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THE RESEARCH ON THE SAFETY PERFORMANCE INDEX FOR IMPACT ATTENUATOR OF COLUMN

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ABSTRACT

A study on measures to reduce the severity and impact during collision with fixed facilities on the roadside such as posts or columns is needed. The management of dangerous objects when considering the road environment in relation to the structural risk when exposed to current roads and traffic environments as well as the proportion and fatality rate of single-vehicle run-off-road crashes and increases in accidents are taken into consideration. The present study allowed the development of vehicle protection facilities that can minimize the damage to drivers and passengers in a vehicle when a single-vehicle run-off-road crash occurs involving posts or columns. Among vehicle protection facilities, guardrails were selected as a target object. The present study reviewed previous literature and guidelines, and proposed an alternative to minimize injuries to drivers and passengers through indoor simulations. The present study developed a curve-shaped guardrail that surrounds a column and proposed an articulated-type guardrail as an alternative. Theoretical Head Impact Velocity (THIV) and Post-Impact Head Deceleration (PHD) were used as evaluation factors to measure the safety of passengers. The analysis result concluded that the farther the collision occurred from the center of posts or columns, the lower the THIV and PHD were measured.

Keywords: *THIV, PHD, Traffic Safety, Safety Performance etc.*

1. INTRODUCTION

The highway safety manual (HSM, 2010) in the USA suggested that traffic accidents occur due to three factors: human factors (93%), roadway/environmental factors (34%), and vehicle factors (13%). In particular, roadway/environmental factors account for approximately 34% of total traffic accidents and can also affect traffic accidents due to human factors such as drivers and passengers in a vehicle, road workers, and pedestrians. Thus, the construction of safe road environments can play an important role in improving traffic safety.

Although the number of traffic accidents has been decreasing due to various efforts to improve traffic safety, in-depth analysis on traffic accidents revealed that single-vehicle run-off-road crashes have not decreased, but rather increased. The overall number of deaths due to traffic accidents has decreased (from 6,376 to 5,092) by 1,284 since 2005. However, the number of deaths due to single-vehicle run-off-road crashes has decreased (from 1,254 to 1,228) by only 26 deaths, Thus, the number of deaths due to single-vehicle run-off-road crashes has not decreased significantly compared to the total number of deaths due to traffic accidents. In particular, the total traffic accident fatalities (= No. of deaths / No. of traffic accidents) in 2013 was 2.4, whereas the fatalities due to collision with roadside objects was 10.7, which was five times the average fatality rate. (Korean National Police Agency, 2014). With detailed analysis the proportions of deaths due to collision with roadside objects showed that structure-related accidents accounted for 17.8% of accidents, which was the third largest proportion following the traffic safety facilities (34.6%) and power and light facilities (19.2%).

Thus, a study on measures to reduce the severity and impact during collisions with fixed facilities on the road side facilities, such as posts or columns is needed. The management on of dangerous objects when considering the road environments in relation to the structural risk when exposed to current roads and traffic environments as well as the

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proportion and fatality rate of single-vehicle run-off-road crashes and increases in accidents are taken into consideration.. The present study allowed the development of vehicle protection facilities that can minimize the damage to drivers and passengers when a single-vehicle run-off-road crash occurs involving posts or columns. Among vehicle protection facilities, guardrails were selected as a target object. The present study reviewed previous literature and guidelines and proposed an alternative to minimize injuries of drivers and passengers through indoor simulations.

2. LITERATURE REVIEW

In Korea, the Guideline for Installation and Management of Road Safety Facilities (vehicle protection safety facilities) has been enacted set standards of impact absorption facilities used, in relation to vehicle protection. The vehicle protection safety facilities refer to installations to prevent vehicles from departing from lanes during driving or to protect passengers, vehicles, pedestrians, or main roadside facilities by preventing direct collision between vehicles and structure. The guideline was recommended by the Ministry of Land, Infrastructure and Transport in 2010. For vehicle protection safety facilities, protection fences installed on roads, medians, and bridges, and impact absorption facilities installed at the front of fixed structures can be found. The present study targets vehicle protection fences, which are divided into nine grades, depending on the strength of installation by design speed in the road. Tests are performed to evaluate performance according to corresponding conditions to have the required strength of the facility in accordance with each grade.

Table 1. The test conditions

<table>
<tr><th>Level</th><th>Impact Velocity (km/h)</th><th>Impact Weight (kg)</th><th>Impact Angle (deg.)</th><th>Level</th><th>Impact Velocity (km/h)</th><th>Impact Weight (kg)</th><th>Impact Angle (deg.)</th></tr>
<tr><td>SB1</td><td>60</td><td rowspan="3">900</td><td rowspan="3">20</td><td>SB5, SB6, SB7</td><td>100</td><td rowspan="2">900</td><td rowspan="2">20</td></tr>
<tr><td>SB2, SB4</td><td>80</td><td>SB3-B, SB5-B</td><td>120</td></tr>
<tr><td>SB3</td><td>100</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Table 1 presents one of the test condition case. It is the test conditions to evaluate the safety of the occupants. The guidelines to protect vehicle occupants used in the USA and Europe are as follows: In the Roadside Design Guide, a manual used in setting guidelines dealing with collision involving roadside posts are specified. In the manual relocation , shielding, and protection of passengers through breakaway or impact absorption are suggested. Clear zone, relocation, protection using guardrails, and post edge treatment were suggested as the measures of protection and risk prevention regarding exposed posts in road side. The Manual for Assessing Safety Hardware replaced the National Cooperative Highway Research Program (NCHRP) Report 350 (H. E. Ross 1993), which was the standard of performance evaluation on road safety facilities to reflect the current traffic flows. It specified performance standards of all road safety facilities. For the protection of passengers through breakaway or impact absorption, collision tests and evaluation methods about these devices were specified. In the Roadside Design Guide, a measure of risk and collision with exposed posts was provided. In particular, the Province of Alberta enacted the Roadside Design Guide to outline a method dealing with the installation of posts for signs, overhead posts for signs, posts for lighting, posts for traffic signal, and electric poles to minimize damage during collision. EN12767 specified how to ensure passengers' safety during collision with post structures in the roadside (sign boards, traffic signal, street light, and posts for all sorts of equipment) on the basis of the Passive Safety Standards used in the EU, and set evaluation standards. It divided posts into NE (Breakaway), LE (Low Energy Absorbing), and HE (High Energy Absorbing); NE posts for high-speed motorcar roads and HE posts for downtowns to prevent secondary accidents due to separated posts. NCHRP Report 350 suggested a procedure to evaluate the performance on various safety facilities on expressways.

Generally, Theoretical Head Impact Velocity (THIV) and Post-Impact Head Deceleration (PHD) are used as the standards to measure the safety of passengers. THIV is an index to evaluate the impact risk of passengers during a collision between a vehicle and a protection safety facility using a passenger's impact speed. It refers to a velocity of passenger's head until the head collides with the left or right space in the vehicle. THIV is calculated using heat flight time (T) and relative velocity (Vx, Vy) in the vehicle coordinate.

PHD refers to a passenger's second acceleration after a first collision of the vehicle with a structure due to an instantaneous secondary collision. It is the maximum value among accelerations applied to the head as it collides with the inside structure of the vehicle as soon as the passenger experiences the secondary collision. PHD is calculated by using the maximum value of 10 ms means of Xc and Yc measured via (t>T) after collision.

3. METHODOLOGY

3.1 Overview of analysis

The present study performed indoor simulations after setting alternatives and experimental conditions to develop a measure to reduce the impact and severity that occurred during a collision with posts and columns and derived an alternative through the indoor simulation results. The present study developed a curve-shaped guardrail that surrounded a column and proposed an articulated-type guardrail as an alternative. The experimental condition was divided into front offset, front 15°, lateral, and lateral 15° to conduct the tests and simulation. A model was set from the existing general straight guardrail shape into a curved shape guardrail and further tests were conducted with curved shape combined with articulated type guardrail. Furthermore, indoor simulations were conducted to provide an alternative to reduce the traffic accident severity and impact by setting the following conditions: guardrail gap (1m, 0.75m, and 0.5m), the number of guardrail installations (1EA, 2EA, and 3EA), guardrail type (2W and 3W), and guardrail joint methods (bolt, block, and block-out).

3.2 Indoor Simulation

The present study divided the installation of guardrails into one to three layers. The experimental results of THIV and PHD before and after collision after performing bolt joint, block-out joint, and combined bolt and block-out joint are presented in Table 2. The combined bolt and block-out joint showed the best result and as the number of rails increased, PHD and THIV were reduced and safety was increased.

Table 2. The result of collision Test

		Rail 1	Rail 2	Rail 3
Bolt	PHD	25.9	23.0	35.9
	THIV	38.6	30.9	16.4
Block Out	PHD	27.9	26.1	36.8
	THIV	46.7	21.5	21.0

Bolt + Block Out	PHD	23.6	25.9	36.7
	THIV	50.3	24.2	15.0

The present study also performed an investigation with regard to guardrail installation gap and guardrail type. The installation gap was divided into 1m, 0.75m, and 0.5m distances. The wave type of guardrails was divided into 2W and 3W. The results according to gap and type are presented in Table 3. The simulation result showed that as a gap of guardrail installation was narrower, and as the number of wave was larger, THIV and PHD became lower.

Table 3. The results according to gap and type

		1m	0.75m	0.5m
2W	PHD	28.2	30.9	33.8
	THIV	21.7	21.5	16.2
3W	PHD	33.5	34.4	46.8
	THIV	13.0	14.4	9.9

It is necessary to install protectors such as posts and columns for the purpose of traffic safety according to realistic considerations. A mean width of safety zones of columns installed in Korea and a gap with impact absorbing facility were measured at field sites. The mean width of safety zone was 1.7m – 5.8m, and a gap with impact absorbing facility was 0.2m – 5m. Thus, installation conditions that were suitable to the Korean values were needed. The present study set the installation gap of guardrails to 0.75m. For guardrails, three-beam guardrails were selected. Tests were conducted according to different impact angles. The collision angle was divided into front, front 15°, lateral, and lateral 15° to conduct simulations. The results were front (THIV :38.5, PHD :15.2), front 15° (THIV :44.8, PHD :9.2), lateral (THIV :43.9, PHD :21.0), and lateral 15° (THIV :50.8, PHD :13.2). The lowest THIV and PHD were revealed when collision occurred farther from the center of the post or column.

4. CONCLUSION

A study on measures to reduce the severity and impact during collision with fixed facilities in roadside such as posts or columns is needed. The management on of dangerous objects when considering the road environments in relation to the structural risk when exposed to current roads and traffic environments as well as the proportion and fatality rate of single-vehicle run-off-road crashes and increases in accidents are taken into consideration. The present study allowed the development of vehicle protection facilities that can minimize the damage to drivers and passengers in a vehicle when single-vehicle run-off-road crashes occur involving posts or columns. Among vehicle protection facilities, guardrails were selected as the target object. The present study reviewed previous literature and guidelines and proposed an alternative to minimize injuries of drivers and passengers through indoor simulations. The present study was performed with an alternative setup, an experimental condition setup, and the indoor simulations derived an alternative through the results. The present study developed a curve-shaped guardrail that surrounded a column and proposed an articulated-type guardrail as an alternative. THIV and PHD were used as evaluation factors to measure the safety of passengers. The collision angle was divided into front, front 15°, lateral, and lateral 15° to perform simulations. The results were front (THIV :38.5, PHD :15.2), front 15° (THIV :44.8, PHD :9.2), lateral (THIV :43.9, PHD :21.0), and lateral 15° (THIV :50.8, PHD :13.2). The lowest THIV and PHD were revealed when collision occurred farther from the center of the post and column.

In order to advance the study result, the following research is needed. First, it is necessary to verify the result through not only simulation results, but also real vehicle collision tests since the present study conducted improvements on passenger's safety only using indoor simulation results. Second, it is necessary to provide an alternative through an additional study on protection fences that are installations to improve the safety of passengers during collisions, since the present study conducted improvements on passenger's safety only with regard to guardrails.

5. ACKNOWLEDGEMENT

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REFERENCES

1. *AASHTO, Highway Safety Manual(2010)*
2. *AASHTO, Manual for Assessing Safety Hardware(2009)*
3. *Ministry of Land & Transportation(MOLIT), Guideline for Safety Barriers(2014)*
4. *Passive safety of support structures for road equipment. Requirements, classification and test methods (2008)*
5. *Roadside Design Guide*
6. *TRB, NCHRP Report 350:Recommended Procedures for the Safety Performance Evaluation of Highway Features(1993)*
7. *http://sts.samsungfire.com/information/regulations/asn/ASN160406/asn_column.html*