Road safety measure(Paving and traffic sign colors)

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ABSTRACT: A traffic safety measure was implemented on Route 4, a national road running north-south of Sendai City in Miyagi prefecture, the heartland of Tohoku region. This road is important since it connects the center of Sendai city and the city's subcenter, Nagamachi district. The road has heavy traffic (approximately 80,000 cars/day) and many traffic accidents. There are many driving lanes, especially near "Aramachi intersection." Here, since the road has left-turn lanes following one another (one that turns at Aramachi intersection and another that turns at the next intersection), the number of lanes decreases at each intersection. Hence, if a driver is not aware of the way how certain lanes are connected to certain destinations, they do not know which lane to take and thus get lost. Therefore, there are many incidents of rear-end accidents due to sudden lane changes and fender bender accidents because the driver was confused about on which lane to drive. To overcome the problem of driver's confusion of on which lane to drive, a traffic safety measure was taken. After implementation of the measure, its impact on drivers was analyzed by videos, and its effectiveness was evaluated from the viewpoints of residents and drivers regarding the area.

KEY WORDS: Colored pavement,colored sign board, traffic accident

1 INTRODUCTION

1.1 Objective

Because of its heavy traffic, "Aramachi intersection" is an accident-prone zone and is known as one of the foremost high traffic accident areas in Miyagi Prefecture. The purpose of the traffic safety measure is, therefore, to reduce the number of traffic accidents in this area. This report describes the pre-existing problems, then measures implemented, and the evaluates the measure taken.

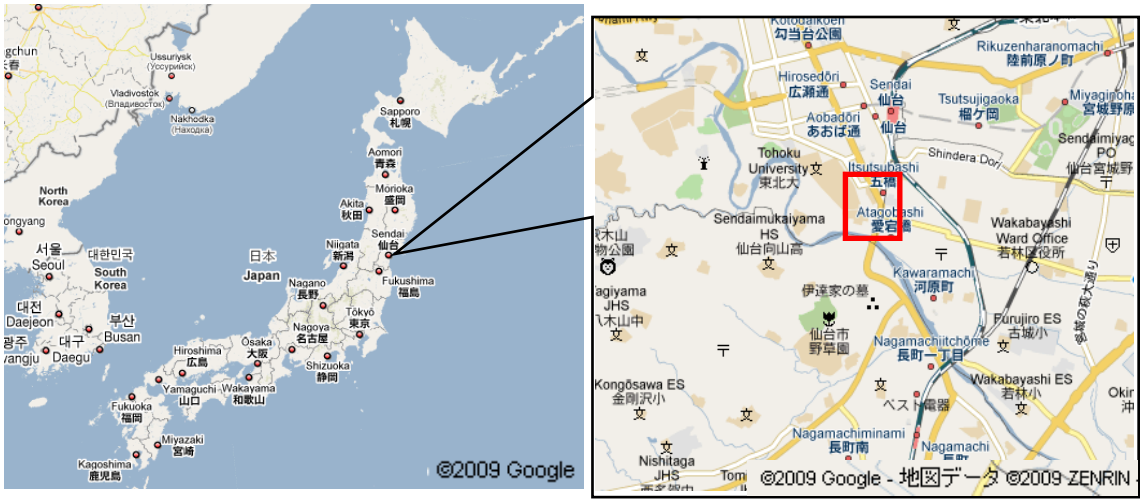


Figure 1: Location map

1.2 General information of Aramachi intersection

Figure 1 shows a general location map of Aramachi intersection. Sendai City is located at the center of the Tohoku region and lies at 36.5 north latitude (about the same as San Francisco and Rome). It is located approximately 360 km northeast of Tokyo, the capital of Japan, and it takes about 100 minutes to travel there from Tokyo using the fastest Tohoku Shinkansen. It is the capital city of the Tohoku region with a population of approximately one million. Aramachi intersection, the place where the traffic safety measure was taken, is on Route 4 that runs north-south through Sendai City (Route 4 is a national road which connects Tokyo and Aomori Prefecture and is 739km long in total.) This road is important as it connects the center of Sendai city and the city's subcenter Nagamachi district. The road thus has heavy traffic (approximately 80,000 cars/day) and many traffic accidents.

Especially around Aramachi intersection, there are ten driving lanes. The side going south, towards Tokyo, has four driving lanes. At this intersection traffic joins going southward from Sendai City. Regarding the way lanes function around Aramachi intersection, the leftmost lane just before Aramachi intersection is a left-turn lane which solely allocated only for turning left at Aramachi intersection. At the following "Atagobashi intersection," the next leftmost lane is also a left-turn lane that is exclusivly for turning left at that intersection. Thus, the number of effective lanes for main traffic decreases after each intersection. As the two leftmost lanes become left-turn lanes to turn at two intersections, the number of lanes decreases from four to three after Aramachi intersection, and then from three to two after the following intersection. The traffic lanes configuration is quite complicated for drivers who are not familiar with the rules in the area. Figure 2 shows the top view of the Aramachi intersection area, and Figure 3 shows a photograph of the current situation.

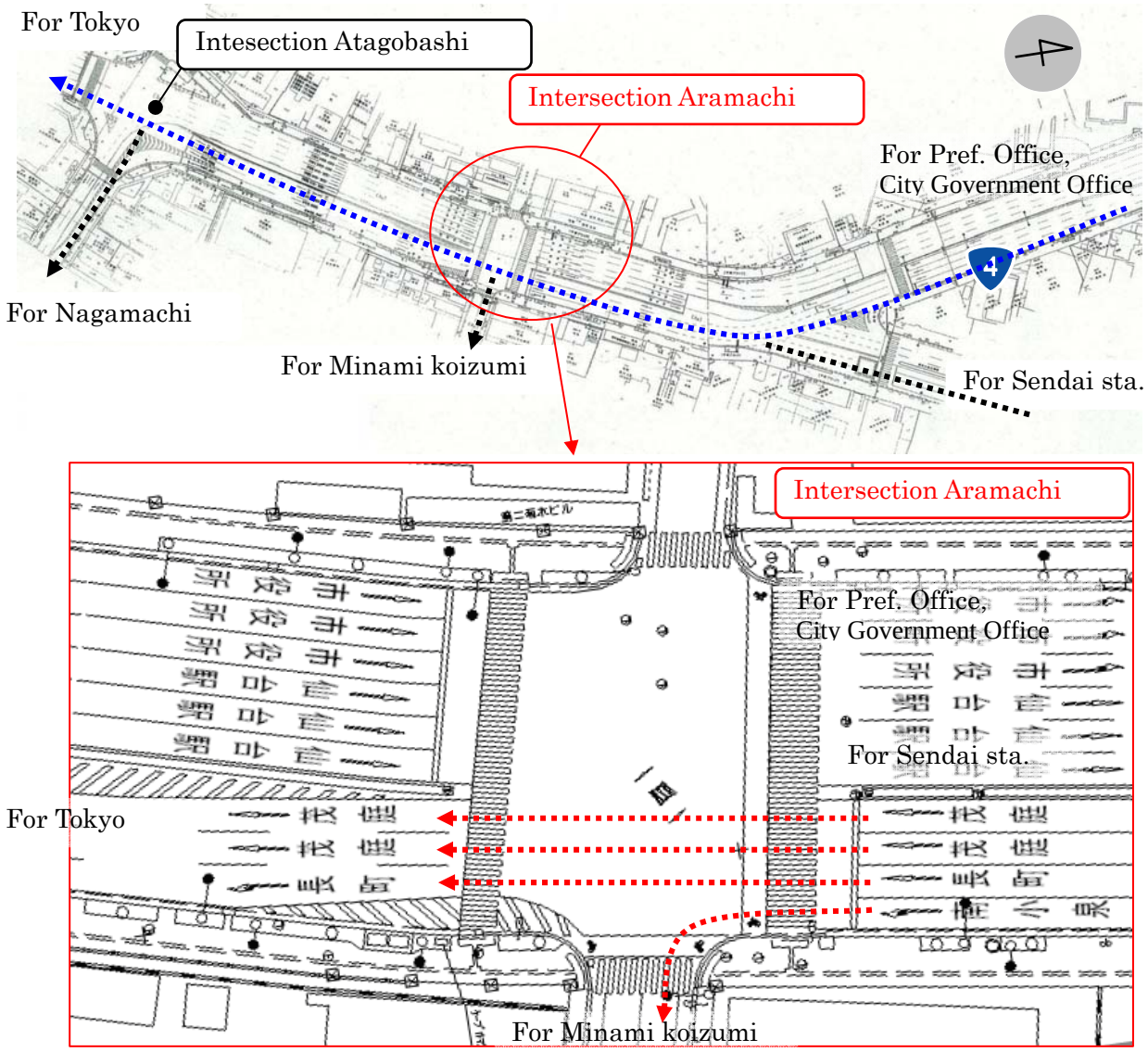


Figure 2: Top view of Aramachi intersection area

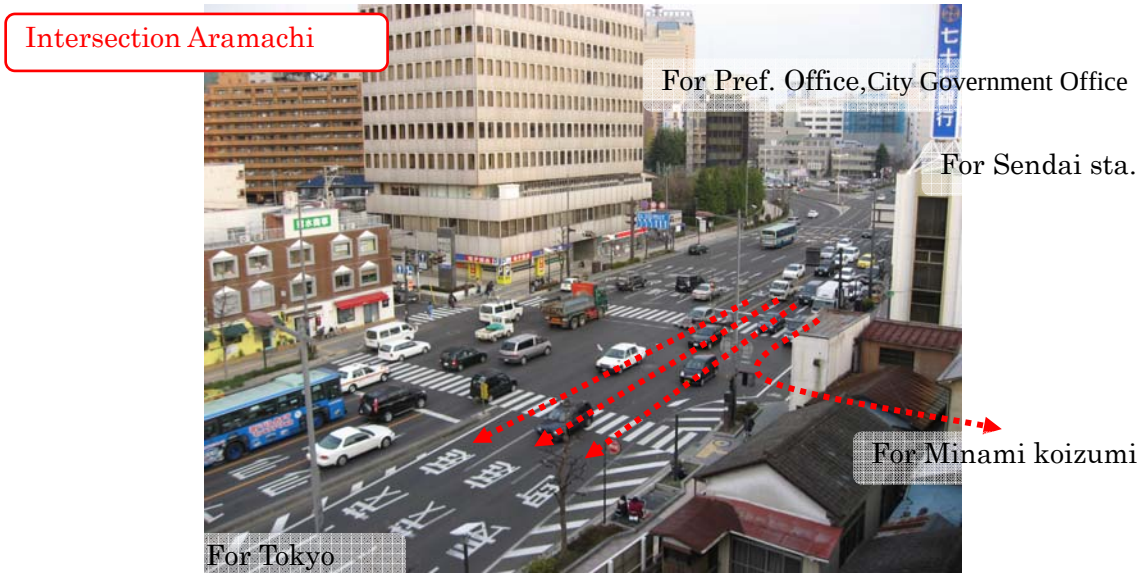


Figure 3: View of Aramachi intersection area (Viewing towards Prefectural Government Office, City Government Office and Sendai Station).

2 TRAFFIC ACCIDENT RECORDS AROUND ARAMACHI INTERSECTION

2.1 Traffic accident occurrence

Figure 4 shows the number of accidents broken down by accident type and Figure 5 shows the number of traffic accidents around Aramachi intersection. During the 5 years, from 2001 to 2005, there were 68 fatal and injury accidents. Broken down by incident type, there were rear-end accidents at the entry and exit areas of the intersection (25 cases), car-to-car collision at the intersection (19 cases), human-vehicle incident (9 cases). While it is not shown in these figures, the accidents occur more frequently during daytime (46 cases) as opposed to evening (22 cases). Most human-vehicle incidents occur during the daytime.

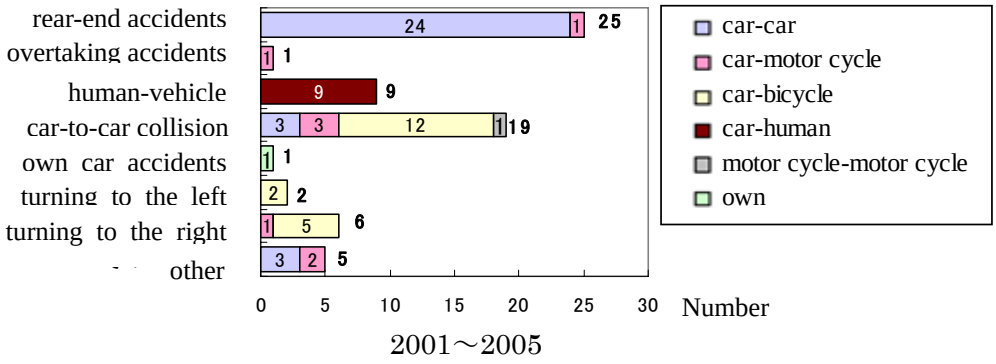


Figure 4: Number of accidents broken down by accident type

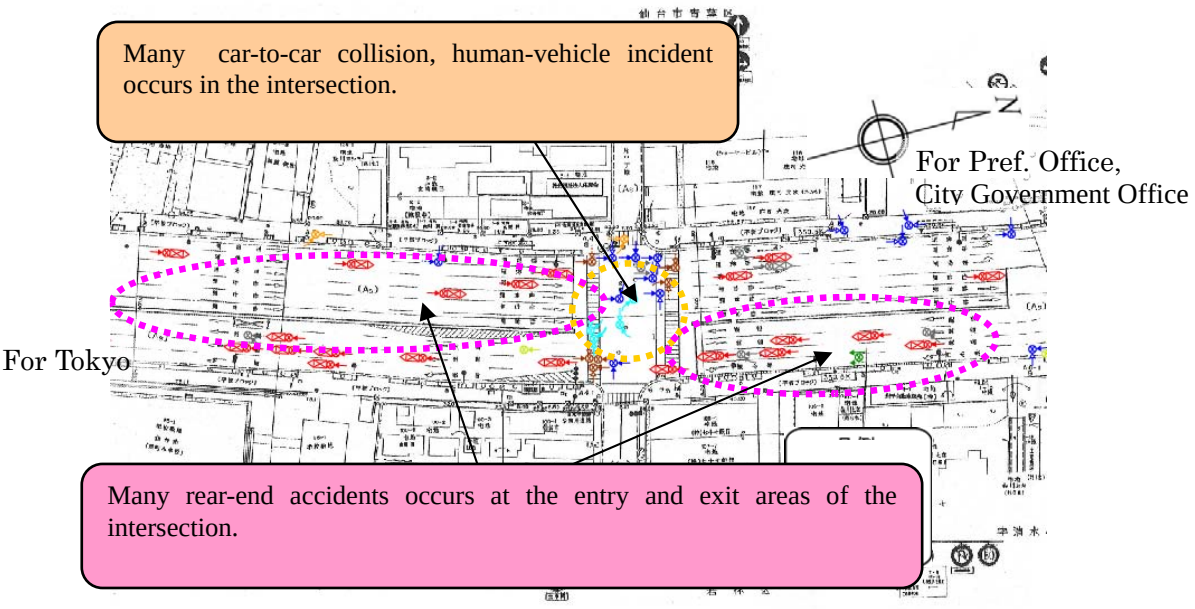


Figure 5: Number of traffic accidents

2.3 User survey

According to the numbers given above, the most frequent type of accident is the rear-end type. Since this type of accident occurs due to the driver's carelessness and breach of manners, it is not easy to control its occurrence. To obtain information for the traffic measure, we conducted a survey in 2006 to understand the possible causes of the problem that are not detectable from

the pre-existing factual data, by asking drivers and pedestrians. Figure 6 shows the situation of the on-the-street survey.

Figure 6: On-the-street survey

According to the survey, many drivers become anxious when driving around Aramachi intersection. This is due to the fact that drivers tend to miss the traffic signs because of the many lanes, consecutive intersections, and/or road congestion. Drivers thus reported that they have a tendency to unnecessarily stray among lanes because they do not know which lane to use, to get into a panic because they happened to drive on the wrong lane and to bump into such straying cars which lost their way. Therefore, we came to the conclusion that the cause of the high traffic accident rate at Aramachi intersection is the complicated traffic rules and the large number of lanes which increase the level of drivers' strain and distract them from driving.

3 PLANNING OF THE TRAFFIC ACCIDENT MEASURE

3.1 Analyzing the causes of traffic accidents

Based on the accident report and survey, it turns out that the main cause of traffic accidents around Aramachi intersection is the complexity and difficult for drivers to understand the destination of each lane. For instance, the recurring changes in number of lanes at every intersection after Aramachi intersection and Atagobashi intersection.

The leftmost lane among the four lanes running before Aramachi intersection (destined to Minamikoizumi) is a left-turn lane. As there is another intersection (Atagobashi intersection), which leads to Nagamachi, 180m after Aramachi intersection, the leftmost lane after Aramachi intersection is another left-turn lane at Atagobashi intersection. Hence, a car wanting to go towards Nagamachi but is running on the leftmost lane right before Aramachi intersection must change the lane to the second lane from the left. Some drivers may stray between lanes because they cannot understand the difference between the two destinations -- Minamikoizumi and Nagamachi -- and thus, with deluding lane design, end up in a collission or a rear-end accident after making a sharp turn. It was necessary to eliminate this confusion so that drivers could concentrate on driving.

3.2 Planning the traffic accident measure

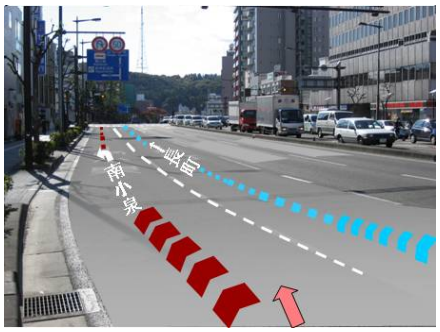
3.2.1 Ways to present the lanes' destinations

Our objective was to come up with a way to direct drivers to the right lane without confusing them. The guide signs that direct drivers to the appropriate lanes were already there, but they were easily missable especially when the road is congested. We thus had to come up with

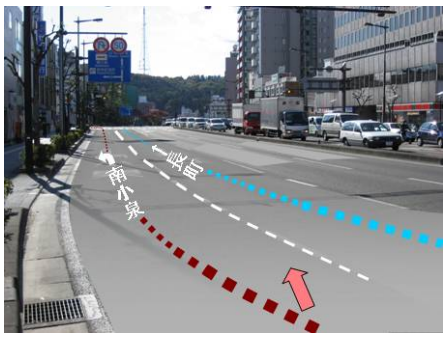
other ways.

First, as there are many types of road displays, we examined various road displays and associated case studies. Figure 7 shows a chart of the road displays examined.

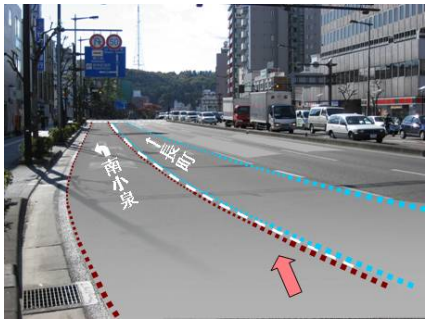
a) Lane's surface entirely colored (entirely colored pavement)



b) Guide line



c) Dotted line (center)



d) Dotted line (both ends)

Figure 7: Examination of various road displays (image chart)

According to the examination from a) to d), entirely colored pavement was superior to others in terms of its visibility and would enable drivers to notice the display even in high traffic congestion. While there was the disadvantage of its high cost, we put priority to the advantage of its visibility and thus took the entire colored pavement option as the traffic accident measure.

In addition, as there is a possibility of instructions on the pavement not being sufficient especially during congestion, a large hanging post with a colored sign above each lane was constructed. As the sign's color coincides with the lane's color, drivers are directed to the appropriate lane in two ways.

3.2.2 Selecting the pavement colors

We examined the combination of the pavement colors. Among the various possible combinations, we first chose red ocher which is commonly used to raise attention, then searched for another color what work well with red ocher. Table 2 illustrates the color combinations examined. These were: ① red ocher + sky blue, ② red ocher + ivory, ③ red ocher + pink (cherry blossom), ④ red ocher + gray

Table 1: Examining color combination for the colored pavement and the colored sign board (image chart)

Color combination	Color pavements (image)	Colored sign boards (image)	Visibility	Landscape	Disturbance	Evaluation
① Sky blue + Red ocher			Contrasts well with red ocher,and white lins is easily Visible.	Strong contrast ,but disturbs the landscape.	Sky blue exhibit strong hue contrast and is resistant to deterioration.	◎
② Ivory + Red ocher			Yellow contrasts well with red ocher,but white line becomes less Visible.	Strong contrast ,but somewhat disturbs the landscape.	Ivory could become less-visible due to deterioration.	△
③ Pink（cherry blossom)+ Red ocher			While it is similar color red ocher,this can become a visible combination if the rightness of the ivory is changed.	Similar color to red-ocher,and blends well with the scenery.	Pink(cherry blossoms) could become somewhat less-visible due to deterioration.	○
④ Gray + Red ocher			Gray contrasts well with red ocher,but does not raise drivers' attention since it is similar to the color of the asphalt.	Blens well with the scenery.	Gray could become less visible as it assimilates with the asphalt's grayish color.	×

After evaluating their visibility and the effect of the combination's color contrast (attention was also paid to the preexisting facilities such as the color of the asphalt), ① red ocher + sky blue was chosen since its strong color contrast is also highly visible in the dark. Considering the issue of the landscape disturbance, there was a concern that sky blue may appear unnatural and thus unsuitable. After careful consultation with transit managers of the Miyagi prefectural police department, however, we came to the conclusion that sky blue is appropriate since visible strong contrast is crucial for the traffic accident measure.

As the road is curved before the intersection, we had the colored pavements starting from 270m ahead of Aramachi intersection. The lane heading towards Minamikoizumi was colored in red ocher, and the one towards Nagamachi in sky blue (This is to simulate with the image color of the national road which is also blue.) Figure 8 describes the plan of the measure, and Figure 9 shows the picture of the completed scene based on the plan

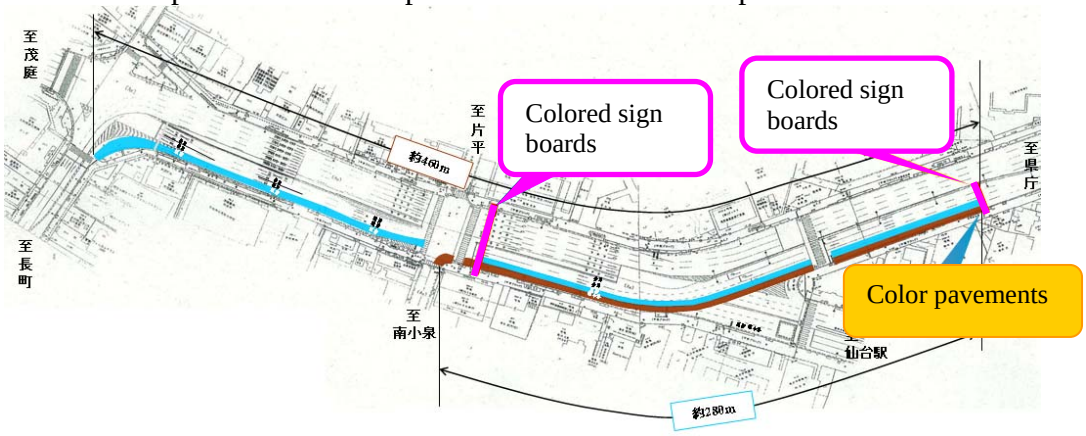


Figure 8: Plan

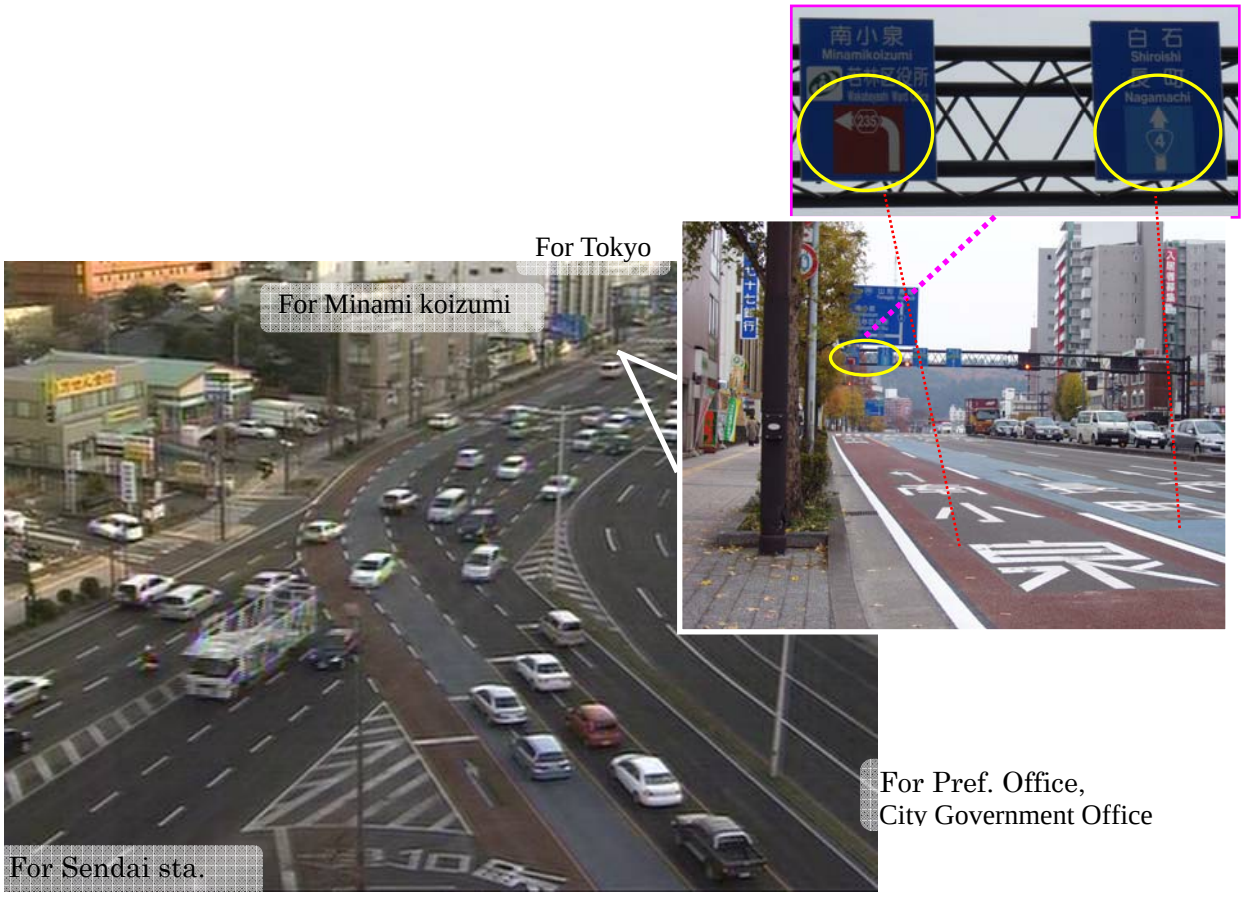


Figure 9: View of the completed scene (Viewing in direction toward Tokyo)

3.2.3 Materials of colored pavements

Regarding the materials for the colored pavements, resin-type anti-skid pavement was used to add the anti-skid effect to contribute to the decrease in the number of accidents. As bonding material (resin binder), a high-viscosity type was chosen considering its compatibility with drainage pavement and durability. Ceramic grain was used as the aggregate and glass cullets (processed scrap) were mixed into this to secure visibility during the nighttime. Considering the 10.8% mixed rate of large size cars, we set the estimated durability target of the color pavement to be longer than five years. (While it depends on how much traffic there is, resin-type anti-skid pavement generally starts showing surface delamination and aggregate scattering problems within 2-3 years. We set the target higher than this number.)

4 THE TRAFFIC ACCIDENT MEASURE AND EX-POST FACTO ASSESSMENT

4.1 Video camera monitoring

To understand the impact of the measure, the movements of cars before and after implementation of the measure were monitored and compared using video cameras.
Cars running on the colored pavements were video taped from the rooftops of buildings in the area. Frequencies of cars changing lanes in the "before intersection zone" and in the "lane change zone" were measured for comparison. Figure 10 shows the map of the areas investigated.

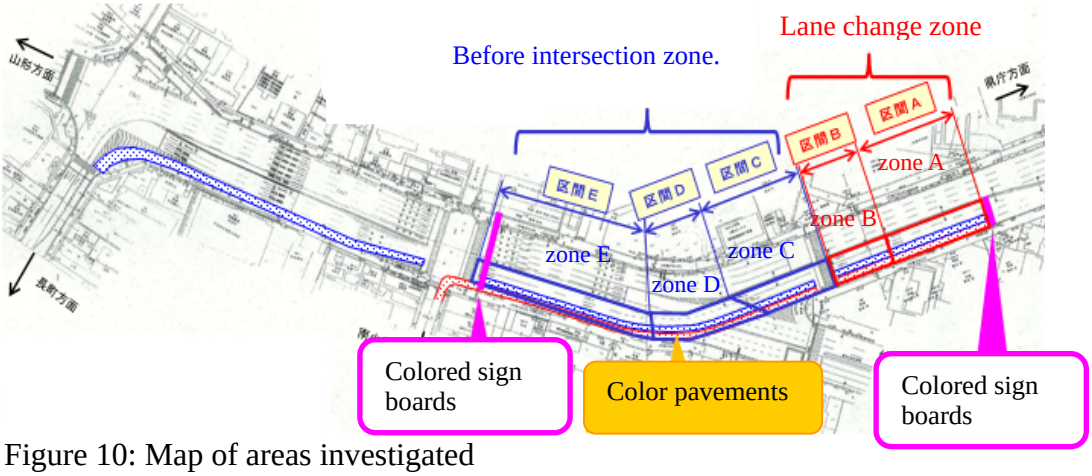


Figure 10: Map of areas investigated

The objective of this study was to understand how much drivers changed lanes in advance due to the colored pavements. We define the "lane change zone" (L=95m) as from A to B, and the "before intersection zone" as from C, D, to E (L=175m). Figure 11 compares the numbers. As one can see from the figure, lane changes in the "before intersection zone" has decreased by 23.0%, from 42.1% to 19.1%. In contrast, lane change in the "lane change zone" has increased from 57.9% to 80.9%. In fact, drivers tend to changing lanes less just before the intersection but rather changing well in advance thanks to the lane coloring measure. We must note here that we do not understand the reason for drivers changing lanes at point E: did the driver changed lane because he knew where he was going or because he did not know where he was going? This is because the number of lane changes at E has not changed significantly before and after implemenation of the measure.

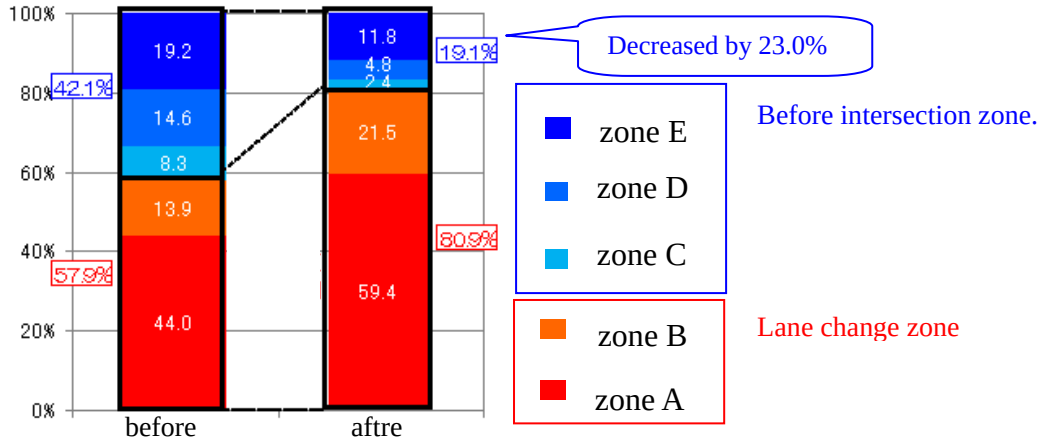


Figure 11: Comparison at the "lane change zone"

4.2 Survey investigation

To understand the impact of the colored lane, a survey was conducted using postcards and the internet. Questionnaires were distributed to pedestrians, residents, and bus and taxi drivers. The number of respondents was 640 (responses via internet was 44, postcard response rate was 7.5%). Figures 12 and 13 show the survey results.

Regarding the colored signs and lanes, people responded: "Drivers can understand where the lane leads to more clearly, and thus can drive more safely" (47.6%); "Cars that are confused and thus straying between lanes decreased and thus can drive more easily" (38.7%); "Nothing has changed" (24.7%); "It became rather dangerous than before" (1.3%) (See Figure 12).

Road users' attitude against this measure was generally positive: "It is a good measure" and "It is somewhat a good measure" accounted for 83.8% of the total (See Figure 13). Yet, there was a comment "I do not understand the meaning of the different colors" which leaves us a future task regarding the way to convey the messages.

The person in charge of the area at the Transport and Communications Division of Sendai Central Police Station, on the other hand, informed us that the amount of drivers' complaints regarding their confusions caused by the lane's restriction has decreased.

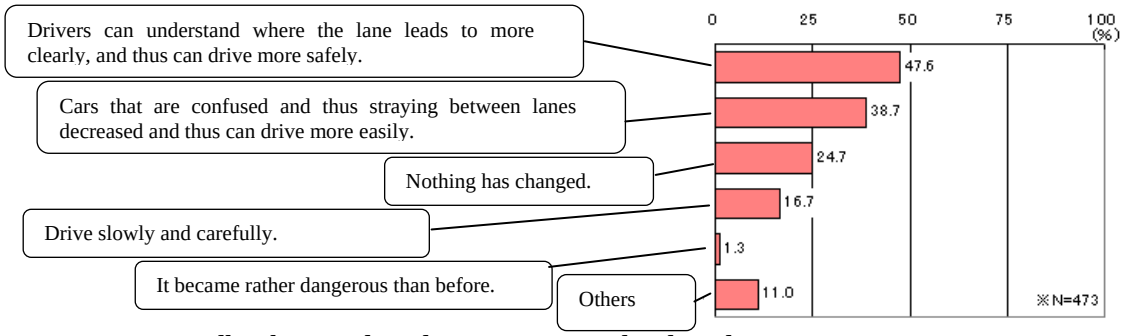


Figure 12: Feedback on colored pavements and colored signs

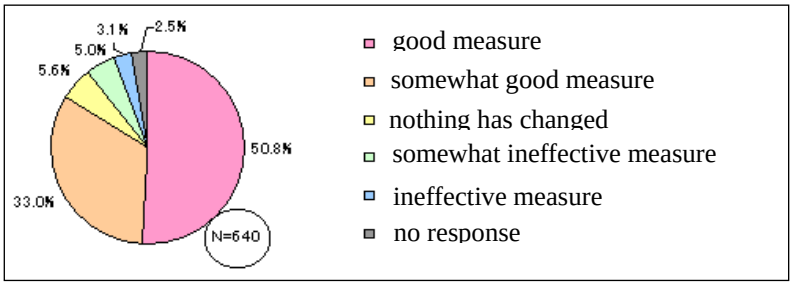


Figure 13: Impression of the colored pavements and colored signs measure taken

4.3 The occurrence of traffic accidents

As for the transition of the number of traffic accidents, the period for verification is limited because it has been about 10 months since the measure was completed. The number of traffic accidents decreased by 3 cases: 7 cases (January 2008-November 2008 during which the measure was not taken) to 4 cases (December 2008-October 2009 during which the measure was taken).I am afraid that now I cannot report about whether the color pavement that was the measure for traffic accidents was effective for the decrease of accidents because the detail of the occurrence of traffic accidents is under investigation.

4.4 Durability of the colored pavement

The durability target of the colored pavement is set at five years. While it has been approximately ten months since the pavements were made, no problem (e.g. surface delamination problem) has been observed at this point. We will follow up on this issue further.

5 CONCLUSION

Since only 10 months have passed since the measure was implemented, we are still in the process of evaluating its effectiveness. We believe that our approach from the viewpoints of residents and drivers regarding the area concerned to evaluate the proposed measures inherent in local intersections can help in the decision making of future traffic accident measures.