DEPARTMENT OF TRAFFIC AND OPERATIONS

A Detailed Study of Accidents as Related to Highway Shoulders in New York State

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• THIS STUDY was undertaken in order to determine more fully the relation between serious highway accidents and the width of highway shoulders. A considerable amount of study has been undertaken in several states under sponsorship of the Highway Research Board's Department of Traffic and Operations Committee. A. Taragin, of the Highway Transport Research Branch of the Bureau of Public Roads, coordinated this work as committee chairman.

The studies undertaken by the Taragin committee and others were based on the data which were characteristic of the highway features and the available accident records of the states under study. As a result, the reports were somewhat different in scope and detail.

Each report, however, indicated significant relations between accidents and shoulder width. For example, the Belmont report (*1*) indicated a tendency for injury accident rates to increase with paved shoulder width, except at traffic volumes below about 2000 vehicles per day; the Head report (*2*) showed a tendency toward a reduction in accidents as gravel shoulder width was increased in the higher ADT ranges only; the Raff report on interstate highways (*3*) indicated that shoulder width considered alone had no bearing on the accident rates of 2-lane tangents, and the New York State Interim report (*4*) indicated that the property damage accident rate decreased steadily with an increase in the shoulder width from 3 to 10 feet, and the fatal and injury accident rate had a downward trend with an increase in the shoulder width from 3 to 8 feet.

DETERMINATION OF DATA

The Department has used the Report of Accident on Highway Form HA-48, since 1947, in the investigation of fatal and serious injury accidents and those accidents occurring on the highway system which involved state-owned motor equipment (see Appendix). This report contains information descriptive of the accident location, weather, light condition, persons and vehicles involved, private and state property damage, accident location details (which include the geometrics of the highway and highway appurtenances at the accident scene), witnesses, accident history, accident diagram, and Department equipment, if involved. The information is in great detail as the form was designed to serve the State in highway accident claims involving negligence, brought before the New York State Court of Claims.

As a basis for this study, the factual data used from these reports included horizontal and vertical alinement, pavement type and width, shoulder type and width, type of accident, light condition, and weather.

The accident-on-highway reports ex-

amined were for the period from October 1947 through July 1955 and covered a great many investigated accidents. For the purposes of this study, however, only those accidents which met the following criteria were used: 1. occurrence on a 2-lane rural highway with 16- to 24-ft pavement, 2. no speed restriction except the legal maximum, 3. location outside village or city limits, 4. no intersection involved, and 5. no structure present. These restrictions resulted in 1753 usable reports. The data from these reports were placed on IBM cards for tabulation and analysis.

Grouping of Accident Data by Geometrics of Highway

The accident data were separated into three shoulder widths, three pavement widths, and four horizontal and vertical alinement groups.

Shoulder width groups were narrow (3 to 4 ft), medium (5 to 7 ft), and wide (8 ft and over). Pavement width was separated into narrow (16 and 18 ft), medium (20 ft), and wide (22 and 24 ft). Alinement and grade characteristics were separated according to the highway features: 1. level tangent, grades and/or curves less than 5 percent and less than 5 deg, respectively; 2. grades over five percent, with alinement of less than 5-deg curvature; 3. curves over five degrees, with grades less than 5 percent; and 4. grades and curves, where coincident (that is, where a curve over 5-deg occurred on a grade over 5 percent).

The exact effect of grades, curves and combinations may have been somewhat masked by the rather large groupings; however, these groupings appeared to suit the accident data well. For example, the level tangent accidents occurred where the average grades and curves for the group were 1.3 percent and 1.2 deg. The grades over 5 percent group, had grades and curves which averaged 7.4 percent and 1.6 deg. Thus, any difference in accident experience between these two groups of accidents was principally due to grade as the average curvature was little different. The same reasoning holds true for the curve over 5 deg group where the average grades and curves were 1.7 percent and 8.8 deg; and the combination grades and curves group where the average grades and curves were 7.4 percent and 8.7 deg.

Table 1 shows the number of accidents used in the study for the various combinations of geometric groupings and other factors considered in the study.

Travel Data

The number of accidents must be related to the miles of travel in order to evaluate accident occurrence. As the data represented a statewide distribution of accidents investigated over an 8-yr period, a distribution of travel (with similar characteristics as the accident data) was necessary in order to relate accident occurrence to travel.

Quantitative annual travel data for sections* of the highway system has been available only since 1952 for this type of detailed study. Examination of the data for later years indicated that these 1952 data were representative of the average annual travel (8-yr period) on the 2-lane statewide mileage with 16- to 24-ft pavement. Other data concerning pavement width, shoulder width, and alinement were obtained from the highway inventory IBM records. These records also showed stationing with the lengths of grades and curves over 5 percent and 5 deg for each contract length or section of highway. Reduction to mileage of grades, curves, or combinations with the corresponding traffic on each type of highway alinement was a relatively simple matter.

To reduce the amount of manual calculations involved in relating the distribution of travel data by the various groupings of geometric data, a 10-percent random sample of the 2-lane highway system by sections was used. Comparison of the percent of mileage in each pavement and shoulder width group for

* Sections, or sequences, are units used to indicate certain portions of a state route defined through three criteria: pavement width, pavement type and age. Inventory data indicate, for each sequence, the geometric section, mileage, AADT, grades 5 percent and over, and curves 5 deg and over.

TABLE 1
SERIOUS ACCIDENTS*

Pavement Width (ft)	Shoulder Width (ft)	Number of Accidents								
			Alinement				Accident Type		Light Condition	
		Total Number	Level Tangent	Grades Over 5%	Curves Over 5 deg	Grades and Curves	Fatal	Injury	Day	Night
16 - 18	3 - 4	95	57	12	21	5	32	63	43	47
	5 - 7	309	177	45	74	13	109	200	144	140
	8 & over	39	33	3	2	1	17	22	15	24
	All	443	267	60	97	19	158	285	202	211
20	3 - 4	128	58	13	41	16	41	87	57	65
	5 - 7	488	287	59	113	29	208	280	202	241
	8 & over	138	107	8	19	4	70	68	63	67
	All	754	452	80	173	49	319	435	322	373
22 - 24	3 - 4	109	63	2	32	12	36	73	44	55
	5 - 7	257	143	33	50	31	109	148	119	126
	8 & over	190	143	15	27	5	111	79	79	95
	All	556	349	50	109	48	256	300	242	276
ALL	3 - 4	332	178	27	94	33	109	223	144	167
	5 - 7	1054	607	137	237	73	426	628	465	507
	8 & over	367	283	26	48	10	198	169	157	186
	All	1753	1068	190	379	116	733	1020	766	860

		Weather				Pavement Type			Shoulder Type		
Dusk	Unclassified	Clear	Rain	Snow	Unclassified	PCC	BT	Unclassified	Earth and/or Grass	Gravel and/or Macadam	Unclassified
5	0	67	19	7	2	51	44	0	55	31	9
19	6	200	54	48	7	166	143	0	123	152	34
0	0	26	6	7	0	27	12	0	13	25	1
24	6	293	79	62	9	244	199	0	191	208	44
5	1	86	25	17	0	39	89	0	64	56	8
39	6	312	101	73	2	209	275	4	214	232	42
8	0	89	31	15	3	78	59	1	44	73	21
52	7	487	157	105	5	326	423	5	322	361	71
9	1	77	24	8	0	17	90	2	56	46	7
12	0	150	62	42	3	98	157	2	140	104	13
14	2	114	44	31	1	95	95	0	61	109	20
35	3	341	130	81	4	210	342	4	257	259	40
19	2	230	68	32	2	107	223	2	175	133	24
70	12	662	217	163	12	473	575	6	477	488	89
22	2	229	81	53	4	200	166	1	118	207	42
111	16	1121	366	248	18	780	964	9	770	828	155

* Reported from October 1947 through July 1955 on 2-lane rural highways in New York State.

the highway system with the 10-percent sample indicated that the sample was large enough to give a sufficiently accurate distribution of travel by pavement width and shoulder width.

APPLICATION OF DATA

Assurance of Reliable Sample of Accidents

Because the data was a sample, a combination of statistical and correlative controls was employed to insure that the accident sampling was valid. A dependable correlative factor between the accident sample and the travel sample was the distribution of highway mileage involved in each system; for comparison purposes, it is assumed that there are two highway systems. The mileage of the highway sections was tabulated by pavement and shoulder width, and a percentage distribution for each of these geometric categories was determined (Table 2) under HA-48 records.

A close correlation between the percentage distributions of mileage on the state system (or 10 percent sample) and the mileage of the system on which accidents occurred, would indicate that the accident sample was taken from a highway system with mileage characteristics for the geometric categories, similar to the statewide system. Also, if the mileage of the system on which accidents occurred corresponded to the mileage of the travel highway system, then it was proper to relate the accidents in one highway system to the travel in the other highway system, because both highway systems were composed of nearly the same mileage distribution.

The comparison of percentage distributions by pavement and shoulder widths of the 10 percent sample mileage with the corresponding distributions for the accident mileage, showed a considerable variation between the percentages in some geometric categories. The largest discrepancies, 9.7 percent and 5.8 percent (Table 2) occurred in the medium width shoulder category on both narrow and wide pavements, respectively. Percentage distributions by shoulder width for both the 10 percent sample and the accident mileage on 20-foot pavements appeared most favorable because the largest difference was about 2 percent. Therefore, rather than exaggerate any accident sampling error, it was advisable to limit further analysis to data obtained for 20-foot pavements.

Statistical Control of Analytical Reliability

Table 3 shows the X^2** contributions of each alinement and shoulder width for the theoretical, or chance, numbers of accidents which were ascertained by distributing the total accidents according to the travel (MVM) in each. The X^2 contribution was the difference between the actual number and the theoretical number in each category, squared and divided by the theoretical number. The total X^2 value was a practical guarantee that the actual accident distribution was not due to chance.

Inspection of the respective X^2 contributions for individual alinement and shoulder width conditions indicated that under all conditions of alinement, the X^2 contribution for accidents on wide shoulders was the smallest. Therefore, the interpretation of the data on wide shoulders is not to be considered as reliable as that for the narrow and medium width shoulders.

The X^2 contributions by alinement were all of sufficient size to indicate reasonable reliability, especially for the curve over 5 deg and combination of grades and curves alinement.

INTERPRETATION OF DATA

The 1952 travel data (MVM) for the 10 percent statewide sample is shown in Table 3 according to alinement and shoulder width for the 2-lane rural highways with 20-ft pavements. The number of investigated fatal and serious injury accidents which occurred where alinement and shoulder width corresponded

** X^2 statistical test for significance. A confidence level of 0.95 was used as a criterion for statistical significance.

TABLE 2
COMPARISON OF DISTRIBUTIONS OF HIGHWAY MILEAGES*

Pavement Width, ft	Shoulder Width, ft	State System		10% Sample		HA-48 Records	
		Miles	Percent	Miles	Percent	Miles	Percent
16 - 18	3 - 4	769.62	8.80	76.87	8.71	239.35	7.07
	5 - 7	2547.88	29.13	266.56	30.24	695.22	20.54
	8 & over	326.41	3.73	33.16	3.76	95.58	2.82
	All	3643.91	41.66	376.59	42.72	1030.15	30.44
20	3 - 4	482.25	5.51	47.38	5.37	198.25	5.86
	5 - 7	2248.63	25.71	218.25	24.75	901.47	26.64
	8 & over	501.84	5.74	50.33	5.71	265.85	7.86
	All	3232.72	36.96	315.96	35.84	1365.57	40.35
22 - 24	3 - 4	350.61	4.01	38.05	4.32	147.69	4.36
	5 - 7	721.10	8.24	69.64	7.90	463.37	13.69
	8 & over	797.80	9.12	81.33	9.23	377.28	11.15
	All	1869.51	21.38	189.02	21.44	988.34	29.21
All	3 - 4	1602.48	18.32	162.30	18.41	585.29	17.30
	5 - 7	5517.61	63.09	554.45	62.89	2060.06	60.88
	8 & over	1626.05	18.59	164.82	18.70	738.71	21.83
	All	8746.14	100	881.57	100	3384.06	100

* On 2-lane rural highways for the state system, the 10 percent sample, and sections on which accidents were investigated.

TABLE 3

COMPARISON OF DISTRIBUTIONS OF TRAVEL AND ACCIDENTS WITH X^2 RELIABILITY FACTORS, BY SHOULDER WIDTH AND ALINEMENT ON 2-LANE RURAL HIGHWAYS WITH 20-FT PAVEMENTS.

Alinement	Shoulder Width, Ft	Travel (10% Sample)		Accidents (1947-1955)		Accident Index*	Theoretical Accidents (No.)	X^2 Contribution
		MVM	Percent	Number	Percent			
Level Tangent	3 - 4	22.72	10.37	58	7.69	0.74	78	5.13
	5 - 7	137.34	62.67	287	38.06	0.61	473	73.14
	8 & over	31.63	14.43	107	14.19	0.98	109	0.04
	All	191.69	87.47	452	59.95	0.69	660	78.31
Grade	3 - 4	1.52	0.69	13	1.72	2.49	5	12.80
	5 - 7	9.97	4.55	59	7.82	1.72	34	18.30
	8 & over	2.26	1.03	8	1.06	1.03	8	0.00
	All	13.75	6.27	80	10.61	1.69	47	31.18
Curve	3 - 4	2.08	0.95	41	5.44	5.73	7	165.14
	5 - 7	7.66	3.50	113	14.99	4.28	26	291.12
	8 & over	1.80	0.82	19	2.52	3.07	6	28.17
	All	11.54	5.27	173	22.94	4.35	39	484.43
Grade and Curve	3 - 4	0.24	0.11	16	2.12	19.27	1	225.00
	5 - 7	1.72	0.78	29	3.85	4.94	6	88.17
	8 & over	0.21	0.10	4	0.53	5.30	1	9.00
	All	2.17	0.99	49	6.50	6.57	8	322.17
All	3 - 4	26.56	12.12	128	16.98	1.40	91	408.07
	5 - 7	156.69	71.50	488	64.72	0.91	539	470.81
	8 & over	35.90	16.38	138	18.30	1.12	124	37.21
	All	219.15	100	754	100	1.00	754	916.09

* Accident index is equal to percent of accidents in any geometric category divided by the percent of travel (MVM) in the same category.

to the categories listed for travel are also shown in Table 3. The percentages of both travel and accidents were calculated using 100 percent for both "all travel" and "all accidents."

The relation of the percent of accidents to the percent of travel in any geometric group shows the relative accident frequency or accident index. An accident index of 1.0 is indicated for the relation between the total group of accidents and the total travel. This represents the average accident expectancy on all shoulder widths and all alinements on 20-ft pavements. An accident index greater than 1.0 indicates a condition where a greater than average number of accidents occur, and an accident index of less than 1.0 indicates a condition where a less than average number of accidents occur.

The accident indices for various shoulder widths under different alinement conditions are shown in Figure 1. Medium shoulders had lower accident indices than narrow shoulders under all conditions of horizontal and vertical alinement. Wide shoulders, which contributed very little to the X^2 test for significance, showed no advantage over narrow or medium shoulders on level tangents, showed a lower accident index than either narrow or medium shoulders on both curves over 5 deg and grades over 5 percent, and had approximately the same accident index as medium shoulders, on combination grades and curves.

Although the accident index had considerable variation according to shoulder width, the variation in the accident index by alinement was much more pronounced.

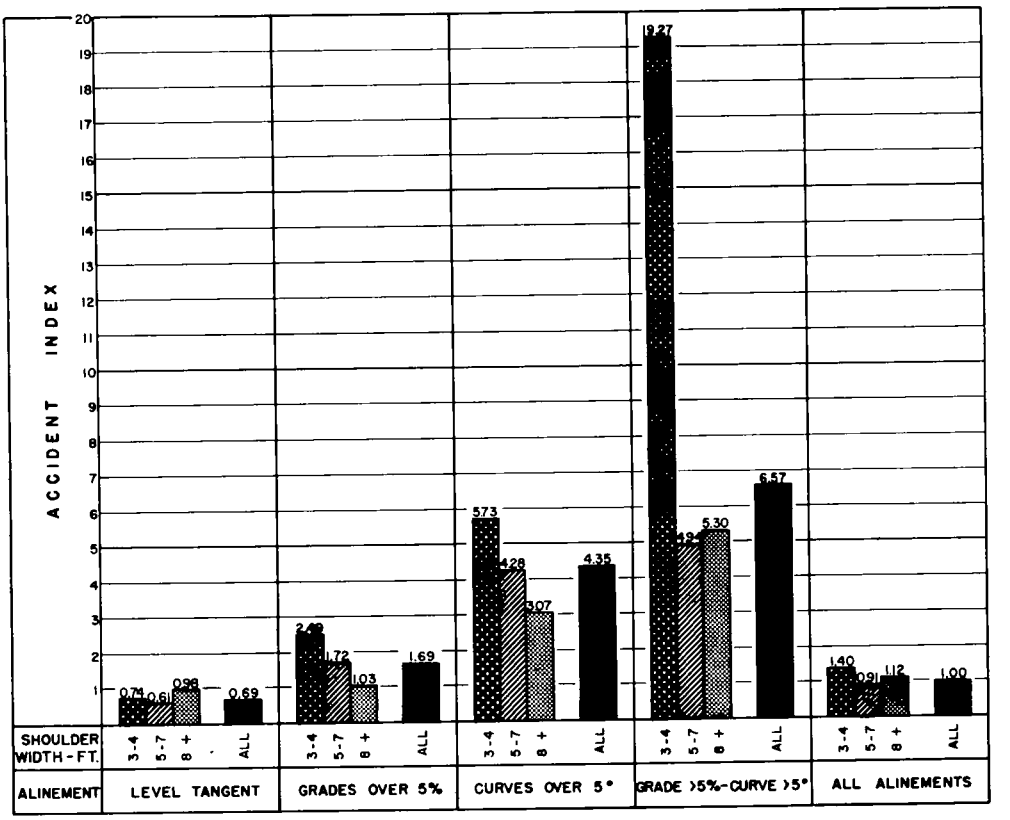

Figure 1. Accident index (accidents relative to travel) by alinement and shoulder width on 2-lane rural highways with 20-ft pavements in New York State.

The accident indices for level tangents, grades over 5 percent, curves over 5 deg, and grades and curves were 0.69, 1.69, 4.35 and 6.57, respectively, for all shoulder widths in each alinement category.

If the accident index on level tangents is to be the base with an accident index of 0.69, then grades over 5 percent (with an accident index of 1.69) experienced 2.4 times as many accidents as the level tangents. Similarly, curves over 5 deg with an accident index of 4.35 experienced 6.3 times as many accidents as the level tangents; and grades and curves with an accident index of 6.57 experienced 9.5 times as many accidents as the level tangents.

The accident indices on level tangents which accounted for 87 percent of the travel on 2-lane, 20-ft pavements, were 0.74, 0.61 and 0.98, respectively, for narrow, medium and wide shoulders.

For the entire data on 20-ft pavements, including the adverse alinement, the accident indices were 1.40, 0.91 and 1.12, respectively, for narrow, medium and wide shoulders.

Shoulder width was secondary to alinement as far as the accident index was concerned. However, medium shoulders had considerably lower accident indices than narrow shoulders under all conditions of alinement. Wide shoulders appeared at a disadvantage on level tangents but generally indicated considerably lower accident indices on poor alinement than narrow or medium shoulders.

SUMMARY

The following results were determined from an examination of the variations between the accident distribution and the travel distribution, for various conditions of shoulder width and alinement, on 2-lane rural highways with 20-ft pavements (the ratio of the percentage of the total number of accidents to the percentage of total travel in any category of shoulder width and alinement is referred to as "accident index." The accident index is indicative of accident experience relative to travel experience):

1. Medium width shoulders had lower accident indices than narrow shoulders under all conditions of horizontal and vertical alinement.
2. Wide shoulders had lower accident indices than narrow or medium width shoulders on poor alinement; yet no such statistically reliable relation existed for either the level tangent or grade over 5 percent alinement.
3. Alinement had more effect on accident experience than shoulder width. Regardless of shoulder width, the accident indices indicated that grades over 5 percent, curves over 5 deg, and combination grades and curves had 2.4, 6.3 and 9.5 times, respectively, the accident frequency of level tangents. Poor alinement, grades and/or curves over 5 percent and 5 deg, respectively, which comprised 13 percent of the travel, accounted for 40 percent of the accidents.

ACKNOWLEDGMENT

This report was for the New York State Department of Public Works under the general direction of B. A. Lefeve, Director of Highway Planning (now Deputy Chief Engineer for Highways). The authors are indebted to A. Taragin for many suggestions and consultation, the Department's Bureau of Safety for furnishing the accident reports, and to Edwin F. Hanford for executing the punch-card procedure.

REFERENCES

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2. HEAD, J. A., "The Relationship Between Accident Data and The Width of Gravel Shoulders in Oregon," A paper presented at Annual Meeting, Highway Research Board, January 16-20, 1956, Washington, D. C.
3. RAFF, MORTON S., "Interstate Highway Accident Study" in *Traffic*

Accident Studies, HRB Bulletin No. 74, 1953, pages 18-45.

4. STOHNER, WALTER R., "Relation of Highway Accidents to Shoulder Width on Two-Lane Rural Highways in New York State," Interim Report, a paper prepared for Committee presentation at Annual Meeting, Highway Research Board, January 16, 1956, Washington, D. C.

APPENDIX

Form HA-48

PAGE 1
4 Page Report

STATE OF NEW YORK
DEPARTMENT OF PUBLIC WORKS

Report of Accident on Highway

INSTRUCTIONS

Investigate as soon as possible after accident occurs. All facts must be reported fully. If necessary use blank sheets. If more than two (2) vehicles were involved or more than three (3) persons were injured use extra copies of Page 1 and number them Page 1-A, Page 1-B, etc. Newspaper accounts and reports by Police, Sheriffs, Coroners, etc. are valuable sources of information or will suggest such sources. Photos and measurements which support your findings on existing conditions, including tracks left in the path of vehicles, etc., shall supplement and accompany this report when practicable. In all serious cases, involving D.P.W. motorized equipment under insurance coverage, notify our CARRIER'S local representative immediately by phone and REPORT PROMPTLY. The original of this report and four (4) copies must be sent to the Bureau of Safety, Department of Public Works, State Office Building, Albany, N. Y.

DISTRICT No. 1	DETAILED ACCIDENT LOCATION 3	WEATHER 4
County Highway No. R. C. No. Route No.	Give name of highway; approximate distance and direction from nearest place and tie to nearest station, pole or structure.	☐ Clear Rain ☐ ☐ Snow Fog ☐ ☐ Freezing Thawing ☐ Or
TIME OF ACCIDENT 2 Date 19 Hour A.M. *or* P.M.		

LIGHT CONDITIONS: Daylight ☐ Dawn or Dusk ☐ Dark ☐ 5

VEHICLE No. 6	VEHICLE No. 6
Make and Type Registration No. (State)	Make and Type Registration No. (State)
OWNER'S Name Residence (City or Town) (State)	OWNER'S Name Residence (City or Town) (State)
OPERATOR'S Name Residence (City or Town) (State)	OPERATOR'S Name Residence (City or Town) (State)

PERSONS INJURED OR KILLED 7

NAME: Nature of Injury: Vehicle No.	Name of Hospital: Slight ☐ Serious ☐ Fatal ☐ Driver ☐ Passenger ☐ Pedestrian ☐		
NAME: Nature of Injury: Vehicle No.	Name of Hospital: Slight ☐ Serious ☐ Fatal ☐ Driver ☐ Passenger ☐ Pedestrian ☐		
NAME: Nature of Injury: Vehicle No.	Name of Hospital: Slight ☐ Serious ☐ Fatal ☐ Driver ☐ Passenger ☐ Pedestrian ☐		

PRIVATE PROPERTY DAMAGE
(Name of garage where private vehicles were taken)

PRIVATE VEHICLE No. 8	PRIVATE VEHICLE No. 8
No Damage ☐ Slight ☐ Heavy ☐ Garage	No Damage ☐ Slight ☐ Heavy ☐ Garage

STATE PROPERTY DAMAGE
Give nature and estimated amount of damage. Submit itemized statement to Claim Bureau separately.

D.P.W. REAL PROPERTY 9	D.P.W. VEHICLE No. 10
ESTIMATE: $	ESTIMATE: $

Form HA-48

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Accident Location Details

PAVEMENT 11

Type: Width: Number of Lanes: Were Lanes marked?

Were opposing Lanes separated? How?

Level ☐ or per cent Grade Tangent ☐ or radius of Curve. Surface was

CONDITIONS:* ☐ Dry ☐ Wet ☐ Muddy ☐ Snowy ☐ Icy

SHOULDERS 12

Type: Width: CONDITION:*

GUIDE RAIL 13

Type: Length: Which side(s)?

CONDITION:*

BRIDGE STRUCTURES 14

Type of Structure: Who maintains Structure?

Type of Pavement: Who maintains Pavement?

Width of Pavement: If Sidewalk(s), which side(s)?

CONDITIONS:*

WARNING AND REGULATORY DEVICES 15

Describe, as to type, size, shape, color, inscription and working condition, all temporary and permanent night illumination, traffic signals, warning and regulatory signs, lights, barricades, etc. which controlled accident location. Locate same on sketch (page 4).

16

Was Highway under construction? By whom?

Name of State Maintenance Foreman:

If Accident occurred under Winter conditions:

Who plows Highway? Was Highway plowed?

Who sands Highway? Was Highway sanded?

What Police Agency investigated?

Name of investigating Officer: Were Photos taken?

*NOTE — In above sections on pavement, shoulders, etc. describe in detail, with measurements and supporting photos, any defect or obstruction. Give length of time it existed before the accident and locate same on sketch (page 4). In serious cases obtain names of two reliable persons, other than State employees, who can testify to conditions as stated above.

Form HA-48

PAGE 3
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WITNESSES 17

(Give names and addresses of ALL known witnesses.)

ACCIDENT HISTORY 18

(Set forth all Factual Information on Accident and/or Conditions obtained from Witnesses named above.)

Form HA-48

PAGE 4
4 Page Report

SKETCH

19

Show all physical features pertaining to accident location. Show direction of travel by arrow → 1 2 ←

Number each vehicle. Use solid line to show path of vehicle before accident → Dotted line after - - - →

Use full size plain paper for sketch and submit blue print copies if desirable.

Indicate

North

DEPARTMENT OF PUBLIC WORKS EQUIPMENT

20

The following questions must be answered by the operator when Department OWNED or RENTED motorized equipment is involved.

Type of Equipment: Motor No. D.P.W. owned?

If rented: Give name of owner:

Give name of Insurance Carrier:

Your age: Yrs. Driving experience: Yrs.

Driver License No. Number of previous accidents:

If Equipment was moving, state your Speed:

If not moving, was Equipment parked clear of Traffic?

If not so parked, how was Traffic warned?

Under whose direction were you operating?

What operation was Equipment performing?

If it was towing other Equipment, state what:

Where was Equipment going? From where?

In your own words fully describe the accident:

Signature of D.P.W. Operator

Signature of person making report Title Date: 19