



Evaluating the effects of supplemental rest areas on freeway crashes caused by drowsy driving



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ABSTRACT

To prevent crashes caused by drowsy driving, supplemental rest areas have been installed in the South Korean freeway system to allow road users to rest. These supplemental rest areas are very small-sized resting facilities located between the larger regular rest areas, which is a unique design. This study aimed to evaluate the effects of the supplemental rest areas on reducing crashes caused by drowsy driving.

Between 2011 and 2012, supplemental rest areas were first installed in the Gyeongbu Freeway, which was selected as the study area for this study. The first 160 km and 178 km stretches of the southbound and northbound lanes, respectively, of the Gyeongbu Freeway were considered the reference areas. For both the southbound and northbound lanes, the downstream stretch of the Gyeongbu Freeway was considered the treatment area where the supplemental rest areas were installed. Based on a negative binomial regression of the crashes estimated in the reference and treatment areas, an empirical Bayes approach was employed to quantitatively validate the effects of the supplemental rest areas on reducing crashes caused by drowsy driving.

The results showed that the supplemental rest areas reduced freeway crashes caused by drowsy driving by 14%. The supplemental rest areas were most effective in reducing drowsy driving related crashes particularly in freeway sections with 2 or 3 travel lanes or with ramps. As the first data-driven study evaluating the effects of these supplemental rest areas, the results imply that supplemental rest areas provide more opportunities to avoid drowsy driving, and, therefore they should be encouraged for freeways as cost-effective safety improvement facilities.

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1. Introduction

Freeways are characterized by simple road geometries, and drivers usually travel on freeways for long distances at high speeds. Therefore, freeway driving is likely to lead to drowsiness that can cause a decline in attention and recognition, which can result in fatal crashes (Rogé et al., 2003). Drowsy driving on freeways is also a serious problem in South Korea (hereafter called Korea). According to the Korea Expressway Corporation (KoEX), crashes associated with drowsy driving accounted for 32% of total fatal crashes on Korean freeways between 2010 and 2012 and are the second highest cause of fatal crashes. Considering the high number of fatalities related to drowsy driving, it is important to attempt to avoid drowsy driving-related crashes on the Korean freeway system. Previous

studies have also highlighted the highway safety issues caused by drowsy driving as follows.

Several researchers have considered the relationship between work characteristics and drowsy driving experiences (Grander et al., 2006; Maycock, 1996; Wang and Pei, 2014). They focused on work characteristics such as total driving and rest time for truck and commercial drivers. The result of their research studies showed that the amount of rest time has significant effects on driving performance and drowsy driving. Wang and Pei (2014) suggested that driving performance measures began to deteriorate after two hours of driving. Their study stated that drivers needed a rest time of at least 15 min to recover. For general types of vehicles, other studies were performed to determine the relationship between rest time and drowsy driving crashes (Chen and Xie, 2014; Grander et al., 2006; Maycock, 1996; Morrow and Crum, 2004; Philip et al., 2003; Phillips and Sagberg, 2013). These studies showed that a lack of rest time contributes to the potential of crash occurrences by significantly decreasing reaction times and degrading overall driving performance. Therefore, these studies have shown the relationship

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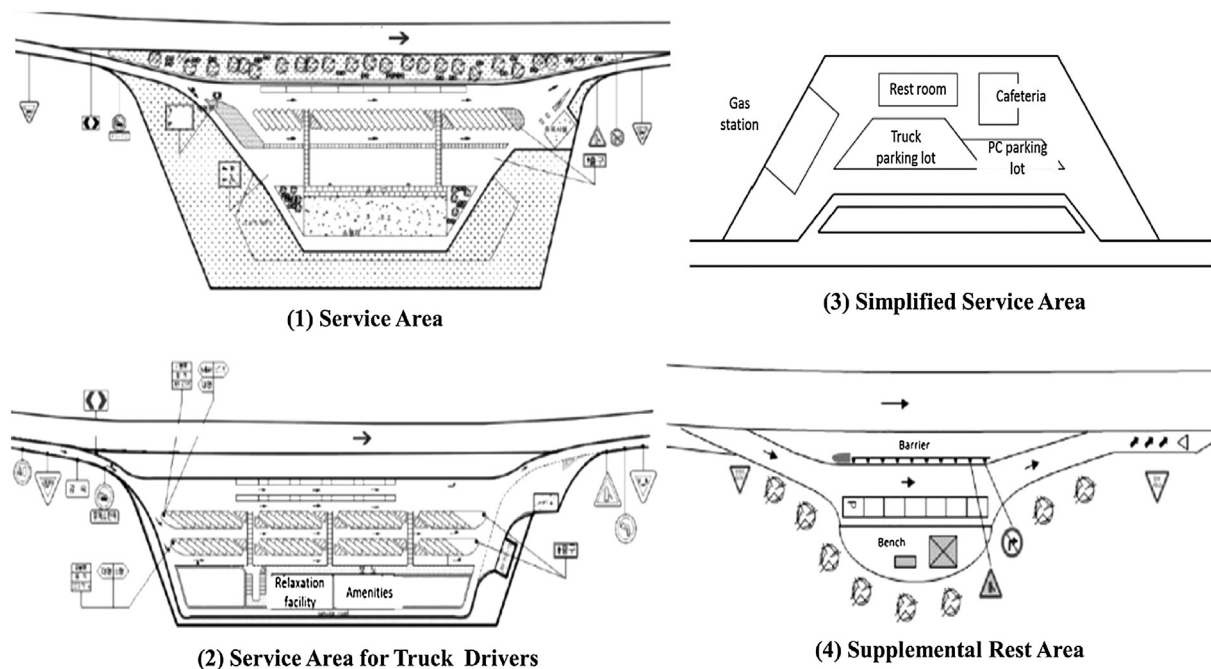


Fig. 1. Category of rest area in Korean freeway system.

between driver drowsiness and road traffic crashes, and they have also evaluated the relevant countermeasures with either survey or quantitative methods to reduce driver drowsiness.

Some past studies have suggested the use of rumble strips to prevent drowsy driving (Anund et al., 2008; Merat and Jamson, 2013; Räsänen, 2005). Merat and Jamson (2013) also analyzed the effect of rumble strips on driver fatigue by using a driving simulator. Their results showed some reduction in a driver's lateral deviation and eye closure when the rumble strips were encountered. In a supporting study, Räsänen (2005) investigated the effect of rumble strips on maintaining the travel lanes in a curved section. In contrast, another study showed that the rumble strips did not have a significant impact on reducing the probability of a severe crash (Wu et al., 2014). Similarly, Anund et al. (2008) concluded that the various aspects of sleepiness are increased before hitting a rumble strip and that the alertness enhancing effect was short as signs of sleepiness returned 5 min after hitting the rumble strip.

Given the limited access points in a freeway system, drivers can rest only in the provided rest areas. According to the Guidelines for Road Structure and Facilities in Korea, a 25 km spacing between rest areas on the freeways is recommended (Korea Ministry of Land, Infrastructure and Transport (KMLT), 2014). However, the current spacing in Korea is comparatively longer than in other countries, which implies that Korean drivers have less opportunity to take rests when driving on the freeways. The KoEX has constructed supplemental rest areas with several parking spaces in the Korean freeway system since 2011. A supplemental rest area is defined as a very small area installed between the regular rest areas (service areas) to provide a space so drowsy drivers can take a break. The supplemental rest areas in Korea are characterized by a small parking area placed on the road shoulder. However, no empirical studies have been conducted in Korea to quantitatively evaluate whether these supplemental rest areas contribute to a decrease in the number of crashes caused by drowsy driving. There is a shortage of comprehensive and analytical studies on the effectiveness of these supplemental rest areas to reduce drowsy driving crashes resulting in highway safety improvement.

As an initiative to evaluate these supplemental rest areas, this study aims to quantitatively validate the effectiveness of these sup-

Table 1
Types of rest area by countries.

Country	Type	Spacing Standard (km)
U.S.	Service Area	100
	Safety Rest Area	40–50
Japan	Service Area	50
	Parking Area	15
U.K.	Service Area	48
Australia	Service Area	100
	Simplified Service Area	50
	Parking Area	30

plemental rest areas for reducing drowsy driving related crashes on Korean freeways. To accomplish this aim, this study employed an empirical Bayes (EB) method to compare the drowsy-driving-related crash occurrences on the entire Gyeongbu freeway in Korea before and after constructing the supplemental rest areas.

2. Rest areas in the Korean freeway system

A rest area is a public facility located next to a large thoroughfare, such as a freeway, where drivers can rest, eat, or refuel without accessing secondary roads. The rest area is also called a service area. In addition to regular rest areas, these service areas, simplified and small-sized freeway rest areas for short period breaks, are provided in some countries. In Japan, for example, service areas are placed every 50 km, and relatively small rest areas, called parking areas, are located every 15 km. The types of rest areas and their relevant spacing in several countries are presented in Table 1 (Cho, 2008).

The types of rest areas in Korean freeway system are classified into the following four categories: (1) service area (regular rest area); (2) service area for truck drivers; (3) simplified service area; and (4) supplemental rest area (a small-sized rest area especially for drowsy drivers) (Korea Ministry of Land, Infrastructure and Transport (KMLT), 2014). The four categories of rest areas on Korean freeways are presented in Fig. 1.

As shown in Fig. 1, a service area is a regular rest area that includes parking lots, a food court, restrooms, and a gas station. A second service area for truck drivers is a specialized rest area

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