Analysing the relationship between freeway flow parameters and safety, through the functional form of a crash prediction model. The case of run-off-road crashes.

Carlos Roque, Laboratório Nacional de Engenharia Civil, Portugal, croque@lnec.pt
João Lourenço Cardoso, Laboratório Nacional de Engenharia Civil, Portugal, jpcardoso@lnec.pt

Crash prediction models (CPM) can be used for various purposes in highway safety analysis. The most common are the quantitative prediction analysis of road crashes and the establishment of relationships between these crashes and different covariates.

The relationship between safety and traffic flow parameters (flow, speed, and density) of freeways may also be explored by examining the functional form of these CPMs. This relationship has significant consequences for transportation planning, freeway design, and management policies.

The conventional functional form of CPMs is based on the assumption that the traffic flow model component continuously increases over the covered range of values. However, the crash phenomenon does not necessarily have to follow a simple monotonous, mathematical function. In the case of run-off-road crashes, using a functional form that shapes the curve between crash frequency and traffic flow in a concave way, the modified Ricker model, shows better quality model fit than a functional form under the assumption that the model component for traffic flow continuously increases with traffic flow.

Run-off-road crashes on freeways may be considered as a by-product of traffic flow; therefore, variations in flow parameters may produce changes in the probability of crash occurrence and differences in crash frequency.

This study first examines the relationship of traffic flow parameters, such as volume, density, and speed, to safety, using a calibrated CPM developed with the modified Ricker model and fitted to Portuguese freeways run-off-road crash data. A possible explanation of the effect on road safety of traffic volumes is formulated and discussed.

Empirical examination of the relationship between traffic flow, density, and speed and the expected crash frequency on selected freeways in Portugal suggests that, when traffic density is low the number of crashes increase at a high rate with an increase in traffic. The mixture of density and speed of traffic is such that the probability of a run-off-road crash increases substantially and thus a steep reach of the function. However, once a critical density is reached (at an Average Daily Traffic of approximately 25,000 vehicles) the function begins to level off, the number of crashes almost stabilizes, and accident rates decrease significantly, due to higher traffic volumes and lower operating speeds. It is also worth noting that the number of crashes reaches its maximum for a density between 11 and 16 passenger cars per kilometre per lane (Level of Service C). Under these circumstances, vehicles speeds are near the freeway Free Flow Speed (FFS), and drivers have restricted freedom. However, lane changes are still possible but requiring more care and vigilance on the part of the driver.

Further examination of the function suggests that past the point of maximum density (for an Average Daily Traffic of approximately 35,000) the function begins to decrease at a slower rate with an increase in traffic. Under constant perception–reaction time, vehicle and roadway characteristics, and speeds, it is highly plausible to expect a decreased probability of run-off-road crash occurrence as a result of 50% more cars in the same space (Level of Service E). The decrease in the number of crashes may be explained by the fact that compression of flow and speed reduction produces headways so small that it becomes difficult or impossible for an errant vehicle to encroach the roadside without previously hitting another car.