

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES EVALUATION OF IMPROVED VARIABLE SPEED LIMIT SIGNS UNDER FOGGY CONDITIONS

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ABSTRACT

Inclement weather particularly fog is the negative factor on traffic flow. In advanced countries, they control the speed in active way using Variable Speed Limit (VSL) depending on climatic condition so as to ensure the stable traffic flow is maintained. In this study, Variable Speed Limit signs with advanced visibility in inclement weather conditions was developed, which was then tested at KICT's SOC R&D center at Yeoncheon through the off-road test and the performance of VSL was compared with conventional ones. Consequently, average legibility distance of newly-developed VSL was improved by 21.9% from the conventional ones.

Keywords: *Foggy, Variable Speed Limit Signs(VSLs), Legibility Distance, Off-road Test.*

I. INTRODUCTION

Fatal accident caused by inclement weather such as snow, rain and fog has been on the rise in Korea and particularly fog among others has the greater effect on sight distance of the driver which further influences on driving speed and behavior causing unstable traffic flow as well as raising the traffic accident risk.

The traffic accidents caused by the fog for past 5 years (2012~2016) totaled as many as 1,824 and though the number of accident itself is relatively less than other factors, fatality reaches to 1-.4% while the fatality at clear weather is 2.02%, cloudy 3.8%, rain 2.6% and snow 2.7% (Korea Road Traffic Authority, 2012-2016)

In other advanced countries including Finland and the United States, they control the speed in active way using Variable Speed Limit (VSL) depending on climatic condition so as to ensure the stable traffic flow is maintained and thus in Korea ranked low in comparing the traffic safety level among the countries, taking more efficient safety measure is more than important.

This study thus is intended to develop the more efficient Variable Speed Limit signs and evaluate the performance both at normal weather and foggy condition through off-road test.

II. DEVELOPMENT OF VARIABLE SPEED LIMIT SIGNS(VSLs) IN RESPONSE TO INCLEMENT WEATHER

Based on review of road traffic act, VSL test operation guideline and requirements of foreign active speed control system, VSLs with enhanced sight distance was developed. The sign comprises of dual lens module, Variable speed limit sign Control Unit (VCU), power supply system and the housing. Performance certification was implemented by the Korea Road Traffic Authority, the internationally authorized test agency.

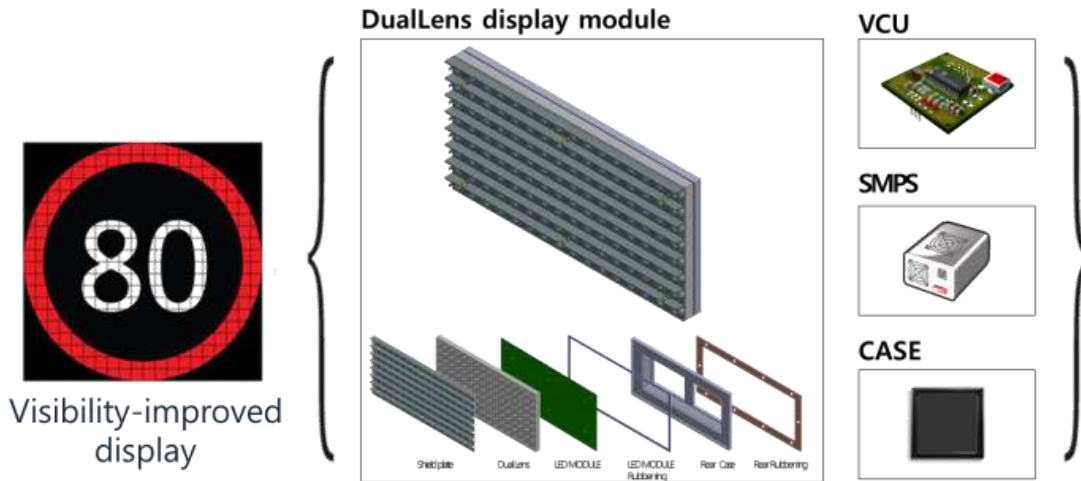


Fig 1. Variable speed limit sign / dual lens sign module power / supply system(SMPS) / housing

III. OFF-ROAD TEST TO MEASURE THE SIGHT DISTANCE OF VSLs

Off-road test summary

In this study, improved performance of VSLs at normal weather and foggy condition was evaluated in a way of comparing the legibility distance of the driver. The test was conducted at KICT's SOC Yeoncheon R&D center on test bed and tunnel shield. The foggy weather was simulated over a 200m-long tunnel shield and the overall layout is as Fig 2 below.



Fig 2. Layout of off-road test

The off-road test plan for measuring the sight distance of VSLs

The off-road test was conducted for 5 days from Oct 30 to Nov 3 2017. Measuring the eligibility distance of VSLs was made in a way of identifying the measurement point by the subject using GPS and then calculating the distance to fixed VSLs. The test procedure was as follows.

- Step 1. Place the subject at the point at a certain distance (beyond the zone where foggy weather is simulated).
 Step 2. While the subject is stationary, the vehicle with VSLs is running and the distance when the letter is legible is measured.
 Step 3. Repeat the process above while changing the luminance of VSLs.
 - Luminance of conventional VSLs: 2,000, 4,000, 6,000, 8,000 nit
 - Luminance of developed VSLs: 2,000, 4,000, 6,000, 8,000, 10,000, 20,000, 30,000, 40,000, 50,000, 60,000 nit

Result

Legibility distance tended to increase in line with increasing luminance at foggy weather condition but when it comes to developed VSLs, legibility distance was rather decreased due to dazzling at certain luminance level or higher. In foggy condition, developed VSLs has the longer legibility distance than conventional ones and appropriate luminance of developed VSLs is estimated at 20,000 ~ 30,000 nit.

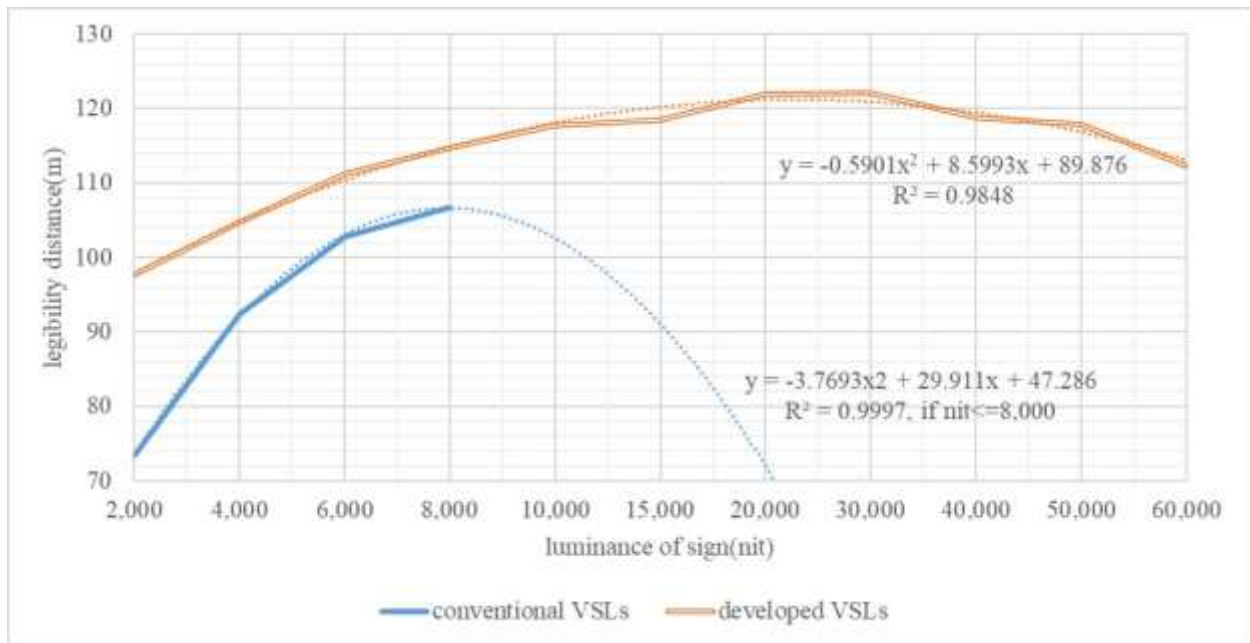


Fig 3. Legibility distance depending on luminance of sign at foggy condition

Off-road test to measure the legibility distance of VSLs is as Table 1. In foggy condition, legibility distance of conventional VSLs was 94m while the legibility distance of developed VSLs was 114m, indicating the improvement by 21.9%.

Table 1. Result of Off-road test to measure the legibility distance of VSLs

Speed limit (kph)	Conventional VSLs		Developed VSLs		Improvement	
	At normal weather (m)	At foggy condition (m)	At normal weather (m)	At foggy condition (m)	Normal	Foggy
50	256	94	264	114	3.1%	21.9%

After placing conventional VSLs and developed VSLs at same location, comparison was made using DSLR camera and as a result, difference was insignificant at normal weather but newly-developed VSLs appeared clearer and at foggy condition, the difference between two signs was significant.



Fig 4. Comparison between conventional VSLs(L) and developed VSLs(R) at normal weather



Fig 5. Comparison between conventional VSLs(L) and developed VSLs(R) at foggy condition

IV. CONCLUSION

This study thus is intended to develop the more efficient Variable Speed Limit signs and evaluate the performance both at normal weather and foggy condition through off-road test and the conclusion of the study is outlined as follows.

- ^ Legibility distance tended to increase in line with increasing luminance at foggy weather condition but when it comes to developed VSLs, legibility distance was rather decreased due to dazzling at certain luminance level or higher.
- ^ Legibility distance in foggy condition was improved by 21.9% comparing to conventional VSLs.

When applying the VSLs developed in this study, it's expected to provide the drivers with VSLs with enhanced visibility, thereby improving the safety, stabilizing the traffic flow as well as making commitment to increasing the traffic management efficiency.

V. ACKNOWLEDGEMENTS

The research was supported by a grant from "Active Speed Management System for Enhancing Road Safety Especially for Night-time and Adverse Weather Conditions (grant number 18TBIP- C111467-03)" funded by the Ministry of Land, Infrastructure and Transport, Republic of Korea

REFERENCES

1. Korea Road Traffic Authority, *Traffic Accident Statistics, (2012-2016)*.
2. LEDO Co. Ltd., “Active Speed Management System for Enhancing Road Safety Especially for Night-time and Adverse Weather Conditions”, *Internal Document(2016)*.
3. S.L. Kim, S.K. Lee and Y.S Kim, “An Analysis on Compliance of Variable Speed Limit under Foggy Conditions using Driving Simulator”, *The Journal of The Korea Institute of Intelligent Transport Systems, 16(2), pp.117-127 (2016)*.
4. S.B. Jeon, Y.T. Han, D.M. Seo and I.B. Jung, “Improved Real-Time Variable Speed Limits for a Stable Controlling of the Freeway”, *KIISE Transactions on Computing Practices, 22(9), pp.405-418 (2016)*.