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Safety in Focus: A Critical Evaluation of Geometric Features' Influence on Pedestrian Safety in Roundabouts

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Extended Abstract

This study aims to investigate the influence of geometric features, in particular splitter islands, on pedestrian-vehicle interaction at roundabouts. A comprehensive understanding of the safe operation of traffic facilities is possible by examining the effect of their geometric features on road users' safety. Traditionally, traffic safety is evaluated based on historical accident data. Accident-based safety evaluation has severe limitations in evaluating, at the microscopic level, the effect of certain geometric features of traffic facilities on road users safety [1]. Alternatively, the surrogate safety approach is widely employed to assess the impact of new traffic design and safety-related issues using computer vision techniques and/or traffic safety simulation [2]. Although the surrogate safety measures (SSMs), which are reliant on the road user's conflict, is an effective approach to evaluating the effect of geometric features on safety, most previous studies have focused on the overall safety and operational performance of traffic facilities [3]. The influence of individual geometric features of traffic facilities on safety is less studied in the literature.

Splitter island is a key feature of roundabout crosswalks that enhance pedestrian safety and traffic operations by providing shelter for walking, controlling vehicle entry speeds, and guiding traffic into roundabouts [4]. Dozens of modern roundabouts were built in Japan after a partial amendment to its Traffic Act in 2012 [5]. However, roundabouts are still uncommon in terms of number due to landscaping requirements, particularly in densely populated urban and suburban areas of Japan. These modern roundabouts are built with some kind of geometric defect; for example, some have wide circulatory roadways and others lack apron steps [6]. Modern roundabout construction without some geometric feature is considered a defect [4]. Among these roundabouts, the Towa-cha roundabout in Nagano prefecture was constructed without the splitter island on minor approaches due to limited space. Although the traffic rules are highly complied with and regulated, road users feel unsafe when crossing these types of traffic facilities, including roundabouts without splitter islands [7]. On the other hand, due to limited cases, the physical splitter island influence on traffic regulation and pedestrian safety has not been comprehensively studied, particularly in Japanese traffic environments. Therefore, it is hypothesized that splitter island substantially affects pedestrian and vehicle interaction.

To accomplish the research aims, the influence of splitter islands on pedestrian safety was investigated using comparative statistical analysis, i.e., ANOVA and t-test, and the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method. We assumed that SSMs could reflect the geometric feature effect on pedestrian safety. Hence, the minimum time-to-collision (TTC_{min}), post-encroachment time (PET), maximum speed (MaxS), and maximum deceleration-to-safety (DTS) measures were used to evaluate the interaction of pedestrians and vehicles. The SSMs were statistically compared between the presence and absence of splitter island conditions. For three days, 33 hours of video data were collected from the Two-Cha roundabout, which has five approaches: three with and two without splitter islands. The

particle tracking velocimetry software was used to extract pedestrian-vehicle conflicting trajectories, and SSMs were calculated for each detected conflict. A total of 342 and 183 potential pedestrian-vehicle conflicts were evaluated for the presence and absence of splitter island conditions, respectively.

The results show that the mean values of SSMs were significantly different between crosswalks with and without splitter islands. It means that geometric features significantly influence the pedestrian-vehicular interaction. This difference is more obvious in collision course conditions, i.e., in a situation where two road users will collide if they do not change their path, for all applied SSMs except PET. In previous studies, PET proved effective in the evaluation of a particular safety intervention [2], [3], and [8]. In contrast, PET in the current study did not show a significant difference between splitter island and no splitter island conditions. The TOPSIS result also shows that a crosswalk with a splitter island had better safety performance than crosswalks without a splitter island by combining all SSMs as a composite indicator. In conclusion, the TTC_{min} measure was observed to be a more applicable indicator to determine the influence of geometric features on safety. In addition, it concluded that SSMs more effectively reflect the influence of geometric features on safety under collision course conditions.

Keywords: Safety, Geometric Feature, Surrogate Safety Measure, Roundabout, and Splitter Island.

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