WARRIP
WESTERN AUSTRALIAN ROAD RESEARCH & INNOVATION PROGRAM

Assessing Heavy Vehicle Speeds and Rollover Risk within Roundabouts

Reference: 2021-005 Internal WARRIP report: September 2023

The overarching objectives of this project were to:

- **Determine the appropriateness of the current Main Roads stability criteria, which requires a roundabout design to enable the design heavy vehicle (HV) to be able to undertake, through simulation, a right-turn manoeuvre at a roundabout at 30 km/h without exceeding an LTR of 0.6.**
- **Validate the inputs assumed for a HV stability analysis which are undertaken as part of roundabout geometric design.**

Based on the investigation, recommend changes to the Main Roads stability analysis guidance documentation.

Background

Roundabouts are generally chosen as a Safe System form of intersection due to their safety benefits in terms of limiting speeds and improving impact angles.

To achieve the desired safety improvements offered by a roundabout, speeds are controlled through the road geometry, including roundabout radius and entry curve radius. However, the geometric layout and approach speed environment of a roundabout also influences the stability of HVs, especially those with a high centre of gravity (CoG) (such as HVs with an overall height of 4.3 m, and/or HVs with a high deck height).

Main Roads has taken the approach of requiring HV stability analysis, via simulation software, to be undertaken on roundabout designs where the roundabouts are located on roads that meet specific criteria (e.g. roads with a posted speed limit of 70 km/h or greater).

The aim of this requirement is to minimise the risk of HV rollovers at roundabouts. The assessment is based on estimating the load transfer ratio (LTR) of a HV as it travels through a roundabout.

Main Roads requires HVs with a high CoG to negotiate a roundabout (right turn) at 30 km/h without exceeding an LTR of 0.6.

Approach

The project comprised of four key stages as follows:

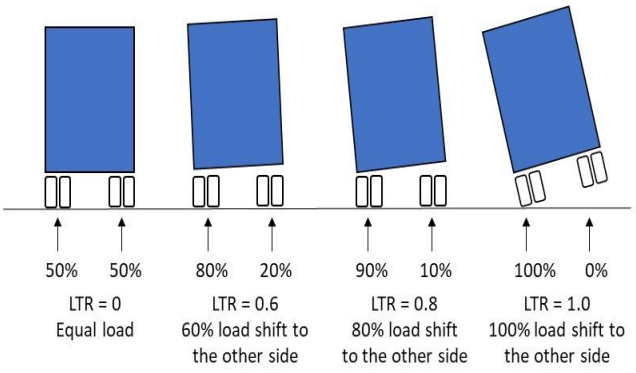
1. Literature review.
2. HV speed data at roundabouts review.
3. Sensity analysis using simulation.
4. Discussion and conclusion on the key findings from the investigation and outline the impacts to the Main Roads stability analysis guidance documentation.

Literature Review

The literature review undertaken confirmed that:

- There are many factors, including HV variables, that influence HV stability and can contribute to a HV rollover.
- The requirement to undertake a HV stability analysis for proposed roundabouts, which meet specific criteria, is considered best practice (both nationally and internationally) and in line with Safe System principles.
- An LTR of 0.6 is widely accepted, and has been for some time, considered as the safe threshold LTR limit.

Figure 1: Load transfer ratio comparison



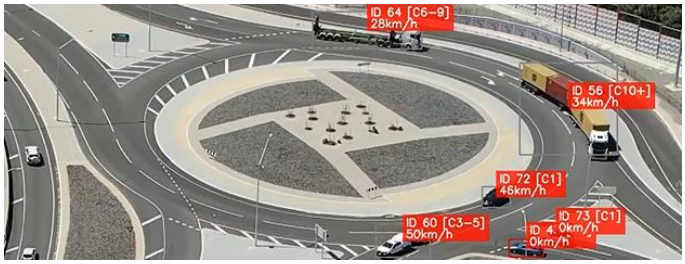
HV Speed Data Review

As part of a separate Main Roads project, speed data was estimated based on analytics of aerial video footage captured via drones. Data was collected at 18 roundabouts. Of these, 7 were determined to meet specific criteria and were selected for review as part of this project.

A review of the available speed data found that:

- At the High Street and Stirling Hwy roundabout (with a central island radius of 29 m) the vast majority of the HVs were observed to be performing the right turn from the outer lane as instructed via a fixed sign. This would give a bigger radius of approximately 34 m as measured via aerial photography. The median speed for the Austroads class 6+ HV was 34.5 km/h.
- In addition, two concrete agitators (which are at higher risk of rollover compared to conventional HVs) were observed undertaking a right-turn movement at the median speed of 30.7 km/h.
- At the Tonkin and Brand Highway roundabout, with radius curves of 60 m (elliptical in shape), the median speed of Austroads Class 6+ HVs was observed to be 38.0 km/h.
- For the remaining 5 roundabouts (all with a radii of less than 30 m) only a small amount of data associated with Austroads Class 6+ HVs was collected. Austroads Class 6+ HVs were observed performing right turns at speeds of 30 km/h or less.

Figure 2: Speed estimation via analytics of aerial video footage



Sensity Analysis

A sensitivity analysis using simulation was undertaken based on a hypothetical roundabout with varying radii and manoeuvring speeds, in addition to the High Street/Stirling Highway roundabout. The key findings from the simulation-based stability analysis are as follows:

- LTR values are sensitive to the design of the roundabout, and minor differences can result in the LTR values exceeding 0.6 at 30 km/h.
- The critical roundabouts, in terms of rollovers while travelling at 30 km/h, are primarily those with a central island radius of less than 30 m.
- For roundabouts with a central island radius of between 20 and 30 m a high CoG HV will likely need to perform the right-turn movement at approximately 20 km/h so to not exceed a 0.6 LTR.
- The differences in speed between a HV safely negotiating a roundabout, compared to being at high risk of rolling over could be 5 to 10 km/h.
- Load height impacts on the speeds required to achieve a specific LTR value.
- HVs with uniform density loads are more susceptible to rollover at lower speeds compared to mixed density loads.

Findings

The investigation did not identify any evidence to suggest amending the need to demonstrate through stability analysis simulations that a high CoG HV can negotiate a roundabout at 30 km/h without exceeding an LTR of 0.6.

The investigation found that this should be the default position for roundabouts which either have/proposed to have a central island:

- with a radius of 15 to 50 m
- that is elliptical in shape and/or will have/has varying radii.

The investigation found opportunities to deviate from the default position and the investigation outlined various recommended changes to the Main Roads guidelines and supplements (Main Roads 2019a; 2019b).

Next stage

Following this investigation, the next stages are for Main Roads to:

- Consider the findings of this investigation and the recommended changes to the Main Roads guidelines and supplements (Main Roads 2019a; 2019b).
- Implement the changes to the Main Roads guidelines and supplements.
- Review and revise the Main Roads guidelines and supplements with the recommended changes implemented and undertake further modifications to ensure that it is suitable for use by consultants external to Main Roads.

References

- Main Roads WA 2019a, *Guidelines for vehicle stability analysis: main roads internal process*.
- Main Roads WA 2019b, *MRWA Supplement to Austroads Guide to Road Design – Part 4B*.

How does this research change the way we think?

The investigation has confirmed the appropriateness of:

- HV stability analysis as part of roundabout designs for roundabouts that meet specific criteria
- a 30 km/h manoeuvring speed and a 0.6 LTR value as the safe threshold limit.

The project has presented Main Roads with an opportunity to update their requirements with respect HV stability analysis at roundabouts.