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# AN ANALYSIS OF THE CROSSING-CRASH FACTOR FROM THE VIEW POINT OF THE FEATURE OF INTERSECTION

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**Abstract :** In the city area in Japan, about 50% of the traffic accident in a non-trunk road is a crossing-crash accident in a non-signal intersection. For this reason, prevention of the crossing-crash accident in a non-signal intersection is important in a city area. However, the research which analyzed the structural feature of the intersection which a crossing-crash accident tends to happen or are easy to occur frequently is not seen. So, in this research, the relevance of the occurrence condition of a crossing-crash accident and some intersectional structural features is analyzed for the non-signal intersection in a city area. The characteristics considered to influence a passing behavior as an intersection feature, such as intersectional size and passing regulation, were used.

**Key Words :** the crossing-crash accident, the non-signal intersection, a factor analysis

## 1. INTRODUCTION

In Japan, a crossing-crash accident has about 30% of all the accident number of cases [1)]. About 70% of the crossing-crash accident is caused in non-trunk roads, such as a road in a city area [1)]. About 70% of the crossing-crash accident in a non-trunk road has happened at the non-signal intersection [1)]. For this reason, prevention of the crossing-crash accident in a non-signal intersection is important in a city area.

The accident factor is clarified in some existing researches [2)3)4)5)6)] on an intersection accident by the analysis based on the traffic behavior in an accident frequent occurrence intersection. And the measure against accident prevention based on these factors is also proved. Moreover, some researches [7)8)9)] of the effect evaluation by introducing the concrete measure to a frequent occurrence intersection are also seen. However, the research which analyzed the structural feature of the intersection which a crossing-crash accident tends to happen or are easy to occur frequently is not seen. It is important to understand the intersection feature in connection with such an occurrence of a crossing-crash accident because of effective and efficient introduction of the measure against an accident.

So, in this research, the relevance of the occurrence condition of a crossing-crash accident and

the structural feature of some intersections is analyzed for the non-signal intersection in a city area. The characteristics considered to influence a passing behavior as an intersection feature, such as intersectional size and passing regulation, were used. In this research, the detailed database about a traffic accident and the characteristic of an area or a road is analyzed for the Kakogawa area (Figure 1) in Hyogo-ken in Japan already developed.

The composition of this paper is as follows.

2. : Explanation of database used for analysis.

3. : Analysis of accident occurrence condition of area for analysis.

4. : It is clearly about the intersection feature to which a crossing-crash accident tends to happen from the relevance of the intersection feature in a non-trunk road, and a crossing-crash accident occurrence condition.

5. : It is clearly especially about the crossing-crash accident frequent occurrence factor in a non-trunk road.

6. : Conclusion.

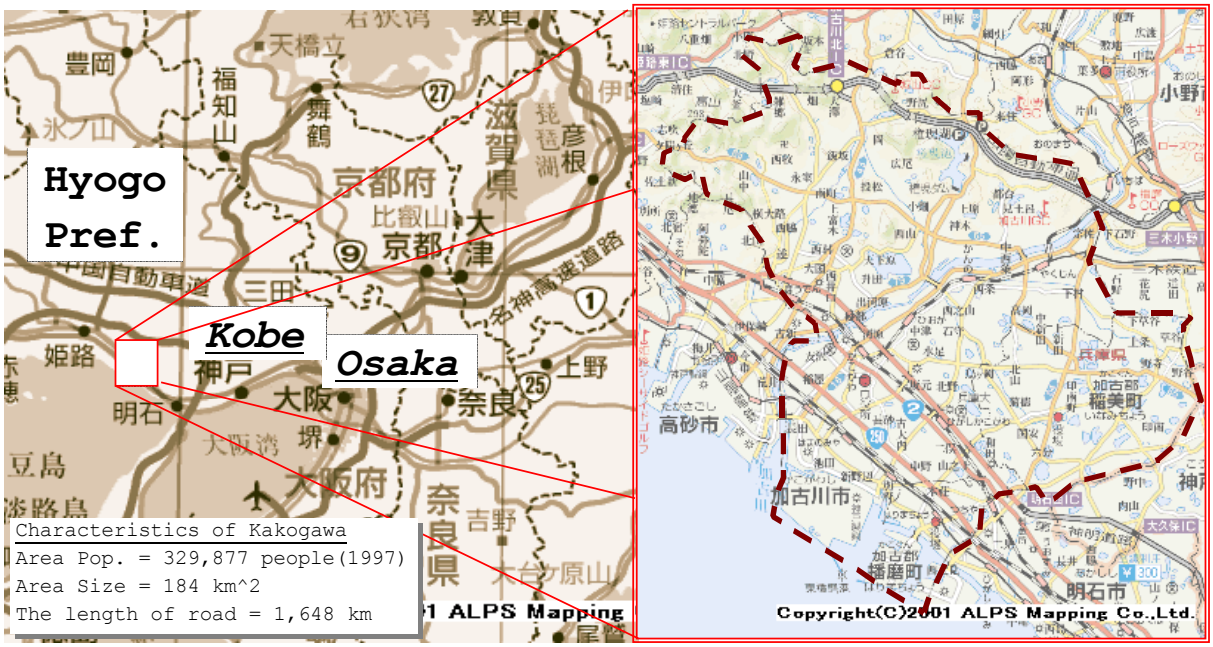


Figure 1. Position Map of Kakogawa Area in Hyogo-ken in Japan

## 2. DETAILED DATABASE IN KAKOGAWA AREA ON GIS USED FOR ANALYSIS

GIS is effective in actual condition analysis of a traffic accident, or examination of safety measures [10)11)]. Authors developed the detailed database about the road network and traffic accident in an area for the Kakogawa area as a use example of GIS. And research is positively advanced about the validity and usefulness of GIS by some accident analysis which utilized this database system [12)13)14)15)].

This research also used this database system for analysis. Based on the information this database is indicated to be by the electronic housing map (about 1/1500 digital map), the information on a road network, building form, an administrative district boundary, etc. (form and attribute) is registered. The road network database of a Kakogawa area displays Figure 2.

Furthermore, the point of the occurrence of all the accidents resulting in injury or death (the number of cases is 4436) that this database caused in 1996 and 1997 is inputted (Figure 3). The information on the characteristic about an accident unites and is built by the point data of this occurrence of an accident.

The intersection feature and the accident characteristic of having used for analysis are shown in Table 1. The structural feature (intersection sizes, such as a difference of road width and road width, classification, some traffic restriction) considered to influence a passing behavior was used for the intersection feature. These structural features were extracted from the built database already. As the accident characteristic, the accident type based on the classification of some crossing-crash accidents was used. The intersection where each accident happened was pinpointed using overlay analysis (this is one of the functions of GIS) with the graphic of

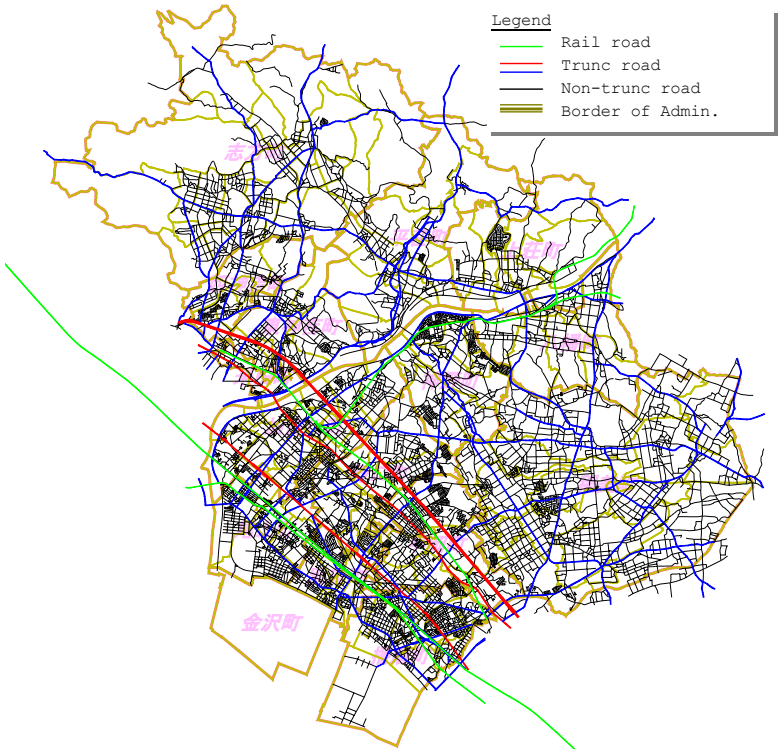


Figure 2. Road Network Database of Kakogawa Area

an accident point, and the surface graphic of the intersection automatically generated from the width of a road. By the intersection where each accident happened being pinpointed, the accident number of cases for every intersection characteristic is calculable. The occurrence number of cases for every accident classification is also calculable. On the other side, the quantity of the intersection for every accident occurrence number of cases is also calculable.

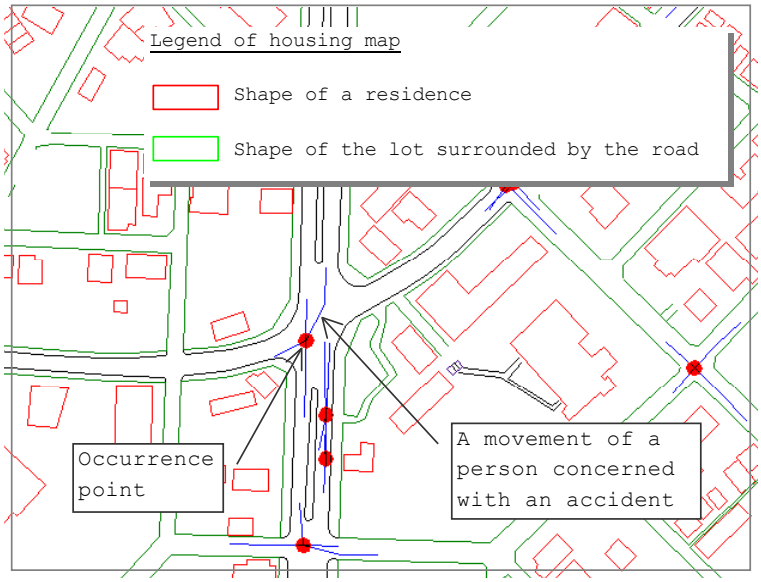


Figure 3. Occurrence Position of Accident Displayed on Housing Map

Table 1. Item of Intersection Feature Used for Analysis

| | | |
|---|---|---|
| **Intersection characteristics** | | |
| Size | Max width of the road flowing in | [width value(m)] |
| | Diffence of width of the road flowing in | [width value(m)] |
| Kind | Cross street combination | [trunc road(both of trunc road)]/ [non-trunc road(other)] |
| Traffic restriction | Signal | [With]/[Without] |
| | Stop regulation(It was installed in the intersection before 1996 of accident data.) | [With]/[Without] |
| | Width of the priority road in a stop regulation intersection | [width value(m)] |
| | Width of the non-priority road in a stop regulation intersection | [width value(m)] |
| | The difference of the width of the priority road and the road non-giving priority in a stop regulation intersection | [width value(m)] |
| **Accident characteristic** | | |
| Type | Crossing-crash | Cars |
| | | Car and motorbike |
| | | Car and bicycle |
| | | Other crossing-crash |
| | Non-crossing-crash | Other accidents |

## 3. ACCIDENT OCCURRENCE CONDITION OF THE ANALYSIS DISTRICT

Table 2 shows the accident number of cases according to characteristic of an accident occurrence place for every road classification in the area for analysis. The half of an accident has happened at the intersection. 64% of all the accident number of cases has happened in the non-trunk road. 43% of the number of cases of all accidents is a crossing-crash accident. 84% of the crossing-crash accident has happened in the non-trunk road. 73% of the crossing-crash accident of a non-trunk road has happened at the non-signal intersection. An analysis area has the high ratio which a crossing-crash accident occupies compared with the average city area in Japan. However, the ratio which the crossing-crash accident of a non-trunk road occupies is equivalent to the average city area in Japan. Judging from these accident occurrence conditions, this analysis area is considered to be suitable, although the intersection feature in connection with the occurrence of a crossing-crash accident is analyzed.

Table 2. The Occurrence Accident Number of Cases on Road in Kakogawa Area (at 1996-1997)

Unit : Number of accidents
<>:Ratio of all the crossing-crash accident number of cases in a non-trunk road
[]:Ratio of all the crossing-crash accident number of cases
():Ratio of all the accident number of cases

| | | Occurence place | | | | Total |
|---|---|---|---|---|---|---|
| | | Road Section | Intersection | | | |
| | | | Signal | Non-signal | Subtotal | |
| Road type | Trunc road | 1365(31%) | 156(4%) | 65(1%) | 221(5%) | 1586(36%) |
| | Crossing-crash | 229 | 55 | 31 | 86 | 315[16%] |
| | Non-crossing-crash | 1136 | 101 | 34 | 135 | 1365 |
| | Non-trunc road | 798(18%) | 450(10%) | 1602(36%) | 2052(46%) | 2850(64%) |
| | Crossing-crash | 241<15%> | 201<12%> | 1169<73%> | 1370<85%> | 1611<100%>[84%] |
| | Non-crossing-crash | 557 | 249 | 433 | 682 | 1239 |
| Total | All | 2163(49%) | 606[27%](14%) | 1667[73%](38%) | 2273[100%](51%) | 4436(100%) |
| | Crossing-crash | 470 | 256 | 1200 | 1456 | 1926[100%](43%) |
| | Non-crossing-crash | 1693 | 350 | 467 | 817 | 2510(57%) |

## 4. RELATION OF INTERSECTION FEATURE AND OCCURRENCE OF CROSSING-CRASH ACCIDENT IN NON-TRUNK ROAD

The relevance of some intersection features and the occurrence of an accident according to accident type is analyzed for the intersection of the non-trunk road where the accident has happened. The accident type was classified into five kinds, the crossing-crash of cars, the crossing-crash of a car and a motorbike, the crossing-crash of a car and a bicycle, the other crossing-crash accident, and other accidents.

Table 3 shows the accident number of cases according to accident type for every intersection with a signal, and signal-less intersection. It is thought that the crossing-crash accident in an intersection with a signal has occurred by ignoring a traffic light. The crossing-crash accident

which has occurred by ignoring a traffic light forms 45% of all accidents. On the other hand, in 73% of all accidents, the crossing-crash accident occupies at the signal-less intersection. The crossing-crash accident of a car and a bicycle occupies most 29%. Subsequently, the crossing-crash accident of cars occupies 25%. The crossing-crash accident of a car and a motorbike occupies 17%. The ratio of the crossing-crash accident of a bicycle and a motorbike is large about 2.5 times compared with an intersection with a signal.

Table 3. The Accident Occurrence Number of Cases According to Accident Type in Intersection with Signal and Signal-Less Intersection in Non-Trunk Road

Unit : Number of accidents (%)

| | Cars | Car and motorbike | Car and bicycle | Other crossing-crash | Except a crossing-crash accident | Total |
|---|---|---|---|---|---|---|
| Signal-less | 399(25%) | 269(17%) | 460(29%) | 41(3%) | 433(27%) | 1602(100%) |
| With signal | 111(25%) | 30(7%) | 56(12%) | 4(1%) | 249(55%) | 450(100%) |
| Total | 510(25%) | 299(15%) | 516(25%) | 45(2%) | 682(33%) | 2052(100%) |

Next, the accident number of cases according to accident type is shown for every inflow road width rank for the non-signal intersection of a non-trunk road as an index which shows intersection size in Table 4. The rate that a crossing-crash accident occupies is so large that the greatest width of an inflow road is small. That is, at the non-signal intersection of a non-trunk road, when an inflow road width is less than 6m, a crossing-crash accident tends to happen. At this intersection, most accidents are crossing-crash accidents.

Table 4. The Accident Occurrence Number of Cases According to Accident Type for Every Inflow Road Width Rank in Non-Signal Intersection of Non-Trunk Road

Unit : Number of accidents (%)

| Max width of the road flowing in | Cars | Car and motorbike | Car and bicycle | Other crossing-crash | Other accidents | Total |
|---|---|---|---|---|---|---|
| 0-6 | 55(26%) | 49(23%) | 83(39%) | 15(7%) | 9(4%) | 211(100%) |
| 6-10 | 212(32%) | 109(16%) | 187(28%) | 9(1%) | 155(23%) | 672(100%) |
| 10-14 | 74(18%) | 73(18%) | 110(27%) | 14(3%) | 132(33%) | 403(100%) |
| 14- (m) | 58(18%) | 38(12%) | 80(25%) | 3(1%) | 137(43%) | 316(100%) |
| All | 399(25%) | 269(17%) | 460(29%) | 41(3%) | 433(27%) | 1602(100%) |

Table 5 shows the accident number of cases according to accident type for every inflow road width difference rank as an index which shows the gap of both of a cross street. The rate that a crossing-crash accident occupies is so large that an inflow road width difference is small. That is, at the non-signal intersection of a non-trunk road, an intersection with few differences of the size of an inflow road tends to cause a crossing-crash accident. The intersection which the priority side road cannot distinguish easily shows that a crossing-crash accident tends to happen.

Table 5. The Accident Occurrence Number of Cases According to Accident Type for Every Inflow Road Width Difference Rank in Non-Signal Intersection of Non-Trunk Road

Unit : Number of accidents (%)

| Diffence of width of the road flowing in | Cars | Car and motorbike | Car and bicycle | Other crossing-crash | Other accidents | Total |
|---|---|---|---|---|---|---|
| 0-2 | 93(30%) | 58(19%) | 101(33%) | 16(5%) | 41(13%) | 309(100%) |
| 2-4 | 143(33%) | 75(17%) | 128(29%) | 4(1%) | 85(20%) | 435(100%) |
| 4-6 | 53(21%) | 46(18%) | 76(30%) | 6(2%) | 75(29%) | 256(100%) |
| 6-8 | 32(17%) | 33(18%) | 47(26%) | 7(4%) | 64(35%) | 183(100%) |
| 8-(m) | 78(19%) | 57(14%) | 108(26%) | 8(2%) | 168(40%) | 419(100%) |
| All | 399(25%) | 269(17%) | 460(29%) | 41(3%) | 433(27%) | 1602(100%) |

On the other hand, Table 6 is shown in order to understand the actual condition of the crossing-crash accident in the intersection with stop regulation which specified the priority side road. In addition, the analysis result only using the accident number of cases of an area which has inputted the information on stop regulation existence is shown here. At the intersection with stop regulation, 87% of the whole accident is formed in the crossing-crash accident. At the intersection without regulation, 78% of the whole accident is formed in the crossing-crash accident. In the intersection with stop regulation, a crossing-crash accident tends to happen rather than a stop-regulation-less intersection.

Table 6. The Accident Occurrence Number of Cases According to Accident Type for Every Stop Regulation Existence in Intersection of Non-Trunk Road

Unit : Number* of accidents (%)

| Stop regulation | Crossing-crash | Other accidents | Total |
|---|---|---|---|
| With | 58(87%) | 9(13%) | 67(100%) |
| Without | 114(78%) | 32(22%) | 146(100%) |
| All | 172(81%) | 41(19%) | 213(100%) |

*)Only the accident number of cases generated at the intersection currently investigated about the existence of stop regulation was used.

From the above thing, the intersection feature which is easy to cause a crossing-crash accident among the non-signal intersections of a non-trunk road was clarified. Next, the intersection feature with which crossing-crash accidents occur frequently is discussed.

## 5. FREQUENT OCCURRENCE FACTOR OF CROSSING-CRASH ACCIDENT IN NON-SIGNAL INTERSECTION OF NON-TRUNK ROAD

Next, it clarifies about the intersection feature in the non-signal intersection of a non-trunk road with which crossing-crash accidents tend to occur frequently. Here, the occurrence state of a crossing-crash accident was specified for every intersection from the number of cases of the accident which happened at the intersection. The occurrence state in an intersection was separated by the occurrence existence of a crossing-crash accident. Furthermore, at the intersection where the crossing-crash accident happened, the average occurrence number of cases of a crossing-crash accident separated frequent occurrence and non-occurring frequently. This classified the occurrence state of a crossing-crash accident into three (frequent occurrence, un-occurring frequently, the occurrence of other accidents).

The total number of intersections of an analysis area is 9090 places. Among these, in the intersection of a non-trunk road, the number of 8935 places and non-signal intersections is 8719. Furthermore, a certain accident has occurred among these at 977 non-signal intersections. This occupies 11% of a non-signal intersection, and 10% of all intersections.

Table 7 shows the number of intersections for every inflow road width rank in the non-signal intersection of a non-trunk road. The ratio of the number of intersections in which the crossing-crash accident happened is so large that intersection size is small. The ratio of the number of frequent occurrence intersections is so large that intersection size is large at the intersection where the crossing-crash accident happened.

Table 7. Number of Intersections for Every Inflow Road Width Rank in Non-Signal Intersection of Non-Trunk Road Where Accident Happened

Unit : Number of accident occurrence intersections [%](%)

| Max width of the road | Occurrence of crossing-crash accidents | | | Occurrence of other accidents | Total |
|---|---|---|---|---|---|
| | Fraquent occurence intersection | Frequently non-occurring intersection | Subtotal | | |
| 0-6 | 33[22%] | 117[78%] | 150[100%](96%) | 7(4%) | 157(100%) |
| 6-10 | 82[23%] | 268[77%] | 350[100%](77%) | 104(23%) | 454(100%) |
| 10-14 | 54[35%] | 100[65%] | 154[100%](75%) | 51(25%) | 205(100%) |
| 14- (m) | 37[36%] | 66[64%] | 103[100%](64%) | 58(36%) | 161(100%) |
| All | 206[27%] | 551[73%] | 757[100%](77%) | 220(23%) | 977(100%) |

Table 8 shows the number of intersections for every inflow road width difference rank in the non-signal intersection of a non-trunk road. The ratio of the number of intersections in which the crossing-crash accident happened is so large that a width difference is small. At the intersection where the crossing-crash accident happened, although there is variation a little,

the ratio of the number of frequent occurrence intersections is in such a large tendency that a width difference is large in general.

Table 8. Number of Intersections for Every Inflow Road Width Difference Rank in Non-Signal Intersection of Non-Trunk Road Where Accident Happened

Unit : Number of accident occurrence intersections [%](%)

| Diffence of width of the road | Occurrence of crossing-crash accidents | | | Occurrence of other accidents | Total |
|---|---|---|---|---|---|
| | Fraquent occurence intersection | Frequently non-occurring | Subtotal | | |
| 0-2 | 42[21%] | 157[79%] | 199[100%](90%) | 23(10%) | 222(100%) |
| 2-4 | 62[28%] | 159[72%] | 221[100%](81%) | 52(19%) | 273(100%) |
| 4-6 | 26[21%] | 98[79%] | 124[100%](76%) | 40(24%) | 164(100%) |
| 6-8 | 23[32%] | 50[68%] | 73[100%](68%) | 35(32%) | 108(100%) |
| 8-(m) | 53[38%] | 87[62%] | 140[100%](67%) | 70(33%) | 210(100%) |
| All | 206[27%] | 551[73%] | 757[100%](77%) | 220(23%) | 977(100%) |

Table 9 shows the number of intersections for every stop regulation existence in the non-signal intersection of a non-trunk road. However, in this analysis, only the number of intersections of the area which has investigated stop regulation existence was used. As for the ratio of the number of intersections in which the crossing-crash accident happened, by stop regulation existence, a difference is hardly seen. However, the ratio of the number of frequent occurrence intersections in the intersection where the crossing-crash accident happened shows 2.5 times of the ratio of the number of intersections without stop regulation.

Table 9. Number of Intersections for Every Stop Regulation Existence in Non-Signal Intersection of Non-Trunk Road Where Accident Happened

Unit : Number of accident occurrence intersections [%](%)

| Stop regulation | Occurrence of crossing-crash accidents | | | Occurrence of other accidents | Total |
|---|---|---|---|---|---|
| | Fraquent occurence intersection | Frequently non-occurring | Subtotal | | |
| With | 13[50%] | 13[50%] | 26[100%](79%) | 7(21%) | 33(100%) |
| Without | 14[21%] | 52[79%] | 66[100%](80%) | 16(20%) | 82(100%) |
| All | 27[29%] | 65[71%] | 92[100%](80%) | 23(20%) | 115(100%) |

*)Only the number of intersections of the area currently investigated about stop regulation existence was used.

Furthermore, at this intersection with stop regulation, analysis of the frequent occurrence condition of a crossing-crash accident was tried from the size relation between the width of a

priority road, and the width of a non-priority road. In this analysis, the discriminant analysis which judges whether crossing-crash accidents occur frequently was applied. Three condition (the case where a priority road is large, the case where a non-priority road is large, and when the same) of a width difference, and the size of a width difference were made into the explaining variable. Table 10 shows this analysis result. According to the group average value, it can be said that it is easy to occur frequently, so that a discrimination score is small. Judging from the value and sign of a standardization discrimination coefficient, when either is large compared with the case where a width is the same, a discrimination score becomes small. The trend is strong when a priority road is larger than a non-priority road. Moreover, a discrimination score becomes small, so that a width difference is large. Therefore, the intersection where a priority road is larger shows the trend for crossing-crash accidents to occur frequently.

Table 10. Result of Discriminant Analysis of Frequent Occurrence and Not Occurring Frequently at Intersection with Stop Regulation of Non-Signal Intersection of Non-Trunk Road

| | | |
|---|---|---|
| Explaining variable (upper row = distinction coefficient / lower berth = standardization coefficient) | Absolute value of width difference of priority road and road non-giving priority | -0.106 |
| | | -0.023 |
| | A priority road is large (dummy variable) *1 | -0.308 |
| | | -0.625 |
| | The road non-giving priority is large (dummy variable)*1 | -0.045 |
| | | -0.100 |
| | Constant term | 0.044 |
| Fit index | chi square value ( degree of freedom:6 ) *2 | 20.833 |
| | F value ( degree of freedom:3,115 ) *3 | 2.777 |
| Group average | Frequent occurrence | -0.151 |
| | Non-occurring frequently | 0.151 |
| Percentage correct | Frequent occurrence | 54% |
| | Non-occurring frequently | 70% |

*1)A dummy variable takes the value of 1, when satisfying it, and when other, it takes the value of 0. When both of widths were equal, both dummy variables took the value of 0.

*2) The hypothesis of homoscedasticity was rejected at 1% of levels of significance

*3) The hypothesis of the difference of population mean was rejected at 5% of levels of significance.

The following things became clear about the occurrence of the crossing-crash accident in the non-signal intersection of a non-trunk road from the above thing. At the intersection where intersection size is small and where a width difference is small, it is easy to cause a crossing-crash accident. However, it does not necessarily occur frequently at the intersection. Conversely, at the intersection where intersection size is large and a width difference is large, crossing-crash accidents tend to occur frequently. On the other hand, a difference is not looked at by the occurrence of a crossing-crash accident by the existence of stop regulation. However, crossing-crash accidents tend to occur frequently like the intersection where the width of a priority road is wide.

## 6. CONCLUSION

For all the intersections of an analysis area, the relevance of the occurrence number of cases of a crossing-crash accident, its occurrence state, and the structural feature of a non-signal intersection was analyzed statistically. Consequently, the intersection feature relevant to the ease of happening and the ease of occurring frequently of a crossing-crash accident was clarified.

The result is summarized to below.

(1) At the non-signal intersection of a non-trunk road, it is easy to cause a crossing-crash accident generally, so that size is small and the difference of crossing road width is small. In an intersection without a signal, the crossing-crash accident of a bicycle, or a motorbike and a car tends to happen about 2.5 times compared with an intersection with a signal.

(2) At the non-signal intersection of the non-trunk road where the accident has happened, crossing-crash accidents tend to occur frequently, so that the width of a crossing road is wide and the difference of road width is large. Moreover, in an intersection with stop regulation, a crossing-crash accident tends to occur frequently. It is about 2.5 times as compared with an intersection without stop regulation.

(3) Especially at the non-signal intersection with stop regulation where the accident has happened, crossing-crash accidents tend to occur frequently, so that the priority road is larger and the difference of the road width of a priority road and a non-priority road is large.

In the measure of the crossing-crash accident of a non-signal intersection, it can be said that not only cars but a bicycle and a motorbike are important. The intersection feature with which crossing-crash accidents occur frequently differs from the intersection feature which is easy to cause a crossing-crash accident.

In this study, the concrete vehicles behavior which influences frequent occurrence cannot be clarified. However, the following vehicles behaviors which can be guessed from the intersection feature are also considered to be the factors of frequent occurrence. - Stop failure in an intersection with stop regulation (a certain reason). - Follow on the increase in the vehicles speed of a priority road, and it is the delay of the sudden stop of priority road vehicles. - By increase of the velocity differential of a priority road and a non-priority road, even if non-priority road vehicles recognize opposite vehicles, it cannot stop before an intersection corner.

For this reason, in order to deter frequent occurrence of a crossing-crash accident, it is important that the vehicles of a non-priority road stop certainly and that opposite vehicles can be recognized further safely. Simultaneously, when passing through the intersection which has the feature with which crossing-crash accidents occur frequently, the speed reduction measure for priority road vehicles may also be necessity.

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