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STUDY ON THE DEVELOPMENT OF A KOREAN-TYPE ROAD DEBRIS REMOVER INSTRUMENT FOR ROAD SAFETY

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ABSTRACT

This purpose of this study is to develop a piece of korean-type road debris remover instrument that can collect a variety of road debris including roadkill on the road.This study developed a detailed design plan to develop piece of korean-type road debris remover instrument that can collect a variety of road debris including roadkill on the road rapidly and safely. For this, a survey was conducted with the road authority to derive a design draft for the equipment and the design plan was developed after confirming the structure and collection range of the developed equipment.The instrument designed in this study can remove a relatively large size of road debris such as roadkill, tire debris, paper boxes, wooden panels, which cannot be removed with existing instruments.This implies that it will be expected to help maintenance works on the road. Furthermore, the instrument for removing road debris can detect roadkill and road debris accurately on the road and remove them as quickly as possible thereby ensuring the safety of workers and heightening traffic safety in the future.

Keywords: *Road debris, Road kill, Road worker, Road safety, Traffic accident*

I. INTRODUCTION

As roads are constantly extended, the spatial distance between road and forest or greenery has become less. The amount of roadkill caused by wild animals that jump onto the road to pass through the interrupted greenery due to new roads has increased more and more. According to the Ministry of Land, Infrastructure and Transport in Korea, the average number of roadkill is 2,000 cases annually on expressways and species of wild animals killed in the road are elks, raccoons, wild rabbits, and wild boars. More specifically, the number of elk killed on the road for the last five years were 1,739 in 2010, 1,914 in 2011, 1,996 in 2012, 1939 in 2013, and1,824 in 2014, which reported a total of 10,952 cases for five years and amounted to 87% of all roadkill (Internal data from the Korea Expressway Corporation). For Seoul City, whose road density is the highest in Korea, the number of handling roadkill for the last three years totaled 18,688 cases, which was approximately 6,229 roadkill per year on average. This means that 17 animals are killed every day on the road in Seoul. Table 1 summarizes the roadkill occurring on expressways and in Seoul City.

Table 1. The amount of roadkill on expressways and in Seoul City

Category (year)	Yearly roadkill statistics (cases)	Yearly roadkill statistics (cases)
2009	1,895	-
2010	2,069	-
2011	2,307	-
2012	2,360	4,163
2013	2,188	5,158
2014	2,039	7,465
2015	-	6,065

Source: the Korea Expressway Corporation and Yonhap News Agency

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In Switzerland where relatively large wild animals inhabit, 7,500 cases of roadkill occur every year. In the USA where road extension is the longest in the world, the annual amount of roadkill reaches 300,000 cases and the cost of repairing vehicles due to roadkill accidents amount to KRW three trillion won (official website of Hyundai Motor). As such, roadkill causes a problem in terms of road management around the world. More critically, roadkill or roadkill-related accidents could cause secondary accidents. A fatality occurring from secondary accidents on expressways in Korea is very high, which is approximately 5.6 times of that of general traffic accidents. The number of secondary rear-end accidents due to roadkill has increased from four cases in 2007 to 14 cases in 2012, which is in a trend of rapid increase.

A collection procedure of roadkill is as follows: once a driver has witnessed the roadkill, he/she reports this to corresponding authority. Then, the road management authority dispatches personnel after the report and collects the roadkill manually. According to on-site personnel interviews, two roadkill collections and up to four occur per day on average. Most workers during roadkill collection work feel psychological stress due to animal corpses and are highly concerned about traffic accidents while collecting roadkill. It is also recommended to overcome hygiene issues such as decomposition and the spread of infectious disease if the collected corpses are handled together with general waste.

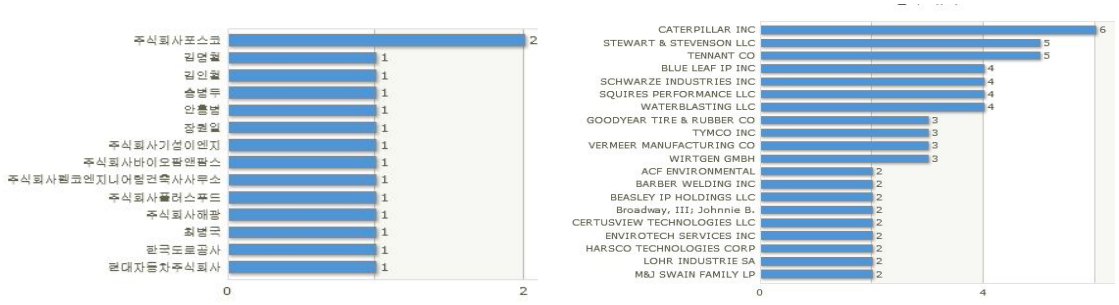
Currently, the USA has developed and used instrument that collects road debris (waste, smallluggage, etc.) on the road but reportedly there is no development on instrument that collects animal corpses on the road.

Thus, this study developed an instrument design to develop a piece of korean-type road debris remover instrument that can collect a variety of road debris including roadkill on the road rapidly and safely. For this, a survey was conducted with the road authority to derive a design draft for the instrument and the design plan was developed after confirming the structure and collection range of the developed instrument. In the future, when a prototype is complete, it can be utilized in road management work.

II. LITERATUREREVIEWANDTECHNOLOGICAL TREND

As mentioned in the above, no collection technology for roadkill can be found so a technological trend was done by searching ‘road debris’ as keywords. First, patents regarding technology of the instruments for removing road debris in Korea were searched and 13 patents were found and seven quotable patents were among them. For oversea cases, a total of 354 patents were found and there were four quotable patents among them.

The patent study results showed that few patents were only for the purpose of road debris collection and most of them concerned collection of road debris by utilizing cleaning instrument. Figure 1 shows the patent application status in Korea and overseas.



Korea Overseas

Figure 1: Patent application status in Korea and overseas

The AAA Foundation for Traffic Safety (2004) tested the risk of accidents related to road debris on North American roads. The Colorado Department of Transportation (DOT) (2014) performed verification on field on-site test using “Gator Getter”, which is an instrument for removing road debris developed by the Colorado DOT and Valdes-

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Vasquez (2014) conducted a performance evaluation on the instrument. Yang (2016) summarized the development direction for the instrument for removing road debris that is suitable for Korean situations.

III. SURVEY

It is important to reflect the opinions of site workers who perform maintenance tasks as much as possible in order to develop an instrument for removing road debris suitable for road conditions in Korea. Therefore, this study performed a survey with the road management authorities that perform the maintenance tasks on the road in order to determine the demand for an instrument for removing debris on the road (Figure 2).

The work load for the collection of debris on the road by the road management authorities was one case or more per day as shown in Figure 3.

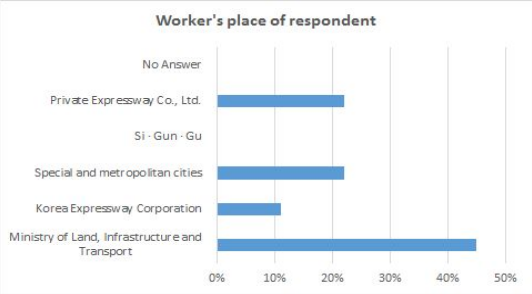

Figure 2: Worker's place of respondent

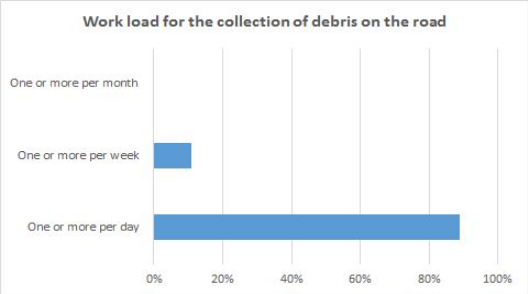

Figure 3: Work load for the collection of debris on the road

Most debris on the road collected are tire debris and paper waste followed by roadkill, plastic waste, and traffic accident-related debris as summarized in Figure 4. Most roadkill and road debris are collected manually by laborers in road management authorities and some road debris are collected via cleaning vehicles.

The respondents answered that 67% of them did not need an instrument for removing debris on the road during night shift work as shown in Figure 5. This indicated that except for emergency cases, most collection works for debris on the road were conducted during the day time. It was also found that guiding materials such as guide posts, slow-down signs and road lane changes and cameras were needed additionally to display the night work. This was to prevent traffic accidents such as rear-end accidents and to block the road lanes during the collection work for debris on the road.

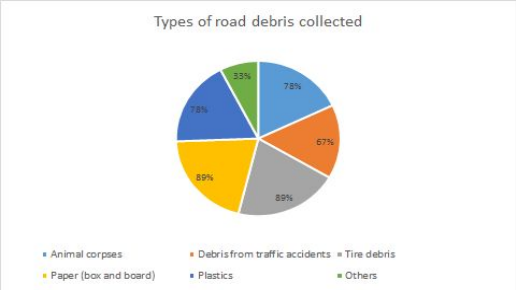

Figure 4: Types of road debris collected

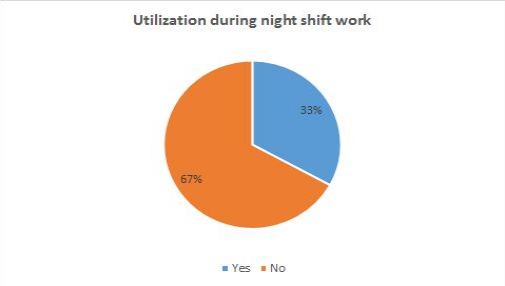

Figure 5: Utilization during night shift work

In the survey, 56% of the respondents answered that the driving speed shall also be considered when collecting road debris using the instrument for removing debris on the road (Figure 6). The respondents answered that an appropriate maximum driving speed was 30km/h or slower followed by 30-40km/h and 80km/h or faster. This result means that collecting work shall be done at not only slow driving but also fast driving.

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The priority of collection work by road types was first placed on expressways followed by national highways in cities and provinces, and roads in cities and suburbs as shown in Figure 7.

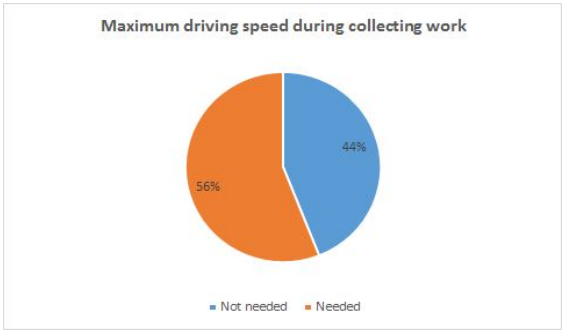

Figure 6: Maximum driving speed during collecting work

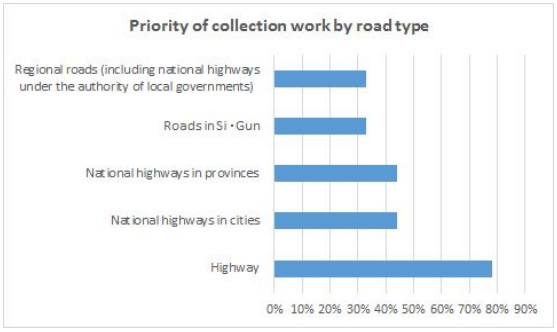

Figure 7: Priority of collection work by road type

The survey result on the purchase of the instruments for removing road debris by road management authorities showed that 44% of the respondent needed two pieces of instrument and 11% answered that more than four pieces of instrument were needed (Figure 8). Note that some of the authorities did not want to purchase the instrument because of the lack of instrument drivers and other types of instrument were already in use.

The respondents said that an appropriate collection capacity of road debris for one cycle was 1 ton or smaller and 11% answered 1 ton and 3 tons or larger capacity needed, respectively. In addition, the most appropriate capacity for collection of debris on the road was a 2.5 ton vehicle (Figure 9).

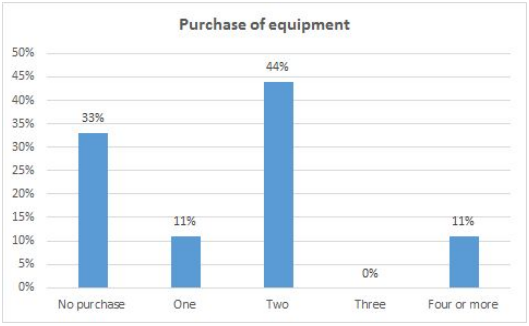

Figure 8: Purchase of equipment

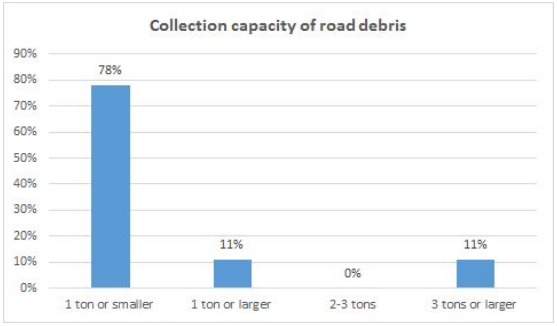

Figure 9: Collection capacity of road debris

IV. INSTRUMENT DESIGN

Based on the survey results, the design and considerations for the development of an instrument for removing road debris were derived as shown in Table 2. The survey result shows that the collection capacity for road debris for one cycle was approximately 1 ton so a 2.5 ton truck was selected for the development in the draft design. In addition, the vehicle structure and collection objects were studied and reflected in the design. In the future, the moving speed and collection weight can also be considered.

Table 2. Considerations during development

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Item	Considerations
Vehicle type	• 2.5 ton long-axis vehicle
Moving speed	• Moving speed during collection work is 10 km or faster
Collection weight	• Normal waste: max 5 kg • Animal corpse: around 11 kg
Collection capacity	• Collection capacity during operation per cycle: around one ton
Vehicle structure	• Structure that can collect both animal corpses and general waste •Structure that can separate animal corpses and general waste to load and store them •Structure that can satisfy the vehicle safety standards
Collection target	• Sand and gravel • Animal corpses and traffic accident debris • All road debris that interrupt road traffic (plastics, wooden pieces, paper box, etc.)

In order to design the layout for the instrument for removing debris on the road, Computer Aided Three dimensional Interactive Application (CATIA) was employed in this study. CATIA is software that helps manufacturing, modification, and management throughout the lifecycle from design of the product model to production in industrial fields. In particular, it has been widely used in the aircraft and automobile-related fields.

Figure 10 and 11 show the plane diagram of the instrument for removing debris on the road. A vehicle frame height was lifted (about 300 mm) to accommodate various road debris in order to install the instrument for removing road debris underneath the vehicle. If the instrument is mounted at the front, it is difficult to acquire a safety certificate of vehicle. On the other hand, if it is mounted at the rear, it is difficult to collect road debris. Furthermore, front mounting limits the types of removable road debris due to the capacity of the instrument and has a considerable drawback of low driving stability at high speed during the work.

As shown in Figure10, road debris is delivered to the lower part of the vehicle via the rotating brush in the front part. Then, road debris is transferred to the collection container via the collection conveyor in the lower part of the vehicle and then delivered to the loading box.For roadkill removal, animal corpses and general road debris were separated and loaded in the loading box in order to solve the hygienic problem.

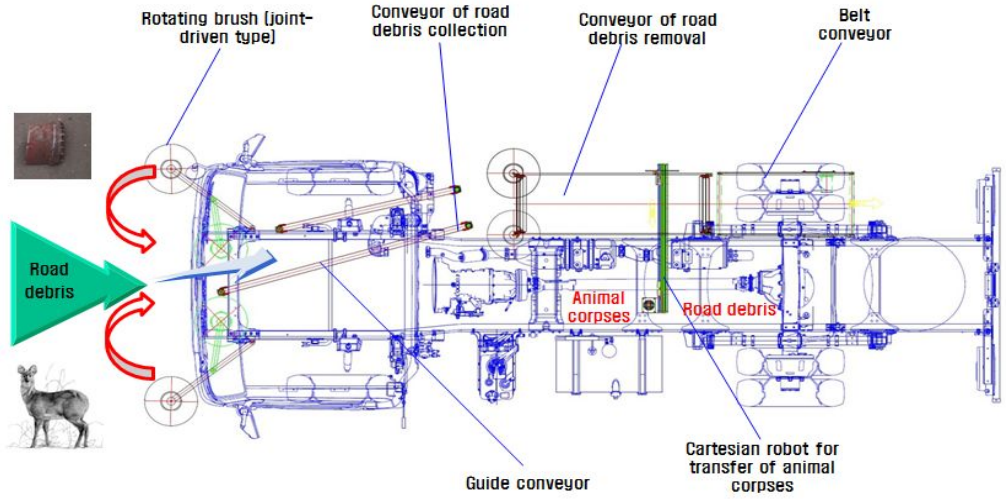

Figure 10: Plain diagram of the layout of removal instrument of road debris

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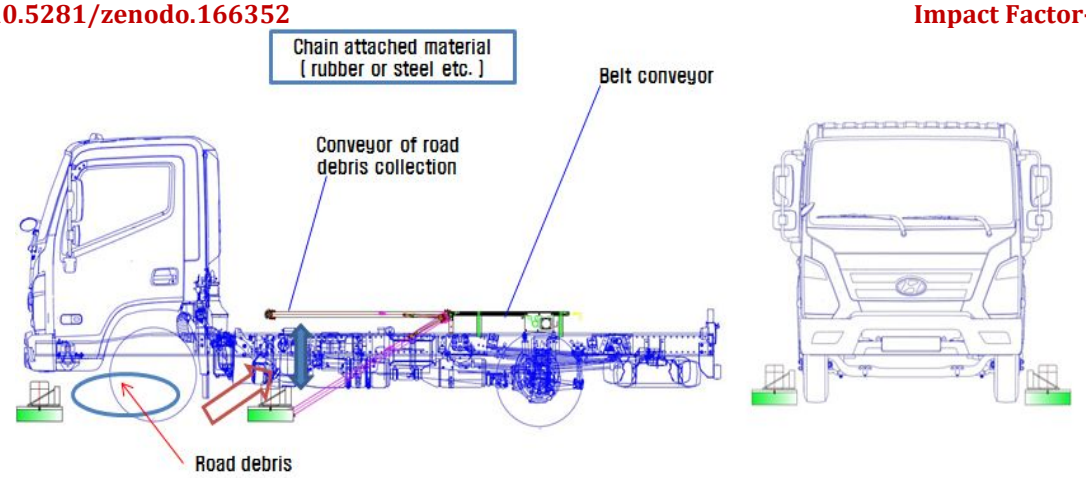

Figure 11: Lateral diagram of the layout of the instrument for removing road debris

V. CONCLUSION

More than 200 persons are killed and 29,000 people are injured due to roadkill in the USA each year. In Germany, more than 50 people are killed and 3500 people are injected by secondary accidents due to roadkill. Thus, the damage due to roadkill has been significant. As a result, roadkill prevention fences and animal ecological corridors have been operated effectively.

However, the seriousness of roadkill-related accidents has not been recognized in Korea due to the relatively small animals killed on the road compared to cases overseas, although roadkill accidents in Korea have increased steadily. Due to the increase in high-standard roads and the number of vehicles, worker's safety-related accidents and secondary rear-end accidents due to roadkill have been critical in recent years.

Traffic accidents due to roadkill and debris on the road can lead to large scale accidents such as secondary accidents, thus it is necessary to provide a preventive measure for workers who handle roadkill and debris on the road.

Thus, this study conducted a survey with workers in charge of road management in order to design an instrument for removing debris on the road suitable to Korean road conditions and the survey results were reflected in the design. Although some traffic authorities employ instruments for removing road debris already, their safety is not yet verified so they are used only limitedly on uninterrupted roads. In addition, existing instruments for removing road debris did not separate animal corpses and general road debris, which is vulnerable to hygienic problems in the summer particularly.

Existing cleaning vehicles and road debris collection instrument can only remove a small size of road debris such as glass or steel on road sides. However, the instrument designed in this study can remove a relatively large size of road debris such as roadkill, tire debris, paper boxes, wooden panels, which cannot be removed with existing instruments.

Accordingly, it will be expected to help maintenance works on the road. Furthermore, the instrument for removing road debris can detect roadkill and debris accurately on the road and remove them as quickly as possible thereby ensuring the safety of workers and heightening traffic safety in the future.

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