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Evaluating the safety risk of roadside features for rural two-lane roads using reliability analysis

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ABSTRACT

The severity of roadway departure crashes mainly depends on the roadside features, including the sideslope, fixed-object density, offset from fixed objects, and shoulder width. Common engineering countermeasures to improve roadside safety include: cross section improvements, hazard removal or modification, and delineation. It is not always feasible to maintain an object-free and smooth roadside clear zone as recommended in design guidelines. Currently, clear zone width and sideslope are used to determine roadside hazard ratings (RHRs) to quantify the roadside safety of rural two-lane roadways on a seven-point pictorial scale. Since these two variables are continuous and can be treated as random, probabilistic analysis can be applied as an alternative method to address existing uncertainties. Specifically, using reliability analysis, it is possible to quantify roadside safety levels by treating the clear zone width and sideslope as two continuous, rather than discrete, variables. The objective of this manuscript is to present a new approach for defining the reliability index for measuring roadside safety on rural two-lane roads. To evaluate the proposed approach, we gathered five years (2009–2013) of Illinois run-off-road (ROR) crash data and identified the roadside features (i.e., clear zone widths and sideslopes) of 4500 300 ft roadway segments. Based on the obtained results, we confirm that reliability indices can serve as indicators to gauge safety levels, such that the greater the reliability index value, the lower the ROR crash rate.

1. Introduction

A roadway departure (RwD) crash is defined by the Federal Highway Administration (FHWA) as “A crash in which a vehicle crosses an edge line, a centerline, or otherwise leaves the traveled way.” (FHWA, 2014). These crashes, involving run-off-road (ROR) and cross median/centerline head-on collisions, tend to be more severe than other crash types (Neuman et al., 2003). Based on FHWA statistics for 2013, 56% of fatal motor vehicle traffic crashes involved RwD crashes. According to a query of six years of crash data (2007–2012) from the Fatality Analysis Reporting System (FARS) database, an average of 57% of motor vehicle traffic fatalities occurred each year due to RwD. Moreover, a total of 7416 people perished in crashes involving fixed roadside objects in 2012, accounting for 22% of the total fatalities in the United States (NHTSA, 2015). In addition, as compiled and reported by the NHTSA’s FARS database, rollover crashes account for 33% of all passenger vehicle fatalities in the United States (NHTSA, 2015). 80% of all ROR fatalities occurred on rural highways, and about 90% of those occurred on two-lane roads (Lord et al., 2011), the roadway type upon which this paper focuses.

Roadside features (e.g., sideslope, fixed-object density, offset to fixed objects) can significantly impact the frequency and severity of ROR crashes (Lord et al., 2011). In order to characterize the potential of accidents with respect to roadside designs, Zegeer et al. (1987) developed a roadside hazard rating (RHR) system, which is used in the accident prediction algorithm for rural two-lane highways. The RHR is a visual and subjective measure defined as the average hazard level in a roadside environment and has seven categories from 1 (best) to 7 (worst) (Fig. 1):

- RHR = 1: Clear zone greater than or equal to 30 ft.; sideslope flatter than 1 V:4H; recoverable
- RHR = 2: Clear zone between 20 and 25 ft.; sideslope about 1 V:4H; recoverable

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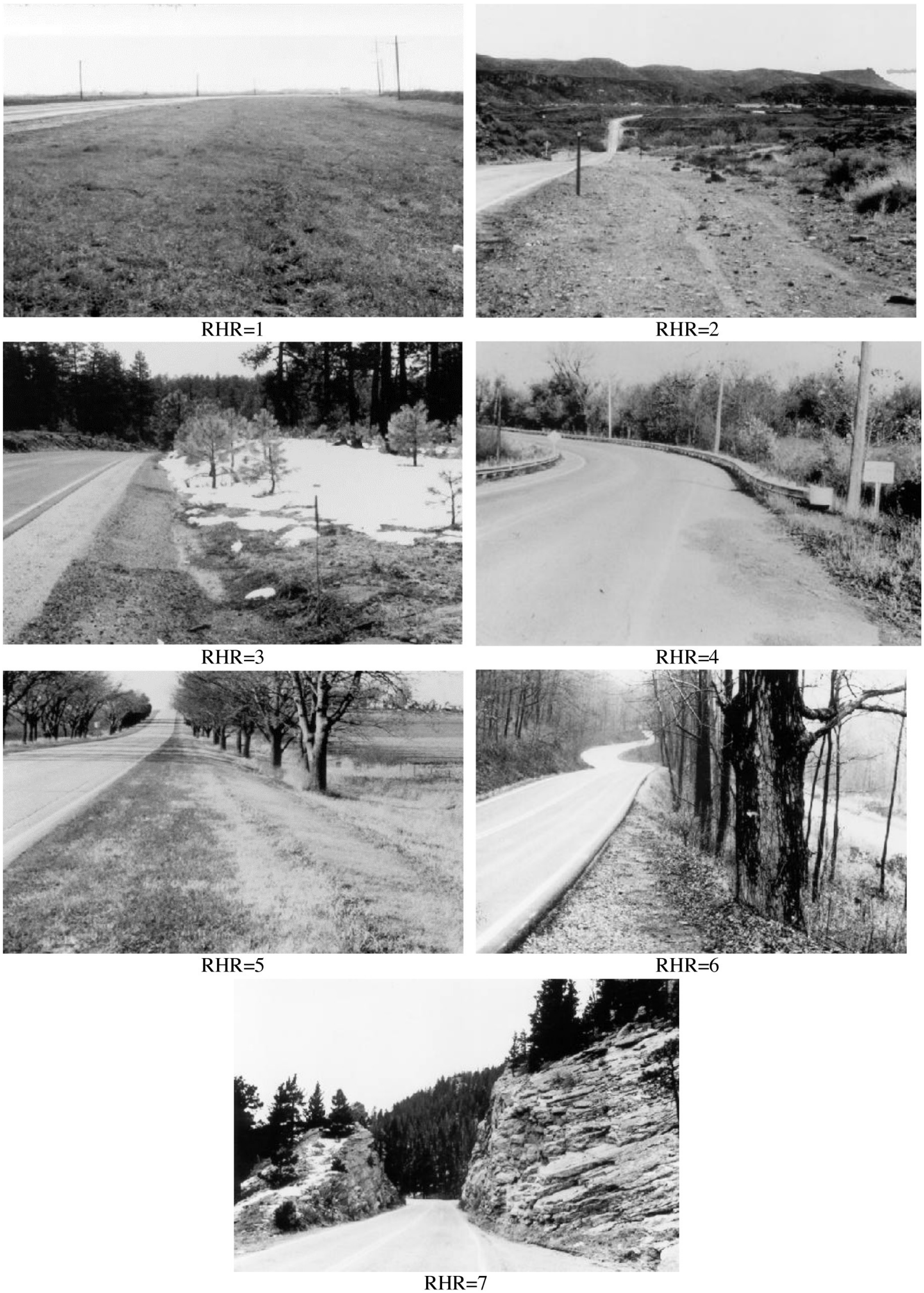

Fig. 1. Roadside Hazard Rating Scale (Zegeer et al., 1987).

- RHR = 3: Clear zone about 10 ft.; sideslope about 1 V:3H; marginally recoverable
- RHR = 4: Clear zone between 5 and 10 ft.; sideslope about 1 V:3H; marginally forgiving