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SAFETY PERFORMANCE EVALUATIONS FOR THE BLOCK LINK TYPE MOVABLE BARRIERS USING FULL SCALE TESTS

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ABSTRACT

Maintenance of the road should be carried out in order to provide the user with comfortable and safety. When repairing the road, it is generally feasible to block the lane and the construction of the road is insufficient for the safety of the occupants. The purpose of this research is to develop block link type movable barriers for protecting the road worker's safety and conduct an evaluation of the occupant safety performance through the full scale crash test. Development target was set at SB2 and the test was conducted as internal test before certification test in two types, with and without side air bumper.

Keywords: *Road Safety, Work Zone, Block link type, Movable Barrier, Crash Test.*

I. INTRODUCTION

Generally, traffic accident occurs due to three major factors such as human factor, vehicle factor and road environment factor as indicated by American HSM(Highway Safety Manual, 2010) and when it comes to the ratio of occurrence factor, human factor is 93%, road environment factor is 34% and vehicle factor is 13% [1].

Though the accidents is in the decline for past 10 years, accident at road construction site has not been reduced but rather increased and the measures to deal with it need to be taken. According to analysis of the accident at road construction site, the fatality totaled 27 among 583 road workers as of 2012 which indicate that 5% of road workers died or injured.

The environment for the road workers is worse on highway. The drivers died at road construction site on highway reached 56 and 47 died and 15 injured on local road over the period, 2008 through 2013.

A trial product of block link type movable barrier which is designed maximize the work space by moving laterally, provide the convenient mobility and reduce the impact so as to protect the workers from the vehicles rushing to road construction site was developed and this study is intended to evaluate the safety performance for the occupants through the full scale crash test.

II. DEVELOPMENT OF TRIAL PRODUCT OF MOVABLE BARRIER

Based on the literatures and website based review, we established the basic concept to develop the movable safety barriers. The first consideration we made is the idea that the type of barriers needs to be varied according to the work zone characteristics. The second is that the barrier should meet the required safety performance designated by Government of Korea.

Figure 1 shows the block link type of movable barrier, which has the series of the block units. While moving, the block unit is folded to meet the vehicle code designated by Government such as the maximum length of the vehicle. When the vehicle begins to service, the folded block is stretched to the certain length to protect the work zone effectively.

A block link type barrier is categorized into large vehicle or special vehicle and is designed to secure the safety of the workers as well as provide the road management function at road construction site. Performance target is set at SB2 and total length of the vehicle when unfolding the barrier is 42m which is designed to cover the sufficient work space over a 30m-long road section.

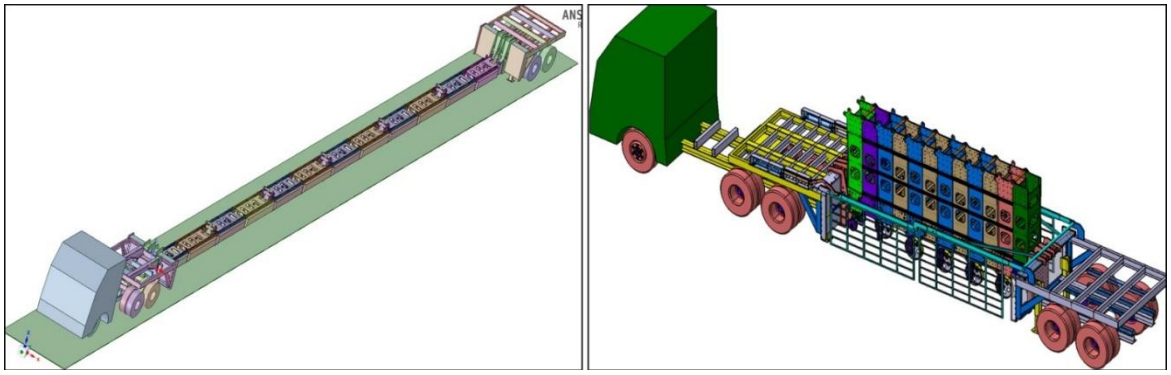

Figure1. Block link type movable barrier (Left: when unfolding, Right: when folding)

III. FULL SCALE CRASH TEST

The full-scale crash test of barriers should be conducted in accordance with the "Installation of Road Safety Facility and Administrative Guideline (Safety facility of barriers for vehicles, 2014)" and performance test should be performed by the performance evaluation institution of road safety facility in order to certify the result of performance evaluation. Table 1 presents the test conditions to evaluate the safety of occupants.

Table 1. Test conditions for occupant protections

Level	Impact Velocity(km/h)	Impact Weight(kg)	Impact Angle(deg.)
SB1	60	900	20
SB2, SB4	80		
SB3	100		
SB5, SB6, SB7	100		
SB3-B, SB5-B	120		

Criteria of occupant protections

The criteria of occupant protection performance evaluation are presented in Table 2. Theoretical Head Impact Velocity (THIV) refers to an instantaneous relative velocity between the "theoretical occupant head" and the vehicle when the vehicle is decelerated after crash with facility and the head is free flight thereby crashing to the virtually set surface in the inner space in the vehicle assuming that the occupant head and vehicle are free flight at the impact speed. Post-impact Head Deceleration (PHD) refers to the calculated maximum of 10 m/s average acceleration of vehicle after THIV is calculated assuming that an occupant maintains a contact with a virtually-set surface inside the vehicle and receives the same acceleration of the vehicle. Acceleration Severity Index (ASI) refers to a value that represents a sum of each ratio of 50 ms average acceleration in the x, y, and z directions, respectively. It is expressed as a dimensionless scalar. It has a positive value always and if the value is larger than one, a risk of occupant becomes larger.

Table 2. Vehicle occupant impact severity criteria

Criteria	Unit	Index severity
THIV	m/s(km/h)	9(33)
PHD	g	20
ASI	-	1.9

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Field setting of crash tests

A full-scale crash test field was constructed by Smart Air Chamber Co. Ltd. that conducted the present study with their own investment in AnsungGyeonggi-do. The test field has been utilized as a full-scale test of front, side, and rear of vehicles. A length of road test drive road, the maximum driving speed, and the maximum weight of tow truck were 150 m, 120 km/h, and eight ton, respectively. During the crash test, the program is automatically interlinked thereby collecting THIV, PHD, and ASI values of speed, acceleration, and angular velocity.

Figure2. Full scale crash test bed(Smart Air Chamber Co., Ltd.)

Full scale crash tests and results

The target level of block link type movable barrier to be developed in this study was set at SB2. Crash test was conducted as full scale crash test prior to conducting certification test in two types, with and without side air bumper. Collision speed and angle was 80km/h and 20 degree, respectively and the vehicle used was passenger car (900kg).

A full scale crash test result, THIV, PHD and ASI value were indicated on table 3, Fig 3~5. As a result of the test, safety of occupants satisfied the performance requirements, both in case of with and without side air bumper.

Table 3. Result of occupant protection

Category	With side air bumper	Without side air bumper
THIV(km/h)	21.59	32.42
PHD(g)	8.04	6.05
ASI	1.08	1.34

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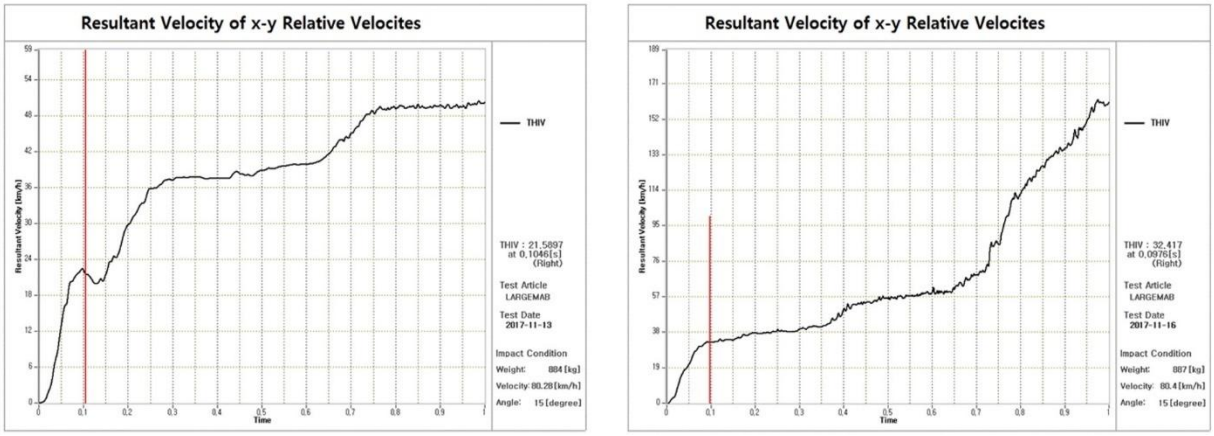

Figure3. THIV curve(L: with side air bumper, R: without side air bumper)

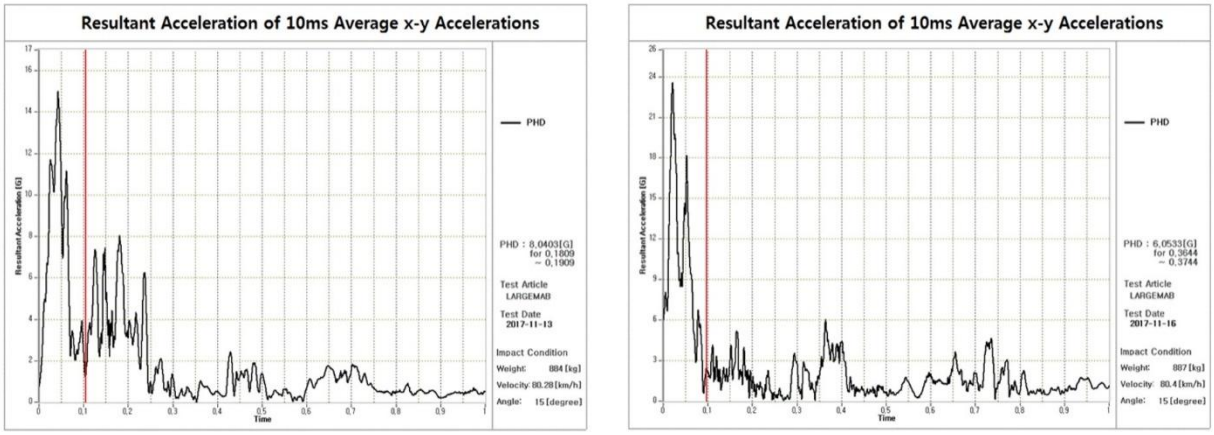

Figure4. PHD curve(L: with side air bumper, R: without side air bumper)

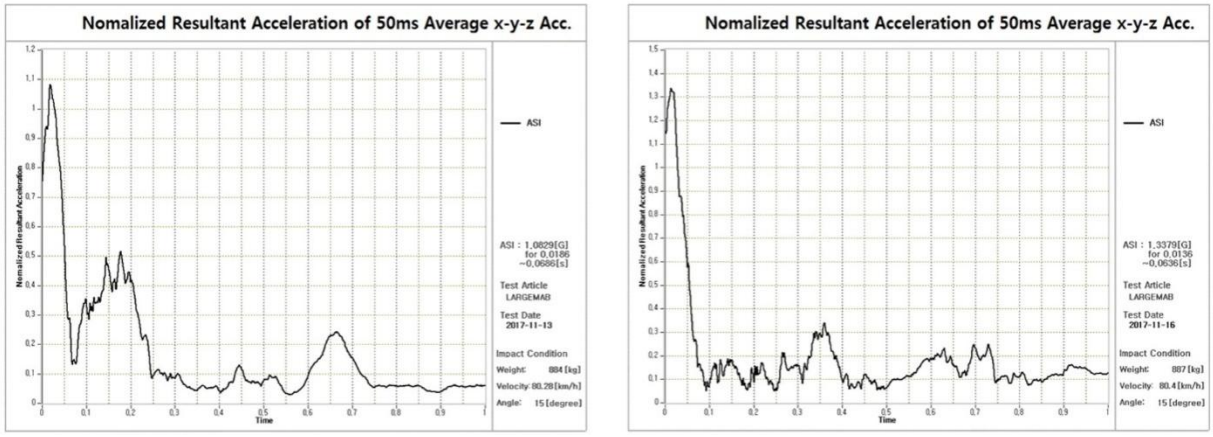

Figure5. ASI curve(L: with side air bumper, R: without side air bumper)

IV. CONCLUSION

This study is intended to develop the trial product of block link type movable barrier and evaluate the occupant protection performance through the internal test and the conclusion is made as follows.

- Target level of block link type movable barrier was set at SB2 and the test was conducted with and without side air bumper.
- As a result of a full scale crash test, safety of occupants satisfied the performance requirements, both in case of with and without side air bumper.

No collision analysis criteria for movable protection barrier has yet to be available which results in the limit in analyzing the test result based on the criteria of longitudinal barrier.
Should the performance be verified through public certification test after the product is developed and used at road construction site, it would make commitment to securing the road worker's safety at road construction site..

V. ACKNOWLEDGEMENTS

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