TRAFFIC CALMING ON HIGHER ORDER ROADS: A CASE STUDY

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ABSTRACT

The use of the more commonly used traffic calming measures, such as speed humps and mini-circles, has mostly been restricted to Class 4 and 5 streets. Inappropriate high speeds and driver behaviour, which cannot fully be addressed by law enforcement, do however also often occur on higher order roads. Application of traffic calming measures suitable to higher order urban roads or even rural roads is not addressed in existing guideline documents, and research and investigation into this issue is required.

The case of Tafelberg Road in Middelburg, Mpumalanga has offered the opportunity to investigate and implement traffic calming on a higher order road. The two-lane road is constructed to very high standards, almost completely straight over more than 2 kilometres, with pavement width in excess of 11 metres and wide verges. Tafelberg Road has multiple functions in the road network - it has a through traffic function, connecting regional roads, while also serving as an access road for an adjacent residential area. The road also carries relative high volumes of heavy vehicle traffic. High speeds and perceived high noise levels lead to numerous complaints from the public.

This paper describes the traffic study that was done to quantify problem areas, including speed, volumes and noise measurements and the methodology used to identify and refine measures to address the problem and an after study that was done, and its results.

The implemented solutions consisted of introducing median islands, road signs and a series of chicanes. A design speed of 80km/h was applied to all elements. The measures were aimed at reducing the sense of openness created by the road environment, which encouraged high speeds. The principal objective was to reduce speed and effect constant speeds, i.e. not to encourage speed change cycles, which are often associated with conventional traffic calming measures, and which could be a source of increased noise levels.

Preliminary results indicate that the project was highly successful in reducing speed, speed differential and noise levels, without noticeably inhibiting mobility.

1. INTRODUCTION

CSIR, Transportek has been appointed by the City Engineer of Middelburg to conduct a traffic assessment of Tafelberg Road, to recommend measures to address specific problem areas being experienced on the road and, subsequently, to design such measures and determine its effectiveness.

The primary problems were high speeds on the road and high traffic noise levels.

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Tafelberg Road forms a link between Roads P30-1, in the west and P154-3 (R555) in the east, passing on the southern side of the Aerorand residential area, as shown on Figure 1 - Location Plan. The two-lane road is constructed to very high standards, almost completely straight over more than 2 kilometres, with pavement width in excess of 11 metres and with wide verges.

Problem areas reported include:

- A relatively recent increase in traffic volumes, coinciding with, and resultant from the extension of Tafelberg Road to the west to form a link between Roads P30-1 (Fontein Street Extension) and P154-3 (R555, Kerk Street Extension, "the Witbank Road") and tolling of the N4 Freeway;
- High speed on the road;
- A large percentage of heavy vehicles using the road;
- High noise levels emanating from the road;
- Accidents occurring on the road.

2. METHODOLOGY AND SURVEYS

Data gathering for the investigation stage of the study included:

- Automatic traffic counts, recording volumes, speed, and headways and classifying vehicles, during the week of 11 March 2002. Results of a similar survey during February 2001 were also available;
- Turning movement counts, by class of vehicle, at the intersections of Tafelberg Road with Roads P30-1 and P154-3 for twelve-hour periods during the same week in March 2002;
- A noise survey, recording noise emanating from the road;
- Visual inspection of the road section, including recording of a video of the road section travelled in both directions, and all relevant details;
- Obtaining design plans of western section of the road and measuring the cross section and longitudinal section of the "old" section.

It was concluded that the root causes of the perceived problems on Tafelberg Road can be related to the role of the road in the network and the design standards that were used:

- Tafelberg Road fulfils a dual function. It acts as a collector/access for Aerorand, classified as a Class 4 Road in terms of the Guidelines for the Provision of Engineering Services and Amenities in Residential Townships. The road also fulfils an Arterial function (Class 2 Road) as a connector between roads P154-3(R555) and P31-1.
- The generous pavement width, long straight section, and wide open verges correspond to a high design speed and give drivers a sense of a high order road, encouraging higher speeds.

There appears to be no feasible approach to reduce traffic volumes and/or heavy vehicle volumes on the road section, as there are no alternative routes that could fulfil its function in the network

In considering measures to address the identified problem areas it was clear that "conventional" traffic calming, e.g. circles, speed bumps, raised intersections, would not be applicable to the road section under consideration, as, amongst others:

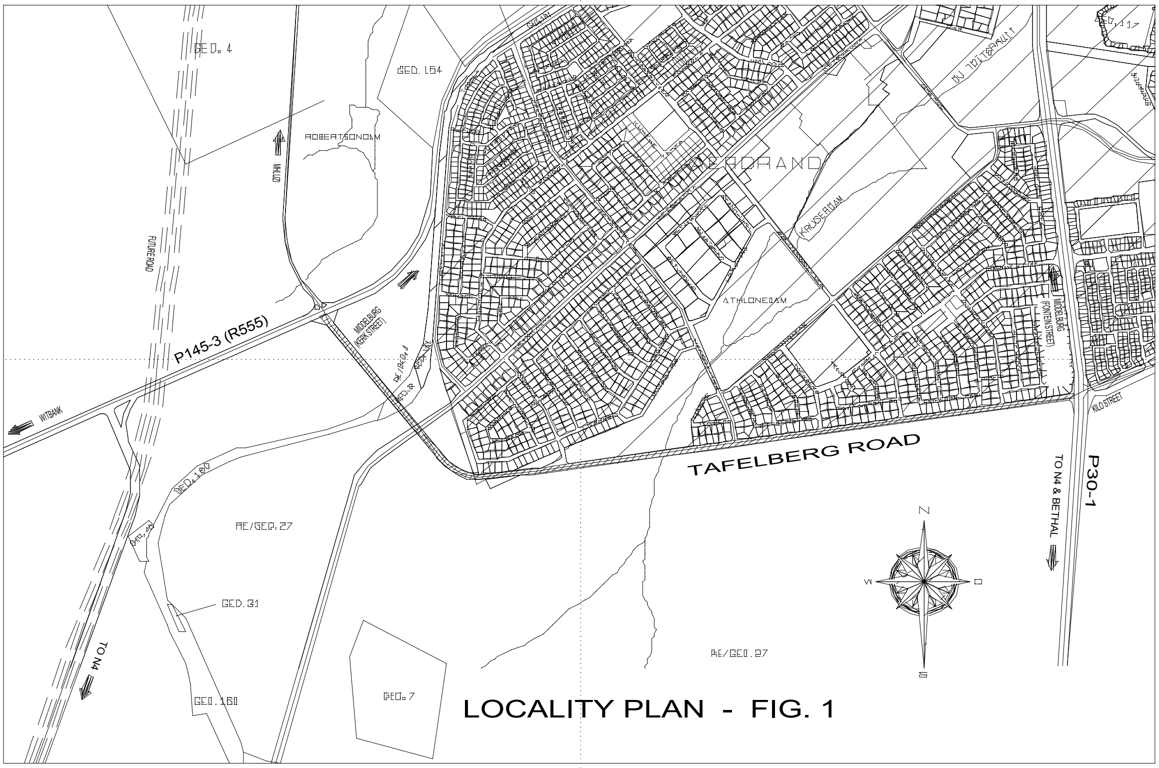
- Guidelines indicate that such measures should be restricted to Class 5 roads only;
- Such measures are not effective in reducing speeds of both light and heavy vehicles;
- It will be contra-productive, especially in terms of noise levels, to reduce speed drastically and have vehicles accelerating again.

Based on the observations and much consideration, it was concluded that the traffic calming measures should be aimed at reducing the sense of openness created by the high design standards, without creating a road where changes in speed through acceleration and deceleration cycles are encouraged. The aim was thus to reduce speeds and maintain constant speed.

This was done by:

- Introducing median islands at both ends of the road section to form "gateways";
- Creating chicanes at spacings of approximately 300 metres. The designs of these were for a design speed of 80 km/h, with tapers of no less than 1:15 and 4 metre wide lanes;
- Painting right turn lanes at four T-intersections on the road. These are approximately midway between chicanes;
- Introducing a speed limit of 70 km/h;
- Installing warning signs and information signs at the ends of the road section.

The median islands and chicanes were first packed out without installation and tested by driving through them at various speeds by the researchers. Simultaneously continuous electronic speed observations were recorded.



LOCALITY PLAN - FIG. 1

When the design was considered appropriate, the islands were constructed and signs and painted markings completed.

During October 2002, electronic counts and speed observations were made and another noise survey undertaken.

3. GEOMETRIC FEATURES OF THE ROAD SECTION

The whole section of Tafelberg Road was a two-lane single carriageway road. The paved width between barrier kerbs of the road is 11,81 m, with painted shoulder lines, and varying shoulder width of 1,3 to 1,6 metres. The lane widths varied accordingly between 4,25 and 4,64 metres. The verges are wide, approximately 12 m on the southern side, and 8,7 m on the side of the residential area. On the northern side small trees, lampposts and occasional road signs are found on the verge. The building line on the northern side was estimated at 5m.

Three local access streets serving the Aerorand Residential area intersects with Tafelberg Road at T-intersection spaced 400 to 500 metres apart.

Approximately 100m east from the intersection with P154-3, Tafelberg Road has a 370m long curve to the left with radius 300m. The super-elevation on the curve is approximately 3%, which corresponds with the required superelevation for speeds of less than 60 km/h. At the south-western corner of the Aerorand residential area, there is a horizontal kink of 2,5° in the road. Past Aerorand the road is straight over a distance of nearly 2,5 km.

With the intersection of P154-3 as Chainage 0, Table 1, shows the vertical characteristics. Chainages and distances are approximate, as the information had to be collated from various surveys and cadastral information, where some minor discrepancies were found. Except for the super-elevation of the horizontal curve, all design features of the road correspond to a design speed in excess of 100 km/h.

Table 1. Vertical alignment.

Gradient	Length of constant gradient	Chainage at BVC	Length of Vertical Curve	K-value
-1,47%	205m	205m	390m	130
-4,48%	511m	1 106m	300m	40
+2,98%	162m	1 572m	110m	108
+1,51%	778m	2 460m	382m	135
-1,29%				

4. TRAFFIC VOLUMES

The automatic counts indicated Average Daily Traffic volumes in a weekday of approximately 3 100 vehicles per day, with high percentage medium and heavy vehicles, ranging between 12% and 25%, depending on the time of day. Figure 2 shows traffic pattern of Tuesday 12 March 2002, which was considered a typical weekday.

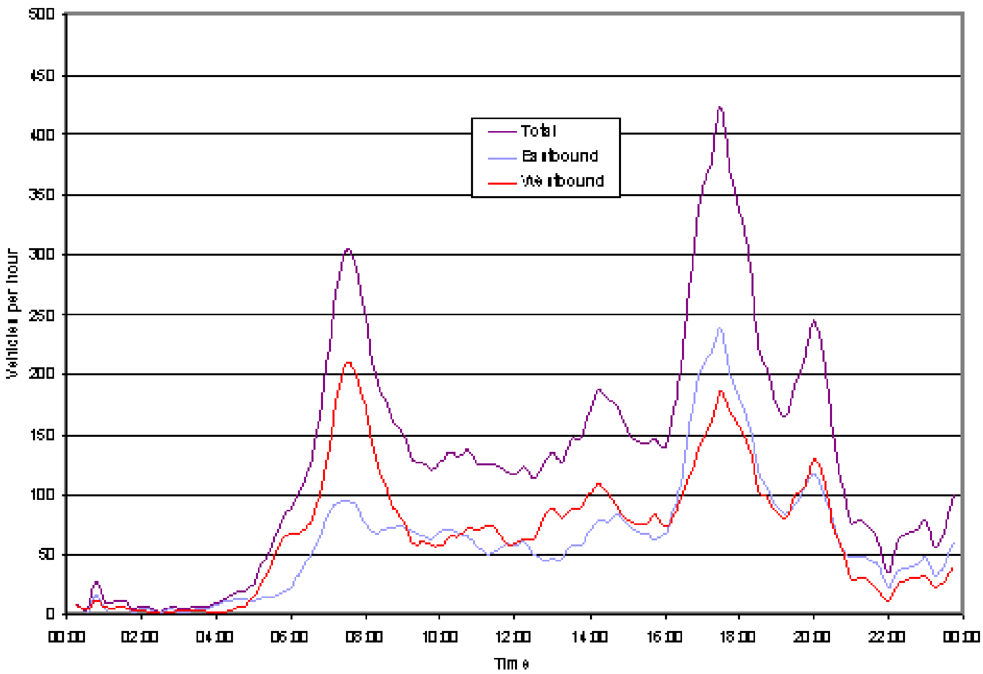


Figure 2. Total traffic by direction – Weekday.

Heavy vehicle traffic appears to be fairly constant during a weekday between 06:30 and 19:00. There are some heavy vehicle traffic (roughly 20 to 30 vehicles per hour using the road between 19:00 and 21:00.

The Sunday pattern was also analysed for application in the analysis of noise levels, discussed below. The traffic pattern for Sunday 17 March 2002 is shown on Figure 3.

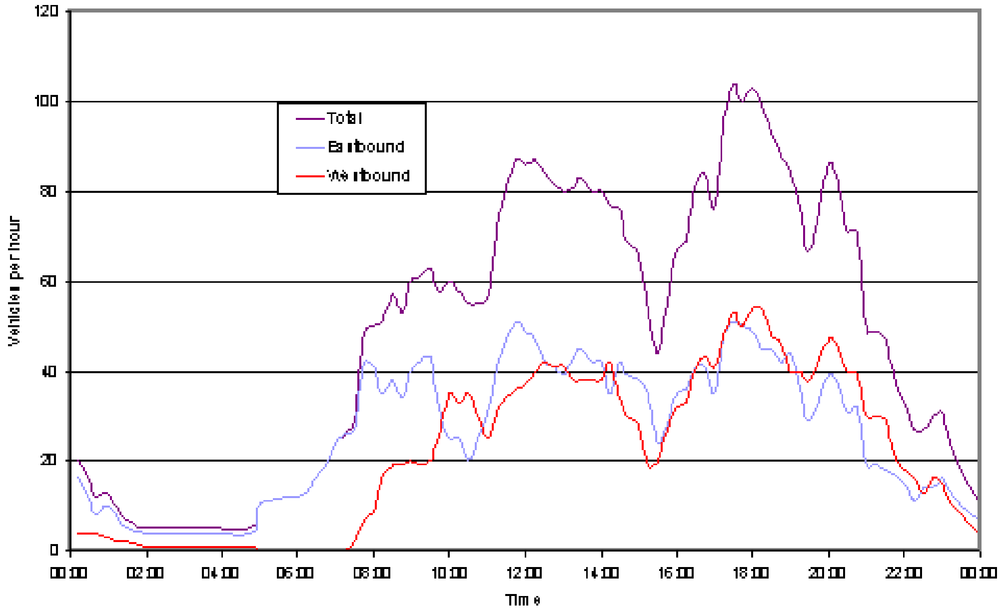


Figure 3. Total traffic by direction – Sunday.

Traffic volumes on a Sunday are, as expected, much lower than on a weekday, fairly constant during the day with a peak of approximately 100 vehicles/hour. Heavy vehicle traffic is relatively high on the Sunday, ranging between 7% and 19% of total traffic volumes.

In no case were the volumes such that it noticeably influenced speed, i.e. operations could be considered as free flowing.

The volumes observed in October 2002 showed a change from those recorded in March, with weekday volumes down and weekend volumes higher. No explanation for this can readily be offered. Given the relative low traffic volumes under consideration it can likely be ascribed to normal variation.

The turning movement counts indicated that the primary origin-destinations of passenger vehicles are:

- P154-3 (R555) direction Witbank and the N4,
- to and from the Mhluzi area,
- Fontein Street to and from the central part of Middelburg,
- Kilo Street to and from east.

The primary origin-destination pairs for heavy vehicles are:

- P154-3 (R555) direction Witbank and the N4,
- Kilo Street to and from the east.

5. NOISE MEASUREMENTS

Noise measurements were taken on Wednesday 13 March 2002, between 07:30 and 10:30 at three locations along the road section.

These were calibrated with actual traffic volumes, percentage heavy vehicles and speeds actually recorded during the same period. From this a model was constructed to estimate noise levels for any time during a weekday and a Sunday using the procedure described by Code SABS 0210:1996, for traffic volumes and speeds actually recorded.

The measurements were taken at a distance of 12m from the centreline of the road, on the northern side. The noise levels were adjusted to reflect an estimated noise level at the building line, 5 meters beyond the road reserve boundary, without considering screening effects. The screening effect of existing boundary walls were also adjusted for, assuming a continuous 1,8m high garden wall on the property boundary, to emulate levels as perceived by residents whose properties front on the road. Almost all of the residences fronting on Tafelberg Road have such walls on the boundary.

Code SABS 0103:1994 provides typical rating levels of ambient noise for six types of districts. None of these districts can be directly applied to Aerorand and Tafelberg Road, but it was considered that a combination of two of the district types could be applicable, namely:

District b): Suburban district with little road traffic;
District d): Urban district with some workshops, with business premises, and with main roads.

To incorporate the three factors which vary by time of day, namely traffic volumes, percentage heavy vehicles and speed, the weekday was divided into nine time regimes where these variables can be considered similar during that period, e.g. 00:00 to 06:00, 06:00 to 07:00, etc. Similarly Sunday was divided into eight regimes.

Noise measurements were again taken at exactly the same positions in October 2002 and a new prediction model constructed. The new measurements resulted in much the same prediction model obtained before. The results of the noise measurements are discussed in Section 8 below.

6. SPEED CHARACTERISTICS BEFORE TRAFFIC CALMING

Traffic speeds during the week in March 2002, when the surveys were undertaken, were affected by various activities on the road. These activities included placing of new loops for the automatic counting station, personnel present on the road conducting the inspection and counts, visibility of the sound detection devices (the microphones had to be placed at a fixed distance from the road and where screening effects of walls does not have an effect, so it was not possible to hide the equipment) and speed checking by the Traffic Department. Speed observation taken during this week was not considered representative of a "normal" day.

Speed data from an electronic count by the Town Engineer's Department from February 2001 were also available. This was taken to reflect a "normal" situation, for before the traffic calming was implemented. The speed data recorded during this period is summarised in a frequency distribution diagram shown on Figure 4. As can be seen the speeds were in general unacceptably high, with high averages, high 85th percentile speeds, and disconcertingly numbers of very high speeds observed.

To illustrate the effect of the visible presence on the road the frequency distribution for a weekday in March 2002 is shown on Figure 5. It is clear that speeds were noticeably lower than on a "normal" day represented by the observations made in February 2001.

To further illustrate this point speed data from 13 and 15 March 2002, for the time 09:00 to 11:00 are shown on Figure 6. This was the period when the noise surveys were made on 13 March. As shown, the speeds, while the noise surveys were in progress, were 5 to 15 km/h lower than during the same time on another day in the same week.

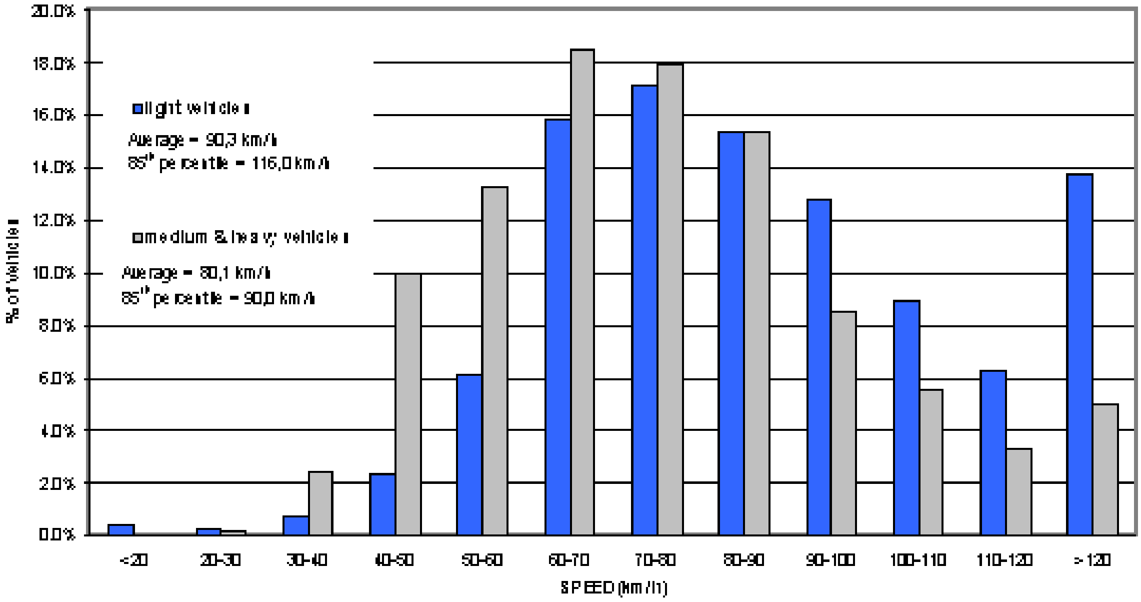


Figure 4. Percentage of vehicles in speed classes – Weekday February 2001.

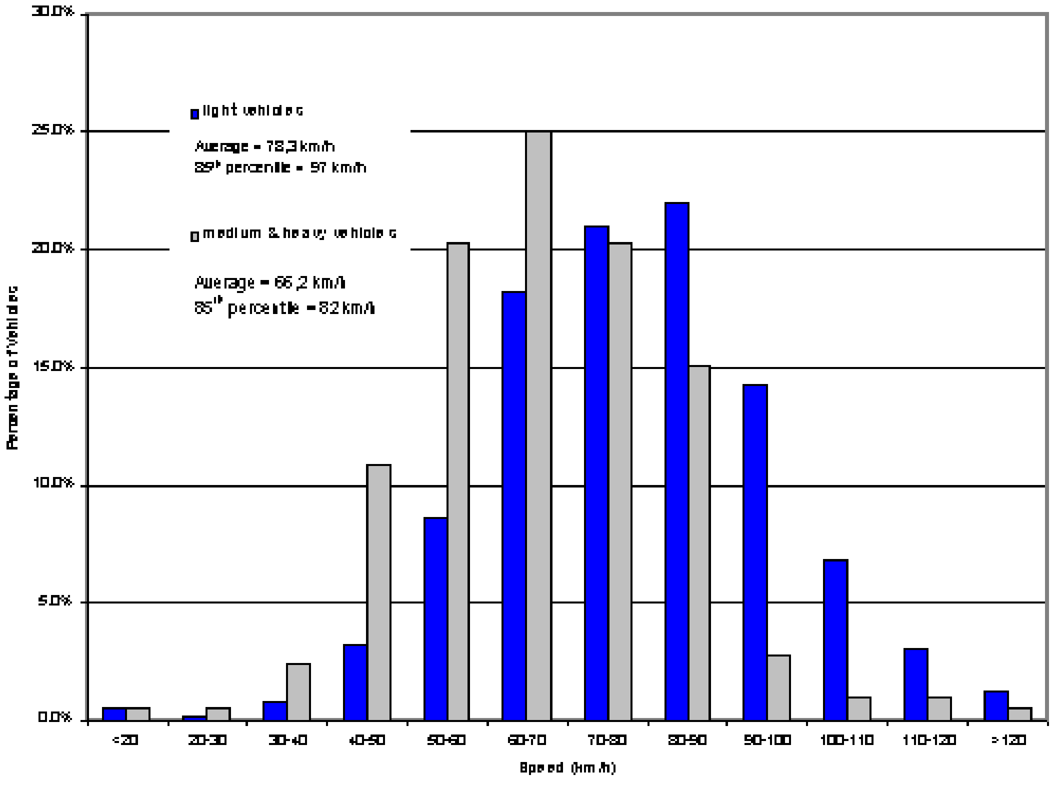


Figure 5. Percentage of vehicles in speed classes – Weekday March 2002.

This indicated that (i) sound measurements had to be adjusted for higher speed values, most importantly, that (ii) visual presence of law enforcement, even if only presumed as such by drivers, has a significant impact on speeds.

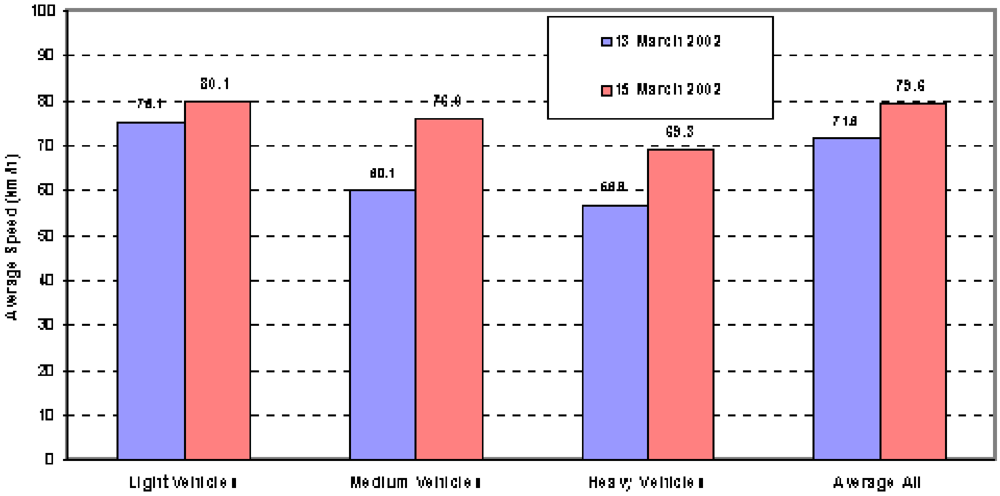


Figure 6. Comparison of speeds: 09H00 to 11H00, 13 and 15 March 2002.

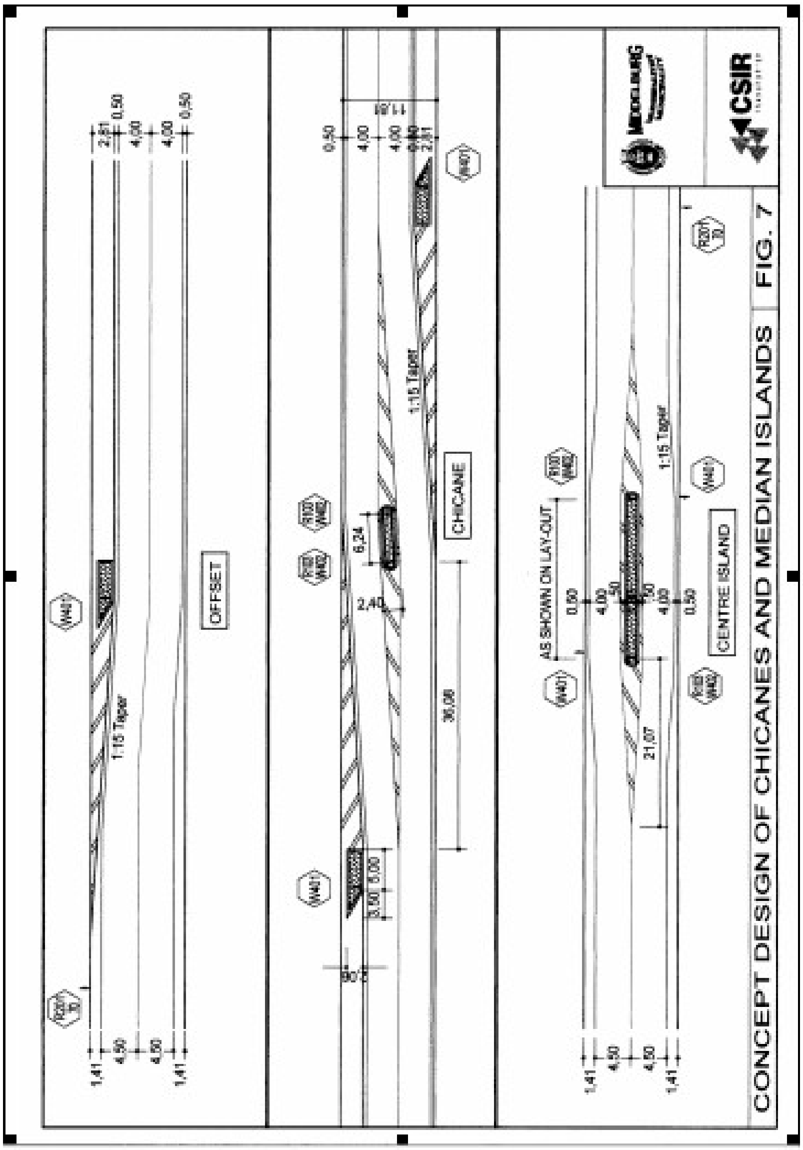


Figure 7.

7. DESIGN FEATURES OF THE TRAFFIC CALMING MEASURES

The median islands and chicanes were designed consistent with a 80 km/h design speed. Tapers of no less than 1:15 were used and lane widths of 4 metres or wider were maintained. Painted shoulders of no less than 0,5 metres were used. The typical designs of the median islands and chicanes are shown on Figure 7.

8. SPEED, NOISE AND VOLUME OBSERVATIONS AFTER THE INTRODUCTION OF THE TRAFFIC CALMING MEASURES

Table 2 below summarises the characteristics of vehicle speeds as observed on weekdays in February 2001, March 2002 and October 2002.

Table 2. Comparison of speed observations before and after the traffic calming.

	February 2001	March 2002	October 2002
Average Speed (km/h)	85,1	76,8	61,6
85th Percentile Speed (km/h)	113,0	95,0	75,8
Standard Deviation of Speed (km/h)	26,0	18,4	17,9

It is clear that the desired effect of reducing speed has been achieved. This is also clear when Figure 8 is compared to Figure 4. It would, nevertheless, still be desirous to have the speeds, which has an 85th percentile above the speed limit, even lower.

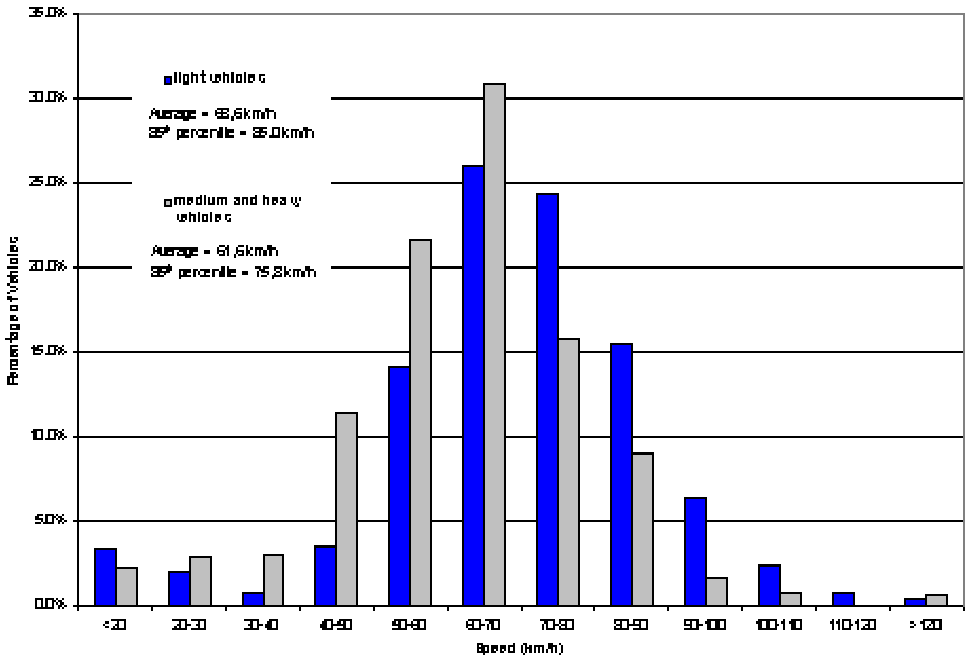


Figure 8. Percentage of vehicles in speed classes – Weekday October 2002.

Table 3 below shows the estimated noise levels through a weekday and a Sunday , based on the speed characteristics observed in February 2001, March 2002 and October 2002 and also shows the values for Districts b) and d) from SABS 0103,1994.

Table 3. Noise values before and after the traffic calming and SABS guidelines.

Time of Day	Noise level; adjusted for building line and 1,8m garden wall (dBA)			SABS 0103 for District b (dBA)	SABS 0103 for District d (dBA)
Weekday	**February 2001**	**March 2002**	**October 2002**		
00:00 - 06:00	49,1	48,1	47,3	40	50
06:00 - 07:00	55,4	54,6	54,0	50	60
07:00 - 08:00	55,4	54,8	54,2	50	60
08:00 - 09:00	55,1	53,9	53,1	50	60
09:00 - 16:00	52,6	51,9	51,1	50	60
16:00 - 17:00	55,0	54,4	53,7	50	60
17:00 - 18:00	52,6	53,1	52,8	50	60
18:00 - 20:00	52,3	52,4	51,4	45	55
20:00 - 00:00	49,5	48,5	48,0	45	55
Sunday	**February 2001**	**March 2002**	**October 2002**		
00:00 - 06:00	44,5	43,2	42,7	40	50
06:00 - 08:00	49,3	49,1	49,1	45	55
08:00 - 11:00	49,3	48,6	48,9	45	55
11:00 - 16:00	49,7	49,1	49,0	45	55
16:00 - 18:00	50,3	49,9	50,1	45	55
18:00 - 20:00	48,3	47,8	48,0	45	55
20:00 - 22:00	47,1	47,0	46,8	45	55
22:00 - 00:00	43,6	43,5	43,1	45	55

The decreases in noise levels reflected by the numbers expressed in decibels level A (dBA) may not appear to be significant. It should however be considered that these are on a logarithmic scale. A decrease of noise level by 1,5 dBA (e.g. from 49,5 to 48,0 dBA or 52,6 to 51,1 dBA) reflects a decrease of more than 40% in actual noise intensity.

SABS 0103: 1994: the Code of Practice for the measurement and rating of environmental noise with respect to annoyance and to speech communication provides a Table 2 (an extract is given below) with typical ambient noise levels for six types of districts. Under normal conditions of traffic and human activity, and in the absence of abnormal extraneous noise sources like a nearby airport or railway line, the indicated ambient noise levels would be expected for each specified period, when evaluated over the full period.

Taking cognisance of Tafelberg Road, the values given for district type (d would be expected in the adjacent residential properties (without any specific traffic noise screening). In the complete absence of a road like Tafelberg Road, where only local residential traffic would be experienced in the area, the values for district type (b would be expected.

Extract from SABS 0103:1994, Table 2: Typical rating levels for outdoor ambient noise in districts, in dBA relative to 20 x 10^{-8} pascal			
Type of district	**Day-time**	**Evenings, Weekends**	**Night-time**
a) Rural districts	45 dBA	40 dBA	35 dBA
b) Suburban districts with little road traffic	50 dBA	45 dBA	40 dBA
c) Urban districts	55 dBA	50 dBA	45 dBA
d) Urban districts with some workshops, with business properties, and with main roads	60 dBA	55 dBA	50 dBA
e) Central business districts	65 dBA	60dBA	55 dBA
f) Industrial districts	70 dBA	65 dBA	60 dBA
NOTES 1. Day-time: 06:00 to 18:00 Evening: 18:00 t0 24:00 Night-time: 12:00 to 18:00 Weekends: Saturday 12:00 to 18:00 Sunday 06:00 to 18:00 2. If the measurement time interval is considerably shorter than the reference time intervals, significant deviations from the values given in the table may result.			

7. ACCIDENT DATA

Some accident data were available. Accident frequency and variation in type were such that it was not possible to relate accidents to any specific character of the road. In general, it can be stated that speed reduction and measures to capture driver attention (e.g. channelisation) work positively towards reducing accident frequency and specifically severity.

8. VISUAL INSPECTION

The following were observed during site inspections in October 2002 and March 2003.

- There was some slight damage to almost all traffic signs mostly apparently being hit by overhangs of heavy vehicles. The signs damaged were mostly on the median islands at the eastern end, where median is on a curve.
- The signs on the centre islands and chicane islands in the middle portion had the less damage, except for the island signs at the low point in the road section, presumably where speeds are the highest.
- There were no damage, and very little tyre marks, on the kerbing forming the chicane and median kerbing, indicating that the design standards are appropriate.
- Some signs appeared to be damaged but closer inspection showed that these were installed skew!
- The kerbstones were painted red and white instead of the preferred black and white.
- In some cases old paint markings were painted over with black instead of being scratched off. This can be expected to cause future problems.
- Where old paint lines were scoured out, the debris was not removed completely, but left on the surface, partly obscuring painted islands.

The conclusion is that this type of traffic calming, as all types of traffic calming, requires extraordinary attention to design and standard of implementation, as well as more than the regular maintenance of signs and markings.

9. CONCLUSIONS

It is concluded that the measures implemented were successful to reduce speeds, encourage relative constant speeds and "removing" excessively high speeds. This positively reflected on reducing noise levels.

The amount of damage to signs is disconcerting. Consideration may be given to using smaller signs and increasing widths of painted shoulders, which will require narrower lanes e.g. 3,5 metres wide.

Average and 85^{th} percentile speeds are, however, still higher than would be desired.

The effect of visible enforcement, even if only perceived as such by drivers has been clearly illustrated. It is also recommended that speed checking be increased and automatic, continuous and visible speed checking, which has been effective in several places in the country and internationally, be seriously considered.

The known concept, namely that traffic calming measures require meticulous attention to detail in design, attention to correct implementation, and more extensive maintenance efforts than other signs and markings, was clearly illustrated.

10. ACKNOWLEDGEMENTS

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