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Understanding safety and driver behaviour impacts of mini-roundabouts on local roads

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Abstract

The City of Monash historically had many local four-way intersections controlled by ‘Stop’ and ‘Give Way’ signs. Since 2004, 43 of these intersections have been replaced by ‘mini-roundabouts’, small, fully mountable roundabouts. This study uses a variety of methods to analyse the impact of mini-roundabouts on road safety and driver behaviour. It does this through analysing crash records three years before and after 40 mini-roundabouts were installed. It also incorporates a case study of two adjacent mini-roundabouts installed in 2016. Observations of driver behaviour were recorded and a questionnaire survey was also conducted to assess community acceptance. Significant road safety benefits were recorded. Crashes reduced 78.9% with serious crashes reducing from 6 to 0. Fewer vehicles exceeded the speed limit after the introduction of new mini-roundabouts, and more motorists complied to giving way than in the traditional give-way system. Surveys suggested the number of conflict and avoidance manoeuvres declined as well. The lower speed and nature of mini-roundabouts meant that crashes, if they were to occur, would be ‘safer’. The improvements were also supported by residents of area, with respondents feeling safer driving and walking at the intersection than before. In the context of improved driver behaviour and safety, mini-roundabouts have changed the landscape of local roads in the City of Monash.

1. Introduction

Roundabouts have long been recognised as a safe and efficient form of traffic control as they reduce conflict points, increase the visibility of the intersection and provide greater clarity of traffic priority (Austroads 2013). Historically, local four-way intersections in the City of Monash, Victoria, Australia employed give way signs and stop signs to assign priority. However, the number of crashes occurring in these local streets continued to be a concerning issue. Traditional roundabouts were not an option at many of these intersections as they carried high volumes of heavy vehicles.

As a response, beginning in 2004 the council progressively installed over 40 ‘mini-roundabouts’. Mini-roundabouts are small, flushed or raised (up to 6mm) fully mountable roundabouts that can be traversed by larger vehicles. Their use in Australasia is still relatively new and it may be questioned whether a mini-roundabout can provide the same safety benefits of a traditional roundabout.

The aim of this paper is to assess the impacts of mini-roundabouts on driver behaviour and road safety on local roads in the City of Monash. There are two major components of the study. A crash analysis was conducted for all mini-roundabout locations in the City of Monash to assess the overall road safety impacts. This was followed by a case study examining the impacts of installing two adjacent mini-roundabouts in 2016. The case study assessed the potential change in vehicle volumes, speeds, driver behaviour and also community attitudes.

The next section reviews the existing literature on mini-roundabouts and describes the case study area. We then outline the methodology used in the crash analysis and before-and-after case study. The results of these studies demonstrate the road safety benefits and the driver behaviour changes associated with implementing mini-roundabouts. We then discuss the findings in the context of past literature.

2. Literature Review

While roundabouts and other circular junctions have been incorporated even in Gregorian architecture as early as the 18th century such as the Circus in Bath, U.K. (visitBath.co.uk 2016), mini-roundabouts did not appear until 1969 (Peterborough Telegraph 2008). They employ either a flush or raised (up to 6mm) central domed island (Austroads 2013). The central island is typically 1m-4m in diameter, and can either be painted or consist of a traversable pad allowing for larger vehicles such as buses or trucks to drive over (see Figure 1). It is sometimes referred to as a ‘humpabout’.

The cost of retrofitting an existing intersection with a mini-roundabout is far lower than a traditional roundabout due to its reduced footprint (Austroads 2015). It is particularly suited to physically constrained locations (Rice 2010).

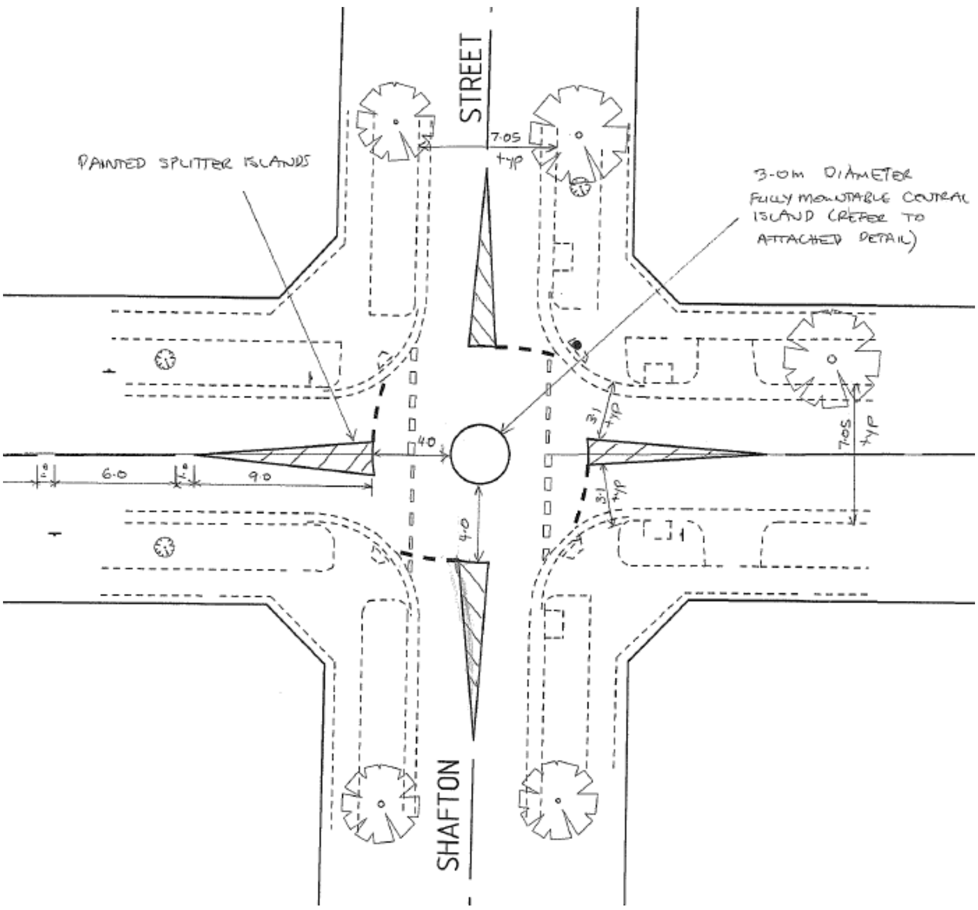


Figure 1 Plan drawing of mini-roundabout (Source: Tillotson 2015)

2.1. Existing Studies: Safety Benefits

Research has been previously conducted on the safety benefits of mini roundabouts and found that the severity and number of crashes is lower compared to those at signalised intersections. The conversion of 13 unsignalised intersections to mini-roundabouts in Germany found a 29% reduction in crash rate (Brilon 2011).

In the Australian context, a study in South Australia found a 62% drop in 85th percentile speeds through intersections with mini-roundabouts (Zito and Taylor 1996). Mini-roundabouts help reduce vehicle approach speeds. This, combined with lower impact angles due to the nature of mini-roundabouts, lead to lower impact energies in the event of a crash – leading to “safer” crashes if they do occur (Candappa 2015). Overall it appears that mini roundabouts reduce injury crashes by an average of 30% (Austroads 2013).

Less is known about *how* mini-roundabouts result in road safety improvement. As a traffic calming device, it is interesting that an object that requires little to no physical deviation can have such a significant impact on road safety. This is likely due, in part, to the sharing of responsibility at a roundabout compared to a give-way intersection.

At an intersection with a give-way system the motorists assuming right of way maintains their travel speed, providing less lime to react to unexpected situations (such as another motorist failing to give way), (Summala and Rasanen 2000). In contrast, motorists at the minor intersection must process dynamic and static objects in both directions in the perpendicular road. Focusing on “too many objects” can lead to inattentiveness (Miller 2015), while trying to analyse so many dynamic events lead to poorer decisions and longer decision-making times (Dalton and Fraenkel 2012).

When compared to the give-way system, a roundabout requires drivers to share responsibilities, allowing for better and safer decision-making at intersections. This is mostly because motorists from all four directions must give way to traffic coming from one direction only, allowing for drivers to make decisions based on a smaller field of view (Dalton and Fraenkel 2012).

Although most of these studies analysed regular roundabouts, the Federal Highway Administration in the United States (Rice 2010) suggests that these benefits also occur for mini-roundabouts.

2.2. Mini-roundabouts: Limitations

For all their benefits, mini-roundabouts share the same disadvantages as traditional roundabouts. The primary concern is for vulnerable road users – pedestrians and cyclists. There are conflicting results on the impact of mini-roundabout on cyclist crashes (Austroads 2013). Mini-roundabouts should not be placed at intersections with known large pedestrian volumes, while cyclists are considered "just as vulnerable" on roundabouts as any other cross-road system (Bode and Maunsell 2006). The same study also argues the case that mini-roundabouts have no effect on drunk and reckless drivers because of a lack of a physical barrier. However, these problems are no different than other intersection treatments, notably the Give Way and All-Way Stop systems (Waddell and Albertson 2005).

3. City of Monash Mini-Roundabouts

The City of Monash's experiment with mini-roundabouts began in 2004 with Shafton Street, a road with direct access to a major arterial (Princes Highway) which has eleven intersections (see Figure 2). The road used to operate with the Give-Way system. There were complaints about speeding traffic and vehicles failing to give way, and since all the priority was given to Shafton Street, it is likely that vehicles approaching from minor roads faced delays.

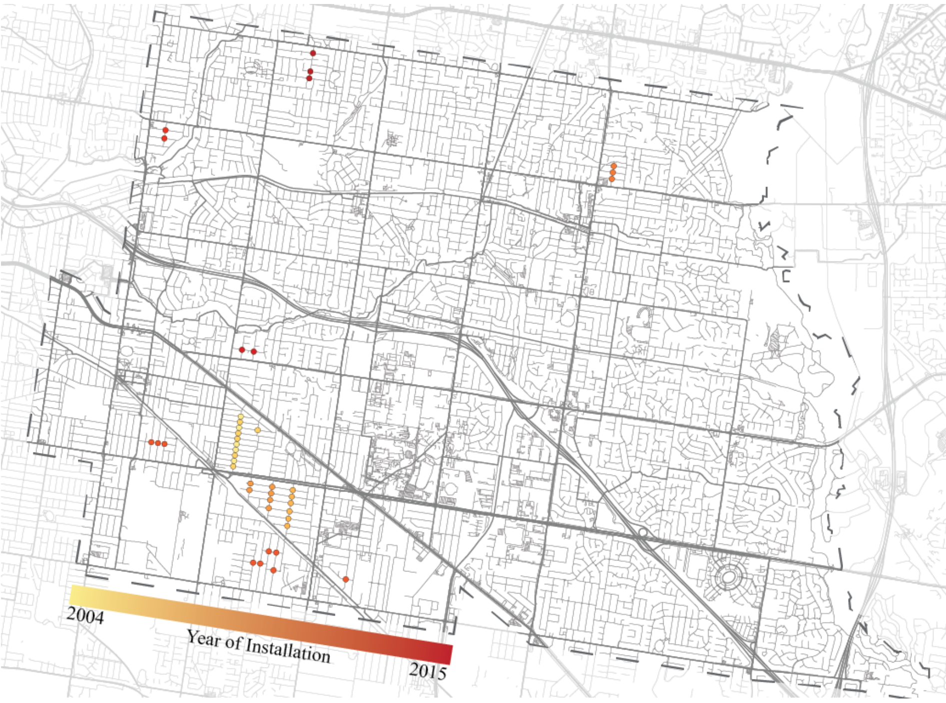


Figure 2 Mini-roundabout locations in the City of Monash

Since implementing mini-roundabouts on Shafton Street, the reduction in crashes was significant – dropping from 14 crashes in 10 years prior to construction to 2 crashes 8-9 years after construction. It encouraged the City of Monash to further implement them across the council. The most recent installation, on Connam Avenue, was completed in 2016.

4. Methodology

This project was conducted as part of a final-year undergraduate research project. It is made up of two components:

- Analysis of crash records for all mini-roundabouts installed between 2004 and 2014
- A 'before and after' assessment of two case study mini-roundabouts installed in 2016

4.1. Crash Records Analysis

All crashes at mini-roundabouts install in the City of Monash between 2004 and 2014 were identified and analysed (40 roundabouts). The analysis focussed on crashes occurring within 3 years before and after installing a roundabout.

Two main data sources were used:

- CrashStats data extract, to identify all crashes since 2006.
  - The database included over 150,000 crashes and contained information such as accident details, people and/or vehicle(s) involved, weather and road conditions etc.
- PDF Extracts of Road Crash Statistics, to identify crashes before 2006.
  - The information provided for each crash involved time, location, traffic control, atmospheric conditions and details of injuries amongst other records.

An initial total of 101 crashes occurred near a mini-roundabout in the City of Monash. Of these, 23 occurred within 3 years before or after the installation of a mini-roundabout. Using the database information, the type of each crash was established using the DCA (Definitions for Classifying Accidents) code. The crash severity was also noted.

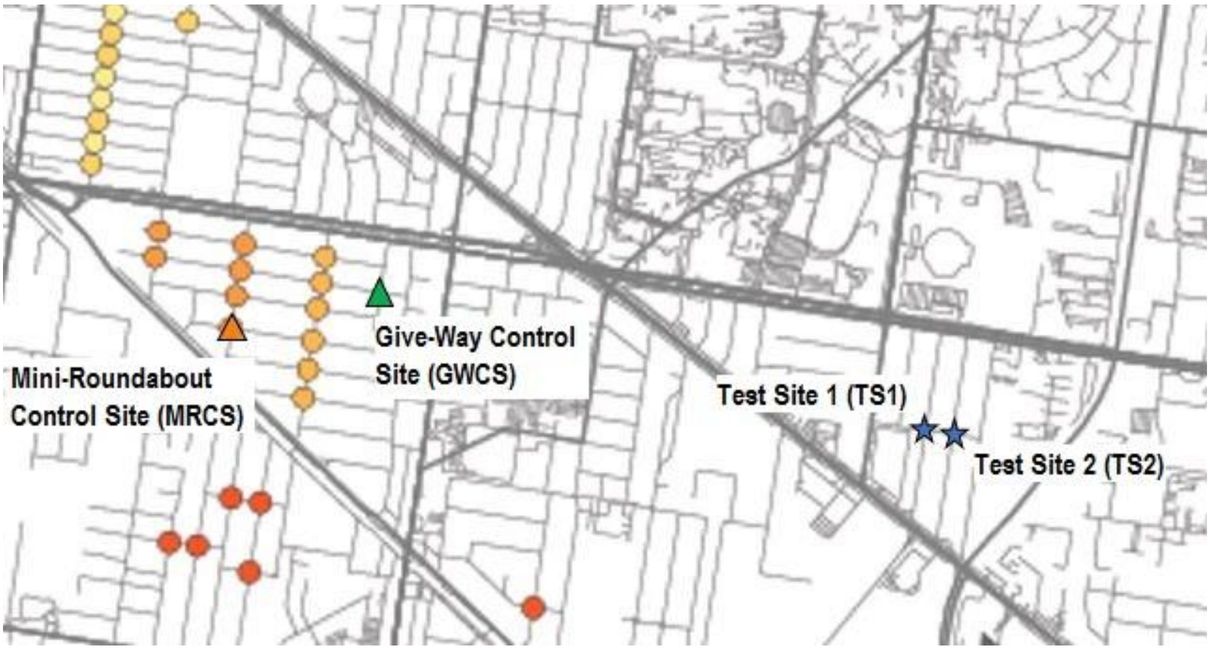
4.2. Before and After Case Study

An in-depth analysis was conducted at a case study location where two mini-roundabouts were installed in 2016 along Connam Avenue (see Figure 3). Mini-roundabouts were installed in adjacent intersections in August of 2016.

Two control sites were also selected for comparison: one that was controlled by a mini-roundabout installed in 2008 and one that was controlled by 'give way' signs. These sites were selected for their similar traffic volumes, geometric characteristics and proximity to the test sites.

To summarise, the four sites were:

- Test Site 1 (TS1): Connam Avenue and Cambro Rd intersection
- Test Site 2 (TS2): Connam Avenue and Renver Rd intersection
- Give-Way Control Site (GWCS): Banksia Street x Manton Road
- Mini-Roundabout Control Site (MRCS): Colin Rd x Margaret St



Note: Circles represent mini-roundabouts installed before 2016

Figure 3 Case study test and control sites

The impacts of the new mini-roundabouts were studied from several perspectives. Three key tasks were accomplished for this component of the study.

4.2.1. Volume and Speed Surveys

The City of Monash Council provided tube count surveys of vehicle volumes and speeds adjacent to the test sites before and after installation of the mini-roundabouts in 2016.

4.2.2. Driver Behaviour Field Surveys

Driver behaviour was observed using field surveys conducted in the May-July and September-October periods of 2016. Most surveys were conducted for 30 minutes each, some more and some less depending on the traffic volume and judgement on the surveyor's part regarding data adequacy (see Appendix).

The results presented in this paper focus on motorist behaviour. Initially, pedestrian and cyclists behaviour was also going to be observed but an insufficient number of pedestrians and cyclists were observed during the surveys. The following information was recorded for each vehicle that approached the intersection:

- Give Way (GW): A vehicle was classified as giving way if they slowed down or came to a full stop when approaching an intersection.
- Assumed Right of Way (ROW): A vehicle was classified as assuming ROW if they failed to slow down while approaching an intersection, regardless of the presence or absence of other dynamic objects on the street
- Encroachment: This is used to observe physical compliance to a mini-roundabout. A light vehicle was classified as 'encroaching' if the vehicle tyres crossed over the painted area of the mini-roundabout. It was classified as 'complying' if it fully deviated around the mini-roundabout. Larger light vehicles (e.g. anything larger than a family SUV) were classified as 'complying' if they clearly deviated in the lane. Note that heavy vehicles (buses, trucks) were always classified as 'complying' as mini-roundabouts are designed to be mountable for these vehicles.

- Avoidance manoeuvre: Avoidance has been defined as any gentle unintended/unnecessary turning manoeuvre or slowing down due to the presence of others.
- Conflict: Conflict has been defined as rapid deceleration or sudden change in direction or both due to the presence of others.

4.2.3. Residential Questionnaire

Further to the observations made in traffic count surveys, residential surveys were carried out following the construction of the mini-roundabouts on Connam Avenue. The aim of the survey was to judge community opinion and acceptance of the mini-roundabouts.

Pedestrians and residents of households adjacent to the test sites were approached and asked to participate. They could fill out their own survey or answer as the questions were read out. The survey was kept deliberately short (9 questions).

5. Results and Analysis

5.1. Crash Records Results

In total, 19 crashes occurred three years before the installation of any of the 40 mini-roundabouts within the City of Monash; within three years after installation this dropped to 4 crashed (78.9% reduction).

Table 1 provides a breakdown of the types of crashes occurring before and after a mini-roundabout was installed. The most common crash type before installation was ‘cross traffic’ and ‘right far’; both of these can result in fairly severe crashes due to the angle of incidence. These crash types virtually disappeared post-implementation with only 1 cross-traffic crash recorded.

Table 1 Crash types before and after mini-roundabouts installed

DCA Code	Crash Type	Before	After
		Frequency	
107	Driveway	0	1
110	Cross Traffic	15	1
111	Right Far	2	0
120	Head on (Not overtaking)	1	0
160	Parked	1	0
173	Right off carriageway into object – parked vehicle	0	1
199	No information available	0	1

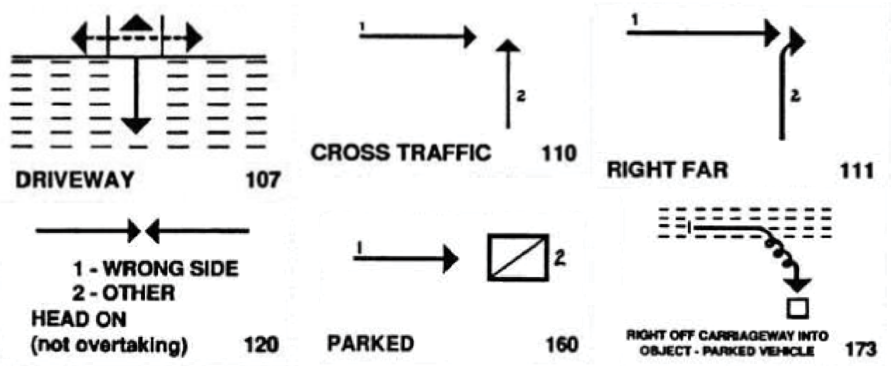


Figure 4 Relevant DCA crash diagrams (Source: VicRoads)

Echoing these findings, the severity of crashes reduced significantly. No fatal crashes were recorded, but 6 serious crashes occurred within 3 years before installation whereas no serious crashes have occurred within 3 years of implementing a mini-roundabout. 'Other' injury crashes reduced 69.2% from 13 to 4.

Table 2 Crash severity before and after mini-roundabouts installed

Severity	Before	After	Difference
	Frequency		
Serious	**6**	**0**	**100%**
Other	**13**	**4**	**69.2%**

5.2. Before and After Case Study Results

The CrashStats analysis suggests that the mini-roundabouts have significantly reduced cross-traffic crashes. This section examines the influence of mini-roundabouts on driver behaviour which may be contributing to these results.

5.2.1. Volume and Speed Surveys

The tube count data provided by the City of Monash helped determined average vehicle approach speeds at the intersection and how many heavy vehicles approached the intersection at the time of recording.

The tube counts were analysed to see changes in speed (if any) brought by the mini-roundabout (see Table 3). The volume of vehicles dropped slightly but the 85th percentile speeds and average speeds did not reduce significantly. However the proportion of speeding vehicles saw a significant drop from 5.4% to 3.4%.

Table 3 Vehicle volume and speed on Connam Avenue (weekday data)

	Connam Avenue	
	Before (May 2016)	**After (October 2016)**
85th Percentile Speed	44 km/h	43 km/h
Average Speed	39.3 km/h	38.5 km/h
Vehicles > speed limit	5.4 %	3.4 %
Vehicles > limit by 10 km/h	0.80 %	0.28 %
Average Weekday Volume	890 veh	800 veh
Volume% = Heavy Vehicles	13.48 %	17.24 %

Note: Speed limit is 50kph

5.2.2. Driver Behaviour Field Surveys

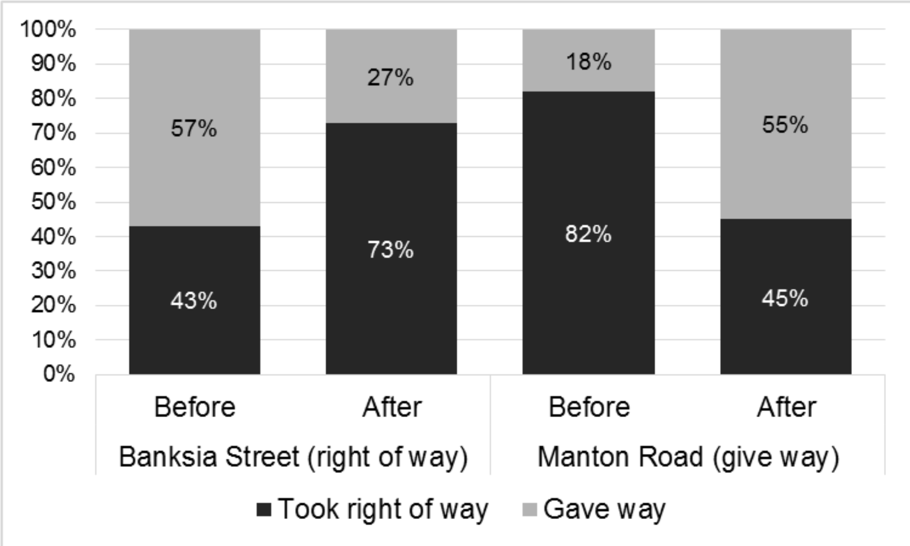
Driver behaviour was examined for the two Test Sites (Connam Avenue) and the two Control Sites (Give-Way Control Site and Mini-Roundabout Control Site). Analysis will include:

- Give-way (GW) versus right of way (ROW) behaviour
- Vehicle encroachment on the mini-roundabouts
- Avoidance and conflict behaviour

5.2.3. Control Sites Give Way Behaviour

Banksia Street was the designated major road at the GWCS, and vehicles on this road have the Right of Way according to the Give Way system. Motorists from Manton Road are supposed to Give Way according to the system in place. The data collected for these streets are presented in *Note: No change in road configuration took place 'before' and 'after' at this control site*

Figure 5 below.

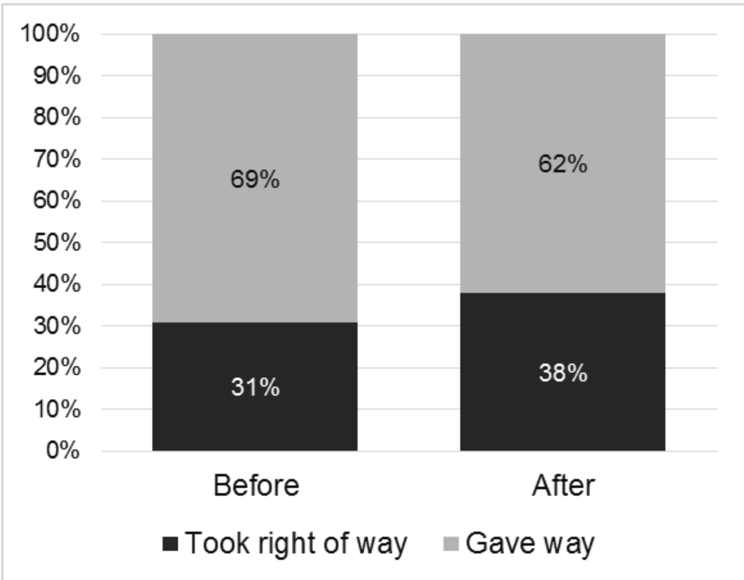


Note: No change in road configuration took place 'before' and 'after' at this control site

Figure 5 Give Way Control Site (GWGS) change in give-way behaviour

The ambiguity at Give Way signs discussed earlier in the literature review is clearly present in the data. Although drivers on Banksia Street have right of way, between 27% and 57% of drivers gave way. Even more interesting is that between 45% and 82% of drivers on the minor road (Manton Road) showed no signs of giving way. Also, surveys on different days tended to yield different results, with no apparent logical explanation.

The mini-roundabout at the Colin Road and Margaret Street intersection yielded better driver behaviour when compared to the Give-Way Control Site, as presented in Figure 6 below. The graph includes motorists approaching from both directions. Over 60% of motorists gave way at this site, far higher than at the GWCS.



Note: No change in road configuration took place 'before' and 'after' at this control site

Figure 6 Mini Roundabout Control Site (MRCS) change in give-way behaviour

5.2.4. Test Sites Give Way Behaviour

Connam Avenue was initially the major road prior to the construction of the mini-roundabout and runs through both test sites. Figure 7 shows that before the mini-roundabouts were installed, the majority of motorists took right of way (73% to 87%). After the installation, the majority of motorists gave way – even to a greater degree than the Mini Roundabout Control Site (Figure 6).

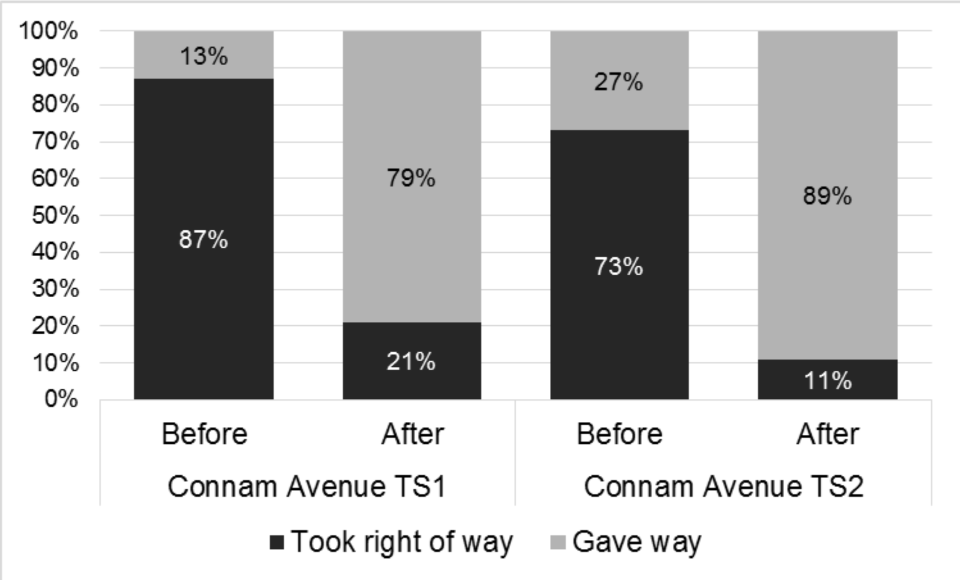


Figure 7 Connam Avenue Test Site change in give-way behaviour

Similarly, motorist behaviour at the minor approaches to the test sites also improved. Figure 8 shows that before the mini-roundabouts, 27% to 39% of motorists did not slow to give way; this dropped to 0%.

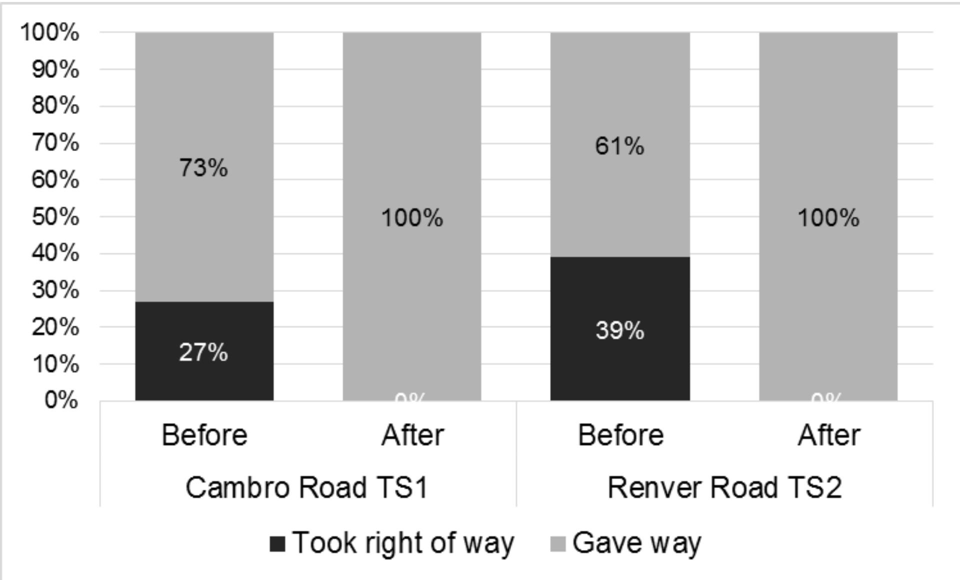


Figure 8 Minor Approach Test Site change in give-way behaviour

The figures can be used to observe how mini-roundabouts better enforce drivers to share responsibilities, as shown by the increasing number of vehicles giving way.

5.2.5. Encroachment, Avoidance and Conflict Behaviour

Driver encroachment was compared between the MRCS and the Test Sites (Figure 9). In the control site (which was installed in 2008), the majority of drivers at least partially encroached on the mini-roundabout (61%). In contrast, the majority of drivers at the test site complied and did not drive over the new mini-roundabouts.

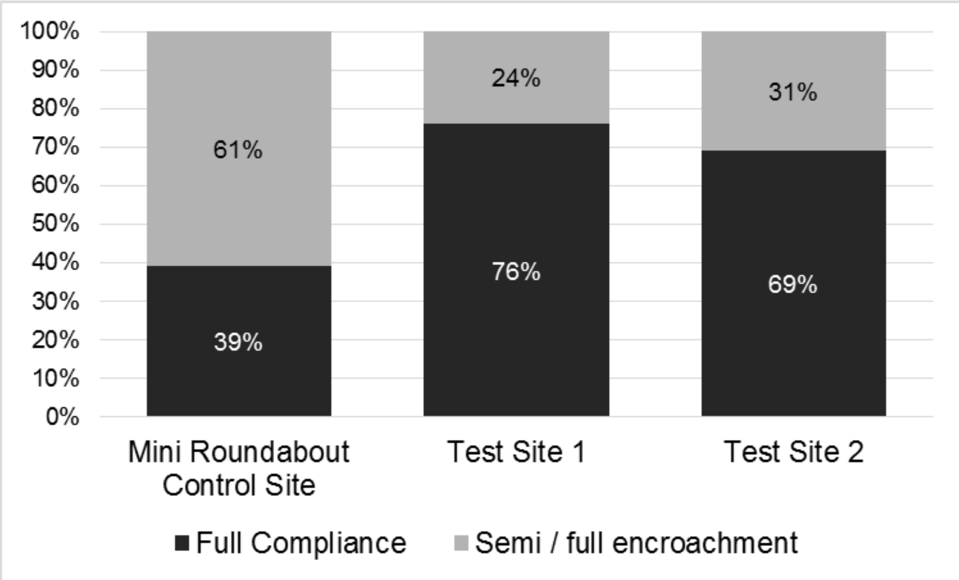


Figure 9 Driver encroachment over mini-roundabouts

Avoidance and conflict manoeuvres were recorded at all sites as defined earlier, and is presented in Table 4.

Table 4 Avoidance or Conflict manoeuvres before and after mini-roundabout construction

	Before				After			
Site	**Vehicles**	**Avoidance Manoeuvres**	**Conflicts Observed**	**Combined (%)**	**Vehicles**	**Avoidance Manoeuvres**	**Conflicts Observed**	**Combined (%)**
GWCS	80	1	1	2.50	98	0	1	1.02
MRCS	89	2	0	2.25	85	1	1	2.35
TS1	157	2	1	1.91	152	0	2	1.32
TS2	114	3	0	2.63	147	0	0	0.00

The before and after comparison for the test sites shows a decrease in avoidance and conflicts as expected from literature. While MRCS shows similar before and after rates, GWCS shows a significant reduction. It could be because of the higher volumes which encouraged motorists to drive safer.

Lower combined avoidance and conflict manoeuvres were observed at both test sites after construction, although they could not be determined as statistically significant. Chi-squared tests suggest it was because of the construction of mini-roundabouts and hence, it was statistically significant. Avoidance manoeuvres themselves were significantly reduced, while the statistical significance of conflict manoeuvres could not be determined due to the limited data collected.

There were more recorded conflicts observed after construction at TS1. Observations from the “after” data suggests both the conflicts were because of the mini-roundabout. One was a pedestrian waiting to cross by standing on the mini-roundabout, while the second was a car performing a U-turn at the mini-roundabout leading to the vehicle following to perform a hard stop, neither of which was likely prior to construction due to the nature of the intersection control.

5.3. Residential Questionnaire Results

In total, 32 surveys were completed; 16 were pedestrians, 16 were residents of nearby properties and 1 was an employee at a local shop. The results are presented Figure 10.

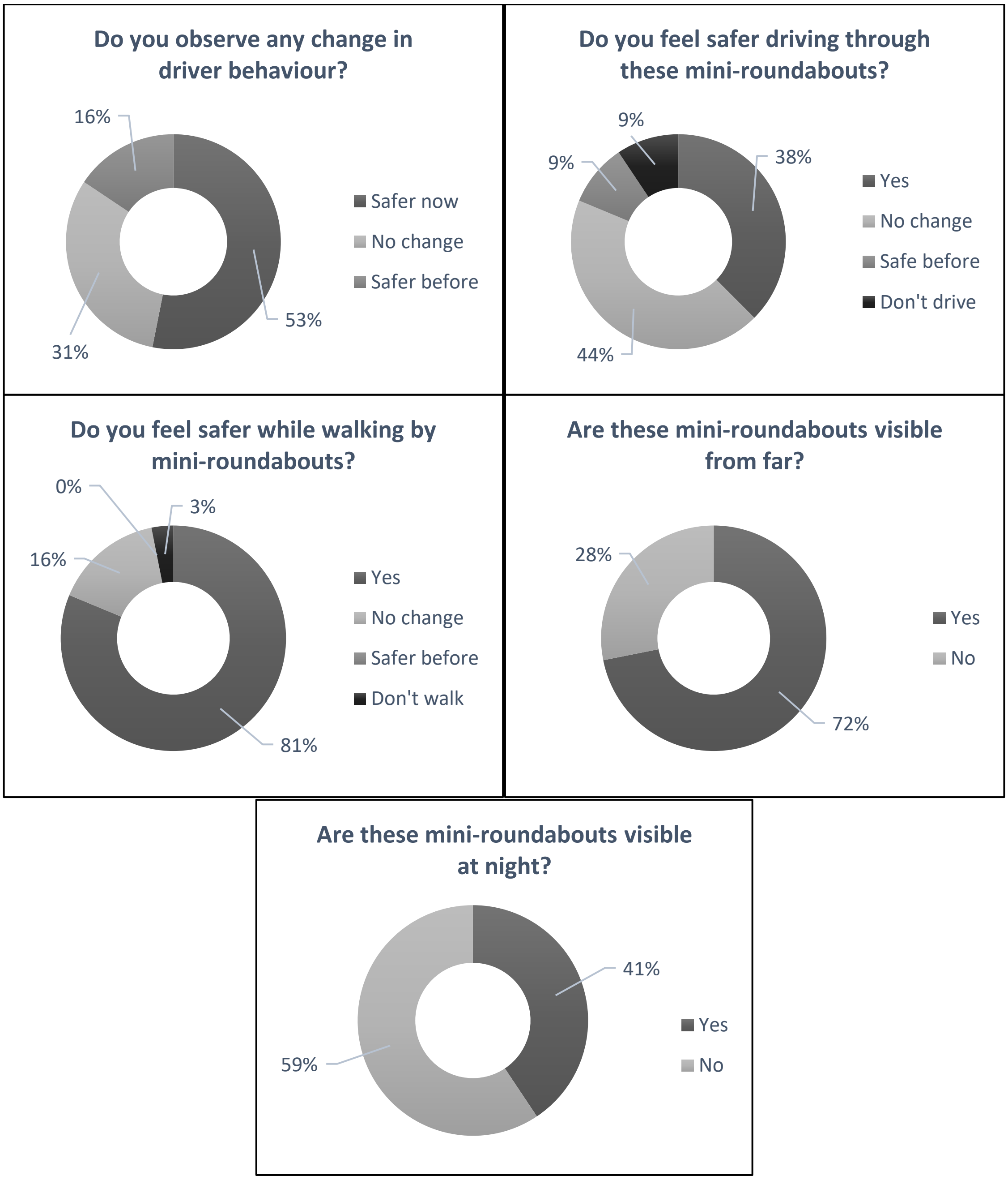


Figure 10 Residential Questionnaire Responses

Community sentiment for the mini-roundabouts is generally positive. Mini-roundabouts seem to bring two major benefits according to the respondents – safety for pedestrians and visibility from a distance. None of respondents thought that the Give Way system was safer than mini-roundabouts. The first is important to know because very few pedestrians were observed crossing the intersections. Furthermore the benefits of mini-roundabouts to vulnerable road users such as pedestrians and cyclists is still an open question. Interestingly, visibility at night seems to be questionable, possibly due to lack of a physical presence.

6. Discussion

Overall this study confirmed many findings from previous research into mini-roundabouts.

6.1. Crash Rates and Reduction

The road safety benefits were significant, reducing crashes by 78.9% in the three-year window before and after implementation. More significantly, serious crashes reduced from 6 to none, most likely due to the significant reduction in cross-traffic crashes (DCA code 110). This was significantly higher than the overall estimate of 30% reduction from Austroads (2013). This could be due in part to two characteristics of local roads in the City of Monash. First, some local roads have significant movements of heavy vehicles due to industrial land uses. Second, some of the first roads targeted for mini-roundabouts were particularly long, straight sections of a historic grid-based network (see Figure 1) which encouraged high travel speeds.

The case study surveys of driver behaviour unpacked some of the reasons for the decrease in crashes. Survey data found that significantly more vehicles give way on a mini-roundabout than the Give Way system. This holds particularly true when considering the Give-way control site. On Manton Rd (Give-way road), only 37% of motorists gave way which was actually *lower* than on Banksia Street (Right of Way road, 39% gave way).

6.2. Residential Questionnaires

Residential questionnaires found that members of the community felt quite positive about the mini-roundabouts. In particular they felt that drivers were being safer and that they felt safer walking near them than before.

6.3. Familiarity with the new mini-roundabouts

There is some evidence that the new mini-roundabouts are treated differently to older roundabouts, most likely because they are still a novelty to residents. For example, a higher proportion of motorists fully complied with the test site mini-roundabouts, compared to the control site where encroachment was much more common.

Similarly, a common observation in locations with no mini-roundabout was vehicles performing mid-block U-turns, something which mini-roundabouts now enable motorists to do safely. However, one observed conflict was a car performing a U-turn on the roundabout leading to another vehicle coming to a hard brake. But this could be simply because motorists are still familiarizing themselves with the mini-roundabout. The second conflict recorded post-construction involved a pedestrian standing on the mini-roundabout while crossing the street. However, whether such incidences are common occurrences remains debatable, especially since no such observations were made at the Mini Roundabout Control Site. Familiarity, therefore, is likely to play a key role in a motorist’s decision making at an intersection.

This issue is probably the biggest limitation of this study. Due the timeframe of the study project and construction of the mini-roundabouts, the surveys were conducted soon after construction, which results in data suggesting exceptional driver behaviour. A longer time frame for data collection would confirm whether this was the case.

7. Conclusion

The study findings suggest that mini-roundabouts are an effective (and cost-efficient) method to control the right of way in four-way intersections on local roads. They may be particularly appropriate in locations with significant bus or heavy vehicle traffic, or in grid-based local road networks.

However it should be noted that very few pedestrians or cyclists were observed during the survey. Although the resident survey suggested that people felt safer walking around mini-roundabouts, further research is clearly needed. In particular, mini-roundabouts may not be appropriate in areas with high cyclist movements on local roads.

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8. Appendix

The data presented in this section of the report is already presented in the main report. The tables here are to indicate when the surveys were undertaken, and their duration. Additional data, such as tube count analysis, has not been presented here.

Table A1. GW and ROW for Right of Way Approach (Banksia Street - GWCS)

Date	Duration	ROW	GW	Ratio (RW% -GW%)
9 Jun	20 mins	12	9	57 – 43
11 Jul	20 mins	3	11	21 – 79
9 Sep	20 mins	19	9	68 – 32
4 Oct	35 mins	17	4	81 – 19
Total	95 mins	51	33	61 – 39

Table A2. GW and ROW for Give Way Approach (Manton Road - GWCS)

Date	Duration	ROW	GW	Ratio (RW% - GW%)
9 Jun	20 mins	16	2	89 – 11
11 Jul	20 mins	21	6	78 – 22
9 Sep	20 mins	12	12	50 – 50
4 Oct	35 mins	10	15	40 – 60
Total	95 mins	59	35	63 – 37

Table A3. GW and ROW for mini-roundabout approaches (Colin Rd and Margaret Rd - MRCS)

Date	Duration	ROW	GW	Ratio (RW% - GW%)
3 May	30 mins	24	36	40 – 60
11 Jul	20 mins	4	25	14 – 86
9 Sep	20 mins	11	20	35 – 65
4 Oct	45 mins	21	33	39 – 61
Total	115 mins	60	114	34 – 66

Table A4. Motor Vehicle Encroachment (MRCS)

Date	Compliance	
	Full (%)	Semi/None (%)
3 May	40	60
11 Jul	21	79
9 Sep	52	48
4 Oct	39	61
Average	39	61

Table A5. GW and ROW for Right of Way Approach (Connam Ave - TS1)

Date	Duration	ROW	GW	Ratio (RW% - GW%)
B 4 May	30 mins	45	6	88 – 12
B 12 Jul	30 mins	28	5	85 – 15
A 2 Sep	30 mins	3	17	15 – 85
A 5 Oct	30 mins	12	39	24 – 76
Total	B 60 mins	73	11	87 – 13
	A 60 mins	15	56	21 – 79

Table A6. GW and ROW for Give Way Approach (Cambro Road - TS1)

Date	Duration	ROW	GW	Ratio (RW% - GW%)
B 4 May	30 mins	12	33	27 – 73
B 12 Jul	30 mins	8	20	29 – 71
A 2 Sep	30 mins	0	26	0 – 100
A 5 Oct	30 mins	0	55	0 – 100
Total	B 60 mins	20	53	27 – 73
	A 60 mins	0	81	0 – 100

Table A7. GW and ROW for (Connam Ave - TS2)

Date	Duration	ROW	GW	Ratio (RW% - GW%)
B 4 May	30 mins	24	6	80 – 20
B 12 Jul	30 mins	9	6	60 – 40
A 2 Sep	30 mins	2	24	8 – 92
A 5 Oct	30 mins	7	51	12 – 88
Total	B 60 mins	33	12	73 – 27
	A 60 mins	9	75	11 – 89

Table A8. GW and ROW for Give Way Approach (Renver Road - TS2)

Date	Duration	ROW	GW	Ratio (RW% - GW%)
B 4 May	30 mins	9	39	19 – 81
B 12 Jul	30 mins	18	3	86 – 14
A 2 Sep	30 mins	0	28	0 – 100
A 5 Oct	30 mins	0	35	0 – 100
Total	B 60 mins	27	42	39 – 61
	A 60 mins	0	63	0 – 100

Table A9. Motor Vehicle Encroachment (TS1, TS2) after construction of mini-roundabout

Site	Survey Date	Compliance	
		Full (%)	Semi/None (%)
TS1	2 Sep	63	37
TS1	5 Oct	81	19
TS2	2 Sep	81	19
TS2	5 Oct	62	38
Average		72	28

Table A10. Avoidance and Conflict Data for all sites

	"Before"						"After"					
	Set 1			Set 2			Set 1			Set 2		
Site	V	A	C	V	A	C	V	A	C	V	A	C
GWCS	39	0	1	41	1	0	52	0	0	46	0	1
MRCS	60	0	0	29	2	0	31	0	0	54	1	1
TS1	96	2	1	61	0	0	46	0	2	106	0	0
TS2	78	3	0	36	0	0	54	0	0	93	0	0

Table A11. Avoidance/Conflict percentage before and after

	Vehicle Volume		Avoidance/Crash %	
Site	Before	After	Before	After
GWCS	80	98	2.50	1.02
MRCS	89	85	2.25	2.35
TS1	157	152	1.91	1.32
TS2	114	147	2.63	0