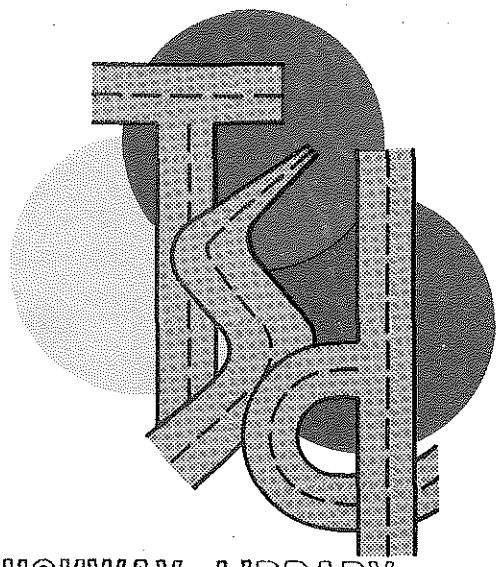
EFFECT OF CLEAR VISION RIGHT-OF-WAY ON TRAFFIC ACCIDENTS AT URBAN AND RURAL SIGNALIZED INTERSECTIONS

TSD - 228-73



TRAFFIC and SAFETY DIVISION

DEPARTMENT OF STATE HIGHWAYS
STATE OF MICHIGAN

EFFECT OF CLEAR VISION RIGHT-OF-WAY ON TRAFFIC ACCIDENTS AT URBAN AND RURAL SIGNALIZED INTERSECTIONS

TSD - 228-73

By

Yung S. Wu

Department of State Highways
State Highways Building - P.O. Drawer K
Lansing, Michigan 48904

July 1973

FOREWORD

Over the years the Michigan Department of State Highways has acquired a considerable number of triangular-shaped parcels of land in the quadrants of major intersections for the purpose of maintaining clear vision for drivers to the opposing motorists. As traffic increased and conflicts became evident certain of these intersections warranted signalization, and the question then arose to the necessity of retaining that extra right-of-way. Commercial interests have sought to acquire the land from the Department in order to place their products and services closer to the traffic stream.

The results of this study provide a third warrant for retaining standard clear vision triangles after signalization. The study was made without bias to determine if significant differences in accident rates had developed. Mr. Wu has applied a statistician's knowledge capably to show the practicing traffic engineer the relationship of sight triangles in combination with stop-and-go traffic signals on the basis of accident experience.

The first warrant was D. J. Mercer's calculation for the occasion of an errant motorist running through the red signal indication and the opposing motorist having to take evasive action. The second warrant is contained in numerous documents and relates to the economic benefit of retaining extra right-of-way. The roads on our system are periodically reconstructed to wider cross-sections. With increasing land prices, particularly at intersections needing auxiliary laneage, it is far better to utilize excess than acquire new properties.

P. H. DeCamp
July 1973

TABLE OF CONTENTS

List of Figures and Tables

(I) Introduction

The need exists for justification to retain or acquire clear vision right-of-way at all signalized intersections on Michigan highways through the study of accident experience.

Most previous studies were conducted to develop the procedures for determining the minimum clear vision requirements under suburban and urban conditions (4, 7). The general warrants for clear vision areas on all networks authorized for design or for right-of-way acquisition presently being used by many states are based on subjective judgment and not on hazard. The objective of this research investigation was to determine the relationship between the severity rate of the occurrence of accidents and the clear vision right-of-way of state highways. To meet the study objective, 192 signalized intersections on Michigan highways were selected for investigation and reports of accidents that occurred in 1971 and that could be attributed to the intersections were studied.

(II) Summary and Conclusions

The results of this research can be summarized as follows:

(1) There was a significantly higher injury accident rate at four-legged signalized intersections (both urban and rural), and urban

Tee signalized intersections with poor vision than at those with clear vision.

(2) There was a significantly higher property damage accident rate at four-legged signalized intersections (both urban and rural), and urban Tee signalized intersections with poor vision than at those with clear vision.

(3) There was a significantly higher accident rate at four-legged signalized intersections (both urban and rural), and urban Tee signalized intersections with poor vision than at those with clear vision.

In conclusion, a clear vision right-of-way at signalized intersections is only one of many factors which affect accident rates on the state highway system. However, an added clear vision right-of-way does contribute to safer intersections. It is felt that the possibility of providing appropriate clear vision right-of-way on state highway routes should be carefully considered in initial purchase, that most existing clear vision right-of-way be retained and that acquisition of clear-vision areas at many intersections in growing areas be acquired before development makes it difficult or impossible.

(III) Procedure

Selection of Study Sites

In undertaking a project of the type and scope described, one needs to be particularly concerned with the homogeneity of the selected areas with respect to roadside development, speed limit and average daily traffic (ADT). One of the difficulties encountered when conducting a comparison study is the problem of maintaining equivalent conditions. If one intersection is compared with another, it is likely that a multitude of unrelated variables will enter the picture: turning movement, orientation and environment, to name a few. To accommodate the possible comparisons for the study locations on the basis of homogeneity, the following procedures were taken:

(1) A one-year period (1971) was selected for investigation and the study was limited to signalized locations on Michigan State Highways during 1971.

(2) The population (i.e. total number of signalized intersections) was divided into subgroups (called subpopulations) by type of intersections - Tee, four-legged, Y and others.

(3) Within these subpopulations, a classification was made according to highway area type (i.e. urban and rural areas).

(4) Use of only four-legged intersections (both urban and rural) and urban Tee intersections.

(5) A sample of 192 locations was then randomly selected for detailed analyses. The sites were chosen on the basis of homogeneity with respect to roadside development, speed limit and average daily traffic (ADT) throughout the length of the highways.

Definitions

The effect of clear vision right-of-way on traffic accidents at signalized intersections cannot be determined easily. Without a good definition of clear vision at an intersection it is impossible to measure how well the clear vision is contributing to safer intersections. To measure the relative safety of an intersection, the following steps are taken:

(1) The right-of-way values (ft) for the approach roads and crossroads at an intersection were examined and recorded. These were taken from the Right-of-Way Book compiled by the Michigan Department of State Highways.

(2) A further classification was then made for the selected study sites using the following definitions:

A. Four-legged intersection with full vision - A four-legged intersection is defined as a full vision location if it satisfies one of the following conditions:

(a) All quadrants of the intersection have additional clear vision right-of-way as shown in Figure 1.

(b) Both quadrant one and quadrant two of the intersection have additional clear vision right-of-way as shown in Figure 2.

(c) The second quadrant of the intersection as shown in Figure 3 has additional clear vision right-of-way.

B. Four-legged intersection with partial vision - A four-legged intersection is defined as a partial vision location if it satisfied one of the following conditions:

(a) One or more quadrants but less than four quadrants of the intersection have additional clear vision right-of-way as shown in Figure 4.

(b) Either quadrant one or quadrant two of the intersection has additional clear vision right-of-way as shown in Figure 5.

C. Four-legged intersection with poor vision - A four-legged intersection is defined as a poor vision location if none of its quadrants

has additional clear vision right-of-way or if the conditions for full or partial vision cannot be met.

D. Tee intersection with full vision - A Tee intersection is defined as a full vision location if both quadrants of the Tee intersection have additional clear vision right-of-way as shown in Figures 6 and 7.

E. Tee intersection with partial vision - A Tee intersection is defined as a partial vision location if either quadrant of the Tee intersection has additional clear vision right-of-way as shown in Figures 8 and 9.

F. Tee intersection with poor vision - A Tee intersection is defined as a poor vision location if the conditions for full or partial vision cannot be met.

The distribution of study locations by type of intersection and the number of clear vision quadrants is shown as follows:

(a) Four-legged intersection: Urban areas

Clear Vision	Population Size	Sample Size	Percent
Full	40	20	50
Partial	65	25	38.5
Poor	700	50	7.1
Total	805	95	11.8

(b) Four-legged intersection: Rural areas

Clear Vision	Population Size	Sample Size	Percent
Full	11	11	100
Partial	11	11	100
Poor	60	20	33.3
Total	82	42	51.2

(c) Tee intersection: Urban areas

Clear Vision	Population Size	Sample Size	Percent
Full	7	7	100
Partial	13	13	100
Poor	160	35	22
Total	180	55	31

FIGURE 1

FULL VISION - 4 LEGGED INTERSECTION
BIDIRECTIONAL TRAFFIC - BOTH ROUTES

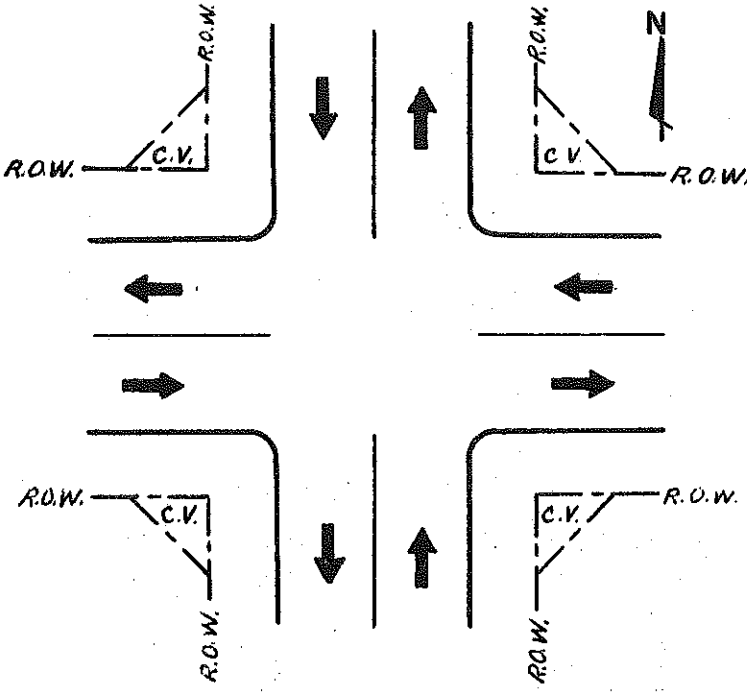


FIGURE 2

FULL VISION - 4 LEGGED INTERSECTION
ONE - WAY CROSSROAD

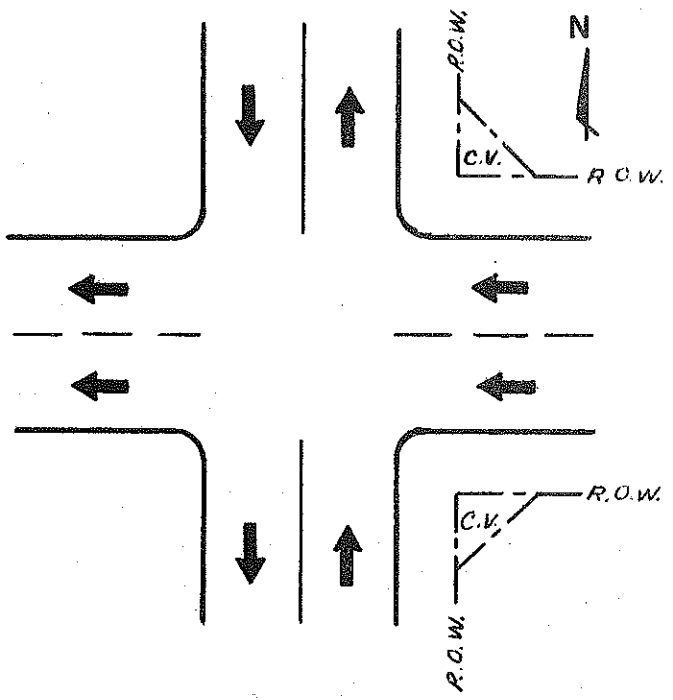


FIGURE 3

FULL VISION - 4 LEGGED INTERSECTION
ONE - WAY TRAFFIC BOTH
ROUTES

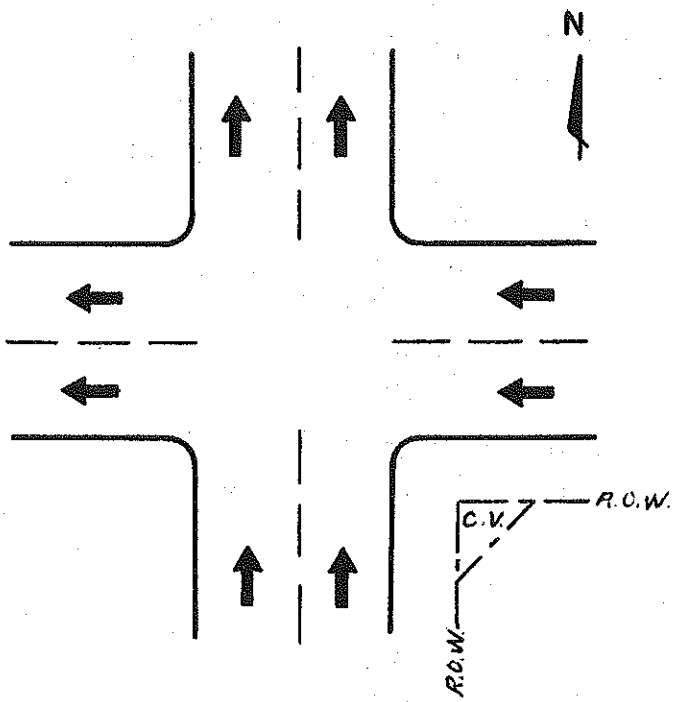
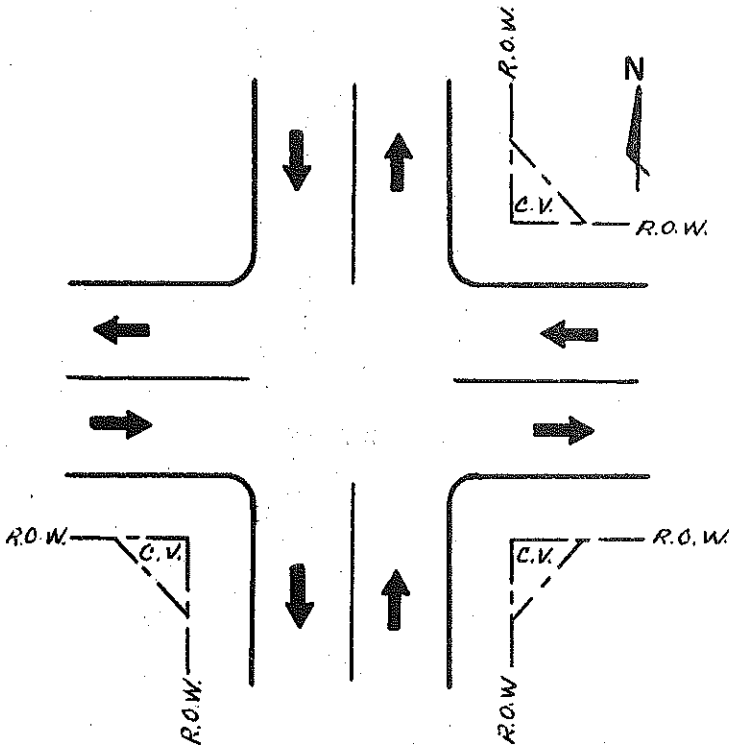


FIGURE 4

PARTIAL VISION - 4 LEGGED INTERSECTION
BIDIRECTIONAL TRAFFIC - BOTH ROUTES



C.V. DENOTES CLEAR VISION
R.O.W. DENOTES RIGHT-OF-WAY

FIGURE 5

PARTIAL VISION - 4 LEGGED INTERSECTION
ONE - WAY CROSSROAD

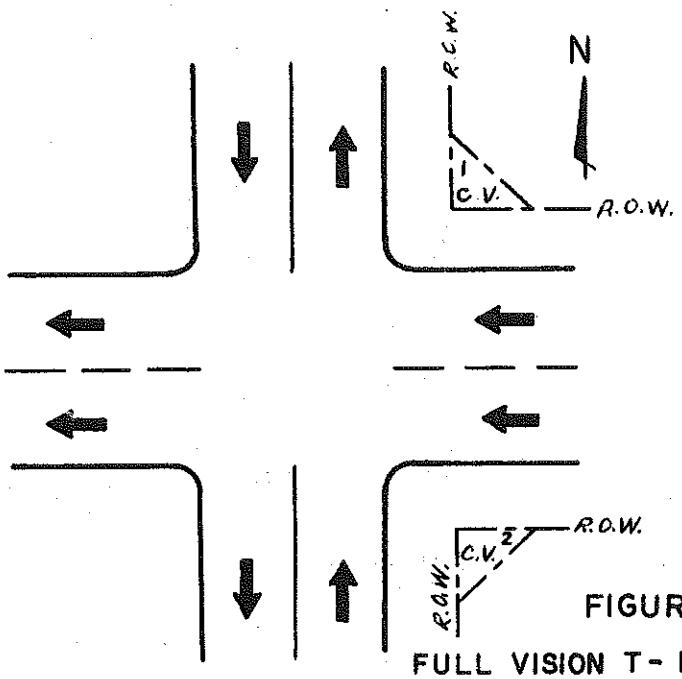


FIGURE 6

FULL VISION T - INTERSECTION
ONE - WAY CROSSROAD

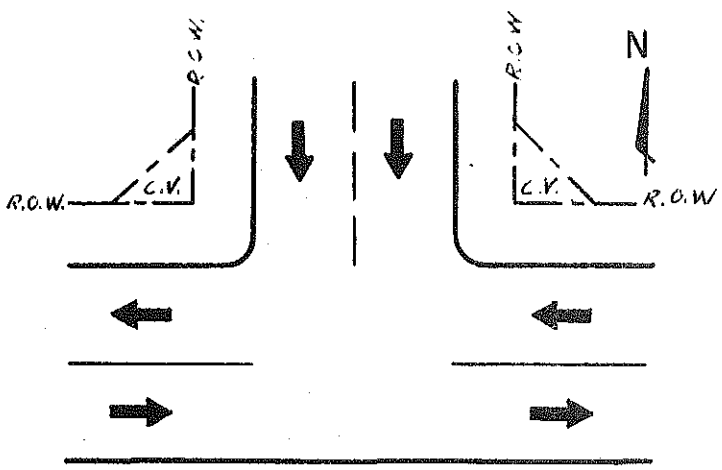
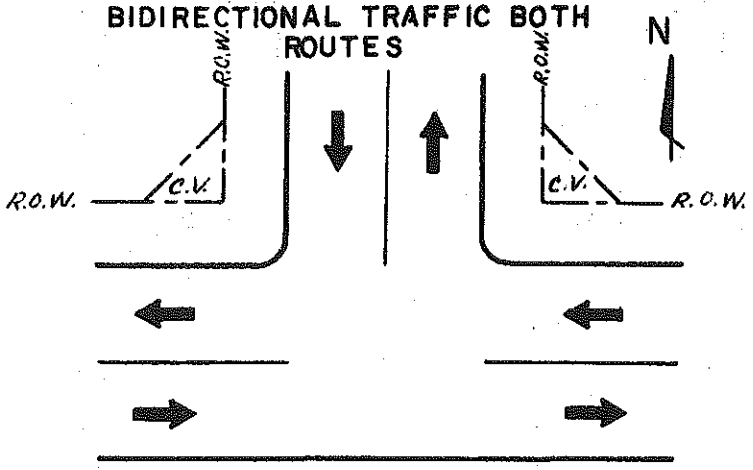


FIGURE 7

FULL VISION T - INTERSECTION
BIDIRECTIONAL TRAFFIC BOTH ROUTES



FIGURES 5, 8, 89 HAVE C.V. IN EITHER IST OR 2ND QUAD.

FIGURE 8

PARTIAL VISION T - INTERSECTION
ONE - WAY CROSSROAD

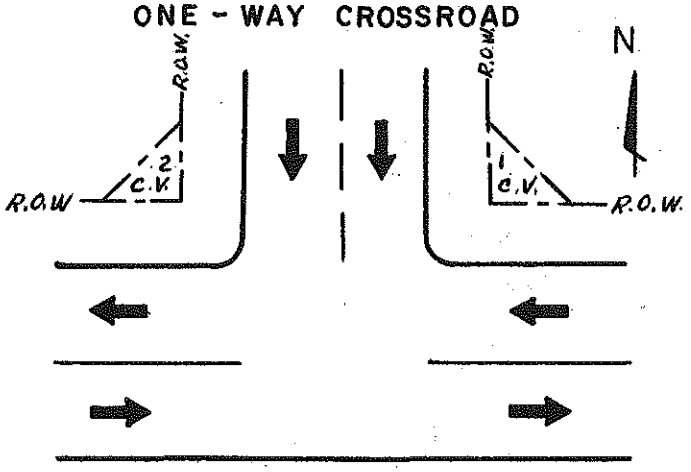
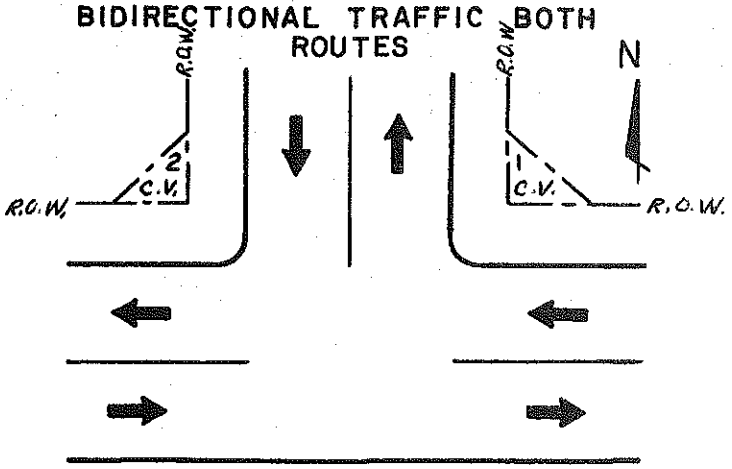


FIGURE 9

PARTIAL VISION T - INTERSECTION
BIDIRECTIONAL TRAFFIC BOTH ROUTES



Data Collection

Accident Data

The accident data used in this study were taken from the records of the Accident Analysis Unit of the Traffic and Safety Division, Michigan Department of State Highways (MDSH). The accidents occurring within 150 feet of all intersections were utilized in the report. The study sties experienced 3785 accidents during 1971. These accidents were then classified by type of accidents as follows:

Multiple-Vehicle Accidents:

(1) Head-on
(2) Sideswipe - same direction
(3) Sideswipe - opposite direction
(4) Angle
(5) Left-turn
(6) Right-turn
(7) Rear-end
(8) Backing
(9) Parking, and
(10) Other (or not known)

Single-Vehicle Accidents:

(1) Pedestrian and motor-vehicle
(2) Fixed object and motor-vehicle
(3) Other object and motor-vehicle

(4) Animal and motor-vehicle

(5) Bicycle and motor-vehicle

(6) Ran-off roadway

(7) Other (or not known)

To minimize the effect of chance variables, the following types of accidents were included in the analyses:

Multiple-Vehicle Accidents:

(1) Head-on

(2) Sideswipe - same direction

(3) Sideswipe - opposite direction

(4) Angle

(5) Left-turn

(6) Left-turn, and

(7) Rear-end

Single-Vehicle Accidents:

(1) Pedestrian and motor-vehicle

(2) Bicycle and motor-vehicle

Traffic Volume Data

The ADT (Average Daily Traffic) values for the study sites during 1971 were taken from two data sources: (a) Trunkline Vehicle Mile Tables, and (b) the Central Traffic Files, both compiled by the Michigan Department of State Highways (MDSH). An inbound ADT value was assigned to each intersection.

The data collected for this analysis is presented in Tables I through III.

Column 1 of Table I shows the reference number of study locations.

Columns 2 and 3 illustrate the study location and its corresponding trunkline right-of-way for approach roads.

Columns 4 and 5 explain whether the location has additional clear vision right-of-way and also the vision classification.

Column 6 shows personal injury, property damage and total accident rates per one million vehicles.

Similarly, Tables II and III present the pertinent data for rural four-legged and urban Tee intersections.

TABLE I
Traffic and Accident Data
For Urban Four-Legged Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
1	M-96 (Kings) @ River Ave.	200	Yes	Full	0.31	0.62	0.93
2	US-10 (Tele.) @ M-59 (Huron)	86	Yes	Full	0.61	1.13	1.74
3	US-31 @ M-40	200	Yes	Full	0.64	0.64	1.28
4	M-59 @ Elizabeth	150	Yes	Full	0.61	1.93	2.54
5	BL-94 @ Washington	100	Yes	Full	0.55	0.99	1.54
6	M-11, M-37 (28th) @ Kalamazoo	100	Yes	Full	0.62	1.79	2.41
7	M-13 Eucl. @ N. Wild	135	Yes	Full	0.09	0.18	0.27
8	US-13 NB Ramp @ M-21 BR	66	Yes	Full	0.00	0.17	0.17
9	M-139 @ Nickerson Road	120	Yes	Full	0.27	1.06	1.33
10	US-31 @ Robbins	200	Yes	Full	0.57	0.94	1.51
11	M-11 @ Buchanan Avenue	100	Yes	Full	0.65	1.22	1.87
12	US-31BR @ Norton	300	Yes	Full	0.41	1.78	2.19
13	M-13 Riverview @ M-43 (Mich.)	66	Yes	Full	0.51	2.02	2.53
14	US-31BR WB Roadway @ NB Ramp	200	Yes	Full	0.12	0.36	0.48

TABLE I
Traffic and Accident Data
For Urban Four-Legged Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
15	US-131 SB Exit Ramp @ M-21BR	66	Yes	Full	0.25	0.75	1.00
16	M-54 Dort @ M-54BR	100	Yes	Full	0.21	0.50	0.71
17	M-59 @ M-97 Clinton	120	Yes	Full	0.30	0.30	0.60
18	US-131 SB @ Pearl	100	Yes	Full	0.33	0.66	0.99
19	US-31 @ Bascule	200	Yes	Full	0.24	0.48	0.72
20	M-43 Oakland @ Cleo	80	Yes	Full	0.12	1.20	1.32
21	BL-94 Mich. @ Dettman	91	Yes	Partial	1.32	2.63	3.95
22	M-11 @ Evan Rest	100	Yes	Partial	0.64	0.73	1.37
23	M-11 @ Wilson	100	Yes	Partial	1.43	3.57	5.00
24	US-31BR @ Southern	200	Yes	Partial	0.26	0.60	0.86
25	BL-94 @ McCalmly	100	Yes	Partial	0.25	2.28	2.53
26	BL-94 @ Upton	66	Yes	Partial	0.27	1.07	1.34
27	M-36 @ Columbia	66	Yes	Partial	0.21	0.86	1.07
28	M-43 @ Hagadorn	100	Yes	Partial	0.97	2.42	3.39

TABLE I
Traffic and Accident Data
For Urban Four-Legged Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
29	US-31 @ 32nd	200	Yes	Partial	0.27	1.35	1.62
30	US-31 @ 1st	66	Yes	Partial	0.82	2.68	3.50
31	M-150 @ Tienken	200	Yes	Partial	0.11	0.34	0.45
32	BL-96 Gr.River @ M-174	80	Yes	Partial	0.36	0.53	0.89
33	M-59 @ Williams Lake	100	Yes	Partial	0.00	0.27	0.27
34	US-24 @ Joy	86	Yes	Partial	0.89	1.64	2.53
35	M-11 @ Burlingame	100	Yes	Partial	0.72	1.11	1.83
36	M-78 Sag. @ Hagadorn	120	Yes	Partial	0.79	1.19	1.99
37	M-43 River V @ Gull	66	Yes	Partial	0.58	3.61	4.19
38	US-12 WB @ Wayne	212	Yes	Partial	0.00	0.46	0.46
39	US-10BR @ Wilson	120	Yes	Partial	0.64	1.00	1.64
40	US-25 @ Macomb	71	Yes	Partial	0.08	0.16	0.24
41	US-12 @ Oakman	200	Yes	Partial	0.27	0.85	1.12
42	M-14 @ US-24 SB	120	Yes	Partial	0.55	0.11	0.66

TABLE I
Traffic and Accident Data
For Urban Four-Legged Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
43	M-153 @ Wayne	86	Yes	Partial	1.57	3.82	5.38
44	M-59 @ Pontiac Lake Rd.	120	Yes	Partial	0.26	0.88	1.14
45	M-11 @ Eastern	100	Yes	Partial	0.76	1.93	2.69
46	M-85 @ Southfield	204	No	Poor	0.99	5.81	6.80
47	M-21 @ Columbia	66	No	Poor	0.55	1.23	1.78
48	BS-96 @ Beech Daly	204	No	Poor	1.57	1.08	2.65
49	M-52 @ King	66	No	Poor	0.54	1.37	1.91
50	BL-94 Mich. @ Milwaukee	99	No	Poor	0.26	.39	.65
51	US-12 @ Outer Drive	100	No	Poor	0.70	1.57	2.27
52	M-99 @ Cass	99	No	Poor	0.20	1.00	1.20
53	BL-69/M-50 @ M-79	100	No	Poor	0.46	1.14	1.60
54	M-99 @ Main	90	No	Poor	0.63	1.41	2.04
55	M-97 @ Common	120	No	Poor	0.59	0.81	1.40
56	US-25 @ 10 Mile	204	No	Poor	0.59	1.55	2.14

TABLE I
Traffic and Accident Data
For Urban Four-Legged Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
57	M-14 @ Beech Daly	93	No	Poor	1.02	2.15	3.17
58	M-85 @ Van Horn	120	No	Poor	1.25	0.87	2.12
59	BL-75 @ Montcalm & E. Blvd.	80	No	Poor	1.98	5.59	7.57
60	M-1 @ 13 Mile	200	No	Poor	1.66	3.53	5.19
61	M-21 @ Dye Road	66	No	Poor	1.37	1.48	2.85
62	M-85 @ Pennsylvania	120	No	Poor	1.15	4.26	5.41
63	M-53 @ 18 Mile	120	No	Poor	1.26	1.69	2.95
64	M-97 @ 9 Mile	120	No	Poor	1.17	1.60	2.77
65	US-12 @ Miller	120	No	Poor	0.97	1.20	2.17
66	M-1 @ 12 Mile	200	No	Poor	1.37	2.81	4.18
67	M-13 (Euclid) @ Thomas	100	No	Poor	0.70	1.57	2.27
68	US-25 @ 9 Mile Road	204	No	Poor	0.97	2.51	3.48
69	US-24 @ 12 Mile	150	No	Poor	1.10	2.37	3.47
70	US-25 Monroe @ 3rd	100	No	Poor	0.68	1.10	1.78

TABLE I
Traffic and Accident Data
For Urban Four-Legged Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
71	M-54 @ Manitou	100	No	Poor	0.73	1.28	2.01
72	M-17 Wash. @ Mansfield	80	No	Poor	1.10	2.19	3.29
73	M-85 @ North Line	204	No	Poor	1.19	3.29	4.48
74	M-13 @ 5th St.	60	No	Poor	1.37	2.74	4.11
75	I-94 Ramp @ Butler	100	No	Poor	1.26	1.26	2.52
76	M-54BR @ Atherton	99	No	Poor	0.96	2.05	3.01
77	M-97 @ 12 Mile	120	No	Poor	4.22	5.25	9.47
78	M-139 @ Empire	120	No	Poor	0.97	0.97	1.94
79	US-131Br @ Turner	66	No	Poor	0.82	2.12	2.94
80	US-31BR @ Pine	66	No	Poor	0.68	0.68	1.36
81	US-10 @ Andersonville	200	No	Poor	0.80	0.40	1.20
82	M-53 @ 9 Mile	106	No	Poor	.66	1.68	2.34
83	M-97 @ Frazho	115	No	Poor	.55	.62	1.17
84	M-150 @ Big Beaver	66	No	Poor	0.88	2.41	3.29

TABLE I
Traffic and Accident Data
For Urban Four-Legged Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
85	M-13 @ Cass	80	No	Poor	0.76	0.95	1.71
86	US-24 @ 14 Mile	150	No	Poor	0.30	1.20	1.50
87	US-31BR @ Spring	66	No	Poor	0.71	1.31	2.02
88	US-23BR Wash. @ Huron	100	No	Poor	1.00	1.08	2.08
89	M-53 @ 15 Mile	160	No	Poor	0.67	1.85	2.52
90	M-85 @ Emmons	204	No	Poor	0.75	1.58	2.33
91	BL-94 Mich. @ Gorham	66	No	Poor	0.63	1.26	1.89
92	M-56 @ Ann Arbor	66	No	Poor	0.51	0.68	1.19
93	US-12BR Mich. @ Prospect	99	No	Poor	0.38	2.46	2.84
94	US-25 Monroe @ Noble	100	No	Poor	0.51	0.38	0.89
95	US-10BR @ South	200	No	Poor	0.37	1.64	2.01

TABLE II
Traffic and Accident Data
For Rural Four-Legged Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
1	M-140 @ BL-196	160	Yes	Full	0.71	0.53	1.24
2	M-59 @ Elizabeth	150	Yes	Full	0.00	0.56	0.56
3	M-54 @ Clio	120	Yes	Full	0.60	0.00	0.60
4	M-47 @ M-46	180	Yes	Full	0.70	2.10	2.80
5	M-54 Dort @ M-54BR (Sag.)	120	Yes	Full	0.51	0.51	1.02
6	M-36 @ US-127	100	Yes	Full	0.27	0.82	1.09
7	US-25 @ Mich. Rd.	120	Yes	Full	0.26	1.29	1.55
8	I-94 @ M-140	120	Yes	Full	0.21	0.42	0.63
9	US-12 @ Inkster	204	Yes	Full	0.00	0.27	0.27
10	M-21 @ M-53	100	Yes	Full	0.51	0.51	1.02
11	US-23 @ M-72	66	Yes	Full	0.00	0.50	0.50
12	M-24 @ Clarkston	180	Yes	Partial	0.78	0.98	1.76
13	M-54BR @ M-57	100	Yes	Partial	0.30	0.15	0.45
14	M-52 @ I-69	190	Yes	Partial	0.54	1.25	1.79

TABLE II
Traffic and Accident Data
For Rural Four-Legged Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
15	US-12 @ US-131	66	Yes	Partial	0.48	0.48	0.96
16	US-131 @ M-60	82	Yes	Partial	0.88	0.88	1.76
17	US-12 @ US-233	200	Yes	Partial	0.71	0.95	1.66
18	US-12 @ M-50	100	Yes	Partial	0.37	0.73	1.10
19	US-223 @ Treat	150	Yes	Partial	0.00	0.55	0.55
20	M-13 @ M-21	120	Yes	Partial	0.38	0.57	0.95
21	BL-94 @ Capital	160	Yes	Partial	0.82	4.38	5.20
22	M-19 @ New Haven	120	Yes	Partial	1.03	0.68	1.71
23	US-12 @ Wittaker	66	No	Poor	1.40	2.91	4.31
24	M-14 @ Sheldon	106	No	Poor	2.74	2.74	5.48
25	M-57 @ Front	99	No	Poor	0.61	0.00	0.61
26	M-84 @ Tittabawassee	80	No	Poor	0.46	1.14	1.60
27	M-24 @ Burdick	100	No	Poor	0.91	2.37	3.29
28	M-83 @ Saginaw Rd.	115	No	Poor	0.84	4.20	5.04

TABLE II
Traffic and Accident Data
For Rural Four-Legged Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
29	M-21 @ 32nd Ave.	100	No	Poor	1.13	1.93	3.06
30	M-53 @ St. Clair	100	No	Poor	1.10	1.28	2.37
31	US-25 @ 21 Mile	147	No	Poor	1.25	2.00	3.25
32	M-19 @ Division	66	No	Poor	0.68	4.45	5.13
33	M-53 @ Marlette	66	No	Poor	0.91	4.11	5.02
34	M-81 @ Burnside	66	No	Poor	0.42	1.26	1.68
35	M-40 Cedar @ M-89	66	No	Poor	0.73	1.10	1.83
36	M-15 @ Lapeer	80	No	Poor	1.48	1.48	2.95
37	M-13 @ 5th St.	60	No	Poor	0.82	1.64	2.46
38	M-21 @ M-15	66	No	Poor	0.87	2.30	3.17
39	M-24 @ Flint	100	No	Poor	0.41	2.88	3.29
40	M-46 @ River Rd.	83	No	Poor	0.29	2.03	2.32
41	M-59 @ Romeo Plank	120	No	Poor	1.83	0.68	2.51
42	M-37 Broadway @ Main	99	No	Poor	0.55	1.65	2.20

TABLE III
Traffic and Accident Data
For Urban Tee Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
1	US-131 SB Ramp @ M-11	100	Yes	Full	0.29	1.05	1.34
2	US-131 NB Ramp # M-11	100	Yes	Full	0.30	0.70	1.00
3	US-131 SB Ramp @ M-44	100	Yes	Full	0.27	1.30	1.57
4	US-131 NB Ramp @ Burton	100	Yes	Full	0.14	1.44	1.58
5	US-131 SB Ramp @ 36th	100	Yes	Full	0.42	1.69	2.11
6	I-96 Ramp @ M-37	66	Yes	Full	0.16	0.32	0.48
7	M-45 SB Ramp @ I-96	100	Yes	Full	0.00	0.00	0.00
8	US-10 @ Silver Lake	120	Yes	Partial	1.19	1.10	2.29
9	US-131 @ Market	100	Yes	Partial	0.10	1.50	1.60
10	US-131 @ Rumsey	100	Yes	Partial	0.14	0.48	0.62
11	BL-96 @ Capital Blvd.	100	Yes	Partial	0.25	1.25	1.50
12	BL-96 Gr. River @ Waverly	100	Yes	Partial	0.20	0.80	1.00
13	US-23 @ M-72	100	Yes	Partial	0.46	0.92	1.38
14	M-13 @ Eud Kiesal	135	Yes	Partial	0.00	0.55	0.55

TABLE III
Traffic and Accident Data
For Urban Tee Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
15	M-44 @ M-44 Conn.	110	Yes	Partial	0.42	0.21	0.63
16	M-78 Ramp @ M-54	100	Yes	Partial	0.30	0.15	0.45
17	US-131 @ Portage	82	Yes	Partial	0.61	2.44	3.05
18	US-23 @ Long Rapids	100	Yes	Partial	0.63	1.05	1.68
19	US-23BR @ M-68	100	Yes	Partial	0.55	1.10	1.65
20	M-44 @ 5 Mile	120	Yes	Partial	0.21	1.05	1.26
21	M-43 Gr. River @ MAC Ave.	66	No	Poor	0.48	3.57	4.05
22	M-85 @ West	120	No	Poor	0.88	2.99	3.87
23	M-54BR @ Hamilton	99	No	Poor	0.57	1.89	2.46
24	M-21 @ M-66 Dexter	66	No	Poor	0.17	3.01	3.18
25	M-1 @ Sears	100	No	Poor	0.89	1.01	1.90
26	M-14 @ Wayne	120	No	Poor	0.99	3.07	4.06
27	M-102 @ Cherrylawn	204	No	Poor	0.22	1.09	1.31
28	US-25 @ Camden	200	No	Poor	0.25	0.91	1.16

TABLE III
Traffic and Accident Data
For Urban Tee Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
29	BL-96 @ Pacific	66	No	Poor	0.63	1.43	2.06
30	US-12 @ Newburgh	204	No	Poor	0.68	1.36	2.04
31	M-85 @ Cicotte	204	No	Poor	0.37	1.00	1.37
32	M-153 @ John Daly	93	No	Poor	0.67	0.80	1.47
33	BL-75 @ US-10BR Oakland	100	No	Poor	0.30	1.20	1.50
34	M-44 Conn @ Woodworth	100	No	Poor	0.34	1.54	1.88
35	M-14 @ Ann Arbor TR	113	No	Poor	0.27	1.92	2.19
36	BL-75 @ University	100	No	Poor	1.19	2.62	3.81
37	M-1 @ Courtland	100	No	Poor	0.39	0.26	0.65
38	US-10BR @ Kennett	100	No	Poor	0.20	0.82	1.02
39	BL-75 @ Howard	70	No	Poor	0.65	1.45	2.10
40	M-85 @ Moran	204	No	Poor	0.65	3.62	4.27
41	US-10 @ Scottlake	120	No	Poor	1.64	4.29	5.93
42	US-24 @ Franklin	150	No	Poor	0.91	2.74	3.65

TABLE III
Traffic and Accident Data
For Urban Tee Intersections

Study Site No.	Route	Trunkline Right-of-Way in feet	With Add'l. Clear Vision ROW	Clear Vision Classification	Accidents/M.V. P.I.	P.D.	Total
43	US-25 Gratiot @ Conn	204	No	Poor	0.11	1.16	1.27
44	M-85 @ Sibley	120	No	Poor	0.37	3.90	4.27
45	M-1 @ Adams	200	No	Poor	0.48	0.82	1.30
46	US-12 @ Mason	204	No	Poor	0.91	1.37	2.28
47	M-102 @ Hagnes	204	No	Poor	0.64	1.55	2.19
48	US-12 @ Gulley	204	No	Poor	0.86	1.61	2.47
49	M-53 @ Timken	106	No	Poor	0.45	0.77	1.22
50	M-43 @ Hillcrest	66	No	Poor	0.21	3.79	4.00
51	M-1 @ Pilgrim	100	No	Poor	0.57	1.37	1.94
52	US-25BR @ Ping Erie	100	No	Poor	0.17	2.57	2.74
53	US-25 @ Couzens	200	No	Poor	0.36	0.72	1.08
54	M-54 @ Franklin	100	No	Poor	0.17	2.05	2.22
55	US-131 @ Woodward	66	No	Poor	0.82	2.47	3.29

Analysis of the Data and Findings

The analysis of variance procedures was employed to analyze the significant difference in the mean severity rate of the occurrence of accidents among full, partial and poor vision intersections. The following null hypothesis was tested: there was no significant difference in the mean severity rate of the occurrence of accidents among full, partial and poor vision intersections. The F-test was utilized in testing significance, and 95% confidence intervals were selected. The first step in analysis was to group the data by accident severity (personal injury, property damage and total accidents) for four-legged intersections (both urban and rural) and urban Tee intersections. Within these major groups, subgroups were made for clear vision classification. The results of the analysis for these groupings are shown in Tables IV through VI.

Column 1 of Table IV through VI contains the sources of variations--clear vision classification and residual error. Columns 2 and 3 indicate the corresponding sums of squares and the degrees of freedom. Columns 4 and 5 show the mean squares and F ratio, respectively. The F ratio indicates whether or not the sample means were significantly different from each other, and were used as a criterion in making the interpretation (Column 6).

With respect to the data samples included in this study, the important findings are:

(1) There was a significantly higher injury accident rate at four-legged intersections (both urban and rural) and urban Tee intersections with poor vision than at those with clear vision.

(2) There was a significantly higher property damage accident rate at four-legged intersections (both urban and rural) and urban Tee intersections with poor vision than at those with clear vision.

(3) There was a significantly higher accident rate at four-legged intersections (both urban and rural) and urban Tee intersections with poor vision than at those with clear vision.

TABLE IV
Analysis of Variance Table
For Urban Four-Legged Intersections
A - Personal Injury Accident Rates

Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio	Interpretation
Clear Vision Classification	5.51	2	2.76	(a) 11.50	There was a significantly higher injury accident rate at intersections with poor vision.
Error	22.05	92	0.24		
Total	27.56	94			

B - Property Damage Accident Rates

Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio	Interpretation
Clear Vision Classification	11.93	2	5.97	(a) 4.89	There was a significantly higher property damage accident rate at intersections with poor vision.
Error	112.62	92	1.22		
Total	124.55	94			

C - Total Accident Rates

Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio	Interpretation
Clear Vision Classification	33.19	2	16.60	(a) 7.54	There was a significantly higher accident rate at intersections with poor vision.
Error	202.26	92	2.20		
Total	235.45	94			

(a) Significant at 5% level of significance: 5 times in 100, F ratio may result from chance.

TABLE V
Analysis of Variance Table
For Rural Four-Legged Intersections
A - Personal Injury Accident Rates

Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio	Interpretation
Clear Vision Classification	3.06	2	1.53	(a) 7.65	There was a significantly higher injury accident rate at intersections with poor vision.
Error	7.96	39	.20		
Total	11.02	41			

B - Property Damage Accident Rates

Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio	Interpretation
Clear Vision Classification	16.87	2	8.44	(a) 7.74	There was a significantly higher property damage accident rate at intersections with poor vision.
Error	42.62	39	1.09		
Total	59.49	41			

C - Total Accident Rates

Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio	Interpretation
Clear Vision Classification	31.95	2	15.98	(a) 11.33	There was a significantly higher accident rate at intersections with poor vision.
Error	55.02	39	1.41		
Total	86.97	41			

(a) Significant at 5% level of significance: 5 times in 100, F ratio may result from chance.

TABLE VI
Analysis of Variance Table
For Urban Tee Intersections
A - Personal Injury Accident Rates

Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio	Interpretation
Clear Vision Classification	.76	2	.38	(a) 3.80	There was a significantly higher injury accident rate at intersections with poor vision.
Error	5.18	52	.10		
Total	5.94	54			

B - Property Damage Accident Rates

Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio	Interpretation
Clear Vision Classification	11.54	2	5.77	(a) 6.50	There was a significantly higher property damage accident rate at intersections with poor vision.
Error	46.17	52	.89		
Total	57.71	54			

C - Total Accident Rates

Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio	Interpretation
Clear Vision Classification	17.79	2	8.90	(a) 7.47	There was a significantly higher accident rate at intersections with poor vision.
Error	61.64	52	1.19		
Total	79.43	54			

(a) Significant at 5% level of significance: 5 times in 100, F ratio may result from chance.

REFERENCES

1. AASHO, A policy on Geometric Design of Rural Highways, 1965, (Bluebook), Washington, D.C. (1966).

2. Anderson, T. E., Kidd, E. A., and Laughery, K. R., A Computerized Simulation Model of Driver Behavior at Intersections, Cornell Aeronautical Laboratory, Inc., Buffalo, New York, (1968).

3. Cochran William G., Sampling Techniques, 2nd Ed., (Wiley), New York (1966).

4. Freund, J. E., Mathematical Statistics, Prentice - Hall, Englewood Cliffs, N. J., 1962.

5. Greenshields, B. D., Schapiro, D., and Erickson, E. L., Traffic Performance at Urban Street Intersections, Technical Report No. 1, Yale Bureau of Highway Traffic, New Haven, Connecticut, (1947).

6. Hoel, P. G., Introduction to Mathematical Statistics, 4th Ed., (Wiley), New York (1971).

7. Mercer, Donald J., Sight Distance at Urban Intersections, Michigan Department of State Highways, May, 1971.

8. Michigan Department of State Highways, Manual of Uniform Traffic Control Devices, Lansing, Michigan, (1963).

9. Scheffe Henry, The Analysis of Variance, (Wiley), New York, 1967.