

# TOWARDS A BETTER UNDERSTANDING OF MODERN ROUNDABOUTS

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## ABSTRACT

The use of the modern roundabout in South Africa as an alternative form of intersection control is gaining popularity with road authorities. There are however groups within the road user fraternity, and road authorities, who have the perception that roundabouts in South Africa do not have the benefits (safety and capacity) that have been determined internationally, both for vehicle and non-motorised transport users.

A recent survey of 37 roundabouts in the Western Cape has confirmed that there is a lack of application of design standards and an inconsistent approach to the design of roundabouts. This inconsistency applies to both single- and multi-lane roundabouts in urban and rural areas.

The purpose of this paper is twofold: to highlight what are some of the elements of the roundabouts that could be contributing to the perception relating to safety and to increase the designer's awareness of the interacting nature of the different design elements. These elements will be compared to design guidelines developed in several countries including Australia, Germany, United Kingdom and United States of America.

The goal, beyond this paper, is to develop guidelines for the design and implementation of roundabouts in the Western Cape.

## 1 INTRODUCTION

The Western Cape Government Transport Branch (WCG) is developing a set of planning and design principles to be used when a modern roundabout is being planned/designed. As part of this development a need was identified to establish, within South Africa, the design standards that have been applied to roundabouts that are currently in operation. The results of the assessment of the roundabouts and the international literature search will assist in the development of principles and requirements controlling the different roundabout design elements.

Among some within the South African engineering fraternity there is a negative perception of roundabouts with some finding that the internationally stated safety benefits of roundabouts over traffic signals are not realised, Aucamp (2014). In his paper Aucamp qualified his findings by stating that the scope of his investigation did not allow for an assessment of the contribution of design to the poor safety record.

The assessment of existing roundabout designs, particularly those constructed within the last 20 years will go some way in identifying if the design standards used are potentially a contributory factor when this perception is created. Focusing on high order roads (Class 3 and above) 37 intersections were identified within the Western Cape for detailed assessment. When selecting intersections, an attempt was made to ensure that there were single and double lane roundabouts located in both urban and rural environments. The table below is a summary of the roundabouts investigated.

**Table 1: Summary of Roundabouts investigated**

	Urban		Rural	
	Single	Double	Single	Double
<b>City of Cape Town</b>	11	11		
<b>George</b>		4	1	1
<b>Other small towns</b>	3	4	1	1

The lack of rural roundabouts to study is evident in the above table. This paper therefore focuses on the urban data. In many instances the rural roundabouts share many of the same observations and issues identified for the urban roundabouts.

## 2 DATA COLLECTED

The following data was collected:

- i. Geometric elements – a comprehensive data set was collected at each roundabout that included the Inscribed Circle Diameter (ICD), central island diameter, truck apron width, lane widths, gradients at various locations on the approaches as well as in the roundabout, sight distances, entry angles, splitter island lengths and widths, road markings and signs, etc.;

- ii. Street lighting;
- iii. Speed measurements (approach, entry, circulatory and exit positions); and
- iv. Visual assessment of the operation of the roundabout and identification of accident evidence (broken glass, damaged kerbs, damaged signs, etc.).

### **3 GENERAL OBSERVATIONS**

During the collection of the data several qualitative issues were identified which strongly indicate a lack of design consistency or understanding of the relationship of the different design elements at many of the roundabouts assessed, and these were:

*Circulatory lane widths.* Widths vary considerably. At some single lane roundabouts, the width was greater than 8m resulting in too small a central island diameter. When coupled with a poorly designed truck apron (no vertical separation) the advantage of controlling speed through the roundabout is compromised.

*Entry lane width.* Too wide entry width negates any benefit achieved through the correct design of other elements resulting in too high entry speed. In instances where the wide entry width is coupled with a wide circulatory lane, the measured speeds through the roundabout often exceeded 60 km/h.

*Truck aprons.* The understanding of the purpose of the truck apron is clearly misunderstood by some designers, when provided. At a fair number of the intersections the truck apron could be considered cosmetic rather than necessary. At one roundabout, external truck aprons were constructed on the entry approaches which have a positive effect on the entry speeds.

*Treatment of pedestrians.* There is mostly inadequate provision and positive guidance for pedestrians which result in pedestrians using the central island for staged crossing. On the centre island at some roundabouts, the area behind the barrier kerb separating the island from the circulatory lane/truck apron is paved. Pedestrians have been observed crossing diagonally through the roundabout and using this paved area as part of a two-stage crossing movement.

*Road signs and markings.* The SADC-RTSM is not very explicit in the treatment of signs and markings at roundabouts and provides several signs which can be used. This is reflected not only in inconsistent but also in the confusing application of signs and markings.

## 4 EVALUATION OF DATA COLLECTED

Some of the findings of the field assessment of the roundabouts are presented in this section.

### a. Inscribed Circle Diameter (ICD) (Figure 1)

A minimum and maximum ICD for single and double lane roundabouts were identified from international literature and are shown as a green band. The data collected indicates that most of the ICDs fall within this range. The roundabouts where the ICD is larger than the maximum, were constructed before the advent of the modern roundabout. International guidelines suggest that the ideal size is on the lower end of the range, reflected by the green line.

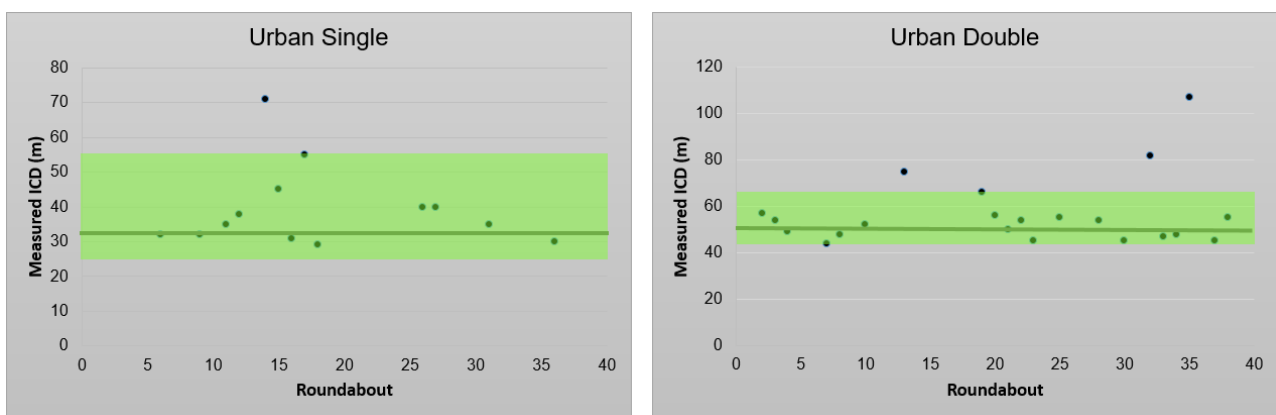


Figure 1: Inscribed Circle Diameter (ICD)

### b. Circulatory roadway width (Figure 2)

The range of the values that were measured varies significantly. For single lane roundabouts, the observed widths are mostly wider than the internationally recommended width (green band). For double lane roundabouts, there is a similar trend although there is less variation in the width and generally there is a smaller deviation from the international norm. It is important to note that the circulatory lane widths exclude the truck apron width, where such an apron has been provided.

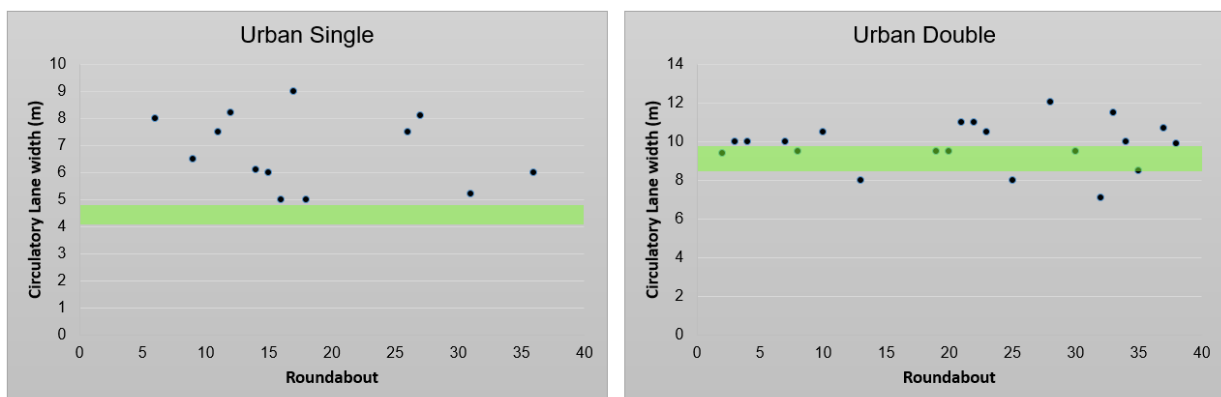
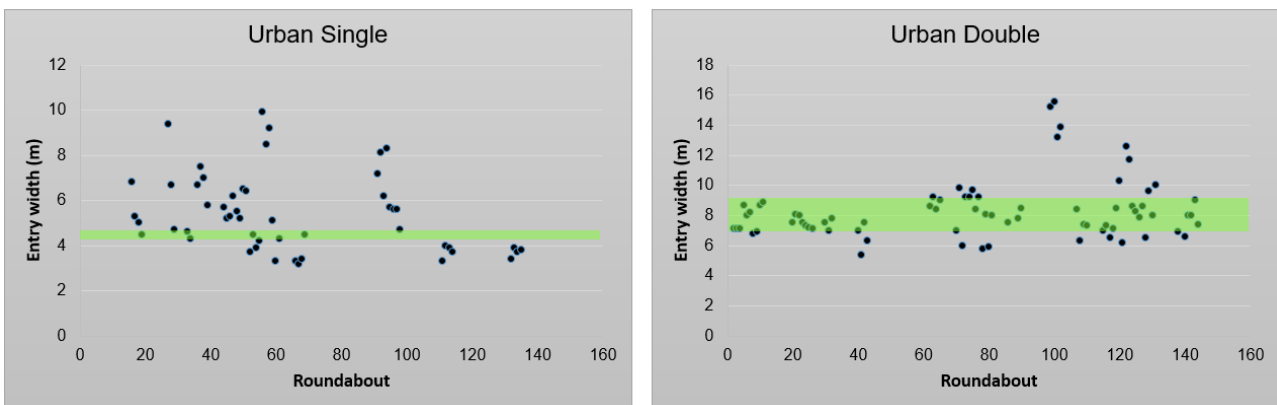


Figure 2: Circulatory lane widths

It is clear that, at most of the roundabouts assessed, the sizing of the circulatory lane is problematic.

**c. Entry lane width (Figure 3)**

The range of values that were measured, varies significantly. The widths are much wider than the international best practice. This contributes to faster speeds through the roundabouts. The acceptable range according to international guidelines are indicated within the green bands.



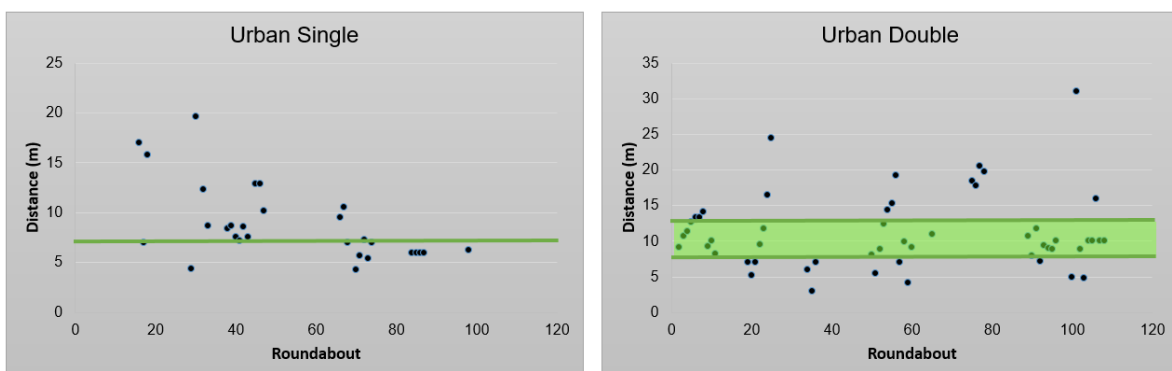
**Figure 3: Entry width**

It is notable that many of the measured entry widths at single lane roundabouts are too wide. There is also evident at the double lane roundabouts, but not to the same extent.

**d. Pedestrian crossing position before yield line (Figure 4)**

This is a critical element in terms of the safety of pedestrians. The correct placing of the pedestrian crossing will also encourage pedestrians to use the pedestrian crossing rather than to cross at other uncontrolled locations (including through the central island).

International guidelines indicate that a pedestrian crossing should be between one and two car lengths behind the yield line, as shown by the green band. There is no consistency in the placing of the pedestrian crossings and many of the crossings are placed too far away.



**Figure 4: Pedestrian crossing set back from yield line**

### e. Truck apron width

The widths measured vary greatly. At the roundabouts where there are no truck aprons, the circulatory lanes are wide enough to accommodate larger vehicles. These roundabouts tend to have higher than acceptable theoretical fastest path speeds and under low volumes could experience too high speeds. The latest international guidelines suggest that the minimum width for a truck apron should be 2 m. Many of the truck aprons observed were not functional for the purpose they are designed for. Below are a few illustrations of inappropriate design and reasonable designs of truck aprons.



**Figure 5: Truck apron not serving the purpose of design**



**Figure 6: Truck apron with better design, but too wide circulatory lane**

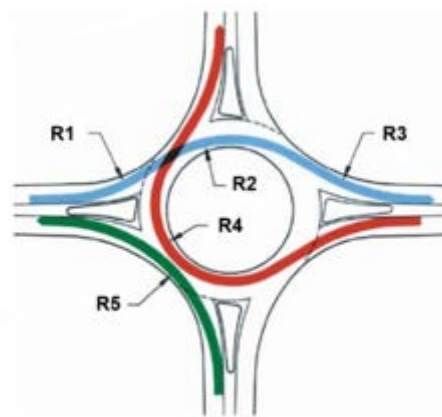


**Figure 7: Truck apron with correct design for use by trucks only with a narrow circulatory roadway.**

## f. Fastest path

The fastest path is used as a check to determine if the geometric design of the roundabout meets the performance and safety objectives and to ensure compliance with the design speed. International guidelines state that the design speeds for the theoretical fastest path should be between 32 and 40 km/h for a single lane roundabout and 40 to 48 km/h for a double lane roundabout.

The *theoretical fastest path* is the smoothest, flattest path possible for a single vehicle to travel through the roundabout, in the absence of other traffic and ignoring all lane markings in the roundabout.



**Figure 8: Fastest Path**

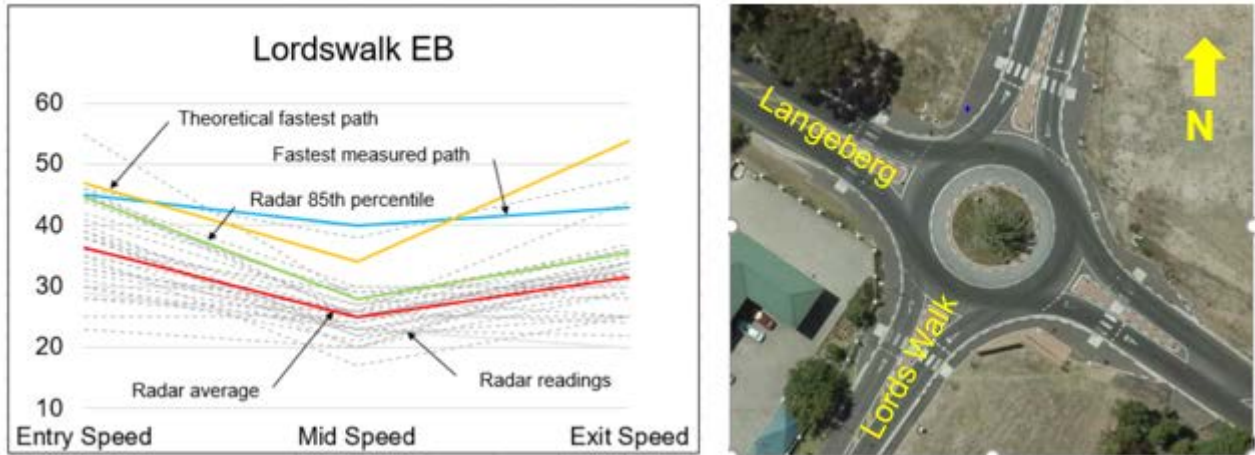
For this paper, only the fastest path for through movements are reported. The speed is based on the radii at R1 (entry), R2 (Mid-point) and R3 (exit).

It must be noted that high theoretical exit speeds are often practically unachievable if the roundabout has been correctly designed due to the available distance within which vehicles can accelerate. The entry and circulatory speed should dictate the exit speed. The following data was collected for all roundabouts:

*Fastest measured speed* – driving through the roundabout with no traffic and ignoring the road markings at a speed which still feels safe. This is considered a subjective measurement as different vehicles have different cornering and acceleration abilities.

*Radar gun speed measurements* – Speed measurements done at points R1, R2 and R3 to determine operational speeds. These measurements were done during the day and reflect typical driver behaviour at roundabouts.

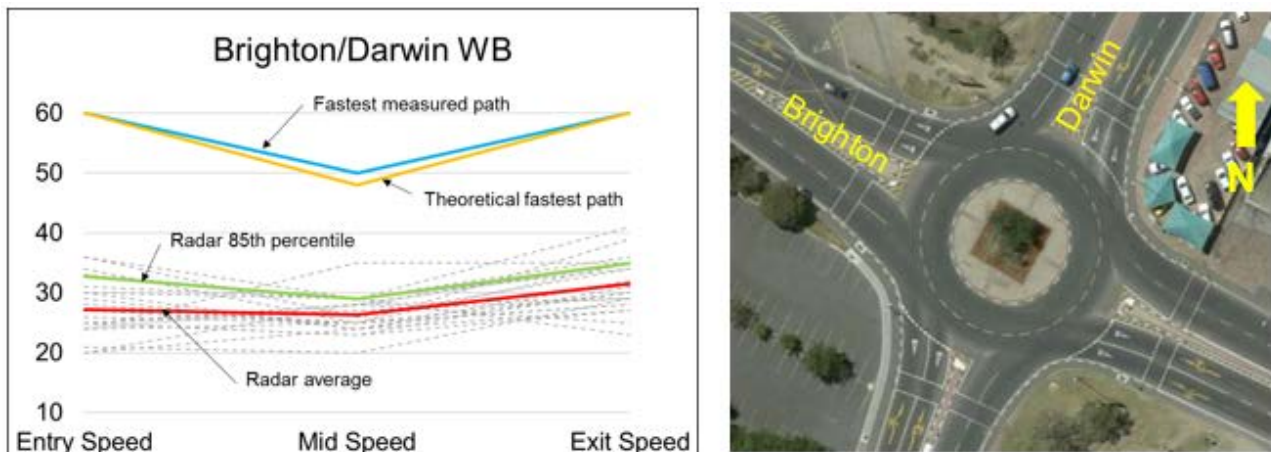
**a. Lord's Walk/ Langeberg roundabout, Durbanville:**



**Figure 9: Langeberg/Lords Walk Roundabout**

- i. This roundabout is considered one of the better constructed roundabouts with the theoretical fastest path achieving a design speed of 30 km/h.
- ii. The fastest measured path through the roundabout is also located within the limits of the recommended design speed.
- iii. The results of the speed gun measurements show that most drivers operate at or below the theoretical speed.

**b. Brighton / Darwin roundabout, Kraaifontein:**



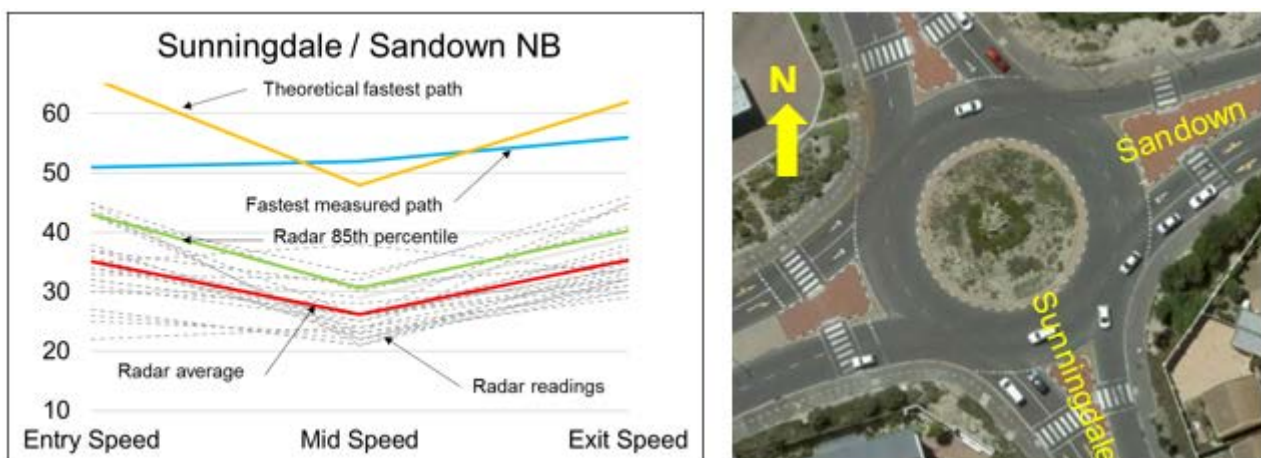
**Figure 10: Brighton/Darwin Roundabout**

- i. The speeds that could be achieved based on the theoretical fastest path show that at this roundabout the upper limit of the recommended design speed (40 km/h) for a double lane roundabout is exceeded and this is confirmed by the actual measured speeds. It is interesting to note how close the actual measured speeds are to the theoretical fastest path speeds.



- ii. The results of the radar gun speed measurements show that during daytime the typical speeds are well below (50%) the theoretical and measured fastest path. This is surprising however, it can mostly be explained by the high traffic volumes. It was difficult to identify any vehicle whose travel speed through the roundabout was not influenced (by varying degrees) by other traffic.
- iii. There is minimal deflection on the approaches at the entry into the roundabout, and without traffic and ignoring lane discipline, one can drive through the roundabout without significant deviation.
- iv. Although possible to drive through the roundabout at high speeds this is generally not the case. During the daytime drivers tend to use the roundabout safely. Even at night time when the average readings are between 5 to 10 km/h higher, the maximum measured speeds were still significantly lower than the theoretical speeds.
- v. During the day, the measured speeds at the entry and exit points, which coincides reasonably well with the position of the pedestrian crossings, are acceptable for the promotion of safe pedestrian movement.

c. **Sunningdale/ Sandown roundabout, Table View:**



**Figure 11: Sunningdale/ Sandown Roundabout**

- i. Similar to the Brighton roundabout discussed above, this double lane roundabout is not considered to be in line with international standards as the theoretical fastest path is significantly higher than the recommended 40 km/h design speed.
- ii. The deflection angles on the entries are too low and the entry speeds are too high.
- iii. While the measured speeds are all lower than the theoretical fastest path speed, the 85<sup>th</sup> percentile speed (on entry and exit) is higher than the recommended design speed of 40 km/h. This is concerning as the measurements were done on a typical

week day where there is significant friction between the entering and circulatory traffic.

- iv. During low traffic flow time periods, it is expected that the average and maximum speeds will increase considerably.

### g. Road Signs and Markings

The variation in the use of road signs and marking reflects either the lack of knowledge, or the lack of attention to detail or the lack of clear guidance (within the SADC-RTSM) for the implementation of road signs and road markings. A few examples of the variation are provided below:



**Figure 12: Difference in signage used at the yield line of roundabouts**

Similarly, road markings are not well maintained, and the variation of road markings is considerable. A few photos illustrating the variation at pedestrian crossings are included below:



**Figure 13: Difference in road markings at pedestrian crossings**

## 5 CONCLUSIONS

- There is a lack of a clear consistent design standards when roundabouts are being planned and designed.
- While the Inscribed Circle Diameters are generally within accepted international guidelines, entry and circulatory lane widths are generally too wide. These widths have the potential to allow too high speed (fastest path) through the roundabouts under low flow conditions, with a resulting compromise in safety.
- Pedestrian requirements often do not get the necessary attention resulting in potentially unsafe conditions.
- The assessment has shown that, even when provided, the truck apron is not used for the purpose intended. This is confirmed when one considers the width of the circulatory lanes, or the design of the apron itself.
- Road signs and markings varies considerably in terms of application, and the SADC-RTSM also lacks positive guidance.
- There are many variables which influences the speed and safety through a roundabout. The correct application of all the various elements are vital in the provision of a safe design.

Could the design of the existing roundabouts contribute to the perception that roundabouts are not safe? The results of the assessment of these 37 roundabouts suggest that the answer is yes, both in terms of vehicle only crashes and crashes involving pedestrians. It therefore clearly begs for a set of design standards in South Africa to assist officials and designers to provide safe and efficient designs. Consideration should also be given to updating SADC-RTSM with specific reference to roundabouts.

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