RURAL INTERSECTION SAFETY

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ABSTRACT
The majority (72%) of fatal accidents and approximately half (49%) of serious accidents in New Zealand occur on rural roads (i.e., those with speed limit of 80km/h and above). If New Zealand is to reach the target of reducing the road fatality toll to 300 by 2010 then the main focus of road safety initiatives needs to be on the rural road network. Accident occurrence is typically low at rural intersections, due to low traffic volumes. Unlike many urban intersections, the low accident occurrence makes it difficult, from the accident history alone, to identify accident trends and justify improvement projects. This technical note outlines research that has produced accident prediction models for rural priority-controlled intersections; based on traffic volume, sight distance, approach speed and geometric design.

Introduction

To achieve the Road Safety 2010 targets proposed and to reduce the road toll and number of accidents further it will become increasingly more important to 'engineer' safer roads. The challenge for engineers is how to make these improvements in the face of increasing traffic volume and limited funding. This is particularly difficult to address on an extensive but relatively low volume rural road network. It is a matter of managing accident risk within this network and focusing funding in two areas, 1) the high volume (high exposure) sections of the rural road network where there is an increased likelihood of accidents, particularly multi-vehicle accidents and 2) at high risk locations, such as narrow bridges or intersections with poor visibility, particularly if the risk of fatality is high (eg. railway crossings).

In New Zealand there are a number of programmes focused on addressing the high volume, high accident occurrence rural (and urban) road sections (and intersections). These sections stand out in the historical accident record. Due to high accident occurrence it is normally possible from the patterns in the various accident types that occur to assess the likely causes of accidents and identify treatments. Where information is limited, we have a number of experienced safety specialists that can assess the route and recommend safety improvements.

There is less emphasis in New Zealand on identifying and treating the high risk, but generally lower volume sites. There are two reasons for this 1) most of the funding available is focused on the sites which have the most accidents, and 2) it is difficult to assess the accident risk and safety problem at a site, where there are limited number of accidents, or no accidents (in recent years), to highlight the problem. It is even more difficult to secure funding for improving such sites, although the new weighted accident procedure in the New Zealand Project Evaluation Manual (Transfund 1997), does in some cases enable an assessment to be made.

While 84% of rural road fatal accidents occur on links, a significant number of fatal accidents also occur at intersections (around 50 fatal accidents per year). This technical note reports on a study that was undertaken by Beca, for the Road Safety Trust and Land Transport NZ, on accident prediction models for rural intersections. These models can be used to assess the effect of visibility, speed and some layout variables on accident occurrence at priority intersections. Using these rural

intersection models, many of the high-risk intersections on the rural road network can be identified and recommended for treatment (generally low cost improvements).
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Predictor variables

The flow variables used in the priority controlled intersection models are based on those defined in Turner (1995), where each movement is numbered in a clockwise direction at intersections, starting at the northern-most approach for crossroads (right turn movement) and the side road approach for T-junctions (starting with right turn movement). Individual movements are denoted as a lower case character for the user type (e.g. q_i). Totals of various movements (e.g. approach or link flows) are denoted with an upper case character (e.g. Q_i). Models are developed for each approach and are defined using the variables for the first approach only.

The visibility and approach speed variables used in the priority intersection models are shown in Table 1. Only some of these variables appear in the preferred models shown below.

Table 1: Visibility and Approach Speed Variables

Variable	Description
S_L	mean speed of vehicles along major road approaching the intersection to the left of vehicles on the minor road;
S_R	mean speed of vehicles along major road approaching the intersection to the right of vehicles on the minor road;
S_{LSD}	standard deviation of vehicle speeds along major road approaching the intersection to the left of vehicles on the minor road;
S_{RSD}	standard deviation of vehicle speeds along major road approaching the intersection to the right of vehicles on the minor road;
V_L	visibility from two metres back from vehicle at the limit lines on minor road to vehicles approaching from the left along major road;
V_R	visibility from two metres back from the limit lines on minor road to vehicles approaching from the right along major road;
V_{LD}	visibility deficiency to the left based on the difference between the available visibility and the minimum safe intersection sight distance (SISD) for the 85th percentile speed. The SISD is described in Austroads Part 5: Intersections at Grade. Where there is no deficiency a default deficiency of 1 metre has been used to enable modeling;
V_{RD}	visibility deficiency to the right based on the difference between the available visibility and the minimum safe intersection sight distance (SISD) for the 85th percentile speed. . Where there is no deficiency a default deficiency of 1 metre has been used to enable modelling;

Modelling Results

A number of variables were tried in both the priority T-junctions and cross-road intersection models, including a number of intersection layout and control variables. Further details on the models fitted can be found in Turner and Roozenburg (2005 and 2006). The preferred models are detailed below. A full set of models is to be published in an upcoming Land Transport NZ research report.

Priority T-junctions

The typical mean-annual numbers of reported injury accidents for rural T-junctions can be calculated using turning movement counts and the accident prediction models in Table 2. The total number of accidents can be predicted by summing the individual predictions for each crash type on each approach.

Table 2: Rural priority T-junction accident prediction models

Accident Type	Equation (accidents per approach)	Error Structure	Significant Model
Crossing – Vehicle Turning (Major Road approach to left of Minor Road)	$A_{RMTP1} = 5.29 \times 10^{-6} \times q_1^{1.33} \times q_5^{0.15} \times (V_{RD} + V_{LD})^{0.33}$	NB (K=8.3)*	Yes
Right Turning and Following Vehicle (Major Road)	$A_{RMTP2} = 5.29 \times 10^{-27} \times q_3^{0.46} \times q_4^{0.67} \times S_L^{11.0}$	NB (K=1.4)*	Yes
Other (Major Road approach to right of Minor Road)	$A_{RMTP3} = 1.59 \times 10^{-5} \times (q_5 + q_6)^{0.91}$	NB (K=1.0)*	Yes
Other (Major Road approach to left of Minor Road)	$A_{RMTP4} = 2.99 \times 10^{-4} \times (q_3 + q_4)^{0.51}$	NB (K=3.0)*	Yes

*K is the Gamma shape parameter for the negative binomial (NB) distribution.

Table 2 shows that when the sum of the visibility deficiency to the left and right of the minor road ($V_{RD} + V_{LD}$) increases, the number of crossing-vehicle turning accidents also increases. The model for crashes involving vehicles turning right from the major road and vehicles travelling in the same direction is strongly influenced by the approach speed. The exponent for this variable is positive, indicating that accidents increase with increased speed. Most likely the accident rate on the side-road is due to other factors that have not been captured in the data collection.

Priority X-Roads

The typical mean-annual numbers of reported injury accidents for rural cross-road intersections can be calculated using the accident prediction models in Table 3. The model for right-turning and following vehicles includes a variable for the presence of a right-turn bay. If a bay is present the prediction is multiplied by the value of this variable (0.22); a 78% reduction in the crash rate.

Table 3: Rural priority crossroad accident prediction models

Accident Type	Equation (accidents per approach)	Error Structure	Significant Model
Crossing (Minor Road vehicle hit from left)	$A_{RMXP1} = 1.20 \times 10^{-4} \times q_2^{0.60} \times q_5^{0.40}$	NB (K=0.9)*	Yes
Crossing (Minor Road vehicle hit from right)	$A_{RMXP2} = 2.05 \times 10^{-4} \times q_2^{0.40} \times q_{11}^{0.44}$	NB (K=2.0)*	Yes
Right Turning and Following Vehicle (Major Road)	$A_{RMXP3} = 1.08^{-6} \times q_4^{0.36} \times q_5^{1.08} \times \phi_{RTB}$ $\phi_{RTB} = 0.22$	NB (K=2.6)*	Yes
Other (Major Road)	$A_{RMXP4} = 1.14 \times 10^{-4} \times (q_4 + q_5 + q_6)^{0.76}$	NB (K=1.1)*	Yes
Other (Minor Road)	$A_{RMXP5} = 3.44 \times 10^{-3} \times (q_1 + q_2 + q_3)^{0.27}$	NB (K=0.2)*	No

*K is the Gamma shape parameter for the negative binomial (NB) distribution.

Table 3 indicates that a right-turn-bay will reduce the number of right-turning and following vehicle accidents by 78%.

Rural cross-roads versus Two T-junctions

A popular treatment of unsafe rural cross-roads is to convert them into two single T-junctions. The accident prediction models have been used to test whether this practice does reduce accidents. Four examples have been used in the analysis. Two combinations of flows have been used; being Option 1) 10,000vpd on the main road and 3,000vpd in total on the side roads; and Option 2) 15,000vpd on the main road and 200vpd in total on the side roads. For each main option two sub-options were considered, a) majority of traffic (2/3) travelling straight through and b) no traffic travelling straight through from the side road. The results of the analysis are shown in Table 4.

Table 4: Comparison between Predicted Accidents at Cross-roads and T-junctions

Example	Major Volume (vpd)	Minor Volume (vpd)	Minor Though Flow	Prediction Cross-road	Prediction 2x T-Junctions #
1a	10,000	3,000	2000	1.19	0.88
1b	10,000	3,000	0	0.48	0.73
2a	15,000	200	133	0.95	0.46
2b	15,000	200	0	0.75	0.54

this is based on the assumption that the two T-junctions are a suitable distance apart so that there are no safety effects resulting from weaving of vehicles across a staggered intersection or associated unsafe manoeuvres.

The analysis shows that in the majority of situations it is safer to have two T-junctions rather than one cross road. The exception occurs when the volume on the side-road is reasonably high, compared with the main road and when the volume of through traffic is low (Option 1b). In such circumstances the APMs should be used to determine whether there is a safety benefit in converting a cross road to two T-junctions. A key factor is the proportion of traffic that is travelling straight through the intersection from the side-road approaches. Given the major accident type occurs when straight through vehicles fail to stop at the 'stop' or 'give-way' signs, it is not surprising that cross roads are safer when there is lower volumes of through traffic on the side-roads.

Summary

This technical note presents accident prediction models that have been developed for rural priority intersections. Separate models have been developed for the major accident types at both priority cross roads and T-junctions.

Using four examples it has been demonstrated that it is not always appropriate to convert rural cross roads to two T-junctions to improve safety. A key factor is the proportion of traffic that travel straight through on the side-roads. Where the side-road volume is relatively high compared with the main road and the proportion of through traffic is low then the accident prediction models should be used to assess whether such a treatment will be effective.

REFERENCES

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