TRAFFIC BEHAVIOURAL EFFECTS OF SAFETY IMPROVEMENTS AT THE SMALL JUNCTIONS IN NEIGHBOURHOOD AREAS

Hideo Yamanaka
Professor
Department of Civil Engineering,
The University of Tokushima
2-1 Minami Josan Jima Tokushima
7708506 Japan
Fax:+81-886-56-7341
E-mail:yamanaka@ce.tokushima-u.ac.jp

Abstract: The aim of this study is to appraise the impact on traffic safety by the improvement of small junctions. This is achieved by comparing analysis of traffic behaviour before and after safety improvements have been introduced. Using video survey data, traffic behaviour was evaluated by measuring the entering speed, deceleration and estimating stopping distance of vehicles, as well as pedestrians' and cyclists' behaviour of paying attention before crossing street. It was found that introducing coloured pavements at junctions resulted in road users paying more attention and slowing down, especially when they enter the junction from the non priority street.

1. INTRODUCTION

Almost half of injury accidents occur in neighbourhood areas in Japan. In addition to this, 70 percent of the total number of accidents in neighbourhood areas occur at or near the junctions(JSCE,1996). These areas have many small junctions lacking traffic lights or physical traffic controls such as round about systems.

In order to make such small junctions safer, various kinds of facilities have been introduced, such as, road markings to make clear the priority for entering junctions, humped pavements, coloured pavements or special lights for getting attention of road users to the existence of junctions, and so on. Since 1996, the Japanese government has begun a new scheme for area wide traffic calming projects similar to the 30km zones in Europe. In these projects, the development of an effective device for small junctions is considered very important, in order to realise effective 30km zone projects in high densely and narrow street network areas.

The aim of this study is to appraise the impact on traffic safety of such improvements for small junctions, through comparing analysis of traffic behaviour before and after safety improvements by employing video survey data.

2. VIDEO SURVEY OF SMALL JUNCTION

2.1 Video Data collection

Data of behaviour of pedestrians, cyclists and vehicles entering and passing a junction was collected in neighbourhood areas in Osaka City. In the case of small junctions, portable video survey equipment which can be set at an elevated level is required due to lack of space.

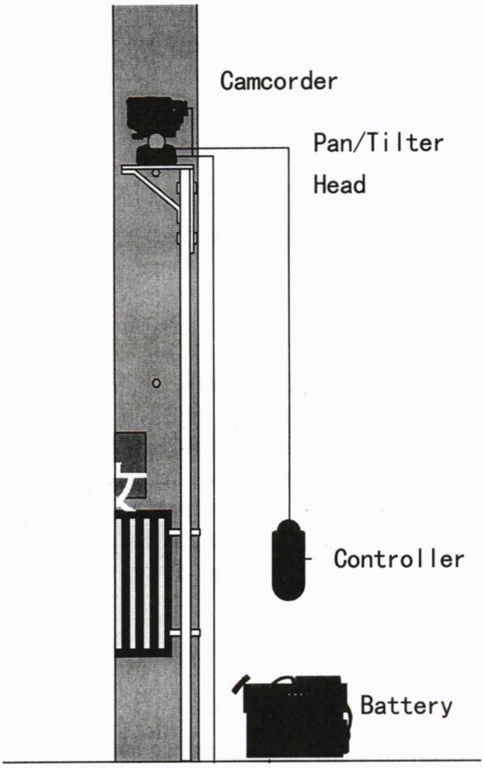


Figure 1. Video survey system

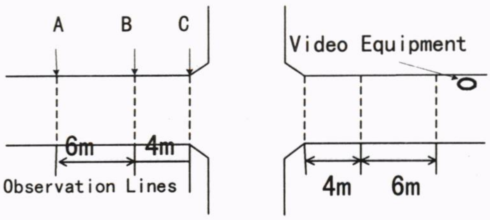


Figure 2. Observation section of junctions

In this research, the system shown in figure 1 was developed. A handy video camcorder, auto pan/tilt head and their remote control unit are set on a 4m steel pole which can be fixed to an electric power pole. This system can be set in few minutes and record traffic behaviour along a 30m long street section by using standard camcorder. Video recording was done from an elevated point from the view points of crossing two streets where a clear view of the entering movement of road users can be achieved.

2.2 Video Data Analysis
In this research, the author aims at studying the behaviour of road users when approaching the junction. The following data was collected from the video recordings.

Passing time and passing point of road users at the cross section lines shown in figure 2 were collected. These observation lines are located at the edge of a junction , 4m from edge and 10m from edge. On each line, markings were placed at intervals of 50cm in order to make clear the running position of road users on the streets.

By using a computer controlled video player, time was automatically entered as a number of video frames of 1/30th of a second, when the position of road users are input via computer keyboard at the point that they are on the observed lines.

3. EVALUATION INDICES OF TRAFFIC BEHAVIOUR

Data of vehicles' behaviour was evaluated by measuring the following indices from the a viewpoint of safety.

3.1 Pedestrian And Cyclist Behaviour With Regard To Attention
Pedestrians' and cyclists' behaviour were evaluated by counting the number of people making the following behaviour with regard to paying attention when approaching junctions.
1)Look to side : Pedestrian or cyclist turned head to look to side.
2)Slow down: Pedestrian walked slower. Cyclist applied on the brake or stopped pedalling.

3.2 Approach Speed And Deceleration Of Traffic

Figure 3 illustrates the assumed change of the traffic speed when approaching a junction. That is, a vehicle passes the line 10m from the junction at a speed of V_0, and slows down at a constant deceleration of α thereafter entering the junction. The passing time T_1 (from A to B) and time T_2 (from A to C) can be obtained from the video survey data. Approaching speed and deceleration can be estimated using the following equations.

$$V_0 = \frac{(L_1 T_2^2 - L_2 T_1^2)}{T_1 T_2 (T_2 - T_1)} \tag{1}$$

$$\alpha = \frac{-2(L_1 T_2 - L_2 T_1)}{T_1 T_2 (T_2 - T_1)} \tag{2}$$

where V_0 : approach speed (m/s)
α : deceleration (m/s^2)
T_1 :passing time from line A to B (seconds)
T_2 :passing time from line A to C (seconds)
L_1 :distance from line A to B (m) = 6m
L_2 :distance from line A to C (m) =10m

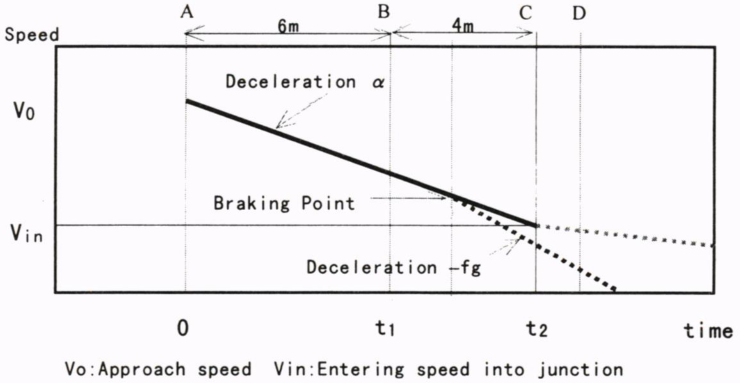


Figure 3. Speed change of approaching vehicle

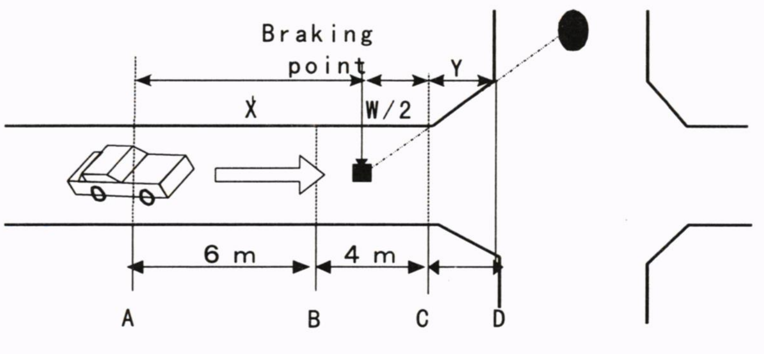


Figure 4. Assumed braking point

3.3 Estimated Stopping Distance

If the vehicle is assumed to apply its brakes from a point where they can first see the approaching road users on the crossing street, stopping distance of the vehicle can be estimated. When a vehicle can stop before the junction, it is assumed to be safe.
Stopping distance measured from line A can be estimated by the following equation if the braking point is X m from line A.

$$D_S = \frac{(V_0^2 - \alpha X^2)}{2fg} + X \tag{3}$$

where Ds : stopping distance from line A (m)
X :braking point measure from line A(m)
fg :deceleration of emergency braking

The deceleration of braking is given a value of 0.5, which is proposed for when a vehicle is travelling at 25km/h on a dry road surface(Matso,1955). To make calculation simple, the braking point is assumed as shown in figure 4 where the vehicle driver can see the approaching road user at the same distance from the junction as him/her.

4. OBSERVED JUNCTIONS

Table 1. shows a list of junctions where video observation was carried out in three neighbourhood streets in Osaka city. The width of the three streets are 5.5m , 6.5m, 6.9m. The width of intersecting streets range from 4.5m to 7.2m at each junction. Traffic volume ranges from 32 to 222 vehicles, 57 to 284 bicycles and 19 to 91 pedestrians. Most of the streets are designated as one- way streets.

Figure 5 provides an example of safety improvement of these streets. Coloured pavement was introduced at every junction as shown in picture 1 in November 1996. Video surveys were carried out before the in July 1996 and after improvement in December 1996.

Table 1. Traffic Volume of Observed Junctions (unit: per hour)

Street	Junction No.	Pedestrian		Vehicle		Bicycle		Motor bike		Intersect-ing street
		before	after	before	after	Before	after	before	after	
O-imazato	1	27	22	109	77	72	117	12	0	5.5m
	2	38	65	198	190	77	111	14	19	7.2
	3	46	29	89	116	67	60	11	8	5.5
	4	31	53	222	140	99	103	20	11	7.2
	5	25	73	184	156	57	90	18	8	5.5
	6	47	54	194	171	119	129	23	8	5.5
Tanabe	1	57	91	58	101	168	137	13	10	4.5
	2	56	79	87	109	284	247	14	12	6.4
	3	19	56	38	59	102	125	5	7	4.5
	4	21	30	87	74	81	104	7	10	6.4
Morishoji	1	69	66	32	33	115	97	7	4	6.3
	2	59	65	73	64	159	154	11	9	4.7

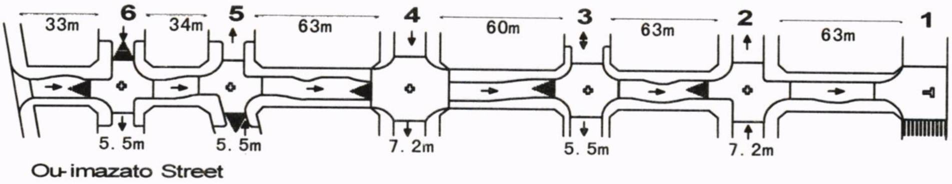
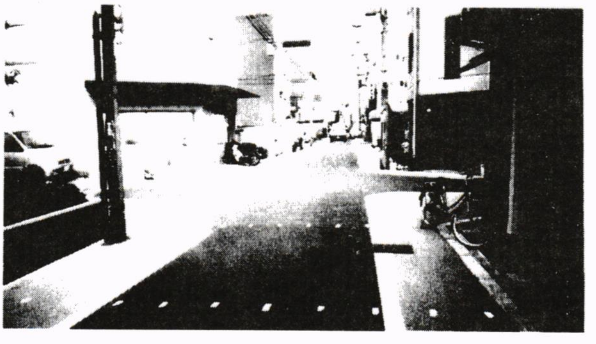


Figure 5 Coloured pavement junction on O-imazato Street



Picture 1. Coloured pavement of sidewalk and junction for narrow streets

5. BEFORE AND AFTER ANALYSIS

5.1 Change Of Pedestrians' And Cyclists' Behaviour For Attentions

Pedestrians and cyclists behaviour was evaluated by counting the number of people who paid attention when approaching junctions. Table 2 shows the changes of the ratio of people who look to the side or slow down. In the present research, priority condition of approach streets for entering junction and type of street are considered in order to compare the ratio before and after junction treatment. Priority approach means that the stop signs are not at the entrance of the junction from this approach, and that there are stop signs on the intersecting streets. For the type of streets, "street 1" means that safety improvement of coloured pavement was introduced, and "street 2" means the intersecting streets

1) Pedestrians' behaviour   In the case of non-priority approaching, it is clear that the ratio of paying attention increases after junction treatment in most streets and street types. People approaching from the priority street do not always tend to pay more attention after treatment.

2) Cyclists' behaviour   The ratio of people paying attention increases in the case of non-priority approaching. Changes of the ratio are not certain in the case of priority approaching, the same as for pedestrians.

Table 2. Change of Behaviour of Pedestrians and Cyclists

Pedestrian Behaviour		Look to the side			Look to the side or Slow down		
Priority	Street	before	after	difference	before	after	difference
Priority Approaching	O-imazato 1	8.0%	5.6%	-2.4% ●	40.9%	43.2%	2.3%
	Tanabe 1	0.0%	2.7%	2.7% ◎	15.6%	28.4%	12.8% ◎
	Morishoji 1	0.8%	0.9%	0.0%	24.6%	21.4%	-3.2%
	O-imazato 2	8.8%	8.1%	-0.8%	23.5%	37.1%	13.6% ◎
	Morishoji 2	0.7%	11.7%	11.0% ◎	12.6%	11.9%	-0.7%
Non priority Approaching	Tanabe 1	8.1%	11.4%	3.3% ◎	43.2%	57.1%	13.9% ◎
	Morishoji 1	7.3%	36.8%	29.6% ◎	46.4%	74.7%	28.4% ◎
	O-imazato 2	6.2%	9.5%	3.4% ◎	41.5%	42.9%	1.3%
	Tanabe 2	8.5%	17.9%	9.4% ◎	45.1%	64.3%	19.2% ◎
	Morishoji 2	5.5%	37.2%	31.7% ◎	37.5%	65.2%	27.7% ◎
Bicycle Behaviour		Look to the side			Look to the side or Slow down		
Priority	Street	before	after	difference	before	after	difference
Priority Approaching	O-imazato 1	25.3%	24.5%	-0.8%	42.6%	44.8%	2.2%
	Tanabe 1	3.2%	1.9%	-1.3% ●	13.8%	25.5%	11.7% ◎
	Morishoji 1	29.1%	75.0%	45.9% ◎	48.5%	75.5%	27.0% ◎
	O-imazato 2	35.8%	19.4%	-16.4% ●	49.4%	41.7%	-7.6%
	Morishoji 2	0.0%	18.8%	18.8% ◎	11.5%	19.1%	7.6% ◎
Non priority Approaching	Tanabe 1	6.5%	16.5%	9.9% ◎	29.6%	39.9%	10.4% ◎
	Morishoji 1	23.6%	45.6%	22.1% ◎	24.4%	47.6%	23.2% ◎
	O-imazato 2	17.9%	27.0%	9.2% ◎	40.2%	49.5%	9.4%
	Tanabe 2	24.5%	33.8%	9.3% ◎	49.5%	52.6%	3.0%
	Morishoji 2	17.5%	80.6%	63.1% ◎	42.3%	80.8%	38.5% ◎

Street 1: street of safety project Street 2 : intersecting street
◎: Siginificant increase ●: Siginificant decrease (t-test 5%)

5.2 Change Of Vehicles' Behaviour For Attention

Table 3 shows the change of vehicles' behaviour before and after junction treatment, by checking occurrence of slowing down and briefly stopping before the entrance

As most vehicles slow down before junctions both before and after treatment, there are few cases of significant change. In the case of priority approach, as changes of behaviour are not regular but an increase in stopping can be seen when a vehicle turns at the junction. When a vehicle comes from non-priority streets, it is relatively clear that stopping behaviour increases after junction treatment in case of both non-turn and turn.

Table 3. Change of Behaviour of Vehicles

Vehicle behavior			Stop			Stop or Slow down		
Priority	Turn	Street	before	after	difference	before	after	difference
Priority Approa-ching	Total	Tanabe 1	18.7%	10.4%	-8.3% ●	80.2%	77.1%	-3.1%
		Morishoji 1	10.6%	28.6%	18.0% ◎	90.3%	85.7%	-4.6%
		O-imazato 2	40.9%	18.3%	-22.6% ●	95.0%	81.0%	-14.0%
		Morishoji 2	21.1%	10.0%	-11.1% ●	81.6%	76.7%	-4.9%
	No turn	Tanabe 1	19.2%	5.8%	-13.4% ●	79.5%	74.4%	-5.1%
		Morishoji 1	10.7%	27.8%	17.1% ◎	92.9%	86.1%	-6.8%
		O-imazato 2	40.0%	11.6%	-28.4% ●	94.5%	84.8%	-9.7%
		Morishoji 2	13.0%	13.0%	0.0%	73.9%	73.9%	0.0%
	L/R turn	Tanabe 1	15.4%	50.0%	34.6% ◎	84.6%	100.0%	15.4%
		Morishoji 1	10.3%	31.6%	21.2% ◎	82.8%	84.2%	1.5%
		O-imazato 2	50.0%	61.5%	11.5%	100.0%	100.0%	0.0%
		Morishoji 2	33.3%	56.3%	22.9% ◎	93.3%	93.8%	0.4%
Non Priority Approa-ching	Total	O-imazato 1	31.2%	35.6%	4.4%	91.8%	91.6%	-0.2%
		Tanabe 1	19.6%	19.7%	0.1%	87.0%	83.2%	-3.7%
		Morishoji 1	11.8%	13.6%	1.8%	83.9%	90.3%	6.4%
		O-imazato 2	18.7%	36.5%	17.9% ◎	88.0%	90.4%	2.4%
		Tanabe 2	20.7%	61.1%	40.4% ◎	88.5%	96.7%	8.2%
		Morishoji 2	7.8%	42.4%	34.6% ◎	91.1%	96.2%	5.1%
	No turn	O-imazato 1	32.7%	37.4%	4.7%	90.8%	94.9%	4.1%
		Tanabe 1	15.9%	15.0%	-0.9%	87.0%	69.9%	-17.0% ●
		O-imazato 2	16.7%	34.2%	17.5% ◎	86.5%	88.2%	1.6%
		Tanabe 2	24.6%	60.3%	35.8% ◎	87.7%	100.0%	12.3%
		Morishoji 2	11.5%	16.7%	5.1% ◎	84.6%	68.8%	-15.9% ●
	L/R turn	O-imazato 1	27.7%	35.2%	7.5% ◎	94.0%	93.7%	-0.3%
		Tanabe 1	30.4%	29.2%	-1.3%	87.0%	87.5%	0.5%
		Morishoji 1	11.8%	13.6%	1.8%	83.9%	90.3%	6.4%
		O-imazato 2	29.2%	42.9%	13.7% ◎	95.8%	96.4%	0.6%
		Tanabe 2	13.3%	62.5%	49.2% ◎	90.0%	90.6%	0.6%
		Morishoji 2	6.3%	35.6%	29.3% ◎	93.8%	94.9%	1.2%

Street 1: street of safety project Street 2 : intersecting street
◎: Significant increase ●: Significant decrease (t-test 5%)

5.3 Change In Vehicle Approaching Speed And Deceleration

Table 4 shows changes in vehicle speed, deceleration and predicted safety stop ratio before and after junction treatment. Significantly, different results can be seen between priority approaching and non-priority approaching.

In the case of priority approaching, vehicles' approach speed decreased whilst deceleration before the junction decreased. The decrease of appears speed appears to be due to street improvement, which is the introduction of a coloured pavement sidewalk. Such pavement design is said to have an effect on speed reduction as a result of some psychological pressure. The decrease in deceleration is due to the decrease in approaching speed. As a result of such effects, the predicted safe stop ratio shows an increase or decrease in some cases.

Table 4. Change of Vehicle Speed and Deceleration

Prio-rity	Turn	Street	Approaching speed Before	After	Dif%	Deceleration Before	After	Dif%	Safety stop ratio Before	After	Dif%
Prio-rity	Total	Tanabe 1	6.93	7.23	4.4%	-1.56	-0.59	-62.1%	64.0%	55.0%	-14.1% ▲
		Morishoji 1	7.01	4.23	-39.7% ◎	-1.72	-0.75	-56.4% ●	96.4%	92.0%	-4.6% ●
		O-imazato 2	7.97	7.54	-5.4% ○	-2.47	-1.17	-52.7% ●	50.3%	44.1%	-12.3%
		Morishoji 2	6.00	2.68	-55.3% ◎	-1.63	0.24	-114.9% ●	82.9%	100%	20.7% ◎
	No turn	Tanabe 1	7.12	5.50	-22.8% ◎	-1.61	-0.56	-65.1%	57.9%	62.0%	7.1%
		Morishoji 1	7.14	4.09	-42.7% ◎	-1.75	-0.34	-80.6% ●	95.2%	90.0%	-5.4% ●
		O-imazato 2	8.21	7.69	-6.3% ○	-2.65	-1.18	-55.6% ●	46.0%	40.1%	-12.8%
		Morishoji 2	5.69	2.91	-48.9% ◎	-1.36	0.22	-116.0% ●	85.0%	100%	17.6% ◎
	L/R turn	Tanabe 1	5.76	5.05	-12.3%	-1.29	-0.84	-35.1%	100%	95.0%	-5.0%
		Morishoji 1	6.48	4.46	-31.2% ◎	-1.57	-1.07	-31.8%	100%	96.0%	-4.0%
		O-imazato 2	5.48	5.41	-1.4%	-0.64	-1.07	67.3%	93.8%	100%	6.7%
		Morishoji 2	6.41	2.12	-66.8% ◎	-2.00	0.31	-115.3% ●	80.0%	100%	25.0% ◎
Non Prio-rity	Total	O-imazato 1	4.90	6.01	22.6% ●	0.14	-1.34	-1036% ◎	65.9%	85.3%	29.3% ◎
		Tanabe 1	5.83	5.84	0.2%	-0.19	-0.48	151.6%	59.8%	62.6%	4.7%
		Morishoji 1	6.57	5.09	-22.5% ◎	-1.25	-1.93	54.4% ◎	93.5%	97.1%	3.8% ○
		O-imazato 2	5.56	6.13	10.3%	-1.32	-1.64	24.8%	64.1%	85.3%	33.0% ◎
		Tanabe 2	4.19	5.12	22.3% ●	-0.44	-1.06	138.8% ◎	96.5%	98.9%	2.5%
		Morishoji 2	5.40	5.92	9.7% ●	-1.05	-1.85	76.6% ◎	84.8%	92.3%	8.8% ○
	No turn	O-imazato 1	5.00	6.09	21.7% ●	0.41	-1.32	-422.3% ◎	58.2%	79.8%	37.1% ◎
		Tanabe 1	5.81	5.57	-4.2%	0.06	-0.09	-258.9%	53.6%	60.2%	12.2%
		O-imazato 2	5.63	6.23	10.6%	-1.42	-1.73	21.7%	60.4%	79.7%	32.1% ◎
		Tanabe 2	4.18	4.90	17.4% ●	-0.41	-0.91	124.6% ◎	94.6%	98.2%	3.8%
		Morishoji 2	5.21	5.91	13.5% ▲	-1.29	-1.80	40.0%	100%	98.0%	-2.0%
	L/R turn	O-imazato 1	4.68	5.85	24.9% ●	-0.46	-1.40	201.0% ◎	83.6%	97.2%	16.2% ◎
		Tanabe 1	5.90	7.25	23.0% ▲	-0.94	-2.51	166.9% ○	78.3%	81.0%	3.5%
		Morishoji 1	6.57	5.09	-22.5% ◎	-1.25	-1.93	54.4% ◎	93.5%	97.1%	3.8%
		O-imazato 2	5.14	5.85	14.0% ▲	-0.73	-1.42	92.8% ◎	85.0%	100%	17.6% ○
		Tanabe 2	4.22	5.51	30.6% ●	-0.51	-1.31	155.4% ◎	100%	100%	0.0%
		Morishoji 2	5.48	5.92	8.2% ▲	-0.95	-1.86	96.8% ◎	78.6%	93.1%	18.5% ◎

Priority	Turn	Approaching speed Before	After	Dif%	Deceleration Before	After	Dif	Safety stop ratio Before	After	Dif%
Priority	Total	7.32	6.26	-14.4% ○	-2.00	-0.82	-59.1% ●	73.6%	64.1%	-12.9% ▲
	No turn	7.56	5.99	-20.8% ○	-2.12	-0.74	-65.2% ●	82.4%	60.6%	-26.5% ●
	L/R turn	6.12	4.44	-27.4% ◎	-1.40	-0.81	-42.4% ●	96.2%	97.5%	1.4%
Non Priority	Total	5.22	5.82	11.5% ▲	-0.40	-1.36	237.8% ◎	67.7%	86.5%	27.8% ◎
	No turn	5.14	5.88	14.4% ▲	-0.13	-1.11	729.4% ◎	65.1%	80.7%	23.9% ◎
	L/R turn	5.34	5.75	7.7%	-0.80	-1.70	113.3% ◎	84.4%	95.5%	13.2% ○

Street 1: street of safety project Street 2 : intersecting street

◎: Significant change of safety improve ●: Significant change of safety decrease (t-test 5%)

○: Significant change of safety improve ▲: Significant change of safety decrease (t-test 10%)

Contrary to the above cases, non-priority approaching vehicles had a tendency to increase approaching speed and increase deceleration. As a result of these changes, the safe stop ratio shows an improvement for most of the streets and for turn type, mainly due to the increase of vehicles' deceleration.

6. CONCLUSION

The results of this research reveal the effects of coloured pavement junction treatment. One of the most notable effects is making clear non-priority approaching of junctions. Safety increased in most case of non-priority approaching and right/left turning vehicles for priority approaching. On the contrary, effects on paying attention in the case of priority approaching could not be appraised

Both vehicle speed and deceleration decreased in the case of priority approaching but increased in the case of non-priority approaching. This results in increased safety for non-priority approaching vehicles, but did not always increase safety in the case of priority approaching, if predicted stopping distance is taken into account.

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