STUDY ON THE ANALYSIS OF INTERSECTION TRAFFIC ACCIDENTS USING REAL TRAFFIC ACCIDENT IMAGES

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1. Abstract

Factors contributing to traffic accidents are numerous, and they interact complexly. Even so, clarification of accident causes is indispensable in planning effective accident prevention measures.

Onsite accident reports filled out by the police conventionally are used as the primary data for clarifying accident causes; however, a sufficient number of cases will never be obtained from such reports alone, no matter how long observations continue.

For this reason, some studies use occurrence of traffic conflict as an alternative evaluation index. However, traffic conflict is rarely used in academic studies because of the difficulty in defining "complication" and the tendency toward subjective bias.

This study proposes methods of investigating and analyzing data on the following: 1. accidents resulting in injury or death (based on onsite accident reports), 2. accidents involving property damage, and near-miss incidents (based on TAAMS images) and 3. traffic disturbances (based on videotaped images). It examines the validity of these analysis methods.

Moreover, the influence of frozen road surface on traffic accidents in winter is examined by TAAMS images in this study.

2. Introduction

There are many factors contributing to traffic accidents, and they interact in complex ways. Even so, clarification of accident causes is indispensable in planning effective accident prevention measures.

Onsite accident reports filled out by the police conventionally are used as the primary data for clarification of causes. These reports, which are filled out based on oral statements by the parties involved, tend to be vague and subjective, which makes it difficult to accurately understand the origin and development of each accident. Furthermore, because

onsite accident reports record only accidents involving injury or death, these reports are few, making the analysis of causes difficult.

This study attempts new methods of investigation and analysis to overcome the above-mentioned limitations and to improve the accuracy of analysis of causes.

3. Investigation Method

Even with long-term observation, there will never be enough cases to analyze factors contributing to traffic accidents if we depend only on conventional traffic accident data obtained from onsite accident reports. Furthermore, when accident prevention measures are taken, it may take many years to measure their effects using those reports.

To overcome these limitations, this study analyzed factors contributing to traffic accidents by comprehensively considering three data sources: onsite accident reports, TAAMS and VTR (Figure 1). The following explains the data sources and their application.

1) The conventional data of onsite accident reports was used as input data for the analysis of causes of accidents resulting in injury or death.
2) The Traffic Accident Auto Memory System (TAAMS) developed by the National Research Institute of Police Science, Japan objectively recorded as moving image data the minor accidents not reported to the police, as well as near misses that did not result in accidents.

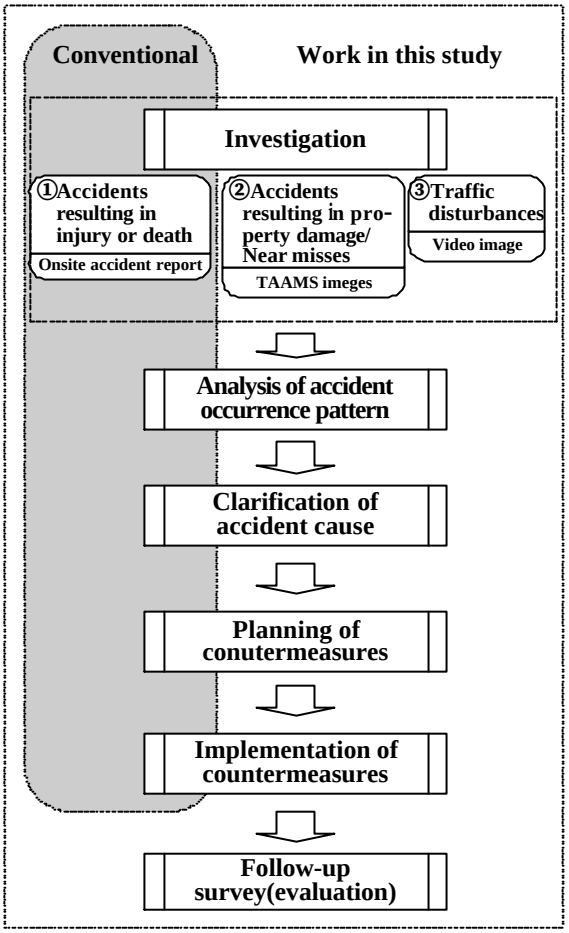


Figure 1 Flowchart of Accident Analysis

3) Cameras and VTRs recorded as moving image data the various traffic disturbances in daily traffic flow.

The data obtained in VTRs recorded was rendered into a single evaluation index by defining 15 major categories (30 subcategories) of traffic disturbance for objective and thorough recording and quantification of investigated results.

The following paragraphs describe the methods of investigating traffic disturbance using TAAMS and VTR.

3.1 TAAMS investigation

As shown in Figure 2, TAAMS comprises a video camera, a sound detector and discriminator, and an image memory VTR. The system automatically records images taken by a camera installed on the street.

At normal times, images are

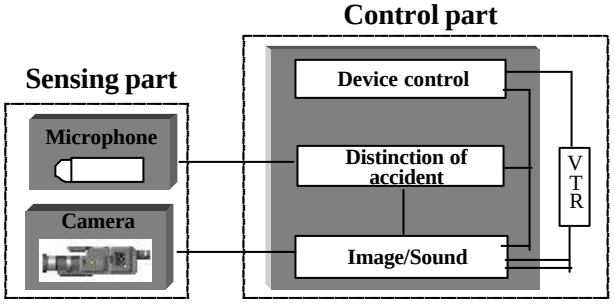


Figure 2 Composition of TAAMS

temporarily stored digitally in memory before being overwritten. When a sound input through a microphone is determined to be the special sound of either an accident or a near miss, the system stores the image data for the preceding and following five seconds, converts it to analog signals and records it on the VTR. It is possible to record all images, by disabling the sound discrimination function.

3.2 Video image investigation

Many traffic accidents are caused by violations of traffic regulations. Violations include dangerous disregarding of a traffic signal and improper right or left turn. The frequency and pattern in which these violations occur are considered to be information that clarifies traffic phenomena.

This study comprehensively defined as "traffic disturbance" the various violations of traffic regulations or dangerous traffic phenomena at an ordinary intersection, and categorized these into 15 types (Table 1). They were subdivided into 30 subtypes, according to the occurrence pattern.

One of the traffic disturbances, for instance, is disregarding of a traffic signal. A distinction is made between disregarding by a vehicle and that by a pedestrian. Disregarding of a traffic signal by a vehicle is divided into three types: entering the intersection with all red (4-1), early start (4-2), and disregarding of a red light (4-3). Disregarding of a red light (4-3) is the most dangerous of the three. Traffic disturbances were defined by picking out items related to ordinary intersections from the types of traffic rule violations.

Table 1 Types of Traffic Disturbance and their Definitions

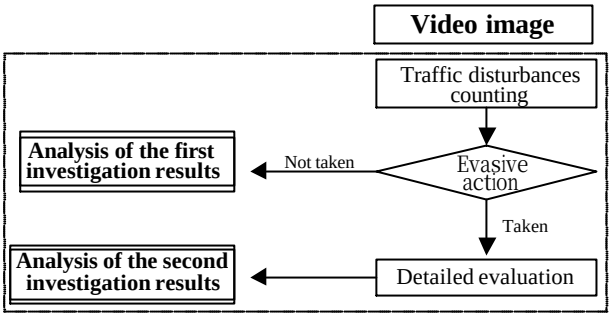
Type			Pattern	
1	**Obstruction of pedestrian**		1-1	Failure of left-turn car to yield to pedestrian
			1-2	Failure of left-turn car to yield to bicycle
			1-3	Failure of right-turn car to yield to pedestrian
			1-4	Failure of right-turn car to yield to bicycle
			1-5	Obstruction of pedestrian by stopping beyond the stop line
2	**Illegal parking/stopping**		2-1	Illegal stopping
			2-2	Illegal parking
3	**Imroper right/left turn**		3-1	Illegal left-turn
			3-2	Illegal right-turn
			3-3	Failure to yield to straight-going vehicle
			3-4	Failure to yield to left-turning vehicle
4	**Disregarding of traffic signal**	Vehical	4-1	Entering the intersection with all red
			4-2	Early start
			4-3	Disregarding of the red light
		Pedestrian	4-4	Disregarding of the walk light
5	**Illegal sudden braking**		5-1	Sudden braking
6	**Illegal course change**		6-1	Lane change in the intersection
			6-2	U-turn in the intersection
7	**Illegal passing**		7-1	Passing in the intersection
8	**Driving without light**		8-1	Driving without light at night
9	**Illegal crossing, etc.**		9-1	Disorderly crossing
10	**Illegal passing through**		10-1	Passing through the sidewalk/bicycle road
			10-2	Entering the intersection from nearby facilities
11	**Traffic zone violation**		11-1	Protrusion of right-turning vehicle
			11-2	Driving beyond the centerline
12	**Illegal cutting in, etc.**		12-1	Cutting in
13	**Stopping beyond the stop line**		13-1	Stopping beyond the stop line
14	**Remaining in the intersection**		14-1	Obstruction during exit
			14-2	Obstruction during entrance
15	**Driving instability due to road surface**		15-1	Driving instability

Traffic disturbances can be divided largely into those with and without evasive action. Furthermore, the degree of danger resulting from a traffic disturbance depends on whether evasive action is taken. If no evasive action is taken, the relationship among the number and the time of occurrences, the indication of the signal, the surrounding environment and the daily traffic flow is crucial. When an evasive action is taken, it is necessary to understand which party has taken the action and to what extent they have done so.

Because of this, we decided to investigate traffic disturbances in two stages.

Figure 3 shows the investigation process, with detailed investigation worksheets below.

In the first stage of investigation, all traffic disturbances in video images were counted and classified. At the same time, the direction of travel, the traffic condition and display of the traffic signal at the time of the disturbance, road surface conditions, snow accumulation (only in winter), the time of occurrence, and presence or absence of evasive action were recorded. Results were analyzed for each inflow section by type and pattern.



First investigation sheet

Traffic disturbance		Inflow section	Traffic condition	Signal indication							Road surface condition				Condition of snow			Time	Evasive action	
				For vehicles				For pedestrians												
Type	Pattern			Green	Yellow	All red	Red	Green	Blinking	Red	Dry	Wet	Compacted snow	Icy	Roadside	Half the left	Left lane		Not taken	Taken
1	1	3	Heavy	○							○							13:30		○
5	1	1	Average		○						○							15:43	○	
4	4	4	Light						○		○							19:16		○
⋮																				
13	1	2	Light			○						○						23:14	○	
6	2	2	Light				○					○						23:15		○
1	1	4	Light	○					○		○							2:34		○

Second investigation sheet

1.Obstruction of pedestrian

Items for evaluation													
Type of the vehicle		Speed		Signal indication							Evasive action		
				For vehicle				For pedestrians			First party	Second party	
First party	Second party	First party	Second party	Green	Yellow	All red	Red	Green	Blinking	Red	Brake /Steering	Brake /Steering	
Car	Pedestrian	30	1.3	○					○		Brake		
Pedestrian	Car	3.5	20	○						○		Brake&Steering	
⋮													
Truck	Pedestrian	50	1.2		○						Brake&Steering	Brake&Steering	

2.Illegal Parking/stopping

3.Improper right/left turn

4.Disregarding of traffic signal

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15.Road surface

Figure 3 Procedure of the Traffic Disturbance Investigation

The second stage of investigation concerned disturbances with evasive action. In this investigation, items including the type of the vehicle, the speed immediately before the evasive action, the display of the traffic signal, and specific action taken were examined in detail for each traffic disturbance, and the degree of danger was evaluated.

4. Investigation Point

The Fushimi intersection at West 21 and South 14 on Kanjo St. in Sapporo was selected as the target of the investigation. This intersection is a commonly traveled four-way intersection, where accidents frequently occur.

The main road has two lanes in each direction and the traffic is heavy. The minor road has one lane in each direction and the traffic is light.

With the installation of TAAMS on a utility pole at the roadside, the investigation started in January 1999 and it is ongoing.

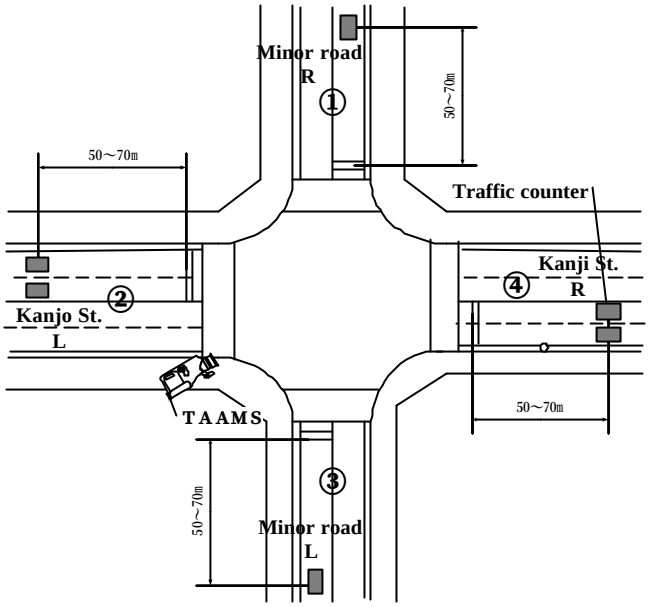


Figure 4 Investigation Sections and Devices

Together with TAAMS, investigation of the traffic volume by traffic counter and the traffic flow conditions by video camera were conducted in summer and winter, for one week each.

Figure 4 shows the configuration of the intersection, as well as the installation locations of each investigation device.

5. Results of the Investigation

5.1 Investigation of onsite accident reports

According to the onsite accident reports during the five years from 1990, thirty accidents at this intersection resulted in injury (two cases of serious injury; 38 cases of minor injury) or death.

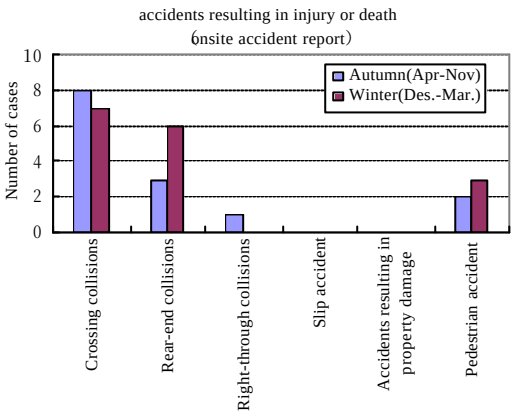
The season and the location of accidents involving injury are shown in Figure 5. An open circle represents a single accident. A closed circle represents an accident with indeterminable travel direction and lane of occurrence, which account for approximately 30 percent of the whole.

According to the onsite accident reports, crossing collisions occurred most frequently, with these accounting for 50 percent of all of accidents, followed by rear-end collisions. Accidents during the four months of winter accounted for 53 percent of the whole; however, the accident pattern was roughly the same in summer and winter.

5.2 TAAMS investigation

5.2.1 Accidents

During the period from January 1999 to June 2001, TAAMS recorded fifteen accidents,



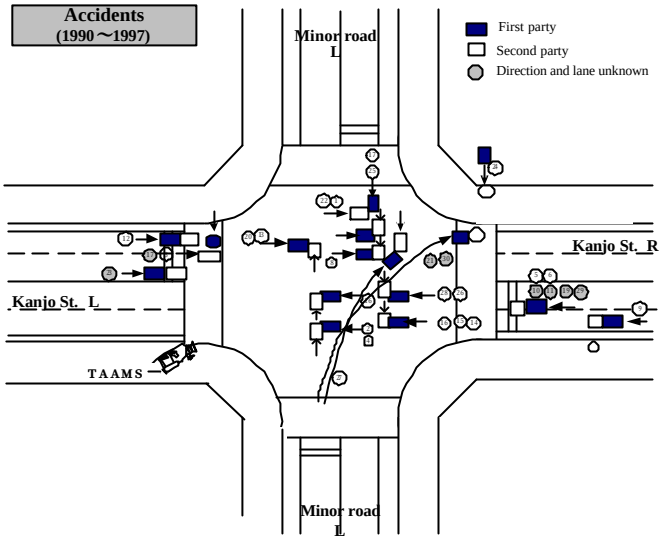
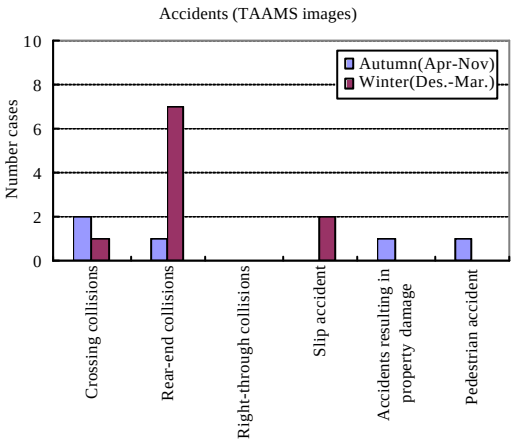


Figure 5 Accidents Based on Onsite Accident Reports



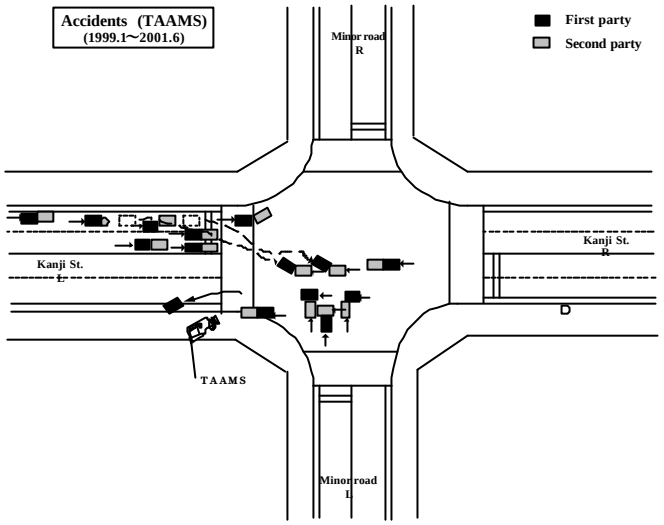
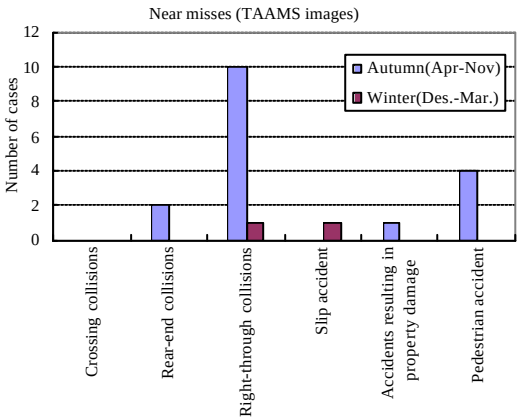


Figure 6 Accidents Recorded by TAAMS



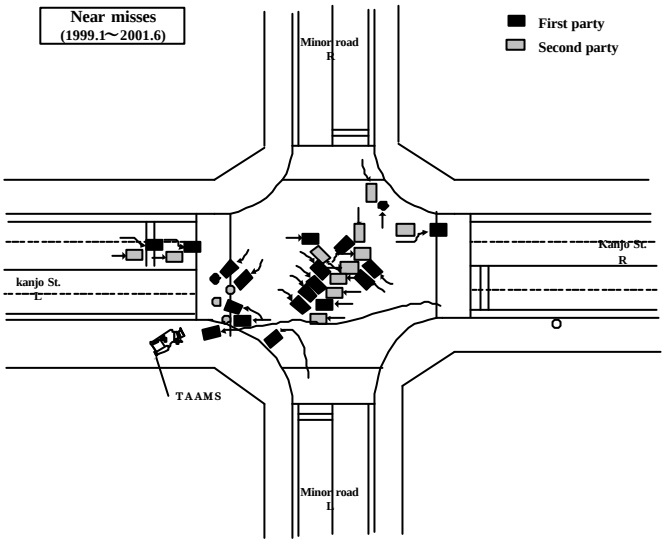


Figure 7 Near Misses Recorded by TAAMS

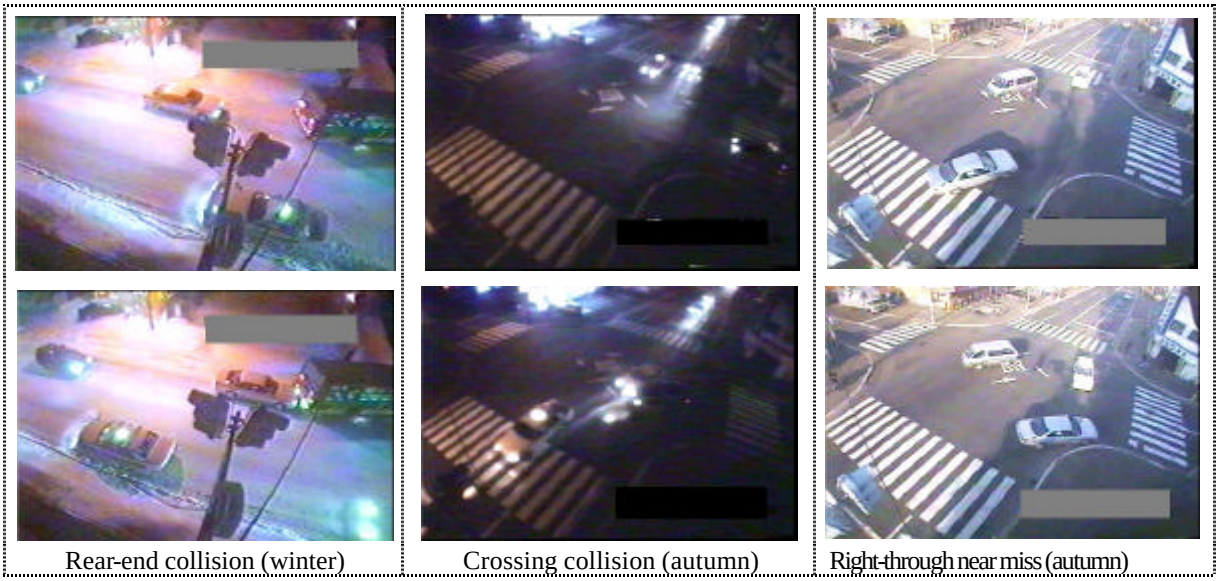
most of which were not reported to the police. The season and locations of those accidents are shown in Figure 6.

According to TAAMS, rear-end collisions at "Kanjo St. L" (see Figure 6) occurred most frequently, followed by crossing collisions. Accidents during the four months of winter accounted for 73 percent of the whole. Furthermore, the accident pattern was found to differ between summer and winter.

Among the accident images recorded by TAAMS, typical rear-end and crossing collisions are shown in Figure 8.

5.2.2 Near misses

There were 19 near misses recorded by TAAMS during the period from January 1999 to June 2001, of which 90 percent occurred in autumn. The locations of near misses are shown in Figure 7.



Rear-end collision (winter) | Crossing collision (autumn) | Right-through near miss (autumn)

Figure 8 Accidents and Near Missed Recorded by TAAMS

According to TAAMS, near misses between right-turning vehicles and straight-going vehicles predominated, followed by near misses between vehicles and pedestrians. The pattern of near miss was found to differ greatly between summer and winter.

A typical right-through near miss captured by TAAMS is shown in Figure 8.

5.3 Video image investigation

Investigation of traffic disturbances was carried out by video camera in summer and winter of 2000, for one week each.

Of the fifteen types of traffic disturbance defined above, eleven were observed at this particular intersection. They are detailed in Table 2.

Traffic disturbances frequently occurring both in summer and winter are improper right/left turn, disregarding of a traffic signal and illegal passing through. Stopping beyond the stop line occurred frequently in winter, often resulting in obstruction of pedestrians.

Furthermore, improper right/left turn tended to occur frequently in the direction of Kanjo St. in winter, and the minor road in summer.

The dominant pattern of disregarding of a traffic signal in winter was vehicle entry into the intersection with all red, as well as pedestrian illegal crossing. The most dangerous disregarding of a red light took place frequently in summer, concentrated in the direction of Kanjo St.

Table 2 Results of Traffic Disturbance Investigation

Type		Pattern	Winter					Autumn				
			Inflow section					Inflow section				
			①	②	③	④	Total	①	②	③	④	Total
1	**Obstruction of pedestrian**	1-1	5			4	9					
		1-2										
		1-3				5	5					
		1-4										
		1-5	22	14	9	9	54				5	5
		Total	27			18	**68**				5	**5**
2	**Illegal parking /stopping**	2-1	18	9	14	67	108		14		31	45
		2-2										
		Total	18	9	14	67	**108**		14		31	**45**
3	**Improper right /left turn**	3-1										
		3-2	89	18	35	27	169	23	31	72	41	167
		3-3	5	5	9	5	24					
		3-4		5		9	14					
		Total	94	28	44	41	**207**	23	31	72	41	**167**
4	**Disregarding of traffic signal**	4-1		35	23	95	153		9	9	67	85
		4-2	27	23	14	18	82		34	14	5	53
		4-3				9	9	5	14		13	32
		4-4	81	9	18	40	148	41	5	18	27	91
		Total	108	67	55	162	**392**	46	62	41	112	**261**
6	**Ilegal course change**	6-1		5			5		5			5
		6-2									4	4
		Total		5			**5**		5		4	**9**
7	**Illegal passing**	7-1									18	**18**
9	**Illegal crossing**	9-1	9	9	5	13	**36**	9	9	14	4	**36**
10	**Illegal passing through**	10-1	121	5		23	149	81	36		68	185
		10-2	40	5	9	14	68	72	9		54	135
		Total	161	10	9	37	**217**	153	45		122	**320**
11	**Traffic zone violation**	11-1										
		11-2	5	4	5	22	36	5	4	9	9	27
		Total	5	4	5	22	**36**	5	4	9	9	**27**
13	**Stopping beyond the stop line**	13-1	126	45	144	50	**365**	9	23	9	18	**59**
14	**Remaining in the intersection**	14-1	4	18	5		27		14			14
		14-2		5		13	18					
		Total	4	23	5	13	**45**		14			**14**
Subtotal of each inflow section			552	200	281	423		245	207	145	364	
Total			1479					961				

6. Analysis of Results

The above investigations revealed the following, concerning the investigated intersection.

(1) Accidents at the intersection involving injury reported in onsite accident reports, most frequently involve crossing collisions. In most cases the accidents were caused by disregarding of the traffic signal by vehicles bound for Kanjo St., although frozen road surface was a factor.

(2) Many accidents recorded by TAAMS occurred at "Kanjo St. L." Of these, rear-end collisions were most common. The causes of the accidents include entering and exiting of nearby facilities and absence of a right-turning bay, as well as frozen road surface. All three crossing collisions originated in disregarding of the traffic signal by vehicles.

(3) Many of the near misses recorded by TAAMS occurred at the intersection. Those between

right-turning and straight-going vehicles on Kanjo St. predominated. Most were caused by reckless right turns. Apart from disregarding of traffic signal by pedestrians, nearly all the near misses between vehicles and pedestrians originated in vehicles running at high speed on the minor road.

(4) Among the traffic disturbances in the video image investigation, most common were improper right/left turn, disregarding of traffic signal, illegal passing through, and stopping beyond the stop line in winter. The situations where these traffic disturbances occurred differed among each inflow section of the intersection.

(5) Among fifteen traffic accidents by TAAMS, ten happened in winter. From the analysis of accident images, seven accidents were caused by frozen road surface clearly. Five accident were Rear-end collisions and two were slip accidents. No doubt, the slippery road surface is a big factor in occurrence of traffic accidents.

We can see that the situations of accident occurrence by accident type and by violation type differed according to whether the investigation was by onsite accident report, TAAMS records of accidents and near misses, and video images (traffic disturbances). For example, where onsite accident reports showed many cases of head-on collisions, TAAMS images showed few cases of near misses that could have been head-on collisions and many cases of near misses that could have been rear-end collisions. The VTR images of traffic disturbance show few disturbances that could have become head-on collisions or rear-end collisions, but they did show disturbances that could have become right-through collisions. In other words, the dominant accident type according to onsite accident reports did not agree with the dominant near misses and disturbances. As another example, near misses and traffic disturbances between right-turning vehicles and straight-going automobiles were frequently observed; however, right-through collisions did not occur frequently. Although rear-end collisions at "Kanjo St. L" occurred frequently, stopping beyond the stop line in this direction took place less often than in other directions. Furthermore, not many straight-going vehicles disregarded the traffic signal; however, there were many crossing accidents due to disregarding of the traffic signal. This suggested the existence of a complex relationship among accident, near miss and traffic disturbance.

Besides, it is known clearly that the frozen road surface influences greatly on occurrence of traffic accidents in winter.

7. Conclusion

An approach for comprehensive analysis using the three data sources of onsite accident report, TAAMS and traffic disturbance was proposed, and was applied for the analysis of specific intersection accidents. The conclusions follow.

1) TAAMS enabled further clarification of the conditions contributing to traffic accident, by recording all accidents and near misses on the spot and making up for the imbalance and shortage of data obtained conventionally. Because of this, we believe TAAMS will be able to contribute greatly to the clarification of accident causes.

2) The investigation of traffic disturbances revealed traffic problems at intersections. Because the traffic disturbances defined in this study are rather clear, they are less prone to

subjective bias. Furthermore, traffic disturbances can be investigated in a short period; therefore, they compensate for the shortage of cases in traditional accident analysis.

3) It is very clear that frozen road surface is the main factor on traffic accidents in winter according to TAAMS images. This is the typical problem for cold, snowy region, and also gives us a big subject that how to manage the road condition varying form moment to moment, and how to provide the information to drives.

This study revealed the very complex relationship among traffic accidents, near misses and traffic disturbances. The way traffic disturbances relate to accidents is a particular issue to be addressed in the future.

We hope to establish this approach as an effective means of accident analysis by applying similar investigation and analysis methods at many traffic scenes and by accumulating data.

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