210	6,240
Total	24	25	49	606	1,924	2,530	3,257	7,075	10,332	3,887	9,024	12,911
Non-Federal-aid system												
State highways	-	-	-	120	-	120	90	272	362	210	272	482
Local systems	26	118	144	1,304	19,933	21,237	4,676	57,316	61,992	6,006	77,367	83,373
Total	26	118	144	1,424	19,933	21,357	4,766	57,588	62,354	6,216	77,639	83,855
Total Federal-aid state highways	64	38	102	2,479	2,659	5,138	7,738	11,102	18,840	10,281	13,799	24,080
Total Federal-aid local systems	-	69	69	45	6,730	6,775	-	16,757	16,757	45	23,556	23,601
Total Federal-aid systems	64	107	171	2,524	9,389	11,913	7,738	27,859	35,597	10,326	37,355	47,681
Total state highways	64	38	102	2,599	2,659	5,258	7,828	11,374	19,202	10,491	14,071	24,562
Total local systems	26	187	213	1,349	26,663	28,012	4,676	74,073	78,749	6,051	100,923	106,974
Total all systems	90	225	315	3,948	29,322	33,270	12,504	85,447	97,951	16,542	114,994	131,536

### ACCIDENT EXPERIENCE BY HIGHWAY SYSTEMS (In Relation to Highway Mileage and Traffic Volumes)

In the rate comparisons given, the efficiencies of the various systems in accident prevention are made evident. Tables 2 and 3 both give accident rates, Table 2 in accidents per mile and Table 3 in accidents per 100 million vehicle-miles. Table 3 is perhaps of more value because it employs the widely accepted method of comparison of accident experience on highways.

TABLE 2  
MOTOR-VEHICLE TRAFFIC ACCIDENTS PER MILE OF HIGHWAY BY HIGHWAY SYSTEM AND  
SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953<sup>1</sup>

Highway System	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Federal-aid primary system												
State highways	0.03	0.08	0.04	1.70	5.66	2.73	4.00	21.92	8.69	5.73	27.67	11.48
Local systems	-	0.14	0.10	0.12	15.66	11.57	-	36.27	26.72	0.12	52.09	38.40
Total	0.03	0.11	0.06	1.54	10.22	4.76	3.61	28.47	12.83	5.20	38.80	17.66
Federal-aid secondary system												
State highways	0.06	0.06	0.06	1.60	5.18	2.25	9.07	30.36	12.91	10.74	35.62	15.23
Local systems	-	0.04	0.01	0.02	3.38	0.88	-	10.46	2.67	0.02	13.69	3.56
Total	0.01	0.04	0.02	0.36	3.65	1.15	1.96	13.45	4.72	2.34	17.15	5.90
Non-Federal-aid system												
State highways	-	-	-	0.85	-	0.77	0.63	19.42	2.33	1.48	19.42	3.10
Local systems	0.00	0.02	0.00	0.08	3.82	1.05	0.31	11.00	3.06	0.40	14.84	4.12
Total	0.00	0.02	0.00	0.09	3.81	1.04	0.31	11.02	3.06	0.41	14.86	4.12
Total Federal-aid state highways	0.04	0.07	0.05	1.67	5.58	2.62	5.23	23.32	9.64	6.95	28.98	12.32
Total Federal-aid local systems	-	0.08	0.03	0.03	8.62	3.07	-	21.48	7.61	0.03	30.20	10.72
Total Federal-aid systems	0.02	0.08	0.04	0.87	7.47	2.86	2.67	22.18	8.56	3.56	29.74	11.47
Total state highway	0.03	0.07	0.04	1.60	5.42	2.49	4.83	23.21	9.10	6.47	28.71	11.64
Total local systems	0.00	0.03	0.00	0.08	4.45	1.25	0.28	12.36	3.51	0.36	16.84	4.77
Total all systems	0.005	0.03	0.01	0.21	4.52	1.35	0.69	13.18	3.99	0.91	17.74	5.36

<sup>1</sup> Derived from Tables 1 and 4.

TABLE 3  
MOTOR-VEHICLE TRAFFIC ACCIDENTS PER 100 MILLION VEHICLE-MILES BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953<sup>1</sup>

Highway System	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Federal-aid primary system	1.88	1.73	1.81	89.59	118.11	103.07	210.96	457.09	327.30	302.40	578.94	432.17
State highways	-	3.91	3.41	8.33	418.28	385.03	-	964.16	843.05	8.33	1,384.35	1,211.51
Local systems	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.73	2.59	2.23	83.24	236.45	171.81	194.48	658.34	462.64	279.42	897.40	636.67
Federal-aid secondary system	7.92	3.81	6.68	190.09	312.97	227.18	1,074.91	1,831.29	1,303.22	1,273.26	2,148.09	1,537.32
State highways	-	2.49	1.27	3.93	199.01	98.78	-	563.77	299.16	3.93	775.28	399.23
Local systems	-	-	-	-	-	-	-	-	-	-	-	-
Total	3.26	2.68	2.45	56.90	206.43	126.69	305.82	759.12	517.37	365.07	968.24	646.56
Non-Federal-aid system	-	-	-	72.28	-	66.07	54.21	568.66	169.15	126.50	566.66	225.23
State highways	1.10	7.34	3.64	55.48	1,241.15	636.83	198.97	3,568.86	1,587.03	255.87	4,817.37	2,107.50
Local systems	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.03	7.13	3.45	56.59	1,205.13	512.15	189.42	3,481.74	1,495.29	247.05	4,694.01	2,010.91
Total Federal-aid state highways	2.63	1.86	2.26	102.14	130.66	115.15	318.82	545.55	422.23	423.60	678.08	539.66
Total Federal-aid local systems	-	3.35	2.30	4.77	327.65	226.13	-	815.82	559.31	4.77	1,146.83	787.75
Total Federal-aid systems	1.89	2.61	2.29	74.91	229.61	159.79	229.68	681.31	477.29	308.50	913.54	639.32
Total state highways	2.48	1.82	2.18	100.23	127.65	112.44	301.88	548.03	410.65	404.58	678.51	535.27
Total local systems	0.78	5.10	3.06	40.97	728.49	402.93	142.04	2,023.85	1,132.75	163.80	2,787.45	1,538.75
Total all systems	1.52	3.91	2.70	67.08	510.56	286.11	212.47	1,487.84	842.37	281.08	2,002.33	1,131.20

<sup>1</sup> Derived from Tables 1 and 5.

Table 2 does indicate frequency of accidents. It shows that the average number of accidents per mile per year on the state highways is 11.6 as compared with 4.7 on local roads. On these two systems their respective mileages were 2,109 and 22,397. Thus the frequency of accidents on the state highways is more than double that on the local roads, but the state highways constitute only 9 percent of the road mileage in the state.

TABLE 4  
MILEAGE BY HIGHWAY SYSTEM IN MASSACHUSETTS: 1953

Highway System	Rural	Urban	Total
Federal-aid primary system			
State highways	1,119	397	1,516
Local systems	119	333	452
Total	1,238	730	1,968
Federal-aid secondary system			
State highways	359	79	438
Local systems	1,301	447	1,748
Total	1,660	526	2,186
Non-Federal-aid system			
State highways	141	14	155
Local systems	14,987	5,210	20,197
Total	15,128	5,224	20,352
Total Federal-aid state highways	1,478	476	1,954
Total Federal-aid local systems	1,420	780	2,200
Total Federal-aid systems	2,898	1,256	4,154
Total state highways	1,619	490	2,109
Total local systems	16,407	5,990	22,397
Total all systems	18,026	6,480	24,506

Table 4 gives the total mileages and Table 5 the total vehicle-miles on each highway system.

It might be noted here that 4,676 million vehicle-miles of travel were recorded on the state highways and 6,952 million vehicle-miles on the local road systems.

TABLE 5

VEHICLE-MILES OF TRAVEL BY PASSENGER CARS ON LOCAL ROADS  
AND HIGHWAYS BY HIGHWAY SYSTEM IN MASSACHUSETTS: 1953

Highway System	Rural	Urban	Total
	Vehicle-Miles	Vehicle-Miles	Vehicle-Miles
<b>Federal-aid primary system</b>			
State highways	2,124	1,904	4,028
Local systems	180	1,253	1,433
<b>Total</b>	<b>2,304</b>	<b>3,157</b>	<b>5,461</b>
<b>Federal-aid secondary system</b>			
State highways	303	131	434
Local systems	762	801	1,563
<b>Total</b>	<b>1,065</b>	<b>932</b>	<b>1,997</b>
<b>Non-Federal-aid system</b>			
State highways	166	48	214
Local systems	2,350	1,606	3,956
<b>Total</b>	<b>2,516</b>	<b>1,654</b>	<b>4,170</b>
Total Federal-aid state highways	2,427	2,035	4,462
Total Federal-aid local systems	942	2,054	2,996
Total Federal-aid system	3,369	4,089	7,458
Total state highways	2,593	2,083	4,676
Total local systems	3,292	3,660	6,952
<b>Total all systems</b>	<b>5,885</b>	<b>5,743</b>	<b>11,628</b>

The accident rates in Table 3 are most revealing. The figures show the following comparisons in accident rates on each system:

1. In the Federal-aid primary system the accident rate (accidents per 100 million vehicle-miles) on the state highways is 432, and 1,211 on local roads.

2. In the Federal-aid secondary system the ratios are reversed with 1,537 accidents per 100 million vehicle-miles on the state highways and 399 on local roads.

3. In the non-Federal-aid system there is a preponderance of mileage on the local roads. There are 225 accidents per 100 million vehicle-miles on the state highways and 2,107 on local roads.

A consideration of the exposure data may be helpful on analyzing the reversal of ratios in the two Federal-aid groups. The average volumes carried on each subdivision in the Federal-aid primary (FAP) system are not too different. This is also true of the total number of accidents in each subdivision of this system. Therefore, accident rates expressed in accidents per 100 M. V. M. vary inversely with respect to mileage. The same is approximately true of state highway and local road subdivisions in the Federal-aid secondary (FAS) system. Thus, in the primary system, the state highway road mileage is three times that on the local roads whereas its accident rate is only one-third that of the local roads.

In the secondary system, the state highway mileage is one-fourth that on the local roads and the state highway accident rate is four times that of the local roads.

The reversal of accident ratios in the various systems became the cause of special study in an attempt to determine the reason therefor. Comparisons of the number of accidents per mile of highway and the number of accidents per million vehicle-miles were both studied in relation to their respective system mileages.

In neither of these possibilities could a definite indication or trend be detected.

There did appear to be a relationship between the number of accidents in terms of vehicle-miles as related to their average traffic volumes. However, this was not sufficiently pronounced to substantiate any definite conclusions as to the reasons for the variation of accident rates in the various systems.

A possible interim conclusion might be that the priority given to the construction of limited-access highways on the FAP system, and financial assistance to the municipalities for local roads in the FAS system since World War II have reduced the accident rates on those systems.

These results do lead to the conclusion that on an accident rate basis, the state highways in the FAP system and the local roads in the FAS system are doing a good job. On the contrary, the results in terms of accident rates on the local roads in the FAP system and the state highways in the FAS system indicate a definite need for improvement on these systems.

This need for improvement most certainly obtains in the case of the non-Federal-aid local roads with their high accident totals, extensive mileage and high rate of accidents per 100 million vehicle-miles.

#### ECONOMIC COSTS—TOTAL

The foregoing has been purposely confined to an explanation of accident experience and accident rates on the roadway systems. This was done in order to promote a clearer understanding of the accident picture in Massachusetts. It is a fact, however, that an important and integral part of any motor-vehicle accident—and aside from the aspect of personal injury, suffering and inconvenience involved—is the monetary cost incurred.

In this paper monetary costs are confined to "direct" costs only. "Direct" costs are defined as the money value of damages and losses to persons and property that were the direct result of these accidents and which might have been saved for the car owner had these accidents not occurred. "Direct" costs are composed of the money value of damage to property, hospitalization, doctors, dentists, and nursing service, ambulance use, medicine, work time lost, damages awarded in excess of other direct costs, attorney's services, court fees, and other miscellaneous but small items.

The Economic Cost of Accidents in Relation to the Highway Systems is given in Tables 6 and 7.

Table 6 covers the over-all costs and Table 7 gives a breakdown showing average cost per accident on each highway system. The value of Table 7 is that it brings into sharp focus the cost to an individual of having an accident and that the cost may vary from \$203, the figure for an average property-damage accident, up to \$5,499 for an average fatal accident in urban areas.

For those who include among their responsibilities the improvement of accident-prone highways the over-all costs of accidents on the highway systems in Table 6 are of special significance.

In 1953 there occurred a total of 131,536 accidents which involved \$50,223,500 in direct costs. Fatal accidents made up 3 percent, non-fatal injury accidents 57 percent and property-damage accidents 40 percent of this cost.

Earlier it was stated that an attempt would be made to point out where special attention is needed in order to reduce accidents and economic costs. The cost breakdown by highway systems provides a means for highlighting the enormous cost of accident-prone highways.

In this cost breakdown it is interesting to examine the cost comparisons in the light of what was previously found through accident rate comparisons. This may be done in three sections as before.



1. Federal-aid primary system. — State highways have a better accident rate than local roads in the ratio of 1 to 3 (Table 3). However, the state highway accident costs (Table 6) exceed those on the local roads, being \$9,909,530 and \$7,282,410 respectively.

The highest costs in each subdivision of the FAP system are those incurred in urban non-fatal accidents; that is, in accidents where non-fatal injuries are involved and they amounted to \$8,863, - 230. State and local roads each show a total cost of approximately \$4,400,000. Thus, in the non-fatal injury accident category, urban areas accounted for 52 percent of the total cost in the FAP system while the state highways make up almost all of the cost in the rural areas.

Property-damage accidents were especially costly in both rural and urban subdivisions but these costs were only 52 percent of the non-fatal figures.

2. Federal-aid secondary system. — On these roads the total accident cost is only 29 percent of that on the FAP roads or \$5,036,540 to \$17,191,940.

Here again the dissimilarity between accident rate comparisons and cost comparisons is worthy of note. On the FAS system local roads have a comparatively low accident rate and state highways a much greater one in the ratio of 4 to 15. Nevertheless, the accident costs are in the ratio of only 4 to 6 on local roads vs state highways.

Another noteworthy fact is that property damage costs are greater on the FAS system than are those of non-fatal injury accidents. This is due to a preponderance of minor, less-costly accidents on the FAS system.

3. Non-Federal-aid system. — These roads form the large network of local streets and connecting highways. Compared with the roads in the other systems they carry less average traffic, their accident rate expressed in number of accidents per mile is less and yet because they compose 20,352 of the state's 24, - 506 mi they account for 83,855 accidents which cost \$27,995,020 out of the total \$50,223,500.

Non-fatal injury accidents account for \$15,974,500, property-damage accidents for \$11,269,060, and fatal accidents for \$751,460 of the \$27,995,020.

TABLE 6  
DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS, 1953

	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)
<b>Highway System</b>												
Federal-aid primary system												
State highways	214,480	179,750	394,170	1,920,530	4,428,550	6,349,080	1,198,760	1,976,320	3,166,280	3,324,710	6,584,820	9,909,530
Local systems	-	269,640	269,640	28,800	4,434,980	4,463,480	-	2,550,290	2,550,290	26,800	7,233,610	7,282,410
<b>Total</b>	214,480	448,390	662,810	1,949,330	8,863,230	10,812,560	1,198,760	4,526,610	5,716,570	3,353,510	13,858,430	17,191,940
Federal-aid secondary system												
State highways	83,700	28,620	111,220	528,500	416,980	945,480	655,220	1,290,530	1,946,750	1,267,420	1,795,730	3,003,150
Local systems	-	115,560	115,560	4,500	950,410	954,910	-	962,220	962,220	4,500	2,029,890	2,033,390
<b>Total</b>	83,700	148,780	227,480	533,000	1,367,390	1,900,390	655,220	2,253,450	2,908,670	1,271,920	3,764,820	5,036,540
Non-Federal-aid system												
State highways	106,390	645,070	751,460	134,400	5,430	134,400	5,430	19,910	25,840	129,830	19,910	159,740
Local systems	106,390	645,070	751,460	859,200	14,980,900	15,640,100	693,040	10,565,660	11,269,060	1,800,630	26,174,630	27,995,020
<b>Total</b>	212,780	1,290,140	1,502,920	993,600	14,980,900	15,974,500	700,470	10,585,570	11,294,900	1,800,460	26,194,560	27,995,020
Total Federal-aid state highways	298,180	207,870	506,050	2,449,080	4,845,530	7,294,560	1,844,980	3,287,050	5,112,030	4,592,130	8,320,550	12,912,680
Total Federal-aid local systems	298,120	384,200	682,320	33,300	5,416,390	5,449,690	-	3,515,210	3,515,210	33,300	9,282,500	9,315,800
Total state highways	298,120	592,170	890,290	2,482,330	10,230,620	12,712,950	1,844,980	6,780,280	8,625,230	4,825,430	17,605,050	22,228,480
Total local highways	106,390	207,870	314,260	2,593,480	4,845,530	5,439,010	1,850,410	3,286,960	5,137,370	6,340,480	13,072,420	16,514,840
Total all systems	404,510	1,237,240	1,641,750	3,475,930	25,211,520	28,687,450	2,545,450	17,348,950	19,894,300	6,423,890	43,797,610	50,223,500

TABLE 7  
DIRECT COSTS PER MOTOR-VEHICLE TRAFFIC ACCIDENTS BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER  
CARS REGISTERED IN MASSACHUSETTS: 1953<sup>1</sup>

Highway System	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)
<b>Federal-aid primary system</b>												
State highways	5,361	5,447	5,400	1,009	1,969	1,529	266	227	240	518	599	569
Local systems	-	5,482	5,482	1,920	850	853	-	211	211	1,920	418	419
<b>Total</b>	<b>5,361</b>	<b>5,468</b>	<b>5,433</b>	<b>1,016</b>	<b>1,167</b>	<b>1,152</b>	<b>266</b>	<b>218</b>	<b>226</b>	<b>521</b>	<b>498</b>	<b>494</b>
<b>Federal-aid secondary system</b>												
State highways	3,488	5,644	3,859	918	1,017	959	201	538	344	329	617	450
Local systems	-	5,778	5,778	150	628	618	-	206	206	150	327	326
<b>Total</b>	<b>3,488</b>	<b>5,751</b>	<b>4,642</b>	<b>880</b>	<b>711</b>	<b>751</b>	<b>201</b>	<b>319</b>	<b>282</b>	<b>327</b>	<b>417</b>	<b>390</b>
<b>Non-Federal-aid system</b>												
State highways	4,092	-	-	1,120	-	1,120	60	73	70	666	73	331
Local systems	-	5,467	5,218	659	752	746	149	184	181	276	338	334
<b>Total</b>	<b>4,092</b>	<b>5,467</b>	<b>5,218</b>	<b>698</b>	<b>752</b>	<b>748</b>	<b>147</b>	<b>184</b>	<b>181</b>	<b>290</b>	<b>337</b>	<b>334</b>
<b>Total Federal-aid state highways</b>	<b>4,658</b>	<b>5,473</b>	<b>4,962</b>	<b>988</b>	<b>1,822</b>	<b>1,420</b>	<b>238</b>	<b>294</b>	<b>271</b>	<b>447</b>	<b>603</b>	<b>536</b>
<b>Total Federal-aid local systems</b>	<b>-</b>	<b>5,568</b>	<b>5,568</b>	<b>740</b>	<b>800</b>	<b>800</b>	<b>-</b>	<b>210</b>	<b>210</b>	<b>740</b>	<b>394</b>	<b>395</b>
<b>Total Federal-aid systems</b>	<b>4,658</b>	<b>5,534</b>	<b>5,206</b>	<b>763</b>	<b>1,080</b>	<b>1,067</b>	<b>238</b>	<b>242</b>	<b>242</b>	<b>448</b>	<b>471</b>	<b>466</b>
<b>Total state highways</b>	<b>4,658</b>	<b>5,473</b>	<b>4,962</b>	<b>994</b>	<b>1,822</b>	<b>1,413</b>	<b>238</b>	<b>286</b>	<b>268</b>	<b>451</b>	<b>593</b>	<b>532</b>
<b>Total local systems</b>	<b>4,092</b>	<b>5,504</b>	<b>5,332</b>	<b>662</b>	<b>7,639</b>	<b>759</b>	<b>149</b>	<b>180</b>	<b>187</b>	<b>280</b>	<b>351</b>	<b>347</b>
<b>Total all systems</b>	<b>4,495</b>	<b>5,499</b>	<b>5,212</b>	<b>880</b>	<b>880</b>	<b>882</b>	<b>204</b>	<b>203</b>	<b>203</b>	<b>388</b>	<b>381</b>	<b>382</b>

<sup>1</sup> Derived from Tables 1 and 6.

Of this amount \$26,194,560 was incurred in urban areas. Thus besides having a high accident rate in terms of accidents per 100 million vehicle-miles on its local road subdivision, the non-Federal-aid (NFA) system is responsible for 56 percent of the monetary cost of accidents in the state.

### ECONOMIC COSTS—RATES

The total costs of accidents on each highway system (Table 6) permits a comparison of total monetary costs.

As previously noted the efficiency of a highway in terms of accidents may be obtained by comparing accident rates. This is also true when comparing economic loss expressed in accident cost rates.

Cost rates are given in Tables 8 and 9 and shown in Figures 2 and 3.

Figure 2 shows costs per mile of highway on each highway system and Figure 3 shows costs per 100 million vehicle-miles.

An analysis of Figure 2 indicates that the highest accident cost per mile of highway, \$16,112, is on the FAP local roads. Second highest is \$6,857 on FAS state highways and third \$6,537 on FAP state highways. Costs per mile on the remaining systems are minor in comparison. It should be stressed here that these costs are average costs only and that costs fluctuate greatly on the many types of roadways in each system. Costs per mile, of course, present only one side of the picture and do not reflect the volumes of traffic carried.

Figure 3 shows cost on a vehicle-mile basis.

The comparison obtainable in Figure 3 may be further simplified by reducing the cost per 100 million vehicle-miles, in dollars, to the cost per car-mile expressed in cents.

The state highways as a whole are costing the motorist an average of 0.28 cents per car-mile while the local roads are costing the motorist 0.53 cents per car-mile as shown in the following comparative summary of the total costs per passenger car-mile on each system:

## System

## Costs in Cents

	S. H.	Local Roads
FAP	0.24	0.50
FAS	0.69	0.13
NFA	0.07	0.70

## ECONOMIC COST BY TYPES OF COLLISIONS

The two main sections into which types of accidents may be grouped are (1) collisions between two or more vehicles and (2) accidents involving only one vehicle (Table 10). Subdivisions of the first group include head-on, read-end, angle, sideswipe (same direction) sideswipe (opposite direction), and other collisions. The last group

TABLE 8  
DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS PER MILE OF HIGHWAY BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953<sup>1</sup>

Highway System	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)
<b>Federal-aid primary system</b>												
State highways	192	453	260	1,716	11,155	4,188	1,063	4,979	2,089	2,971	16,586	6,537
Local systems	-	807	594	242	13,317	9,875	-	7,659	5,642	242	21,783	16,112
<b>Total</b>	<b>173</b>	<b>614</b>	<b>337</b>	<b>1,575</b>	<b>12,141</b>	<b>5,494</b>	<b>961</b>	<b>6,201</b>	<b>2,905</b>	<b>2,709</b>	<b>18,957</b>	<b>8,736</b>
<b>Federal-aid secondary system</b>												
State highways	233	357	256	1,472	5,278	2,159	1,825	16,336	4,442	3,530	21,971	6,857
Local systems	-	259	66	3	2,126	546	-	2,154	551	3	4,539	1,163
<b>Total</b>	<b>50</b>	<b>273</b>	<b>104</b>	<b>321</b>	<b>2,600</b>	<b>869</b>	<b>395</b>	<b>4,284</b>	<b>1,331</b>	<b>766</b>	<b>7,157</b>	<b>2,304</b>
<b>Non-Federal-aid system</b>												
State highways	-	-	-	953	-	867	39	1,422	163	992	1,422	1,031
Local systems	7	124	37	57	2,875	784	46	2,085	557	111	5,024	1,378
<b>Total</b>	<b>7</b>	<b>123</b>	<b>37</b>	<b>66</b>	<b>2,868</b>	<b>785</b>	<b>46</b>	<b>2,023</b>	<b>554</b>	<b>119</b>	<b>5,014</b>	<b>1,376</b>
<b>Total Federal-aid state highways</b>	<b>202</b>	<b>437</b>	<b>259</b>	<b>1,657</b>	<b>10,180</b>	<b>3,733</b>	<b>1,248</b>	<b>6,864</b>	<b>2,616</b>	<b>3,107</b>	<b>17,480</b>	<b>6,608</b>
<b>Total Federal-aid local systems</b>	<b>-</b>	<b>493</b>	<b>175</b>	<b>23</b>	<b>6,904</b>	<b>2,463</b>	<b>-</b>	<b>4,504</b>	<b>1,597</b>	<b>23</b>	<b>11,901</b>	<b>4,234</b>
<b>Total Federal-aid systems</b>	<b>103</b>	<b>471</b>	<b>214</b>	<b>857</b>	<b>8,145</b>	<b>3,060</b>	<b>637</b>	<b>5,398</b>	<b>2,078</b>	<b>1,596</b>	<b>14,015</b>	<b>5,351</b>
<b>Total state highways</b>	<b>184</b>	<b>424</b>	<b>240</b>	<b>1,596</b>	<b>9,889</b>	<b>3,523</b>	<b>1,143</b>	<b>6,708</b>	<b>2,438</b>	<b>2,923</b>	<b>17,021</b>	<b>6,198</b>
<b>Total local systems</b>	<b>6</b>	<b>172</b>	<b>51</b>	<b>54</b>	<b>3,400</b>	<b>949</b>	<b>42</b>	<b>2,348</b>	<b>659</b>	<b>103</b>	<b>5,919</b>	<b>1,659</b>
<b>Total all systems</b>	<b>22</b>	<b>191</b>	<b>67</b>	<b>19</b>	<b>3,891</b>	<b>1,171</b>	<b>141</b>	<b>2,677</b>	<b>812</b>	<b>356</b>	<b>6,759</b>	<b>2,049</b>

<sup>1</sup> Derived from Tables 4 and 6.

TABLE 9  
DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS PER 100 MILLION VEHICLE-MILES BY HIGHWAY SYSTEM AND SEVERITY FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953<sup>1</sup>

Highway System	Severity of Accident											
	Fatal			Non-Fatal			Property Damage			Total		
	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)	Rural (\$)	Urban (\$)	Total (\$)
<b>Federal-aid primary system</b>												
State highways	10,095	9,441	9,786	90,420	232,592	157,624	56,015	103,809	78,807	156,531	345,841	246,016
Local systems	-	21,440	25,725	16,000	253,925	311,478	-	208,535	177,989	16,000	578,899	508,193
<b>Total</b>	<b>9,306</b>	<b>14,203</b>	<b>12,137</b>	<b>84,606</b>	<b>280,748</b>	<b>197,996</b>	<b>51,639</b>	<b>143,390</b>	<b>104,690</b>	<b>145,552</b>	<b>436,341</b>	<b>314,613</b>
<b>Federal-aid secondary system</b>												
State highways	27,624	21,543	25,788	174,422	318,305	217,853	216,244	985,137	448,329	418,290	1,324,985	691,970
Local systems	-	14,427	7,393	591	118,653	61,095	-	130,215	61,607	591	253,295	130,095
<b>Total</b>	<b>7,869</b>	<b>15,427</b>	<b>11,391</b>	<b>50,047</b>	<b>146,716</b>	<b>95,162</b>	<b>61,523</b>	<b>241,786</b>	<b>145,652</b>	<b>119,429</b>	<b>408,929</b>	<b>252,206</b>
<b>Non-Federal-aid system</b>												
State highways	-	-	-	80,964	-	62,804	3,271	41,479	11,941	84,235	41,479	74,645
Local systems	4,527	40,166	18,995	38,563	932,808	400,407	29,576	656,629	284,219	70,665	1,629,804	703,622
<b>Total</b>	<b>4,229</b>	<b>39,001</b>	<b>18,021</b>	<b>39,491</b>	<b>905,739</b>	<b>383,082</b>	<b>27,841</b>	<b>536,972</b>	<b>270,241</b>	<b>71,560</b>	<b>1,583,710</b>	<b>671,343</b>
<b>Total Federal-aid state highways</b>	<b>12,263</b>	<b>10,220</b>	<b>11,342</b>	<b>100,908</b>	<b>238,110</b>	<b>163,482</b>	<b>76,019</b>	<b>160,543</b>	<b>114,568</b>	<b>189,210</b>	<b>408,872</b>	<b>289,392</b>
<b>Total Federal-aid local systems</b>	<b>-</b>	<b>18,705</b>	<b>12,824</b>	<b>3,535</b>	<b>262,176</b>	<b>180,954</b>	<b>-</b>	<b>171,042</b>	<b>117,263</b>	<b>3,535</b>	<b>451,923</b>	<b>310,941</b>
<b>Total Federal-aid systems</b>	<b>8,940</b>	<b>14,482</b>	<b>11,937</b>	<b>73,682</b>	<b>250,199</b>	<b>170,461</b>	<b>54,763</b>	<b>165,817</b>	<b>115,651</b>	<b>137,294</b>	<b>430,498</b>	<b>298,049</b>
<b>Total state highways</b>	<b>11,497</b>	<b>9,984</b>	<b>10,823</b>	<b>99,631</b>	<b>232,623</b>	<b>158,874</b>	<b>71,362</b>	<b>157,799</b>	<b>109,987</b>	<b>182,480</b>	<b>400,406</b>	<b>279,564</b>
<b>Total local systems</b>	<b>3,332</b>	<b>28,122</b>	<b>16,336</b>	<b>27,111</b>	<b>556,448</b>	<b>305,790</b>	<b>21,113</b>	<b>384,205</b>	<b>212,269</b>	<b>51,456</b>	<b>988,775</b>	<b>534,394</b>
<b>Total all systems</b>	<b>6,874</b>	<b>21,543</b>	<b>14,119</b>	<b>59,064</b>	<b>438,986</b>	<b>246,710</b>	<b>43,253</b>	<b>302,087</b>	<b>171,090</b>	<b>109,191</b>	<b>762,626</b>	<b>431,919</b>

<sup>1</sup> Derived from Tables 5 and 6.

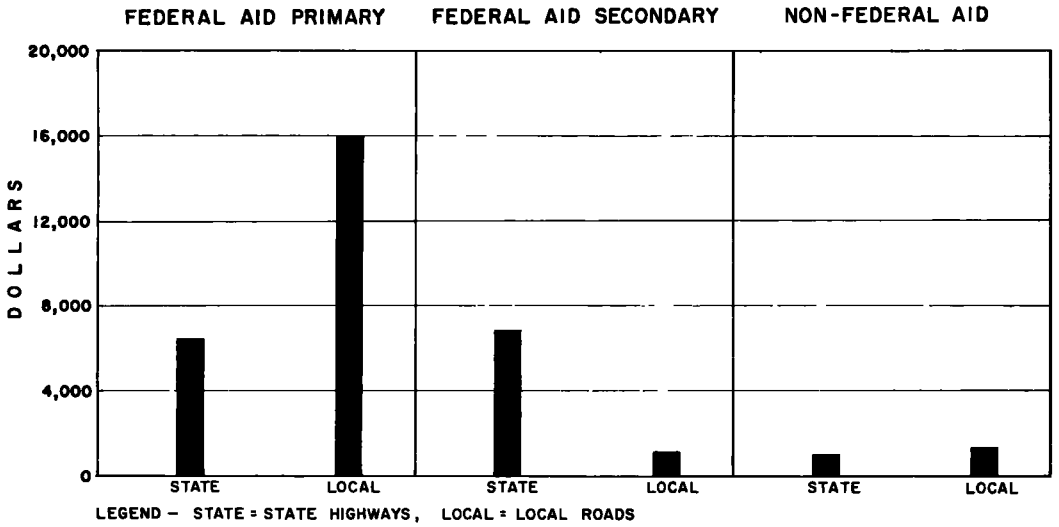


Figure 2. Direct cost of accidents per mile of highway by highway systems.

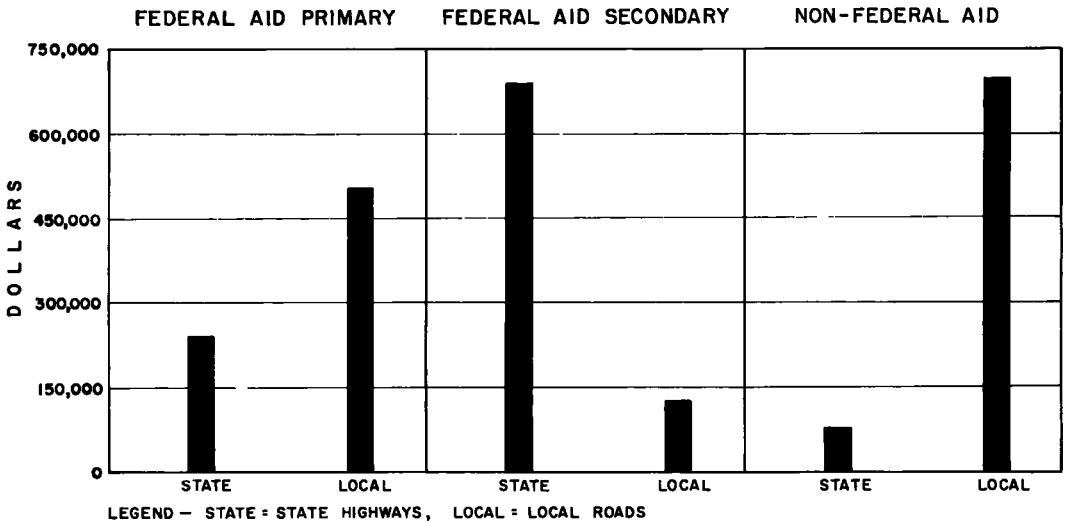


Figure 3. Direct cost of accidents per 100 million vehicle-miles by highway systems.

includes turning movements, parking maneuvers, and backing in traffic lane. The second main grouping includes pedestrian, fixed objects, other objects, and non-collision accidents. Other objects include vehicles such as bicycles, scooters, etc.

In these two groups, 109,730 (84 percent of the total) are two-car accidents while 21,806 (16 percent) are single car accidents. Angle collisions are first in number, rear-end collisions second, other collisions third, and head-on collisions fourth.

A comparison by types of collisions on the six highway systems is also given in Table 10. The percentage breakdowns on the state and local systems are most interesting. While rear-end collisions on each system bear about the same proportion to the total collisions in the system (17 percent on state highways and 17 percent on local roads), angle collisions are more frequent being 23 percent on state highways

TABLE 10  
MOTOR-VEHICLE TRAFFIC ACCIDENTS BY TYPE OF ACCIDENT AND HIGHWAY SYSTEM  
FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953

Type of Accident	Federal-Aid Primary System		Federal-Aid Secondary System		Non-Federal-Aid System		Total	Total	Total	Total
	State Highway	Local System	State Highway	Local System	State Highway	Local System	Federal- Aid Systems	State Highway	Local Systems	All Systems
Collision with:										
One or more motor-vehicles										
Head-on	2,306	1,462	631	514	15	7,751	4,913	2,952	9,727	12,679
Rear-end	3,403	3,395	864	1,273	15	13,363	8,935	4,282	18,031	22,313
Angle	4,367	7,726	1,276	2,000	15	34,484	15,369	5,658	44,210	49,868
Sideswipe—same direction	1,281	1,070	150	151	-	4,397	2,652	1,431	5,618	7,049
Sideswipe—opposite direction	433	226	15	90	-	708	764	448	1,024	1,472
Other collisions	2,129	1,333	1,086	1,050	181	10,570	5,598	3,396	12,953	16,349
Total	13,919	15,212	4,022	5,078	226	71,273	38,231	18,167	91,563	109,730
Pedestrian	201	327	248	283	30	4,759	1,059	479	5,369	5,848
Fixed objects	745	734	679	726	15	4,361	2,884	1,439	5,821	7,260
Other objects	1,751	875	1,146	153	181	2,358	3,925	3,078	3,396	6,464
Non collision	792	213	577	-	30	622	1,582	1,399	835	2,234
Total	3,489	2,149	2,650	1,162	256	12,100	9,450	6,395	15,411	21,806
Total	17,408	17,361	6,672	6,240	482	83,373	47,681	24,562	106,974	131,536

and 44 percent on the local systems. Pedestrian collisions account for only 2 percent of the collisions on state highways against 5 percent on local roads. Collisions with fixed objects are in about equal proportion, 6 percent on state and 5 percent on local roads.

The costs of the various types of accidents are given in Tables 11 and 12. Table 11 gives total costs and Table 12 gives costs per 100 million vehicle-miles. Table 12 furnishes the data for Figures 4 to 9. These figures show the direct cost of (1) collisions between passenger cars or between passenger cars and other motor vehicles and (2) single car accidents.

An analysis of the results may be made by grouping them into the three main highway systems and comparing the costs per 100 million vehicle-miles on the state highways and on the local roads in each system.

1. Federal-aid primary system. — Figure 4 in the FAP system furnishes a comparison of the costs per 100 million vehicle-miles of each of the six types of collisions in cases where two or more vehicles are involved. Figure 5 gives cost rates of each of the four types of collisions where single-vehicle accidents are involved.

Comparisons are also obtainable on the state and local road systems.

The highest cost rate on the state highways is found in head-on collisions, with rear-end second and angle types third. On local roads the order of cost rates is angle collision first, rear-end second and head-on types third.

In the local road system several types have much higher cost rates than their respective types in the state highway system; that is, angle types, rear-end collisions, fixed object and pedestrian types. The head-on collision cost rate is higher on the state highways.

Reduced to a cost per passenger car-mile basis, the total cost in the FAP system for all types of collisions on the state highways is 0.24 while the local road cost rate is 0.50 cents.

2. Federal-aid secondary system. — Figures 6 and 7 show the cost breakdown by types on the FAS system.

The highest cost on the state highways is in rear-end collisions with angle types second, and "other" types third. The latter include parking maneuvers, backing, and turning movements.

The highest cost on the local roads is in angle types with rear-end second, and head-on third.

Cost rates of all types on the state roads exceed those on local roads. In terms of

TABLE 11  
DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS BY TYPE OF ACCIDENT AND HIGHWAY  
SYSTEM FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953

Type of Accident	Federal-Aid Primary System		Federal-Aid Secondary System		Non-Federal-Aid System		Total	Total	Total	Total
	State Highway (\$)	Local System (\$)	State Highway (\$)	Local System (\$)	State Highway (\$)	Local System (\$)	Federal- Aid Systems (\$)	State Highways (\$)	Local Systems (\$)	All Systems (\$)
	Collision with:									
One or more motor-vehicles										
Head-on	3,857,550	958,730	312,490	288,060	36,950	3,513,630	5,416,830	4,206,990	4,760,420	8,987,410
Rear-end	1,745,000	2,140,330	761,900	490,670	20,400	5,561,050	8,137,900	2,527,300	8,192,050	10,719,350
Angle	1,406,100	2,503,180	528,530	658,060	16,500	11,973,340	5,185,870	2,041,130	15,134,580	17,175,710
Sideswipe—same direction	487,980	221,920	83,310	39,640	-	1,104,170	832,850	571,290	1,365,730	1,937,020
Sideswipe—opposite direction	339,850	97,100	43,500	33,040	-	186,460	513,490	383,350	316,600	699,950
Other collisions	452,570	293,600	465,170	186,600	5,430	912,600	1,397,940	923,170	1,392,800	2,315,970
Total	8,379,050	6,214,860	2,194,900	1,696,070	79,280	23,251,250	18,494,880	10,653,230	31,162,180	41,815,410
Pedestrian	150,250	268,980	55,220	62,710	31,500	2,799,550	537,160	236,970	3,131,240	3,366,210
Fixed objects	547,850	670,290	225,310	145,710	35,400	1,395,380	1,589,160	808,560	2,211,380	3,019,940
Other objects	122,350	93,520	194,170	128,900	10,860	135,150	538,940	327,380	357,670	684,950
Non collision	710,030	34,760	333,550	-	2,700	253,950	1,078,340	1,046,280	268,710	1,334,990
Total	1,530,480	1,067,550	808,250	337,320	80,460	4,584,030	3,743,600	2,419,190	5,988,900	8,408,090
Total	9,909,530	7,282,410	3,003,150	2,033,390	159,740	27,835,280	22,238,480	13,072,420	37,151,080	50,223,500

TABLE 12  
DIRECT COSTS OF MOTOR-VEHICLE TRAFFIC ACCIDENTS PER 100 MILLION VEHICLE-MILES BY HIGHWAY  
SYSTEM AND TYPE OF ACCIDENT FOR PASSENGER CARS REGISTERED IN MASSACHUSETTS: 1953<sup>1</sup>

Type of Accident	Federal-Aid Primary System		Federal-Aid Secondary System		Non-Federal-Aid System		Total	Total	Total	Total
	State Highway (\$)	Local System (\$)	State Highway (\$)	Local System (\$)	State Highway (\$)	Local System (\$)	Federal- Aid Systems (\$)	State Highways (\$)	Local Systems (\$)	All Systems (\$)
	Collision with:									
One or more motor-vehicles										
Head-on	95,768	66,904	72,002	18,430	17,266	86,818	72,631	89,970	68,476	77,119
Rear-end	43,322	149,360	175,553	31,393	9,533	140,573	68,891	54,048	117,837	92,186
Angle	37,142	174,661	121,781	42,102	7,710	302,663	69,535	43,651	217,701	147,710
Sideswipe—same direction	12,115	15,486	19,196	2,536	-	27,911	11,167	12,218	19,645	16,658
Sideswipe—opposite direction	8,437	6,776	10,023	2,114	-	4,713	6,885	8,198	4,554	6,020
Other collisions	11,236	20,489	107,182	11,939	2,538	23,069	18,744	19,743	20,035	19,917
Total	208,020	433,696	505,737	108,514	37,047	587,747	247,853	227,828	448,248	359,610
Pedestrian	3,730	18,770	12,723	4,012	14,720	70,767	7,203	5,088	45,041	28,966
Fixed objects	13,601	46,775	51,915	9,322	16,542	35,273	21,308	17,292	31,809	25,971
Other objects	3,038	6,526	44,740	8,247	5,075	3,416	7,226	7,001	5,143	5,891
Non collision	17,627	2,426	76,855	-	1,261	6,419	14,450	22,375	4,153	11,481
Total	37,996	74,497	186,233	21,581	37,598	115,875	50,196	51,736	86,146	72,309
Total	246,016	508,193	691,970	130,095	74,645	703,622	298,049	279,564	534,394	431,919

<sup>1</sup> Derived from Tables 5 and 11.

cost per passenger car-mile, the total cost in the FAS system on state roads was 0.69 cents as compared with 0.13 cents on local roads.

3. Non-Federal-aid system.—Figures 8 and 9 show the cost breakdown by types on the NFA system.

The highest cost on the state highways is in fixed object cases with pedestrian accidents second.

The highest cost on the local roads is in angle types and amounts to \$302,663 per 100 million vehicle-miles. This, incidentally, exceeds the figures on any type in any highway system by a wide margin. Second in cost-rate are rear-end types, third head-on, and fourth pedestrian accidents. In comparing costs in each of the two highway subdivisions in the NFA system, it should be stressed that the mileage on the state roads is only 155 while that on the local roads is 20,197.

The cost per passenger car-mile in the NFA system on the state roads is 0.07 cents while the cost per passenger car-mile on the local roads is 0.70 cents.

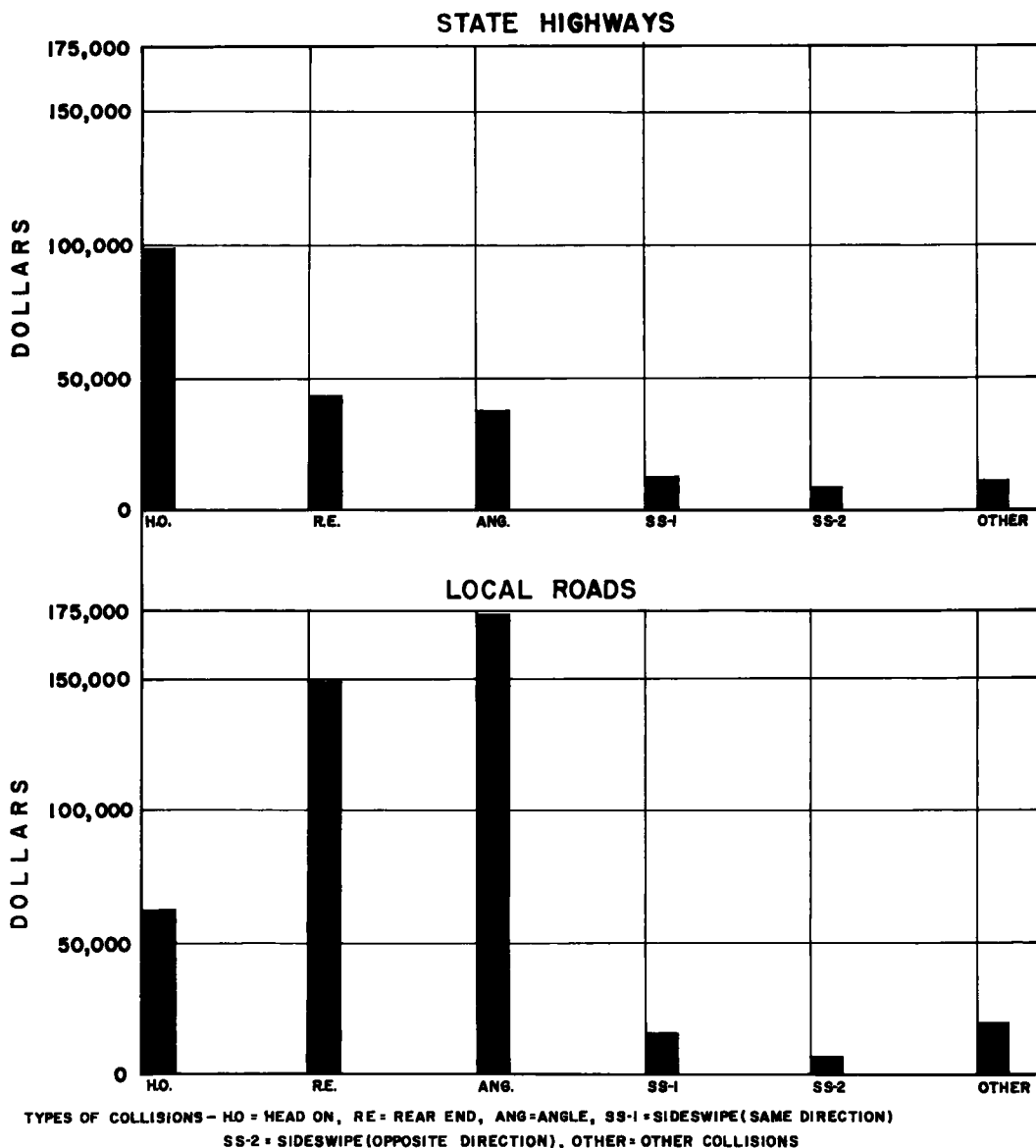


Figure 4. Federal-aid primary system—direct cost per 100 million vehicle-miles of collisions between: (a) passenger cars, and (b) passenger cars and other motor vehicles.

#### ECONOMIC COSTS ON SELECTED SECTIONS OF STATE HIGHWAYS IN MASSACHUSETTS

In the analysis of the accident records and economic costs on the six highway systems a general picture has been obtained on a statewide basis. To get an idea of the economic costs on specific sections of highway it may be of interest to consider the results contained in an Accident Rate and Cost Study prepared in 1957. This study was based on the accidents reported to the Registrar of Motor-Vehicles in 1955. The purpose of the study was to determine the direct costs of accidents on two types of state highways; namely, those having no control of access and those on which access was controlled. Four highways were selected of the former type and they included

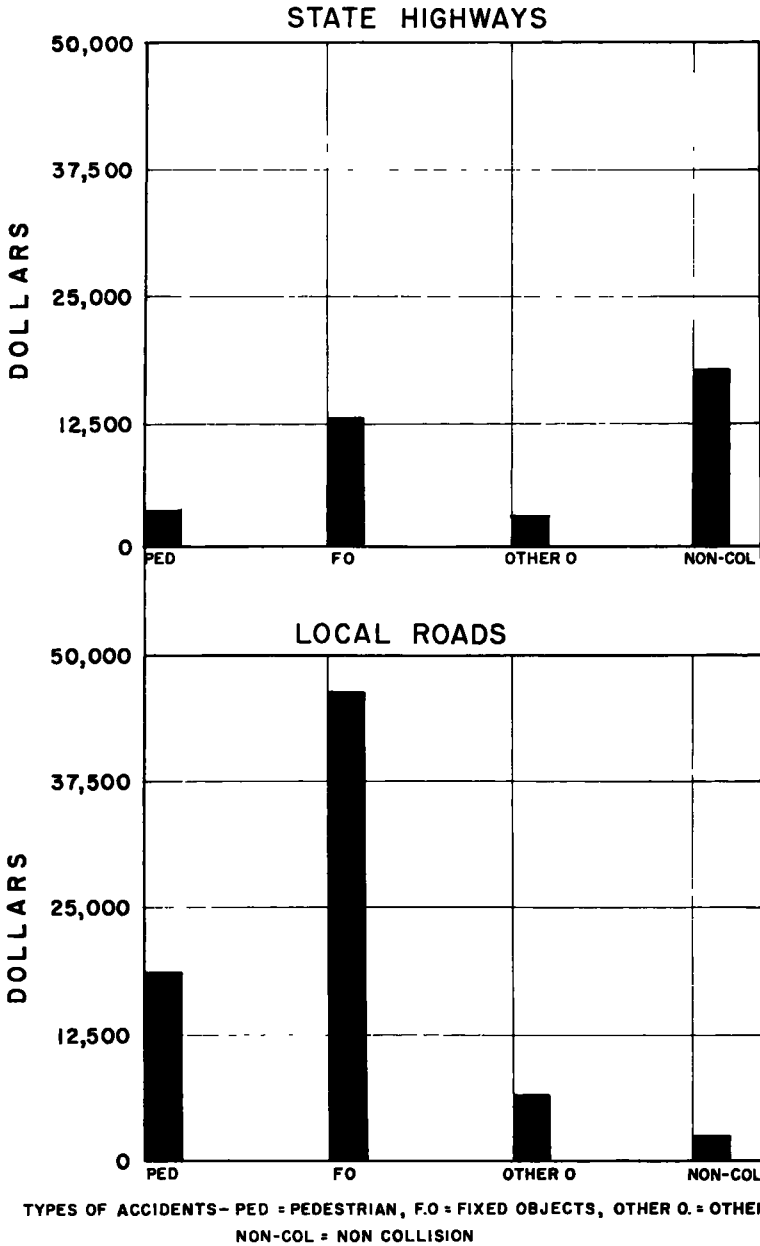


Figure 5. Federal-aid primary system--direct cost per 100 million vehicle-miles of single car accidents (passenger cars only).



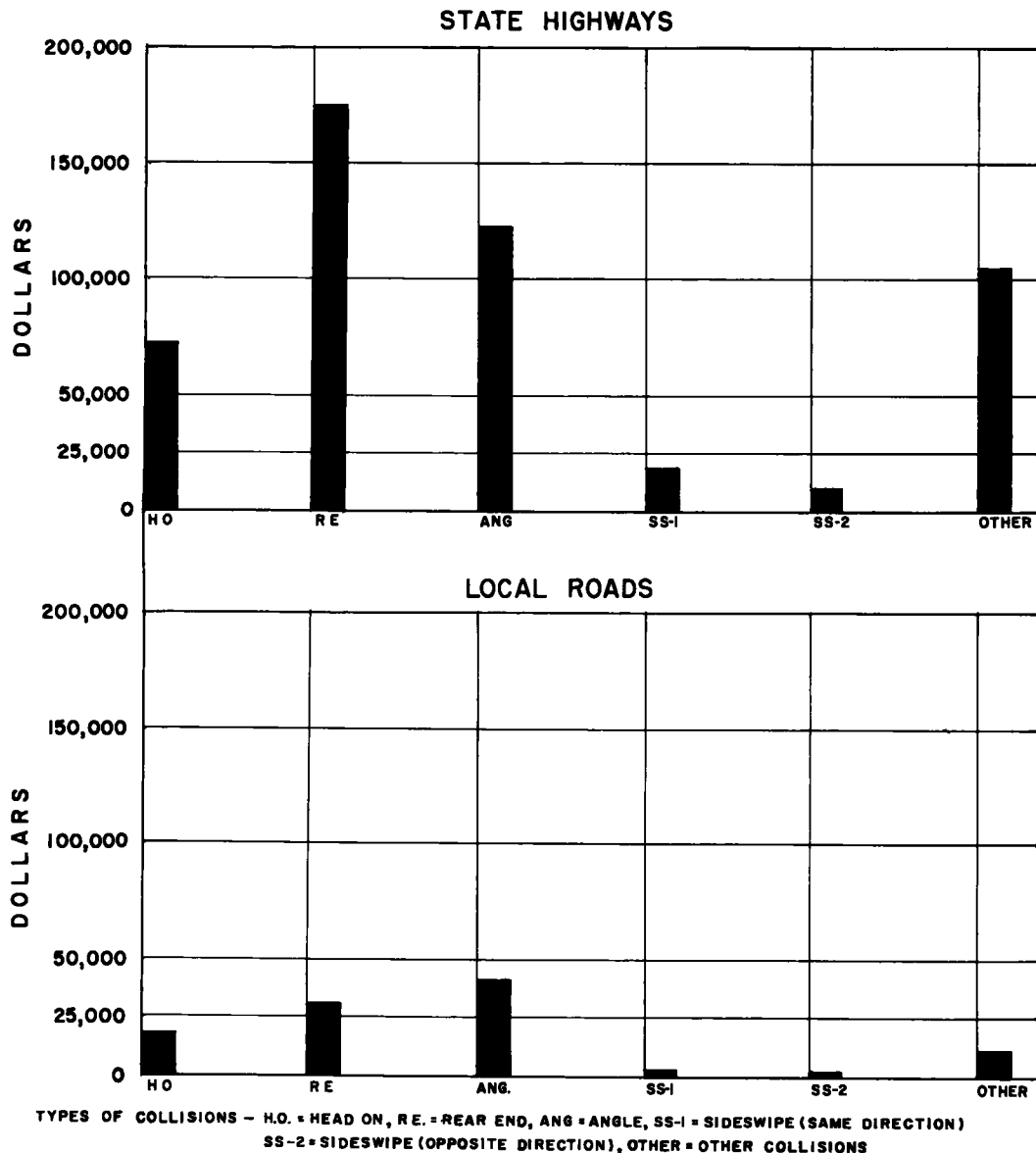


Figure 6. Federal-aid secondary system—direct cost per 100 million vehicle-miles of collisions between: (a) passenger cars, and (b) passenger cars and other motor vehicles.

2-, 3-, 4- and 6-lane roads. Five highways were of the latter type and all of these were 4-lane divided roads which had been opened to traffic since June 1952. As part of the study, two curves (Fig. 10) were prepared by plotting the yearly accident cost per mile against traffic volume (ADT) for each of the nine sections of highway. The costs used were based on the results of the Massachusetts Accident Cost Study and were direct costs only. This chart shows a yearly saving in cost of accidents per mile of highway of \$18,000 at 10,000 vehicles per day and \$68,000 at 25,000 vehicles per day on the controlled-access roads.

It was pointed out in the study that because this was an initial attempt, future studies

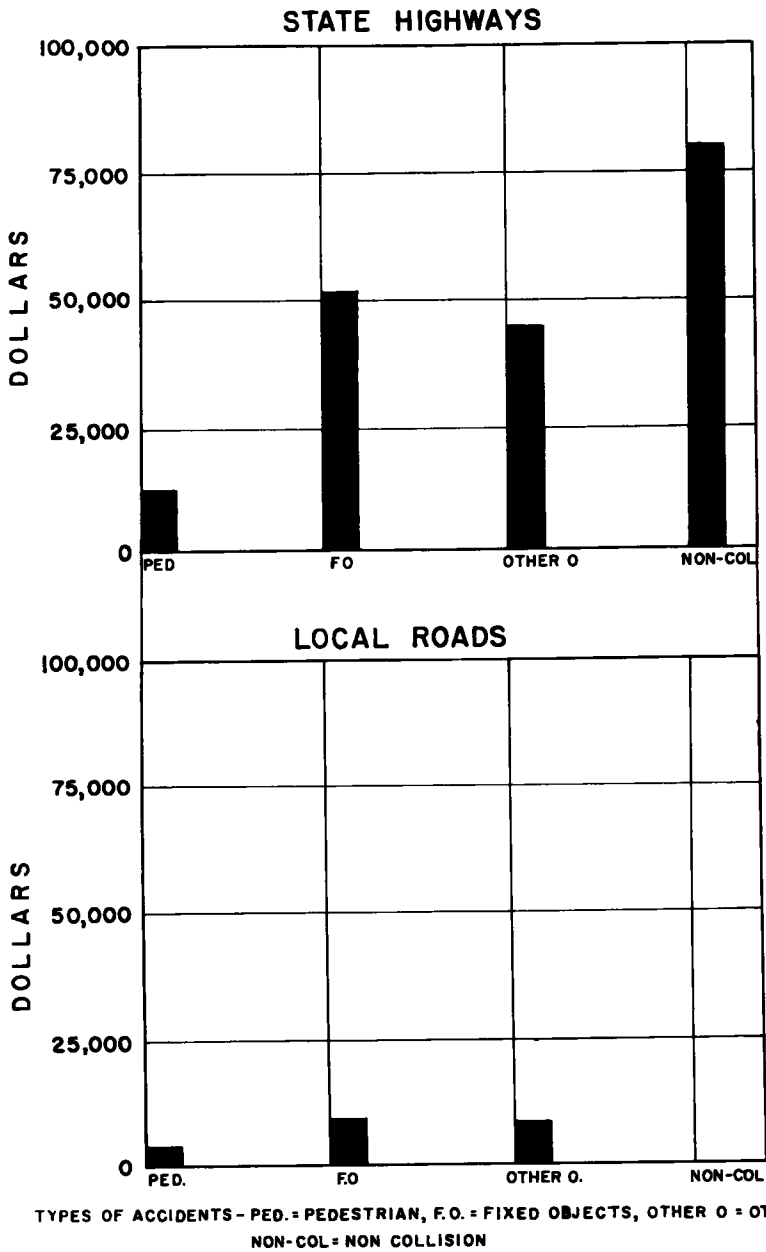


Figure 7. Federal-aid secondary system—direct cost per 100 million vehicle-miles of single car accidents (passenger cars only).

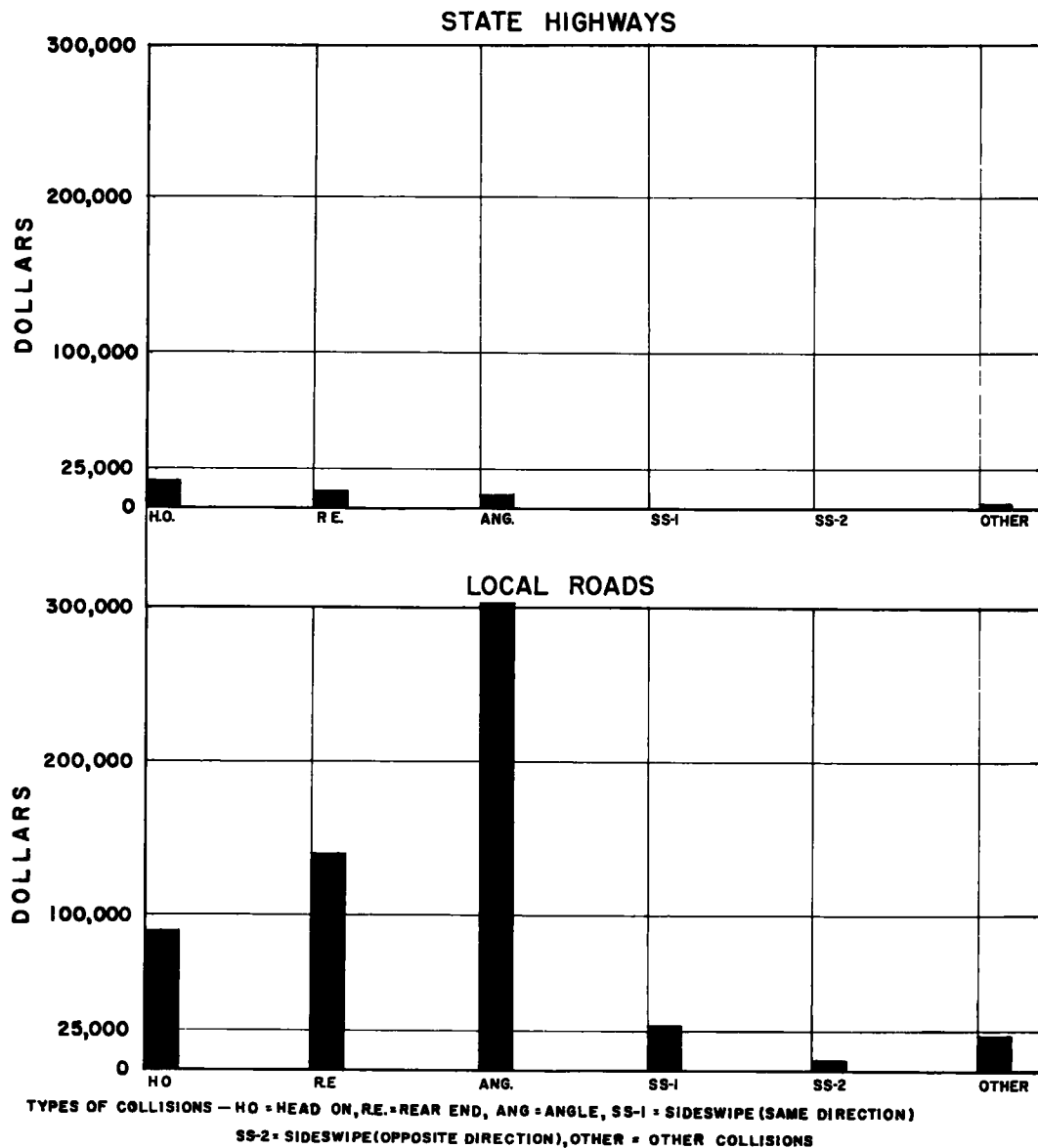


Figure 8. Non-Federal-aid system—direct cost per 100 million vehicle-miles of collisions between: (a) passenger cars, and (b) passenger cars and other motor vehicles.

might alter the results obtained. Since this study was completed, a new comparison of accident costs on eight of the nine highways has become available and the figures are given in Table 13. The 1957 records of accidents submitted to the Registry are used in this table. A comparison of the results in accident costs per mile with the curves in Figure 10 proved to be of special interest inasmuch as volumes on the highways had changed since 1955. In one case—Route 20-2, the so-called Southwest Connection—volumes had decreased substantially because of the opening of the Massachusetts Turnpike. Its accident cost per mile versus the new volume figure agrees quite closely with the curve.

Figures on the other highways are likewise quite consistent with the curves with

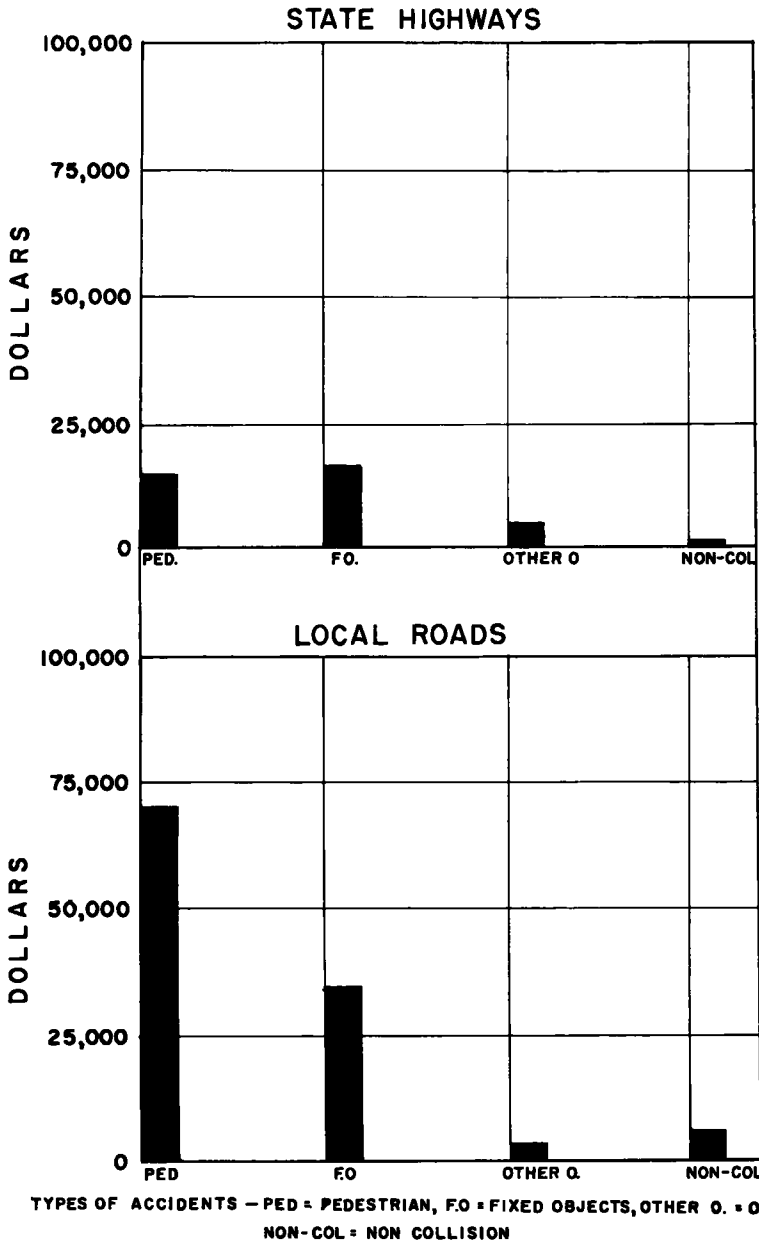


Figure 9. Non-Federal-aid system—direct cost per 100 million vehicle-miles of single car accidents (passenger cars only).

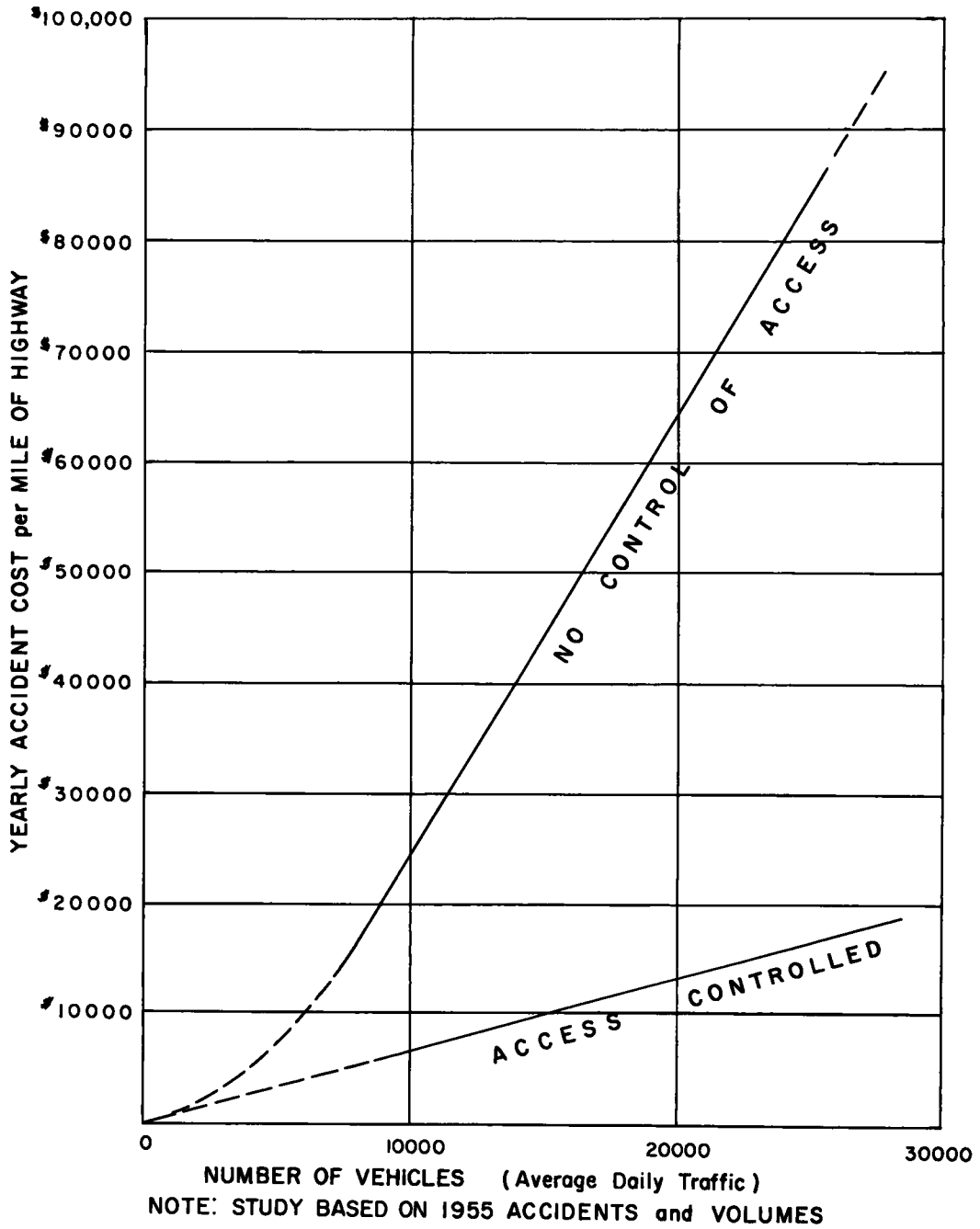


Figure 10. Accident costs on state highways with no control of access and with access controlled.

TABLE 13  
ACCIDENT RATES AND COSTS ON STATE HIGHWAYS IN MASSACHUSETTS COMPARING ACCESS-CONTROLLED  
ROADS WITH ROADS WITH NO CONTROL OF ACCESS: 1957

Roads with Access Controlled										
Sections of State Highway	Miles	Volume ADT	Killed	Fatal Accidents	Non-Fatal Personal-Injury Accidents	Property-Damage Accidents	Total Accidents	Persons Injured	100 MVM Accidents*	Direct Costs Per Mile
Route 128 (Wellesley to Lynnfield)	24.6	32,200	3	3	254	211	468	495	161.7	\$ 30,100
Route 15 (Sturbridge to Holland)	6.7	15,700	2	2	26	17	45	50	117.2	13,900
Route 2 (Concord to Westminster)	29.4	7,600	8	4	43	58	105	117	128.7	7,250
Route 1 (Danvers to Salisbury)	21.6	15,500	5	5	88	68	159	200	130.1	14,800
<b>Total</b>	<b>82.3</b>	<b>17,700**</b>	<b>18</b>	<b>14</b>	<b>409</b>	<b>354</b>	<b>777</b>	<b>882</b>	<b>146.2</b>	
Roads with No Control of Access										
Route 1 (Revere to Peabody)	7.8	30,900	5	3	213	109	325	420	370.5	79,700
Route 20-1 (Northboro to Weston)	20.5	8,200	1	1	72	68	141	119	230.2	9,700
Route 20-2 (Northboro to Auburn)	15.9	8,600	3	2	122	83	206	213	412.7	21,600
Route 9 (Brookline to Framingham)	19.9	30,400	8	6	572	339	917	1,018	415.3	78,500
<b>Total</b>	<b>64.1</b>	<b>17,900**</b>	<b>17</b>	<b>12</b>	<b>979</b>	<b>598</b>	<b>1,589</b>	<b>1,770</b>	<b>378.4</b>	

\* Accidents per 100 million vehicle-miles.

\*\* Weighted average.

one exception. In the volume range above 25,000 vehicles per day there is some variation from the 1955 curves. Values on the uncontrolled-access roads were somewhat lower than the curve in this volume range. One explanation for this may be that the overcrowding of the free-access roads actually tends to prevent certain types of collisions.

Only one example of a controlled-access highway in this high volume range was available. This was Route 128 north, a section of the Northern Circumferential Highway. This road, though opened in 1952, has been reaching capacity and it is now being widened and modernized. Its accident rate was 161.7 accidents per 100 million vehicle-miles in 1957. This was twice its rate in 1953. Its accident cost per mile had increased from \$19,100 in 1955 to \$30,100 in 1957. When reconstructed, this section of Route 128 should, without doubt, reverse this upward trend.

In summation, it may be stated that the low accident rates and costs on the controlled-access highways are consistent with previous findings and that they most certainly contribute their part in maintaining a comparatively low accident rate on the state highways in the FAP system.

## CONCLUSION

This study emphasizes the immediate need for action through accident prevention on all highway systems in Massachusetts.

Local roads in the NFA system deserve special consideration in the urban areas. Because many accidents are occurring in the cities of the Commonwealth this problem should be given special attention.

In the FAP system, state highways have a decidedly lower average accident rate than that on the local roads. Nevertheless, both represent large economic losses sustained through highway accidents.

In the FAS system, the state highways have a high accident rate and also involve high economic losses.

On the brighter side, it is evident that in the state highway system, the highways with full control of access experience much lower accident rates, at a given volume, than do those highways where access is uncontrolled. Economic losses are also comparatively low on the controlled-access roads.

In summary then, this study indicates the need for accelerated efforts in accident prevention from the viewpoint of reducing personal injuries and economic losses as well. In addition, it pinpoints the highway systems where, through road construction and reconstruction, traffic control, enforcement and other means, remedial measures should be given priority.