Synergy effect of speed management and development of road vicinity in Wrzosowo

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Abstract. In the era of increasing traffic volumes and traffic calming problems, the challenges that connect a number of related, although at face value independent, issues involving different social groups seem to be fundamental. The fundamental problem in smaller towns and villages is to ensure the road safety at pedestrian crossings on through roads. The domestic and international guidelines of road design recommend introducing traffic calming devices at places where the traffic enters a built-up area and in central zones, to reduce speeds along the road cutting through a village. One solution is to construct traffic calming devices in the entry zones. As a result, one obtains the so-called speed zoning even before a zone directly related to the scattered or dense housing development. The second issue is to apply traffic calming means in the built-up area. It would seem that the task should pose no difficulty and that it should be the responsibility of the road workers. However, research and analysis into the effectiveness of traffic calming devices show that the best effect is obtained through synergistic efforts of road builders, local authorities, urban planners and many other specialists. The example discussed in the paper, a village of Wrzosowo, clearly supports the thesis. The mere application of traffic calming devices may not necessarily bring the expected results. Combined efforts of road builders and urban planners can, however, be successful in the effective control of speed zoning and reduction in some road sections. The paper presents results of speed reduction measurements of a pedestrian crossing on a regional road in an exemplary village. Measurements of road conditions were conducted three times, before the reconstruction, after it and after the introduction of all the elements of traffic calming, as designed by road builders and urban planners responsible for the development of the vicinity of the road. Analysis of results showed that the chicanes constructed in the entry zones to the village, if used alone, did not provide speed reduction along the throughway cutting through the village. It was only a combination of traffic calming devices and elements of road vicinity development that brought about the expected speed reduction, providing better environmental conditions and improved road safety. Conclusions drawn on the basis of the conducted analysis confirm that the location of chicanes, the use of central reservation strip and traffic barriers must be closely linked to the development of the road vicinity and the location of the road signs that inform motorists about the built-up area.

1. Introduction

The dynamic growth of the road transport and increasing traffic congestion result in a diversion of some part of the traffic flow to the secondary roads which are not prepared for that. The advance of civilization and construction of second homes by the sea by city dwellers result in increased volume of traffic in
summer and during weekends. These are some of the reasons for the dynamic increase in the need for upgrading the existing roads, including safety improvement treatments. Let us consider, as an example, the coastal region in Poland and the vicinity of one of the regional roads leading to the seaside. Taking into account the rapid increase in the traffic volume and unsatisfactory condition of the pavement and driving conditions, a portion of regional road DW107 at the village Wrzosowo was upgraded, providing, as a result, a road with paved shoulders which largely contributed to higher speeds of travel. Considering an improved design of the road and higher practicable speeds of travel asymmetric islands have been provided at the village entry transition zones to reduce speeds, in particular in free flow condition. The remaining treatments included a roundabout and channelization of the main intersection. A raised median was provided at the entry to the village from an open area to separate the two directions of traffic.

According to the conclusion of the monograph [1], such simple measures related to infrastructure and handling of traffic should have been combined with environmental, social and last and foremost - urban planning aspects, namely spatial development features along the road. The conclusions of the monograph [1] clearly indicate the need for synergy in this respect and point to its influence on the effectiveness of the applied measures. Without such a combination of different aspects, the expected traffic calming may not be attained. Both the society and the responsible authority can reasonably expect that the traffic calming measures will, as the final effect, improve the safety of traffic, reduce the safety hazards, improve the driving and environmental conditions and, last but not least, bring aesthetic benefits to the locality.

The example of traffic calming project completed in a village in Poland demonstrates the need for and a good effect of collaboration between road engineers, local authorities and urban planners.

2. Assumptions and characteristics of the tested sections

The speed measurements on the section of regional road DW107 running across the village of Wrzosowo were carried out in free and continuous traffic flow conditions and included traffic counting. Specialist measuring equipment was used, equipped with automatic speed and counting data recording function. The measurement data were subjected to statistical analyses to confirm their consistency, distribution type and completeness of the sample. The data passed all the tests at the significance level of $\alpha=0.05$. The measurements were carried out in a few places across the village in order to establish the variation of speed and its expected reduction at three points in time: before upgrading, after upgrading and after installation of roadside features in the central area of the village. Figure 1 presents the traffic control conditions adopted as input for the design of upgrading of regional road DW107 and the desired traffic calming in the village.

![Figure 1. Speed zoning in the village of Wrzosowo](image)
Referring to the suggested conventional zoning scheme presented in [2] a similar scheme was adopted by the authors for Wrzosowo. The location of signs indicated in Figure 1 coincides with the actual chainages on road DW107. Wrzosowo is spatially divided village with its second part called Wrzosowo Osiedle spaced away by over one kilometre from the main part and thus, there is no E-17 sign on the right-hand side of the drawing which reflects the real situation.

In accordance with the guidelines [2] and [3] if there is a high amount of pedestrian traffic in the surrounding area speed restriction to 50 km/h should be applied along the road leading to the central area of the village. In Wrzosowo in the surrounding area there is a mixed use path spaced from the roadway DW107 edge by ca. 6 m and, with no transverse pedestrian traffic, different speed restrictions have been applied. Conversely, the central area of the village features scattered buildings, the concentration of transverse pedestrian traffic in the central intersection area, as well as near shops, post office and other public buildings. For this reason, speed restriction to 40 km/h posted on speed limit sign B-33 was applied on a short section. Since the value of 85th percentile speed \(v_{85}\) was much above the 50 km/h speed limit (default speed limit for built-up areas) in the next step of the upgrading project additional speed reducing measures were applied, namely safety barriers installed between the B-33 signs on either side of the street. This explains the need to carry out the speed measurements in three successive periods.

3. Synergy of speed controls and features along the road
One of the several traffic calming treatments applied in upgrading of road DW107 on the section across Wrzosowo were chicanes with asymmetric semi-circular islands, 6 m wide and ca. 40 m long installed in the entry transition zones (Figures 2 and 3).

![Figure 2. Chicane on the lane coming from Dziwnówek](image1)
![Figure 3. Chicane on the side of the second part of Wrzosowo Osiedle](image2)

Figure 4 presents the schematic of the situation after upgrading and implementation of traffic calming treatments in Wrzosowo. The single carriageway road with two traffic lanes was upgraded to a road DW107 with paved shoulders which extend almost to the small roundabout when driving from Dziwnówek and up to the first buildings in the village when driving from Wrzosowo. In addition to the chicanes, a small roundabout (with \(D_r=28\) m external diameter) was provided on the road DW107 in the central area of the village, accompanied with corner islands combined with pedestrian crossings and 170 m long raised median island in the exit zone, reaching up to the second chicane provided at the entry from Wrzosowo Osiedle. In the final stage, post-and-chain barriers were installed on both sides of the street in the central area of the village having a total length of almost 400 m.
Figure 4. Schematic of the situation after the road DW107 upgrading project in Wrzosowo

The synergy of upgrading, new traffic management and installation of roadside features turned out to be very dynamic and effective as the desired speed reduction in free flow condition was achieved only when alteration of the road geometry was combined with traffic calming treatments, change of traffic controls combined with alteration to spatial arrangement and installation of post-and-chain barriers. This speed reduction covered both the 85th percentile speed (Figure 5) and average speed (Figure 6).

Figure 5. Profiles of $v_{85}$ speed before and after upgrading on the section of regional road DW107 in Wrzosowo
Figure 6. Profiles of $v_{av}$ speed before and after upgrading on the section of regional road DW107 in Wrzosowo

From the data presented in the diagram (Figure 5) we can see that improvement of driving conditions on the road DW107 (construction of paved shoulders - Figure 4) stimulated the increase of speed $v_{85}$ of traffic incoming from Dziwnówek. On the other hand, chicanes, roundabout, channelizing of traffic, alteration of traffic controls (including, in particular, placing B-33 signs limiting the allowable speed to 40 km/h) contributed to a considerable decrease of $v_{85}$ on the section in the central area of the village. This speed was further reduced by post-and-chain barriers installed on 400 m long section in the central zone. However, with so many traffic calming measures in place, the value of $v_{85}$ on the section across the village still exceeds the speed limit posted on the B-33 sign.

Conversely, these traffic calming measures have considerably reduced the average speed (Figure 6) on the section of regional road DW107 across Wrzosowo and the roadside features provided in the central zone have yet reduced the average speed in free flow condition down to the allowable speed posted on the speed limit sign B-33. This allows us to conclude that owing to synergy the combined effect of the road upgrading, alteration of traffic controls and roadside features installation contributed to a considerable speed reduction on the section of the regional road DW107 within the village limits.

4. Analysis of speed reduction in the entry transition zone of village Wrzosowo (Dziwnówek-Wrzosowo Osiedle lane)

Taking account of different speed restrictions posted on B-33 signs in the approach zones from the two directions, separate detailed analyses were performed for each direction of traffic. On the lane from Dziwnówek to Wrzosowo, there are E-17 and D-42 signs placed ca. 370 m downstream of the installed chicanes No. 1 and the centre of the small roundabout is spaced by as much as 550 m from the chicanes axis. The residential buildings start effectively from the small roundabout and the road is lined with footpaths on both sides. Pedestrian safety fences are provided at the edge of footpaths starting 90 m from the roundabout and the median islands and pedestrian refuges are spaced away from the roundabout by as much as ca. 210 metres. The above mentioned roadside features and spatial arrangement of the village are the main determinants of speed reduction obtained on the DW107 section across Wrzosowo in the final effect.
Figure 7 presents the percentages of the respective speed ranges before upgrading. From these data, we can see that in the central area of the village only 18% of the drivers drove within the default speed limit for built-up areas (50 km/h). Moreover, on the approaches to the central area this speed was considerably exceeded by ca. 94-97% drivers.

![Percentage of actual speeds of travel on the Dziwnówek-Wrzosowo Osiedle lane](image)

**Figure 7.** Percentages of the actual speeds of travel on the Dziwnówek-Wrzosowo Osiedle lane

The results of measurements carried out on the lane from Dziwnówek to Wrzosowo Osiedle after upgrading (Figure 8) show that a considerable speed reduction was obtained with 71% of drivers reducing their speed of travel at the entry to the central zone, i.e. after passing the roundabout to within the default speed limit for built-up areas (50 km/h) and not exceeding it until reaching the second new installed chicane. Conversely, as much as 94% of the drivers considerably exceeded this limit on the approach to the central zone after passing the first chicane. Such a high percentage of speeds exceeding 50 km/h is attributed to the construction of paved shoulders being the primary cause, with a secondary role played by the big distance from the chicane to the roundabout (550 m) and to the built-up area sign D-42 (370 m).
Figure 8. Percentages of the actual speeds of travel after upgrading (Dziwnówek-Wrzosowo Osiedle lane)

Exceeding the speed limit by as much as 29% of the drivers can be most likely attributed to the long driving distance from chicane No. 1 to the roundabout. Therefore, in accordance with the guidelines [2] and [3] the spatial arrangement of the village and the road vicinity were altered by installation of post-and-chain barriers (Figure 9) which limit the space available to drivers and positively force them to keep within the default speed limit for built-up areas (Figure 10).

Figure 9. Alteration of the spatial arrangements and vicinity of the road by installation of post-and-chain barriers and channelizing of the central intersection
Figure 10. Percentages of the actual travel speeds on the Dziwnówek-Wrzosowo Osiedle lane after installation of post-and-chain barriers

5. Analysis of speed reduction in the entry transition zone of village Wrzosowo (Wrzosowo Osiedle-Dziwnówek lane)

The driving conditions, traffic controls and spatial arrangements of the village and the road vicinity are quite different in the other direction of traffic. On the approach from Wrzosowo up to B-33 speed limit sign reducing the allowed speed to 40 km/h the road is lined with fields on both sides and residential buildings are can only be seen at a distance. The village skyline is well visible, yet without any access to buildings from the road DW107, it does not have the slow down effect on the drivers. Moreover, the D-42 sign located 70 m upstream of the centreline of chicane No. 2 with no visible building having access from the road only increases the driver's confusion. Before upgrading the speed limit was exceeded by all the drivers on the approach to the central zone (Figure 11) and the causes of this situation include the above-mentioned factors. In the central zone, the percentage of drivers exceeding the limit speed of 50 km/h dropped sharply to 64%.
Figure 11. Percentages of speeds below and above 50 km/h before upgrading

After installation of the chicanes and the median island with the total length of ca. 170 m (Figure 12) only 27% drivers exceeded the speed limit of 50 km/h in the central zone which number increased to 44% at the exit from the central zone. On the other hand, paved shoulders installed during upgrading did not have the slow down effect since 97% of them considerably exceeded the speed limit of 50 km/h at chicane No. 1 (on the exit lane from Wrzosowo to Dziwnówek) which can be explained by the presence of D-42 and B-33 signs displaying 70 km/h speed limit.

Figure 12. Percentages of speeds on the Wrzosowo Osiedle-Dziwnówek lane
For a more detailed presentation of the percentages of speeds after installation of post-and-chain barriers on both sides of the road see Figure 13. Installation of barriers, on its own, has reduced the number of drivers exceeding the speed limit of 50 km/h to 20%. This still high percentage of speeds above the limit is attributed to a lack of buildings on the right-hand side of the road when heading to the central zone and placement of the B-33 sign (40 km/h) not earlier than right at the first residential buildings. Thus, with the built-up area sign D-42 placed ca. 70 m upstream of chicane No. 2 and with a lack of residential buildings over a 210 m long section, the drivers slow down in the last moment, i.e. when they spot the B-33 sign (40 km/h).

![Figure 13. Percentages of the actual travel speeds on the Wrzosowo Osiedle-Dziwnówek lane after installation of post-and-chain barriers](image)

The situation with the lack of buildings downstream of chicane No. 2 when driving from Wrzosowo Osiedle to the central zone is presented in Figure 14 and a satellite image of the analysed village and forest area is presented in Figure 15. The analysis of the existing features to the right of the road DW107 at chicane No. 2 shows a presence of a forest rather than scattered or dense housing which the driver would expect having seen the built-up area sign D-42. This situation, accompanied with a wide paved shoulder on the approach to chicane No. 2, results in only a slight reduction of speed across the chicane. This is because the driver does not expect any direct safety hazard associated with buildings, such as cars or pedestrians suddenly entering the carriageway, etc. With a large forest to the right of the road, the D-42 sign becomes ineffective in getting the driver slow down.
Figure 14. Surroundings of road DW107 at chicane No. 2 when driving from Wrzosowo Osiedle with no visible buildings to the right that would make the driver slow down

Figure 15. Google Earth Pro satellite image of Wrzosowo and its vicinity [4]

6. Conclusions
The analysis of results obtained in this research, as presented in 4 and 5 above, allows us to draw the following conclusions regarding the synergy of the combination of speed controls and alteration of the road vicinity:

1. Planning of traffic calming treatments aimed at speed reduction on roads passing through villages should include consistent and comprehensive analyses of a variety of aspects as only in this way their effectiveness can be multiplied by synergy and the required speed reduction becomes a fact.
2. For the traffic calming project to be a success interdisciplinary approach is indispensable, integrating various areas of transport, spatial development, environmental and social expertise as this is the only way to improve the functionality of the applied treatments and obtain effective speed reduction.
3. Planning of traffic calming treatments should include detailed analyses of their location and function while paying attention to features located in the road vicinity.
4. Careless placement of signs, especially the built-up area sign, placed where it is, cannot be associated with actual buildings, makes the drivers question the reliability of the information displayed on signs imposing speed limits.

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