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Rollover roundabouts

Road safety risk exists at intersections for freight-carrying heavy vehicles. Trucks need time and space to safely travel through an uncontrolled intersection. The most dangerous activity is to turn right because finding a suitable space in the oncoming traffic is difficult on a busy road. If the truck is a combination, the trailer will cut-in so the starting position on the road is likely to encroach into the lanes of other road users. This disrupts the overtaking traffic flow. Roundabouts remove these challenges.

While roundabouts make intersections safer for heavy vehicles, they bring a new risk of rollover. This risk arises because the truck driver no longer needs to stop when turning. In fact, the rollover risk even exists for trucks going straight because the through lanes are bent!

I recently investigated a truck rollover at a roundabout on a major highway that skirts a rural city in Victoria.

The roundabout is new. It had been inserted into the highway to replace a dangerous Tee-intersection. The roundabout is justifiable, but it has created a significant hazard for heavy combination vehicle drivers.

I considered the design of the roundabout and whether it could have been made safer for heavy vehicles. The main considerations are the alignment of the road through the roundabout, visibility, the distance between arms, road camber on the inner lane, road surface friction and roundabout diameter. The heavy vehicle driver has control of vehicle speed. So what is a safe speed? Too slow and cars may take dangerous paths around the truck; too fast and the truck rolls over. This article attempts to identify some speed rules that come from the basic physics of the situation.

A raised concrete encroachment zone increases rollover risk.

The road owners usually design roundabouts according to guidelines in the AustRoads *Guide to Road Design Part 4B, Roundabouts.* This guide anticipates that the trailer on a semi could cut in by 1.5m when the heavy vehicle turns right at the roundabout. Consequently, an encroachment zone around the island is recommended where heavy vehicles are expected. The recommended encroachment profile has a step of 80-90mm to discourage car drivers from going onto the raised lip around the island. An example is shown in the below photo.

One consequence of the raised lip is that the right-side wheels of the heavy vehicle could be about 120mm higher than the left-side wheels when the vehicle turns right. This is equivalent to a six per cent cross slope and it increases the rollover risk.

Roundabouts on highways will often have dual lanes. The Austroads guide notes that the larger the diameter of the central island, the faster the entry speed is likely to be. For example, if the roundabout is in an 80km/h signposted road, the desirable diameter of the centre island is 48m. Speed control features are desirable at 80 km/h and above. The design speed on the inner lane is 60 km/h (Table 4.1 in the AustRoads guide). However, a heavy vehicle going around at this speed could roll over.

Roundabouts on main roads often have advisory speed signs. For a double-lane roundabout on an arterial road, the advisory speed is often signposted at 40 km/h. For some heavy articulated vehicles this is an unsafe speed.

Back to the rollover I investigated; the diagram on the next page illustrates the roundabout after it was inserted into the rural highway. The original alignment of the highway is shown by a red-dotted line. The sign-posted speed limit on the highway is 80 km/h. Notice that the path through the roundabout now has an S-bend. What was a relatively safe curve in the highway for heavy vehicles, is now treacherous.

The safe speed for many heavy vehicles should be lower than 30 km/h.

A simple index of rollover risk is the Static Rollover Threshold. The SRT = Track Width/Height of the Centre of Mass doubled. For laden trucks, a satisfactory value of SRT is 0.35 or greater. The vehicle will rollover if the lateral acceleration exceeds the SRT. The limiting cornering speed is calculated as follows: $V^2 = SRTx9.806xR$. R is the radius of the curve in the road.

This formula over-estimates the safe speed when there is an adverse cross-slope, which is often the case at a roundabout. S-bends also make things worse. For tankers and concrete agitators, S-bends result in the liquid load being on the wrong side for stability when the tanker gets into the roundabout. Trucks carrying livestock are also vulnerable. Even trucks with fixed loads may lean the wrong way when the van reaches the roundabout.

S-bends are a problem!

For the roundabout shown below, the radius R is about 47m. Assuming the effective SRT = 0.3, the rollover speed is 42 km/h! The layout of the roundabout could have been laid out to avoid the S-bend. Considering that the highway carries many heavy vehicles, road design was poor. So far, I have considered rollover risk. A truck with low centre-of-mass height will not rollover but it may slide sideways. There is a jack-knife risk if the driver has to use the brakes in a roundabout. Surface polishing of the bitumen increases the risk factor for this.

So what is a safe speed for a heavy truck to go through a roundabout? Of course, that depends upon the load, the truck design and roundabout design. The Table shows the rollover speed for a semi-trailer with an assumed SRT=0.3 for several roundabout diameters. The safe speed in many instances is below 30 km/h!

Roundabout island diameter (m)	Rollover speed assuming an SRT=0.3	Likely location
100	45	Major divided highway
90	43	Major divided highway
80	41	
70	38	
60	36	Main urban road
50	33	Main urban road
40	30	
30	27	
20	23	Residential street
15	21	Residential street

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An S-bend was created in a rural highway. It could have been avoided by thoughtful road design.