SPEED MANAGEMENT IN TRANSITION ZONES BETWEEN HIGH-SPEED RURAL AND LOW-SPEED URBAN AREAS

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ABSTRACT

The study was performed on an existing national road in the Eastern Cape, South Africa. The R336 is a surfaced single carriageway two-lane two-way road starting at km 0.00 at the intersection with the R75. The study extends from the 16.75 km marker west of Kirkwood, up to the intersection with the R335 in Addo. The length of road assessed in the case study is 31.5 km and passes through 3 distinct urban areas namely Kirkwood, Sunland and Hermitage. The road is sign posted for 100 km/h in the rural areas and 60 km/h in the urban areas. Local residents reported severe accidents and complained of speeding in the urban areas.

A literature study was conducted on how road authorities, engineers and planners have dealt with similar challenges. The case study's safety concerns and mitigation measures then analyzed the best methods of reducing the speed approaching and within urban areas. Finally, recommendations were discussed as to the effectiveness of the case studies proposed mitigation measures as to how speeds can be reduced. The important conclusion was made that a motorist must be made aware that they are within an urban area. This was achieved by implementing the following in all three towns:

- The urban cross section was adjusted.
- The road surface width was reduced through the urban section.
- A kerbed side walk on one or both sides of the road was used to create the sense of the urban area.
- High visibility signage was used on all the transition zones.
- Raised pedestrian crossings were kept to a minimum and placed in strategic locations.

1. INTRODUCTION

South Africa, as in many developing countries, has frequent small urban areas situated along rural road corridors. Rural roads are designed for their high mobility to get across South Africa's vast open areas as well as accessibility to the local communities. The TRH 26 Road Classification and Access Management Manual (COTO, 2012) sets out the local ideal standards. There is despite the guidelines a constant debate over balancing mobility and accessibility how to retrofit higher standards to the legacy of poor planning. Care must be taken to manage transition zones between high and low-speeds on approaching these rural settlements. The subject is substantial and aspects of spatial development, master planning through to road design are all crucial factors which should be considered. This study focused on the transition zone between high-speed rural areas and low-speed urban

areas. The transition zone is defined as a section of road that connects a road with a high posted speed limit to a road with a lower posted speed limit where drivers need to adapt the speed they are travelling. The transition zone should not be considered as a specific point along a roadway were a speed change is to occur, but rather a length of roadway (Torbic, 2012).

The paper is based on a case study to analyze these transition zones. The case study was performed on an existing national road in the Eastern Cape, South Africa. The R336 was proclaimed a National Route in June 2016, prior to that it was a Provincial Road serving towns and the citrus industry The R336 is a surfaced single carriageway road starting at km 0.00 at the intersection with the R75. The case study extends from the 16.75 km marker to the west of Kirkwood, up to the intersection with the R335 in Addo, (km 48.2). The length of road assessed in the case study is 31.5 km and passes through 3 distinct urban areas namely Kirkwood, Sunland and Hermitage. The road is sign posted for 100 km/h in the rural areas and 60 km/h in the urban areas. Local residents reported severe accidents and complained of speeding in the urban areas. The case study did not verify these allegations, as the client assumed the claims to be probable and instructed the consultant to focus on the design of counter measures.

The objective of this study was to investigate 5 of the 6 transition zones, entering and exiting the urban areas and propose mitigation measures used to safely reduce and manage the speeds within these zones. The investigation was restricted to this specific case study with defined parameters and care should be taken when using these mitigation measures for other cases. Most of the information was obtained from the visual assessment and observations. The study was performed after the concept and detailed design was completed. The paper starts with a literature study. The study assessed the existing situation at the transition zones to understand the current situation. The study's mitigation measures were then discussed as to their effectiveness for reducing speeds within the transition zones. Conclusions and recommendations are discussed.

2. LITERATURE STUDY

A literature study was performed to find out which mitigation measures produce the best results in reducing speeds as road users entered the low-speed area. It specifically researched the effectivity of using the geometry of the road rather than warning methods such as road sign and markings.

Gilmore (2013) showed that in the USA roundabouts and transverse pavement markings, also known as Control of Speed by Optical Illusion Lines (COSBI) lines, gave the best results in controlling speeds in transition zones. The study only looked at three treatment methods and is thus not a very broad spectrum of treatment methods. The study did show that using roundabouts and transverse pavement markings improved the compliance to the posted speed limit by 15% and 20% respectively.

The focus of Forbes (2011) (USA) was the use of mitigation measures in these transition zones. Different treatment methods were measured on operational benefits, safety benefits, or both. These measures were then used in reporting the effectiveness of each treatment method. The treatment methods were grouped into four categories namely, geometric design, traffic control devices, surface treatments and roadside features.

The outcome of the study was as follows:

- Small, basic treatment methods produce low-speed reduction results in the transition zones.
- Larger and stronger treatment methods produce higher speed reduction results.
- It is important that the roadside's look and feel matches the desired speed in the low-speed area.
- There is no generic solution to all transition zones and each case should be carefully studied in a holistic approach and contextualised within the current environment.
- Care should be taken to maintain the desired speed with complementary measures through the low-speed area.

When using treatment methods on their own in transition zones very little effect was found in lowering speeds in Australia. When using multiple treatment methods together significant effects on speed reduction were found up to 15 km/h. (Turner, 2009).

German research shows that when driving for a period of time at a high-speed, a driver will underestimate their speed when entering a low-speed area and not conform to the lower speed limit. They state that two principles should be considered when designing transition zones (Speed Management, 2006):

- Mitigation measures should be applied cumulatively such that a driver will feel the full effect once they reach the end of the transition zone. This can be achieved by using design combinations such as kerbing, lane narrowing and introduction of trees or other vertical elements. Design and implementation of these vertical elements should be done carefully to not compromise road safety.
- Care should be taken to maintain the desired speed with complementary mitigation measures through the low-speed area.

In conjunction with this study another study was performed looking at the effectiveness of using COSBI lines within transition zones. The results of the study show that average speeds were reduced by between 10 and 15% measured immediately after road marking application and one month later (van der Spuy, 2019).

3. CASE STUDY

3.1 Location and background

The road in the case study is located in the Eastern Cape Province, South Africa, on Road R336 from Kirkwood West (km 16.75) to the intersection with the R335 in Addo (km 48.2). The R336 is a strategic route in the area for two main reasons. The route provides access to one of South Africa's important national parks, Addo Elephant National Park. The route also runs through one of the largest export citrus production areas in the country.

The road passes through 3 distinct urban areas namely Kirkwood, Sunland and Hermitage shown in Figure 1. The existing road is sign posted at 100 km/h in the rural areas and 60 km/h in the urban areas.

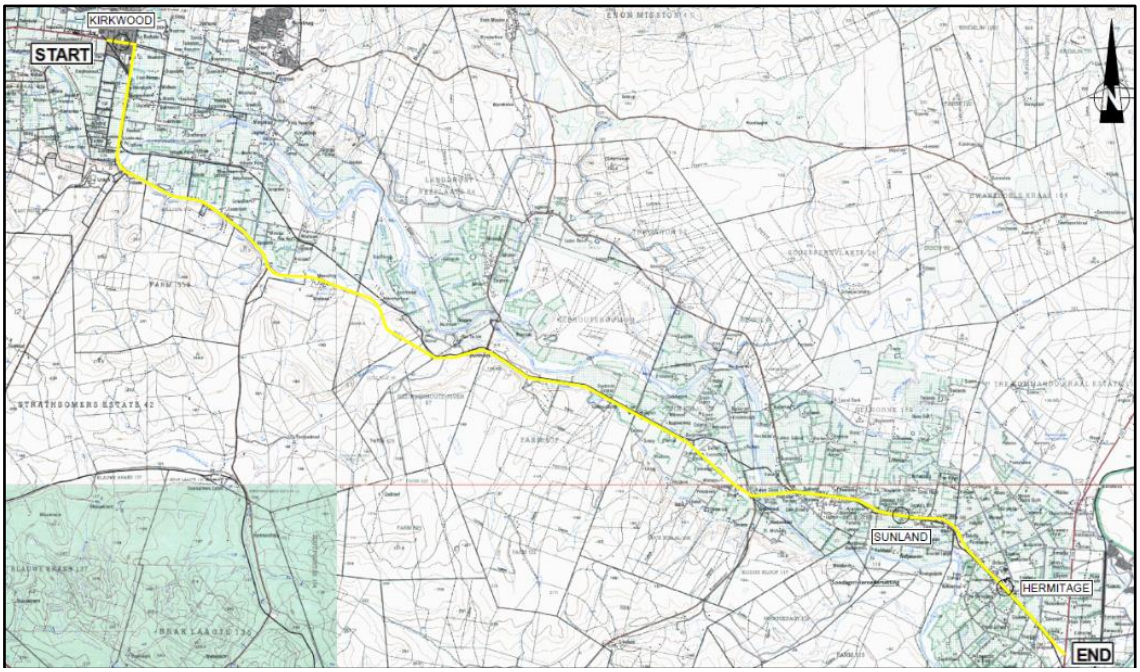

Figure 1: Locality Plan

Following the visual assessment, concept design and detailed design of the case study, the design was assessed to understand how the safety concerns were addressed within the 3 urban areas and their transition zones.

3.2 Kirkwood

Kirkwood, Figure 2, is the largest of the 3 urban areas. The town of Kirkwood is more established and has a more distinct urban edge. This distinct edge allows drivers approaching the town to identify when they are entering the town and inform them of the low-speed area.

The Western approach to Kirkwood was not assessed in detail as it was outside the extent of the case study. When entering Kirkwood from the South, as shown in Photograph 1, a natural transition zone with a distinct change is not as evident with the agricultural land running right up to the edge of the residential area. The adjacent residential area also has lower levels of activity compared to the central business district (CBD) which is situated more to the Western side of Kirkwood and this does not provide the drivers confirmation that they are entering an urban area. The 60 km/h sign is located 500 m before the urban edge on the Southern approach.

The wide road reserve including an open railway line hides the urban edge and does not provide for a natural transition zone. The section of road is straight with a flat grade. This situation leads to the encroachment of the high-speed area beyond the urban edge and before the motorist can reduce their speed they are within the residential area. There is a large access to Sun Citrus Packhouse at the urban edge with slow heavy vehicles turning in and out of the access. A severe accident was reported by the local residents in front of the Sun Citrus access. The accident involved a passenger vehicle colliding with a heavy vehicle turning at the access.

Figure 2: Kirkwood

Photograph 1: Southern Approach to Kirkwood

3.3 Sunland

The town of Sunland, shown in Figure 3, is located 7 km to the West of the R336/R335 intersection at Addo towards the end of the project. Sunland is situated on a 1 km stretch

of the R336 with a Packhouse, school and residential houses in the town, of which the school and the small residential area lie adjacent to the R336. This is the smallest of the 3 towns in the area and the low density and poor definition of the urban area and edges makes it difficult to distinguish between the high-speed rural area and low-speed urban area.

Figure 3: Sunland

Approaching Sunland from the West, Photograph 2, the road is straight with a vertical crest curve hiding the first intersection. There is very little distinction between the high-speed rural area and low-speed urban area. There is a railway level crossing just before the intersection approaching from the West. The 60 km/h sign is located 100 m before the urban edge on the Western approach.

Photograph 2: Western Approach to Sunland

The Eastern approach to Sunland is straight and flat, as shown in Photograph 3. The natural vegetation, wide road reserve including an open railway line hides the urban edge and does not provide a natural transition zone. The short urban area frustrates motorists having to slow down for such a short section of road on their typical longer through journey. The 60 km/h sign is located 200 m before the urban edge on the Eastern approach.

Photograph 3: Eastern Approach to Sunland

3.4 Hermitage

Hermitage is situated just before the end of the project, as shown in Figure 4, 1 km from the R336/R335 intersection at Addo. The town has a micro CBD area of 200 m situated in the middle of the town. Hermitage is slightly spread out over 700 m with isolated pockets of development along the R336. A large Packhouse, school and industrial activities are located in Hermitage.

When approaching Hermitage from the North-West the transition zone between the high-speed rural area and the low-speed urban area is slightly better than the South-East approach. It is still not good but the residential houses are visible as seen in Photograph 4. There is a short distance of 3.5 km between Sunland and Hermitage, therefore the transition zone on the Sunland side of Hermitage and the transition zone on the Hermitage side of Sunland is acceptable as drivers had already gone through a town. The distance between the two towns is such that driver have not become used to traveling at high-speed and may therefore more readily adapt to low-speed. The road is straight and flat leading into the town and there is a railway line inside the road reserve. The 60 km/h sign is located 100 m before the urban edge on the North-Western approach.

Figure 4: Hermitage

Photograph 4: North-Western Approach to Hermitage

The South-East approach to Hermitage seen in Photograph 5 is more deceptive than the North-West approach. It is at the end of the first straight, 1.5 km in length, after turning onto the R336 in Addo. The natural vegetation conceals the urban edge significantly in this zone. The road is straight and flat in this transition zone. A small school is hidden away in this section which creates a very dangerous situation with motorists travelling at high-speeds right past the school. The 60 km/h sign is located 100 m before the urban edge on the South-Eastern approach.

Photograph 5: South-Eastern Approach to Hermitage

4. APPLICATION TO R336

The safety measures which were implemented in the design common to all 3 towns will be discussed followed by the application of the safety measures for each town.

4.1 Common safety measures

An important aspect found in the study was making motorists aware that they are within an urban area and to keep the design measures uniform across the 3 towns. This was achieved by implementing the following:

- The urban cross section was adjusted.
- The road surface width was reduced through the urban section.
- A kerbed side walk on one or both sides of the road was used to create the sense of the urban area.
- High visibility signage was used on all the transition zones.
- Raised pedestrian crossings were kept to a minimum and placed in strategic locations.
- “Welcome to …” signed to create a gateway to the town.

4.2 Kirkwood

The Western approach to Kirkwood was not assessed in the case study. Raised pedestrian crossings were proposed in three locations within the CBD of Kirkwood to maintain the low-speed within the urban area.

One of the most effective measures in reducing speeds in transition zones is to use the road geometrics. A roundabout with a large enough horizontal deflection was proposed in

the case study at the access to Sun Citrus, at the Southern approach to Kirkwood. The following safety measures were implemented:

- The roundabout improved access to the road at this location and lowering the speed in this area.
- High visibility signage.
- COSBI lines.
- Raised speed bump blocks placed on the painted islands. Example illustrated in Photo 6.

Photograph 6: Raised Speed Bump Blocks Example

All the safety measures were used in combination within the transition zone to warn motorists and reduce the speed as shown in Figure 5.

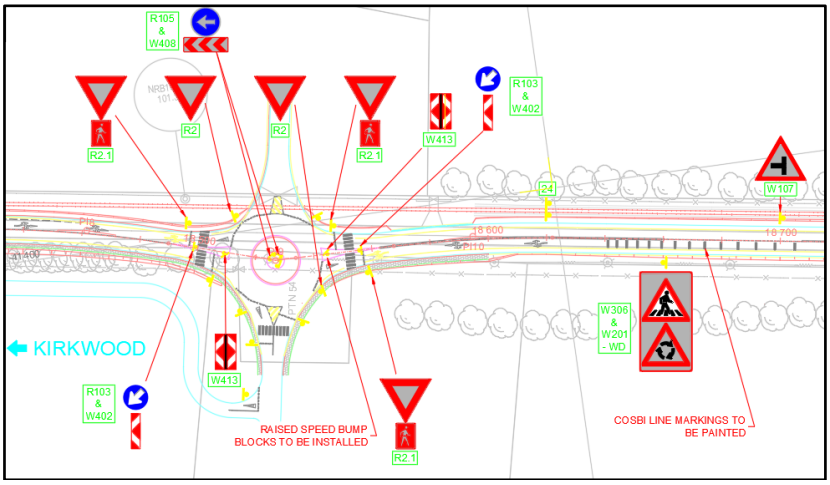

Figure 5: Case Study Transition Zone Safety Measures

4.3 Sunland

The Western approach from Kirkwood to Sunland is a critical approach as the motorist has travelled on a high-speed rural area for over 20 km. An adjustment to the geometry was again proposed in the case study on this approach and the following safety measures were implemented:

- A roundabout.
- High visibility signage.
- COSBI lines.
- Raised speed bump blocks placed on the painted islands.

The safety measures were all used to create a similar and uniform effect matching the case studies proposals at Kirkwood. A raised pedestrian crossing was proposed in front of the school in the study to protect the children and maintain the speed within the town.

The speeds on the Eastern approach to Sunland is more acceptable as there is only a distance of 3.5 km between Sunland and Hermitage. Only signage was proposed in the Eastern transition zone.

4.4 Hermitage

The North-West approach to Hermitage is similar to the Eastern approach to Sunland as the distance between the two towns is short. Only signs as safety measure in the transition zones were proposed.

The South-East approach to Hermitage is at the start of the R336. The important to set the tone for the entire length of R336 was highlighted in the case study. It was therefore proposed in the case study to adjust the geometry by means of the following:

- A roundabout.
- High visibility signage.
- COSBI lines.
- Raised speed bump blocks placed on the painted islands.

5. CONCLUSIONS

Gilmore (2013), Forbes (2011) and Turner (2009) investigated mitigation measures that were useful in reducing speed within high to low-speed transition zones. These measures provided a starting point for the design of transition zones on the R336.

The R336 case study found that the transition zones are not visible and that drivers end up within the urban area travelling at higher than recommended speeds creating dangerous situations through the 3 towns, Kirkwood, Sunland and Hermitage. Measures were required to be implemented within the transition zones to reduce the speed from the high-speed rural areas to the low-speed urban areas.

6. RECOMMENDATIONS

It was found that the following recommendations within the case study made the largest impact to the reduction of speed within the transition zones at the Southern approach to Kirkwood, the Western approach to Sunland and the South-East approach to Hermitage:

- The urban cross section was adjusted.
- The road surface width was reduced through the urban section.
- A kerbed side walk on one or both sides of the road was used to create the sense of the urban area.
- High visibility signage.
- Raised pedestrian crossings were kept to a minimum and placed in strategic locations.
- A roundabout.
- COSBI lines.
- Gateway signage.
- Raised speed bump blocks placed on the painted islands.

The remaining 3 transition zones namely the Western approach to Kirkwood, the Eastern approach to Sunland and the North-West approach to Hermitage, only high visibility signage were implemented warning motorists of the change in environment.

It is also recommended that more South African research be done on transition zones, that speed measurements be performed before and after implementation of transition zone mitigation measures and that further measurements be performed for at least 2 years after implementation.

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8. REFERENCES

COTO, 2012. The TRH 26 Road Classification and Access Management Manual. South African National Roads Agency, Pretoria.

Forbes, GJ, 2011, NCHRP Synthesis of Highway Practice 412: Speed Reduction Techniques for Rural High-to-Low Speed Transitions. Transportation Research Board of the National Academies, Washington, D.C.

Gilmore, DK, Bauer, KM, Torbic, DJ, Kinzel, CS and Frazier, RJ, 2013, Treatment Effects and Design Guidance for High- to Low-Speed Transition Zones for Rural Highways, Transportation Research Record, 2348(1), pp. 47-57. doi: 10.3141/2348-06.

Speed Management, 2006, Joint Transport Research Centre, Organisation for Economic Co-Operation and Development and European Conference of Ministers of Transport, Germany.

Torbic, DJ, Gilmore, DK, Bauer, KM, Bokenkroger, CD, Harwood, DW, Lucas, LM, Frazier, RJ, Kinzel, CS, Petree, DL and Forsberg, MD, 2012. NCHRP Report 737: Design Guidance for High-Speed to Low-Speed Transition Zones for Rural Highways, Transportation Research Board of the National Academies, Washington, D.C.

Turner, B, 2009. Engineering Based Approaches to Reducing Rural Speed. Australasian Road Research, Policing and Education Conference, Sydney, New South Wales, Australia.

Van der Spuy, J and Schröder, M, 2019. The Effectiveness of Control of Speed by Optical Illusion Lines, South African Transport Conference (Unpublished).