THOMSON REUTERS
ENDNOTE

[Kim ,3(12): December 2016]
DOI- 10.5281/zenodo.208935

ISSN 2348 – 8034
Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

NEW DESIGN CONCEPT OF PAVEMENT DIRECTION MARKING TO IMPROVE VISIBILITY AND SAFETY AT INTERSECTION AREA

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ABSTRACT

From various pavement markings at intersections, direction guidance markings to guide drivers on moving directions are designed to provide guidance on turn directions for vehicles approaching the intersection; however, it is also an important facility carrying significances from the safety perspective at the same time. While pavement markings at intersections are indicated on the pavements of intersections and intersection approaches, it is not easy to distinguish whether a dedicated lane for left or right turn is installed based on the pavement marking design of MUTCD, and the dedicated lanes for left turn or through-and-right turn can only be noticed after reaching the intersection. If the lanes can be identified whether they are dedicated for left, right or U turn before reaching the intersection, traffic safety at intersections can also be highly elevated.

Consequently, this study investigated the current status of pavement direction markings by looking into those markings in Korea, European nations and the U.S., and examined potential problems which may be caused by current pavement markings. And the study also suggested new pavement markings in order to address those potential issues at intersections. Moreover, for the purpose of improving the visibility of pavement markets, the study presented a measure applying technology where LED is placed at each arrow on the pavements.

New pavement markings proposed by this study is deemed to improve visibility compared to existing pavement markings. These new markings help drivers intuitively recognize the information on the lanes for left or right turn at intersections, which is expected to improve safety throughout the entire intersections.

Keywords: *Pavement marking, Direction, Intersection, Safety, Visibility*

I. INTRODUCTION

In general, pavement markings at intersections are installed for the purpose of providing guidance for turning directions for vehicles approaching intersections. While pavement markings at intersections are indicated on the pavements of intersections and intersection approaches, the design of pavement markings in Korea, European nations or MUTCD makes it difficult to notice whether the lanes for left or right turn are installed at the intersection, and drivers are able to find out their installation only after they reach the intersection. These situations is bound to heighten the possibility to cause abrupt lane changes due to poor visibility of pavement markings, and it is likely to incur traffic accidents if any vehicles are closely nearby [1].

If a driver is able to notice the availability of dedicated lanes for left or right turn or lanes allowing for turns before reaching the intersection, it is very much possible to enhance traffic safety at intersections.

Hence, this study proposed new design for pavement markings which allow drivers to easily recognize information on lanes for left or right turn at the intersection approaches. New pavement markings suggested by this study are deemed to have improved visibility compared to conventional pavement markings. As new markings help drivers intuitively recognize information on lanes for left or right turn at intersections, it is expected to overall safety at intersections.

This study examined the current status of pavement direction markings related to information on lanes for left or right turn at intersections in Korea, Germany and MUTCD; and it proposed new design of pavement markings after investigating the accidents at intersections in Korea.

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II. REVIEW OF CRITERIA FOR PAVEMENT MARKINGS

There are not much of substantial differences in shapes or designs of pavement markings between Korea and other nations, and it is rare to find any studies on effective designs for pavement markings. Of course, there has been a study conducted to learn which shape is better visible after selecting a few designs of arrows used at the road signs [2]. As most studies on pavement markings are associated with visibilities, they mostly focused on the nighttime visibility [3], minimum reflection standards [4] and the width and size of pavement markings [5].

Criteria in Korea

Pavement markings in Korea are governed by the Working Manual on Traffic Signaling System Installation (2000) established by the National Police Agency [6], and the portion corresponding to this study from the manual above refers to the direction markings and directional guidance markings. Pavement markings need to be installed at the entrance of intersection, and the manual prescribes that one marking shall be installed when the length of taper is less than 25 meters while 2 or more markings shall be installed when the length exceeds 50 meter.

When direction marking and directional guidance marking is indicated at only one lane out of the lanes at the intersection (the marking is indicated 2 to 3 meters away from the stop line), those lanes are mostly found at rural areas whereas the markings are indicated at two or more lanes at urban areas where traffic is more congested along with bigger number of lanes and longer length of tapers.

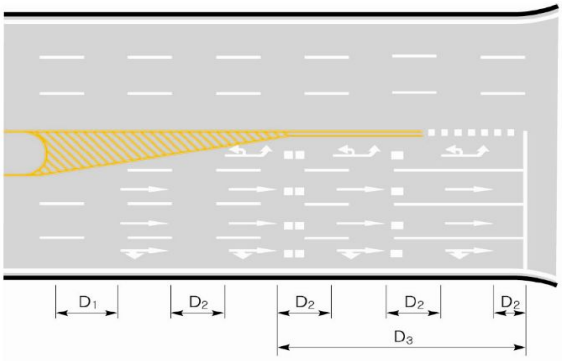

Figure 1:Korea guideline of preliminary pavement direction markings(PPDM) at intersections

Upon such occasion, current marking practice allows drivers to notice only the availability of lanes for left, right or U turn at the intersection yet prevents them from identifying whether the lane for turns is dedicated for turns or shared with through lane. These pavement marking practice often leads to an accident or causes congestion as the driver is unable to find his/her moving direction after entering the intersection. In other words, taking 2-lane one-way road for an example, the current guidance system is designed for the vehicle driving on the 1st lane to run straight at the intersection in general; however, when traffic flow for the left turn is heavy, additional lane is designated and guided as a lane for left turn in addition to a dedicated lane for left turn.

In such case, a vehicle running on the 1st lane with intention to go straight is forced to change lanes to the right (through lane) when realizing the 1st lane is for left turn; therefore, these incidents are prone to cause traffic congestion or accidents. Especially with severe deterioration of pavement markings, there are many occasions where nighttime visibility at intersections is hardly secured(Figure 1). Figure 2 shows typical type of preliminary pavement marking on the rural road in Korea national highways.

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Figure 2:Korea case of PPDM at intersections

Criteria in Europe

Figure 3, 4 demonstrates pavement markings for direction and directional guidance at intersections in Germany. German pavement markings are not distinguished with main marking and forewarning marking like road signs do just as shown at the Working Manual on Traffic Signaling System Installation (2000) [7]; however, the second pavement marking functions as practical forewarning sign at the intersections with 2 or more installations.

It means that it assumes the role providing the status information on the lane for left or right turn of the intersection at the front of crossroad in advance, but no information is available whether the lane for left or right turn ahead is a dedicated lane or shared lane.

Figure 4 shows typical type of preliminary pavement marking on the rural road in Frankfurt Germany rural roads.

Figure 3:Germany guideline of PPDM at intersections

Figure4:Germany case of PPDM at intersections in Frankfurt

MUTED Criteria

Looking into the MUTCD (Manual on Uniform Traffic Control Devices) [8] of the U.S., its design method on pavement markings for direction and directional guidance only presents the standards and locations without delivering information on the lanes for left or right turn of intersections at the forefront of the intersection. In the event of right turn, it allows drivers to determine whether the lane for turns is a dedicated lane or shared lane only after entering the dedicated lane for turns(Figure 5).

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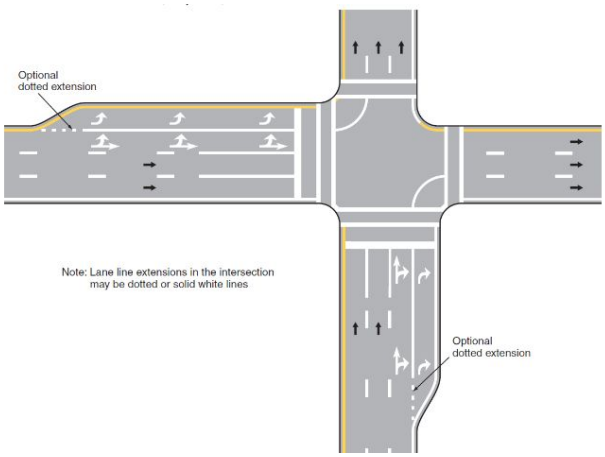

Figure 5:MUTCD guideline of pavement direction markings at intersections

III. CURRENT SATAUS AND PROBLEM

Due to conventional practices of current pavement markings, a number of dangerous situations are prone to occur at intersections.

When information on the lanes for turns is not available, a problem shown at the Figure 2 may occur although it is quite a rare occasion. First, a vehicle driving straight forward on the 1st lane is to realize the lane that the vehicle is on is a dedicated lane for left turn only after it reaches the intersection; and if another vehicle to make a left turn approaches from behind, the vehicle is likely to cause congestion throughout the entire intersection as it hinders the left-turn traffic flow. Second, if there is yet another vehicle to make a left turn approaching from behind while the vehicle in question is making a lane change from the dedicated lane for left turn to the through lane, it poses a great deal of danger for collision.

Examining traffic safety-related index on traffic accidents, the accidents occurred at intersections consist mere 38.5% (52.6% at a single route, 9.9% others) of all accidents. Despite the above, looking into the type of accidents occurred at intersections, vehicle-to-vehicle accidents are responsible for 46.1% (whereas a single vehicle accident is the highest with 74.2% at a single route) implying that a significant number of collisions occurred at intersections, and it is believed to be the cause to slowing down the traffic control at intersections [9].

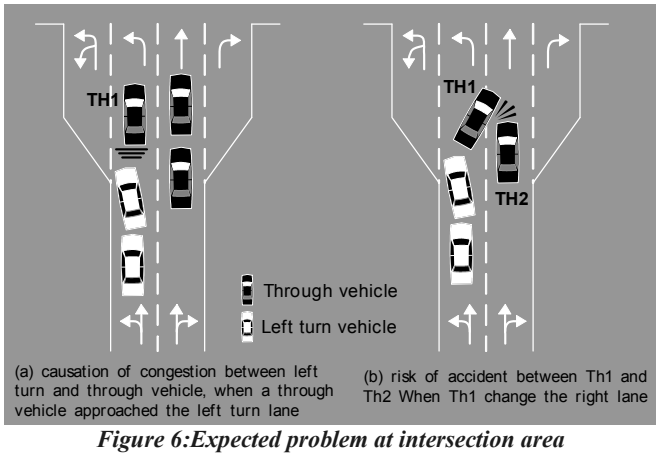

Figure 6:Expected problem at intersection area

ISSN 2348 – 8034
Impact Factor- 4.022

In addition, when saturation flow rate per lane is determined from the aspects of capacity of signalized intersections, it explains that the traffic capacity deteriorates as much as the time of congestion occurred (the time for a vehicle travelling straight forward at the left-turn lane to take to change lanes from the though lane to the next lane as shown at the figure 6) [10].

As a matter of fact, it take at least 30 minutes to process an accident when collision occurs at the intersection, it is believed that the impact from congestion is quite severe when assuming that it occurred during rush hour at downtown area. Thus, in order to resolve these types of problems, this study developed an improvement measure by redesigning the second pavement marking (actual forewarning indication feature) from pavement markings for direction and directional guidance at two or more locations [11, 12].

IV. IMPROVEMENT MEASURES ON PAVEMENT MARKINGS

Improvement Principle

- Pavement markings drawn at intersections (pavement marking 2 to 3 meters away from the stop line) are to be identically maintained in the existing format; and this study is to redesign only the second pavement marking for direction and directional guidance provided at the front part of intersection;

- When the lane for turns is a shared lane with the through lane, the pavement marking shall be the same as the previous one;

- When the lane for turns is a dedicated lane, markings for through lane and turn lane shall be separately indicated within the same lane;

- If possible, all information on actual lanes for turns shall be made available.

Presentation of Alternatives

- Redesign measures on pavement to mitigate congestions and enhance safety at intersections are presented as shown at the Figure 7 pursuant to the 4.2 Improvement Principle. In additions, all other similar principles shall be deemed as identical means.

- Since there is no dedicated lane for turns, it may be maintained as it has previously.

Figure 8 suggests an idea for improving visibility of the road marking on intersection lanes at night. It is considered to be one of the effective methods of securing visibility so that road surface information using light sources such as LEDs can be easily recognized through the road surface display at night in order to know the information of the turning lane ahead of the intersection.

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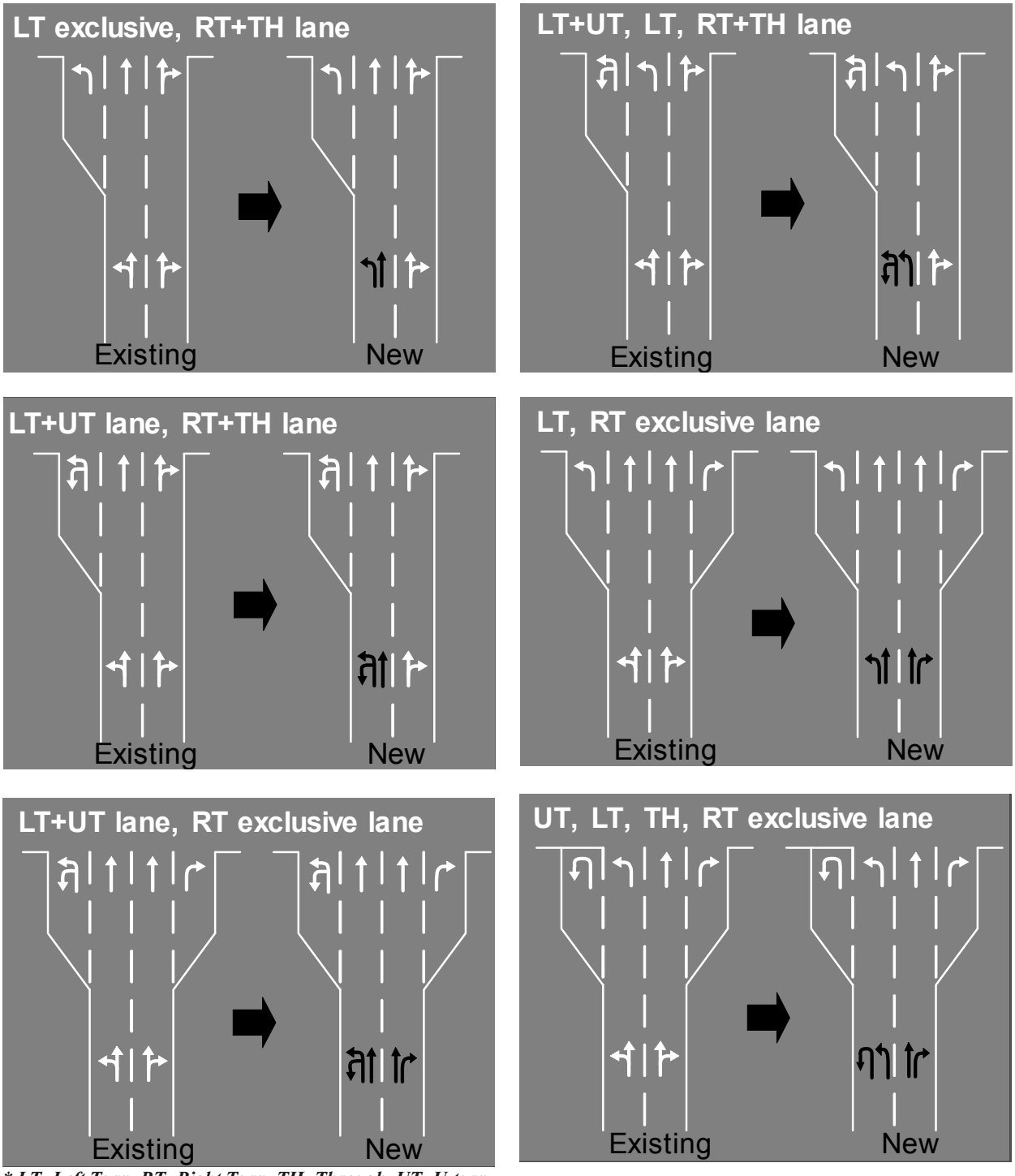

** LT=Left Turn, RT=Right Turn, TH=Through, UT=U-turn*

Figure 7:New design concept of PPDM to improve visibility and safety at intersection area

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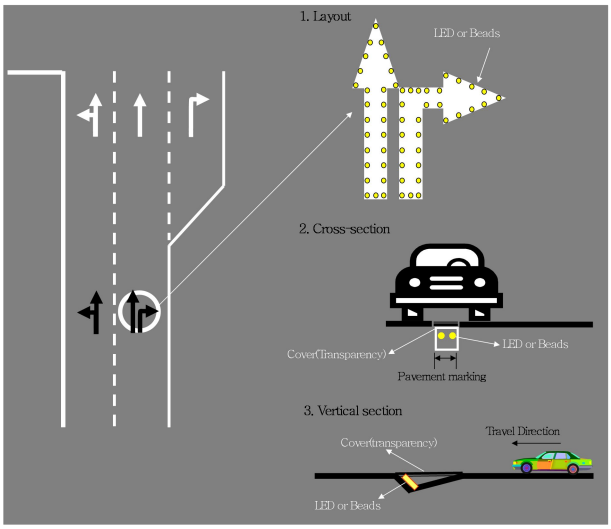

Figure 8: Installing method of PPDM to improve nighttime visibility

V. CONCLUSION AND FURTHER STUDY

This study proposed measures to redesign pavement markings in order to enhance safety and mitigate congestion at intersections. At the same time, light sources or glass beads may be employed in order to improve visibility of pavement markings, and they can be dynamically adjusted depending on the demand of rotational traffic flow at intersections.

Redesign measures on pavement markings presented by this study failed to be completed upon current effect effectiveness evaluation or verification measures; and it was due to difficulty of actual on-site application as well as difficulty of mock tests through proper simulation programs. Therefore, these insufficiencies are suggested for future study issues; and at the same time, it is expected that the said future study will be more effective if the experiment is conducted at intersections of multiple-lane roads (one-way road with 4 lanes or more) at busy downtown rather than the relatively simple intersections at 2-lane or 4-lane routes. Moreover, when designs proposed by this study are employed, it may seem a bit complicated compared to the conventional designs; therefore, it needs to conduct new studies on the criteria in order to prevent further complications.

ACKNOWLEDGEMENTS

This research was supported by a grant from a Strategy Research Project (Development of Enhancement and Evaluation Technologies for Driver's Visibility on Nighttime - Part III Development of Enhancement and Evaluation Technologies for Driver's Visibility on Nighttime) funded by Korea Institute of Civil Engineering and Building Technology.

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