Effectiveness of Road Chicanes in Access Zones to a Village at 70 km/h Speed Limit

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Abstract. The development of motoring has increased life quality and pace. As a result, not only cities but also smaller towns and villages with roads face transportation challenges. The fundamental problem in smaller towns and villages is to ensure road safety at pedestrian crossings on through roads. The guidelines of road building recommend to introduce traffic calming devices at places where traffic enters a built-up area, to reduce speeds at the entry of a city or village. Chicanes curve the trajectory of traffic and consequently cause speed reduction. The authors conducted a series of speed measurements in free and continuous traffic flow conditions on major local roads with different types of road chicanes. For each case, additional data regarding road characteristics in the vicinity of a chicane were gathered, including the contour of the town visible while approaching the chicane, the distance from the chicane to the nearest buildings in the village, how visible the road continuity behind the chicane was, developments of the greenery and the type of traffic arrangement used. The paper analyses road sections with 70 km/h speed limit before the chicane, as on B-33 road sign. For comparison purposes, speed measurements were also conducted at the entry to the village, where although no chicanes were built, there was B-33 road sign with the speed limit of 70 km/h. The comparative tests aimed at determining whether drivers reduce speed when they see the road sign, because of the chicane or following another determinant. Comparative analysis showed that given B-33 sign (which introduces 70 km/h speed limit) at the entry zone to the town, drivers’ speeds significantly exceed 70 km/h in free traffic flow. Even in continuous traffic flow, speeds usually oscillate around 70 km/h. The speeds are significantly lower behind the chicane. The maximum reduction of speed at the entry to the village was achieved for other determinants recorded in the study, including a clearly visible silhouette of the village, closely located houses, a horizontal curve behind the chicane with limited visibility of the further section of the road. >90% of motorists behind the chicane drive with speeds <70 km/h. At the entry zone which was an open space, with a well visible silhouette of the village, with the chicane approximately 200 m away from the nearest houses or at the entry zone covered with forest and poor visibility of the built-up area, 70-77% of motorists behind the chicane drive with speeds <70 km/h. If the access to the town is preceded by a long stretch of straight road section, with poor visibility of the silhouette of the village, only approximately 50% of drivers enter the village with speeds <70 km/h. Depending on the determinants recorded in the study, motorists in most cases exceed 70 km/h and enter the village with much greater speeds if there is no chicane.

1. Introduction
The on-going growth of the motor vehicle use, while leading to an improved quality and a faster pace of life, causes also increasing transport problems which are not limited to big cities but are also an issue
of concern in smaller towns and villages located on the road network. The key challenge in smaller towns and villages is ensuring the safety of traffic along the through roads. In Denmark fourteen traffic calming treatments that have been developed for use in towns and entry transition zones [1]. Application of these treatments has become since then an obligatory requirement in many countries. In accordance with the above-mentioned road design guidelines it is also recommended to implement traffic calming treatments in the transition zones aimed at reducing the speed of traffic right at the entry to a town or village. One of traffic calming treatments recommended for use in the entry transition zones are chicanes which deflect the driving path, thus making drivers reduce their speeds. The German guidelines [2] relating to road chicanes include the results of tests which confirm the relationship between the attainable speed reduction and chicane offset depth.

Bearing this in mind, in this research speed measurements were carried out on the sections of regional roads entering villages where various chicanes were implemented in the entry transition zones, accompanied with speed restriction to 70 km/h posted on the B-33 sign. The tests covered three types of chicanes (Figure 1): 2.00-2.14 m wide asymmetric rectangular/ curved centre islands, 2.00 m wide asymmetric rectangular centre islands and 2.00 m wide symmetric rectangular centre island.

2. Assumptions and characteristics of the tested sections

Speed measurements 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 analysis to confirm their consistency, distribution type and completeness of the sample. All the tests were passed at the significance level of \( \alpha = 0.05 \). The measurements were carried out upstream and downstream of the chicane with the purpose to check the approach speed and determine the attainable speed reduction in the village entry transition zone. For the sake of comparison in a few situations speed was also measured upstream of villages where speed limit posted on the B-33 sign was the only traffic calming treatment. In these cases, the travel speed was measured upstream of the entry sign E-17 and downstream of built-up area sign D-42, i.e. within the built-up area limits. The entry sign E-17 and built-up area sign D-42 were spaced by ca. 50 m. Sign B-33 was typically accompanied by sign D-42.

In order to eliminate the effect of the pavement condition on the speed of travel the test sections were the sections of regional roads that were thoroughly upgraded in the recent years, including renewal of pavement and installation of chicanes. The pavement condition on all the test sections was rated as “very good”. Considering that the roads were upgraded in the recent years the pavement markings and the traffic signs were assumed to be in a very good condition. This ensured consistency of the total population with the differences between the test sections limited to the presence or lack of chicanes,
terrain conditions and traffic controls. This paper analyses the results of tests conducted on sections with speed restricted to 70 km/h on the speed limit sign B-33.

According to the guidelines [3] and [4], if the value of 85th percentile speed $v_{85}$ is much above the speed limit of 70 km/h other traffic calming measures should be implemented (including signage, supervision) instead of further reducing the maximum allowed speed. This was one of the main reasons to install various chicanes in the village entry transition zones. This said, there are a number of other factors which must be considered when selecting the chicane type and location, such as apparent horizontal deflection of the route, disappearance of route sections, offsets of the route in the visual field. The purpose of these recommendations is to implement zoned speed limitation on the sections passing through smaller towns and villages.

Referring to the suggested conventional zoning scheme presented in [3], [4] a similar scheme was adopted for the tested section which is presented in Fig. 2. The siting of the road signs presented in Figure 2 is indicative and generally refers to sections without chicanes where E-17 and D-42 signs are, as a rule, spaced away. On the test sections analysed in this paper the E-17 and D-42 signs are located differently in relation to each other: in some cases they are placed together, in other spaced away. The same applies to their location in relation to the installed chicane, as presented in Tables 1 and 2. Table 1 gives the parameters of the test sections listed in the order of decreasing speed $v_{85}$ upstream.

![Figure 2. Speed zoning scheme on the analysed test sections](image_url)

The findings made during the research included different locations of chicanes in relation to the E-17 and D-42 signs, different views of the village skyline upstream of the chicane and different locations of the nearest buildings in relation to chicanes, as well as different driving conditions related to the road curvature downstream of the chicane limiting the view of the road ahead and different features along the road (such as forest, row of trees or open area on the approach section). The analysis of the results shows that these can be significant determinants which (Table 1), together with speed restriction posted on speed limit sign B-33 and chicane installation, can be crucial to obtaining the required speed reduction. The additional data on the analysed test sections are presented in Table 2.
Table 1. Characteristic features of the test sections which can be significant determinants of speed reduction in the final effect

| No | Test section | Speed distribution parameters, km/h | Features along the road | Determinants | Traffic controls |
|----|--------------|-------------------------------------|-------------------------|--------------|-----------------|
|    |              | before | after | \( \Delta v \) | Rooftop geometry | Distance from the chicane centreline in metres in upstream (+) and downstream (-) directions |
| 1  | Jarzysław 2  | \( v_{85} \) | 103.0 | 97.2 | 5.8 | yes | 2200 | – | 0 | 0 |
|    |              | \( v_{av} \) | 89.6  | 86.8 | 2.8 | – | – | 2200 | – | 175 | -35 |
|    |              | \( v_{av}^{pp} \) | 89.0  | 85.4 | 3.6 | – | – | 2200 | – | 175 | -35 |
| 2  | Krosino 1    | \( v_{85} \) | 101.1 | 87.4 | 13.7 | – | – | 1800 | left curve | 100 | -90 |
|    |              | \( v_{av} \) | 92.7  | 71.2 | 21.5 | yes | yes | 1800 | right curve | 100 | -90 |
|    |              | \( v_{av}^{pp} \) | 88.9  | 65.1 | 23.8 | yes | yes | 1800 | right curve | 100 | -90 |
| 3  | Bielkowo 1   | \( v_{85} \) | 86.5  | 84.2 | 2.3 | – | yes | 1400 | – | 0 | 0 |
|    |              | \( v_{av} \) | 71.4  | 69.5 | 1.9 | – | yes | 1400 | – | 0 | 0 |
|    |              | \( v_{av}^{pp} \) | 71.8  | 70.2 | 1.6 | – | yes | 1400 | – | 0 | 0 |
| 4  | Jarzysław 1  | \( v_{85} \) | 84.9  | 75.4 | 9.5 | yes | yes | 2100 | right curve | 100 | -90 |
|    |              | \( v_{av} \) | 73.1  | 61.0 | 12.1 | yes | yes | 2100 | right curve | 100 | -90 |
|    |              | \( v_{av}^{pp} \) | 72.3  | 61.1 | 11.2 | yes | yes | 2100 | right curve | 100 | -90 |
| 5  | Iwięcino 1   | \( v_{85} \) | 78.8  | 78.2 | 0.6 | yes | yes | 1400 | left curve | 120 | -80 |
|    |              | \( v_{av} \) | 69.7  | 62.8 | 6.9 | yes | yes | 1400 | left curve | 120 | -80 |
|    |              | \( v_{av}^{pp} \) | 68.7  | 61.3 | 7.4 | yes | yes | 1400 | left curve | 120 | -80 |
| 6  | Iwięcino 2   | \( v_{85} \) | 77.3  | 74.3 | 3.0 | yes | yes | 2200 | left curve | 100 | -115 |
|    |              | \( v_{av} \) | 67.3  | 63.6 | 3.1 | – | – | 2200 | left curve | 100 | -115 |
|    |              | \( v_{av}^{pp} \) | 66.4  | 62.0 | 4.4 | – | – | 2200 | left curve | 100 | -115 |
| 7  | Uniemyśl     | \( v_{85} \) | 76.5  | 73.4 | 3.1 | – | – | 550 | right curve | 105 | -87 |
|    |              | \( v_{av} \) | 68.3  | 64.5 | 3.8 | – | – | 550 | right curve | 105 | -87 |
|    |              | \( v_{av}^{pp} \) | 65.8  | 64.8 | 1.0 | – | – | 550 | right curve | 105 | -87 |
| 8  | Dębostrów 1  | \( v_{85} \) | 74.0  | 67.0 | 7.0 | yes | yes | 700 | left curve | 35 | -150 |
|    |              | \( v_{av} \) | 66.3  | 59.1 | 7.2 | yes | yes | 700 | left curve | 35 | -150 |
|    |              | \( v_{av}^{pp} \) | 65.4  | 58.3 | 7.1 | yes | yes | 700 | left curve | 35 | -150 |
3. Analysis of speed reduction in village entry transition zones depending on the volume of traffic

The driving conditions directly influence the relationship between the speed of travel and the traffic density. Taking this into consideration a comparative analysis was carried out for the obtained speed reduction depending on the recorded traffic density in the village entry transition zone. The analysis of the data presented in Figure 3 showed that reduction of certain speed distribution parameters in free flow and continuous flow conditions does not depend on the traffic density. The same speed reduction values were observed for different traffic densities. Moreover, different speed reduction values were noted on two different test sections with the same traffic densities. On this basis, the authors have excluded the traffic density from determinants to be considered for analysing the speed reduction effect in the village entry transition zones.

![Figure 3](image)

**Figure 3.** Differences in the speed distribution parameters depending on the density of traffic on the test sections with 70 km/h speed limit posted on the B-33 sign

4. Analysis change of speed on the approach to the transition section to village, where posted 70 km/h speed limit

As the next step the next determinant was analysed, namely the type of chicane with probable and expected effect on the magnitude of speed reduction. The test sections included three types of chicanes, as specified above. For the sake of comparison, the analysis covered also the results from two test sections where the only treatment was speed restriction to 70 km/h posted on the B-33 sign. The purpose of this comparison was to check if speed reduction in the village entry transition zone is to be attributed solely to the traffic sign B-33 or does the chicane play some role in it and whether the chicane type is relevant. The results of the performed analyses are presented in Figure 4.

From Figure 4 it can be seen that reduction of speed $v_{85}$ varies and different values of $\Delta v_{85}$ obtained for the same chicane show that it does not depend on the chicane type. Also average speed reductions in free flow traffic conditions are not proportional to differences in $\Delta v_{85}$. This confirms the initial hypothesis that there must be some other determinants influencing the estimated reduction besides the speed limit sign B-33 and the chicane (of the same type in all places). Besides, some anomalies were observed, such as a smaller value of speed reduction $\Delta v_{85}$ in Iwięcino where chicane was installed (designated Iwięcino 2 in Figure 4), as compared to two sections without chicanes. Focusing solely on the level of speed reduction we see that it was effectively attained only on the following three test sections: Bielkowo 1, Krosino 1 and Iwięcino 1.
The greatest reduction of $v_{85}$ speed in free flow condition was obtained with asymmetric rectangular centre island. However, on the remaining three sections provided with the same chicane type the value of $\Delta v_{85}$ was much smaller or there was no speed reduction at all. Conversely, in transition zones (Jarzysław 2) with B-33 sign as the only traffic calming treatment the speed reductions were slightly higher or comparable. Small speed reduction noted on section 2 Jarzysław 2 (as compared to section 1 Jarzysław 1) can be attributed to poor visibility of the several buildings located there which can be discerned through shrubs no sooner than after passing the entry sign E-17 (Figure 5).

This is quite different from the situation on the approach to the village of Bielkowo 1 (Figure 6). In this case the greatest speed reductions were noted. Approaching the chicane, the driver acts sensibly by reducing the speed of travel across the chicane from where he/she can see very close buildings of the

Figure 4. Speed reductions on the test sections with different chicane types (speed limit posted on traffic sing B-33 70 km/h)

Figure 5a. Jarzysław village skyline (test section Jarzysław 2)

Figure 5b. Jarzysław village skyline (test section Jarzysław 1)
village, winding street ahead, footpath along the street and has poor visibility of the road section ahead of the left curve. These determinants, together with the speed limit posted on the B-33 sign and the installed chicane effectively and considerably reduce all the three speed distribution parameters (Figure 4).

Figure 6. Bielkowo village skyline (test section Bielkowo 1)

Conversely, on the Iwięcino section which offers good visibility of the village skyline, a minimum value of $\Delta v_{85}$ was noted, with much greater reductions of both average speeds. This disagreement of speed reduction values results, most probably from the fact that in free flow condition the driver sees a relatively long section of the road ahead and E-17 and D-42 signs located at a distance while the following drivers see only the village skyline (the E-17 and D-42 signs are not visible to them).

Figure 7. Iwięcino village skyline (test section Iwięcino 2)

When analysing the efficiency of speed reduction and/or considering the traffic calming related issues one should consider both the 85th percentile speed $v_{85}$ in free flow condition and average speed $v_{av}$ in continuous flow condition. Also relevant are the percentages of drivers that reduced the speed of travel over the transition zone chicane below the speed limit posted on the B-33 sign. In this respect the authors analysed the percentages of speeds in free flow condition both upstream (Figure 8) and downstream (Figure 9) of the chicane.

From the percentages presented in Figure 8 we can see that the approach speeds on regional roads vary over a wide range. According to the guidelines [4] when the value of $v_{85}$ is much above the speed limit posted on the B-33 sign (Figures 4 and 8) and the village skyline is visible when approaching the transition section or there are buildings along the road in view there is a very high probability of considerable speed reduction irrespective of the type of chicane used. Conversely, with the value of $v_{85}$ not higher than the speed limit posted on the B-33 sign the attainable speed reduction is unfortunately small.

However, for the purpose of assessing the efficiency of chicane it is important to evaluate the percentages of the speeds of travel measured right before the village entry (Figure 9), i.e. right after sign D-42 location. In this case the siting of chicane in relation to sign D-42 (Table 2 and Figure 9) turns out to be quite important. In combination with speed limit sign B-33, entry sign D-42 placed ca. 80-150 m after the chicane centreline, visible village skyline and visible nearest buildings we get the percentage of speeds of below 70 km/h approximating or exceeding 75%. If the first buildings of the village can be
spotted from the chicane location the percentage of speeds below 70 km/h can increase up to more than 90% (Figure 6 and 9).

Table 2 gives more detailed determinants which, probably in combination with the applied speed restriction (speed limit of 70 km/h posted on the B-33 sign) and the installed chicane, contribute to the attainable speed reduction.

**Table 2.** Characteristic features of the test sections which in the final effect can significantly influence the effectiveness of chicanes in attaining the required speed reduction in the village entry transition zones

| No. | Test section | Determinants | Signs |
|-----|--------------|--------------|-------|
|     | Development features | Geometry | Signs |
| 1   | Jarzysław 2 | Visibility of individual buildings or urban features (footpaths) and of the village skyline | Limited forward visibility; curve types | Information on entering a built-up area (entry sign E-17 or built-up area sign D-42, upstream, within or downstream of chicane) |
|     | | Open space upstream of chicane | | |
|     | | Thick vegetation in chicane area | | |
|     | | Curved section downstream of chicane | | |
|     | | Horizontal curve | | |
|     | | Visibility limitations | | |
|     | Individual buildings near the road | | |
|     | Village skyline | | |
|     | Farmland | | |
|     | No. 35 0 -35 -35 | | |
| 2   | Jarzysław 1 | Very poor visibility | | |
|     | – – yes Farmland | | |
|     | – – 0 50 0 – – | | |
| 3   | Krosino 1 | Very poor visibility | | |
|     | – – Tak | | |
|     | 175 – – -35 -35 | | |
| 4   | Uniemyśl | Very poor visibility | | |
|     | – – Forest | | |
|     | left – 100 – – -115 -115 | | |
| 5   | Iwięcino 2 | Numerous buildings in view | | |
|     | yes yes Farmland | | |
|     | left – 120 – – -50 -80 | | |
| 6   | Iwięcino 1 | Numerous buildings in view | | |
|     | yes yes Farmland | | |
|     | right – 100 – – -55 -90 | | |
| 7   | Dębostrów 1 | – – – Forest | | |
|     | yes right low visibility 105 – – -31 -87 | | |
| 8   | Bielkowo 1 | Numerous buildings in view | | |
|     | yes yes Farmland | | |
|     | right yes 100 13 – – -90 | | |
| 9   | Bielkowo 2 | Numerous buildings in view | | |
|     | yes yes Farmland | | |
|     | right yes 35 – – -120 -150 | | |

Key to designations: Highlighted in bold are the determinants which in the authors’ opinion contribute to speed reduction across the chicane in combination with the posted speed limit and the chicane, i.e. result in obtaining ca. 70% (Figure 9 – section Iwięcino 1 and 2, Uniemyśl 1 and Dębostrów 1) or ≈90-95% (Figure 9 – section Bielkowo 1 and 2) of speeds below 70 km/h.
Figure 8. Percentages of speeds below 70 km/h and above 70 km/h on the approach to the transition section depending on the chicane type and for the 70 km/h posted speed limit

Figure 9. Percentages of speeds below 70 km/h and above 70 km/h on the transition section behind chicane, depending on the chicane type and for the 70 km/h posted speed limit

5. Conclusions
The analysis of results obtained in this research as presented in 4 above allows us to draw the following conclusions regarding the speed reduction efficiency of chicanes:

1. The type of chicane installed in the village entry transition zone, namely with asymmetric rectangular or rectangular/curved or symmetric rectangular centre island, accompanied with speed restriction to 70 km/h posted on the speed limit sign B-33 has no significant effect on the speed reduction variation.

2. The greatest speed reduction in free flow condition in the village entry transition zone with 70 km/h posted speed limit can be expected when 85th percentile speed $v_{85}$ recorded on the
approach to the transition zone is much above the speed limit and the village skyline and the first buildings appear when approaching the chicane and the village.

3. If the chicane is followed by a left curve and the visibility of the road ahead is limited one should expect speed reduction of approximately 15-20 km/h.

4. In designing the traffic calming treatments in the village entry transition zone attention should be paid to accurate placement of the chicane and the associated E-17 and D-42 signs which are important and significant factors that in combination can increase the percentage of speeds below 70 km/h up to over 75%.

5. The remaining determinants, i.e. visibility of the village skyline and of the individual buildings located near the road, location and type of horizontal curve in the close vicinity of the road, presence or lack of features along the road (i.e. open space or shrubbery hiding the buildings from view or forested area) are, however, as important in engineering and speed management analyses. This is because the above-mentioned determinants can, in combination with the speed restriction posted on the speed limit sign B-33 and the installed road chicane, effectively reduce the speeds in the village entry transition zones and thus result in calming of traffic. Note, however, that the effect of chicanes, especially narrow as in the cases analysed in this research, is limited in space and they must be accompanied with other traffic calming treatments placed ahead, i.e. in the central zone of the village in order to ensure obtaining the planned and expected travel speeds of vehicles across the village.

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