Effect of Traffic Calming Measures Implemented on the Approach to the Tempo–30 zone on the Degree of Speed Reduction

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Abstract. Tempo–30 zones are implemented primarily to calm the traffic by reducing the operating speed to the desired level of 30 km/h. To this end, various traffic calming measures are installed. With the purpose to determine the traffic calming measures that are the most effective in terms of speed reduction speed measurements were conducted on a few chosen Tempo–30 zone approach sections containing various traffic calming measures: traffic circles, raised junctions, speed tables, speed bumps/ humps and horizontal deflections on raised junctions. Another factor differentiating the sections chosen for the research was the Tempo–30 zone entry feature, such as a mini roundabout or a simple or signalled junction. The measurements were carried out under free-flow traffic conditions during peak hours. During all the measurements the weather was dry and such was the pavement surface. The 85th percentile speed $v_{85}$ and the average speed were calculated. For simultaneous measurement on the respective measurement points P1, P2, … Pn SR4 electronic speed and traffic volume measuring systems equipped with automatic recording function were used. The measurement data were analysed and the results show that the obtained operating speeds were below 30 km/h (that is below the maximum permitted speed in Tempo–30 zone) only on a few sections. The most sustained speed reduction effect was obtained on two research sections containing several vertical traffic calming measures, including raised junctions, speed tables or speed bumps/ humps. The effectiveness in speed reduction was ascertained for combined use of different traffic calming measures imposing vertical and horizontal deflections of the vehicle paths of travel. However, the most effective arrangement was a series of vertical traffic calming measures provided on the Tempo–30 approach section. Conversely, a mini roundabout, traffic circle or signalised junction at the entry to the Tempo–30 zone had only a minor speed-reducing effect. The same applies to repeated small horizontal deflections on the approaches to raised junctions.

1. Introduction

The ever growing volumes of traffic in urban result in growing problems related to the capacity of the road system, road safety, increased noise and air pollution. A number of solutions have been widely used in different west European countries and they can be copied by large cities management bodies. They include, without limitation, closing chosen streets to vehicular traffic, one-way working [1, 2, 3, 4], implementation of Tempo–30 zones [5, 6], woonerf [7] and shared spaces [8].
In Poland Tempo–30 zones are one of the most commonly used solution to cope with the problems related to handling of vehicular traffic. Tempo–30 zones are designated with B-43 and B-44 upright signs and calming of traffic is their primary function. Although they can be provided with various woonerf and shared space features, they do not classify as either of them. In downtown areas Tempo–30 zones are expected to increase the safety of traffic, reduce noise and air pollution from vehicle exhausts. Improvement to parking arrangements and enhanced appearance are other benefits. Also important is reduction of the speed of travel resulting from the installed traffic calming measures. The available traffic calming measures are specified and described in different national guidelines [2, 3, 4], including information on their speed-reducing effect. However, they are not sufficiently specific in defining the treatments should be used at the entry to the Tempo–30 zone in order to immediately bring down the speed of vehicles entering the zone to the desired level right at the beginning of the zone area.

Considering this, the author carried out speed surveys on a few chosen Tempo–30 approach sections to verify the effect of the applied traffic calming measures on the operating speeds and to identify those which have the desired traffic calming effect at the entry to Tempo–30 zone and bring down the speed to the desired level. This paper presents the results of speed surveys carried out on five Tempo–30 zone approach sections that had been provided with different traffic calming measures. The hourly traffic volume was similar on all the sections under analysis. The width of travel lanes are the same on all sections and slightly different are only the footway widths and character of buildings.

Each tested section started with a street element of a different type, namely: a traffic circle, speed table, raised junction and a mini roundabout provided as Tempo–30 zone entry treatment and with a signalled junction in the last case under analysis. HGV and coaches were allowed to enter only two of the tested sections: one with a mini roundabout and the other with a signalled junction at the entry.

2. Method and summary of results
The speed measurements were carried out during peak hours, i.e. 12:00–14:00 using SR4 traffic detection devices [9] for simultaneous recording the speeds of travel and traffic volumes on all the test stations sited along the test section. The hourly traffic volume on the five sections was ca. 450 veh./day. A smaller value was obtained only on one sections provided with speed tables. A few more stations were chosen per the test section with the purpose to verify the performance of the installed traffic calming measures. In each case, the stations were located before and after the traffic calming treatment in question. Thus, the number of test stations, numbered P1, P2, ..., Pn depends on the number of traffic calming devices installed on a given section. At least a hundred (100) speed measurements were taken per test station and per direction of traffic.

The speed data were divided into traffic directions to calculate the 85th percentile and average speed values. Each population of data was subjected to statistical processing, including normality, homogeneity and outlier tests and also independence and median tests. In all cases the statistical tests yielded positive results, confirming normal distribution and reliability of data for further analyses. The independence and median tests performed for the data recorded on the subsequent test stations confirmed independence of the two analysed populations. The values of 85th percentile and average speed for the five test sections are compiled in Table 1.

3. Results and discussions
Test section 1 included the greatest number of different traffic calming measures (Figure 1 and Figure 2). On this section traffic circle was provided as the entry treatment, followed by the raised table of staggered T-junction. The junction table ends with a speed hump (Figure 2). There is another traffic circle located ca. 20 m down the street.
Table 1. Speed distribution parameters obtained from the test data, km/h

| Test section                          | Parameter | Subsequent test stations along the Tempo–30 entry section |
|---------------------------------------|-----------|----------------------------------------------------------|
| Test section No. 1 starting with a traffic circle | \( v_{85} \) | 30.1 21.8 19.7 20.0 24.2 25.5 29.8 27.8 35.3 |
|                                       | \( v_{av} \) | 25.9 19.1 17.7 15.1 19.2 21.8 26.1 23.5 31.2 |
| Test section No. 2 starting with a speed table | \( v_{85} \) | 32.5 30.3 20.6 17.6 34.0 38.6 – – – |
|                                       | \( v_{av} \) | 26.9 25.7 16.0 13.9 28.0 26.3 – – – |
| Test section No. 3 starting with a raised junction | \( v_{85} \) | 44.3 35.2 35.8 29.3 29.7 29.7 – – – |
|                                       | \( v_{av} \) | 38.6 27.8 30.6 25.1 24.4 24.9 – – – |
| Test section No. 4 starting with a mini roundabout | \( v_{85} \) | 43.6 41.8 33.1 41.5 45.8 – – – – |
|                                       | \( v_{av} \) | 37.2 29.9 26.4 35.5 34.6 – – – – |
| Test section No. 5 starting after signalled junction | \( v_{85} \) | 47.4 45.2 42.5 38.7 – – – – |
|                                       | \( v_{av} \) | 42.0 38.1 37.4 31.4 – – – – |

The values in bolds in cells with blue background are below the Tempo–30 speed limit.

Figure 1. Aerial view of the test section No. 1 starting with a traffic circle

Figure 2. Speed hump at the end of raised junction table

Considering irregularity of variation of the analysed speed distribution parameters given in Table 1 non-typical bar graphs turned out to be more useful in further analysis to present the percentage of a given speed range estimated before and after the traffic calming treatment in question (Figure 3). Figure 3 includes, beside the graph, a diagram showing the sequence of the test stations and the traffic calming measures to clarify their locations. The data in Figure 3 were analysed and the raised junction table, ended with a hump, the former elevated 7 cm and the latter 14 cm above the adjacent pavement surface, (Figure 2) turned out be the most efficient among the analysed speed management devices.

A smaller speed-reducing effect was noted at the traffic circles. The percentage of speeds in excess of 30 km/h was small yet still in the range of 6–17%. The most efficient speed management device was the speed hump at the end of raised junction table (Figure 2). The percentage of speeds in the range up to and including 20 km/h was very high in this case, falling in the range of 85%–92%. Speeds in excess of 30 km/h were not noted in the raised table area. All the drivers slowed down to below the Tempo–30 speed limit.
In the second test section, the Tempo–30 entry treatment comprised two 14 cm high speed tables and one 7 cm high speed bump (Figure 4). Instead of a ramp a chamfered kerb was installed as the speed table end treatment (Figure 5), making the drivers considerably reduce the speed in order to avoid sudden change of elevation. The Tempo–30 zone entry is located on a road section with ca. 3% longitudinal gradient. This had a bearing on exceeding the permitted speed by the drivers entering the Tempo–30. Considering a sudden change of elevation before and after the speed table, speed limit 20 km/h signs were placed before both speed tables. The two speed tables are spaced by ca. 50 m and the speed bumps is located 70 m further down the road.

The percentages of the speed ranges in consideration, estimated before and after each of the respective traffic calming measures are presented in Figure 6. In addition, there is a diagram in Figure 6 showing the sequence of the test stations and the traffic calming measures to clarify their locations. The data in Figure 6 were analysed and the speed tables turned out be the most efficient speed management devices, so effective in making the drivers slow down that none of them exceeded the speed limit of 30 km/h on the approach to the first speed table. On the approach to the second speed table...
table 97% drivers did not exceed 20 km/h. On the approach to the speed bump 83% drivers did not exceed 20 km/h. Right after the speed tables small percentages of vehicles, namely 20–30% travelled faster than 30 km/h.

Figure 6. Percentages of speed ranges on the respective test stations sited on the test section No. 2 at the entry to Tempo–30 zone with speed table as the entry treatment

The traffic calming measures located in the third test section include a raised junction, elevated 7 cm above the adjacent surface, followed by a 7 cm high speed bump located 5 m away and a choker located ca. 50 m further down the road (Figures 7 and 8). The percentages of the speed ranges in consideration, estimated before and after the traffic calming measures are presented in Figure 9. In addition, there is a diagram in Figure 9 showing the sequence of test stations and traffic calming devices. The analysis of the speeds measured at the respective test stations sited along the test section No. 3 yielded fifty-fifty division of speed ranges on the approach section to the speed bump. The drivers tend to slow down just before the bump where 89% of all speeds were below 30 km/h. This percentage did not change up to the approach to choker. Conversely, quite considerable changes were noted on the section preceding the Tempo–30 entry sign. On this section, right after the mini roundabout (with 30 m central island diameter) 95% of vehicles travelled faster than 30 km/h. The split into the analysed speed ranges occurred as the vehicles approached the signs marking the entry to Tempo–30 zone (Figure 9).

Figure 7. Aerial view of the test section No. 3  
Figure 8. Choker on the test section No. 3
Also on the test section No. 3 vertical traffic calming measures proved to have the greatest speed-reducing effect.

![Figure 9](image)

**Figure 9.** Percentages of speed ranges obtained at the respective test stations sited on the test station No. 3 at the entry to Tempo–30 zone with raised junction as the entry treatment

The fourth test section at the entry to Tempo–30 zone starts after a mini roundabout with 30 m central island (Figure 10). At a distance of 120 m from the carriageway edge of the mini roundabout a raised junction with the table raised 14 cm above the adjacent surface had been installed as a traffic calming treatment. The junction table is raised over the length of 86 m. This portion of the pavement is surfaced with cobblestone pavers. The triangular ramp having a gradient of 1:15 is surfaced with natural stone blocks arranged in alternating lighter and darker stripes (Figure 11). In the analysed case the opposing traffic flows are separated with a traversable median, surfaced also with cobblestone pavers. Two pedestrian crossings are located there. Before and after the raised junction the median flares out to accommodate splitter islands. The splitter islands located at the mini roundabout and at the raised junction provide a small horizontal deflection of the travel path (Figure 11). The percentages of the speed ranges in consideration, estimated before and after the respective traffic calming measures are presented in Figure 12, together with a diagram showing siting of test stations and the locations of traffic calming measures, including entry lane horizontal deflection treatment.

According to the percentages of the speed ranges in consideration obtained from the measurements taken on the test section No. 4 (Figure 12) there is no significant speed reduction on the deflected section of the street following the exit from the mini roundabout. On the mini roundabout exit section 86% drivers travelled faster than 30 km/h. Speed reduction was noted no sooner than on the horizontally deflected section along the splitter island and further on, along the bus lay-by where this percentage dropped to 30–40%. However, just before the raised junction the drivers tended to accelerate again. Further on, within the raised junction the percentages of speed ranges varied depending on the numbers of pedestrians crossing the street and vehicles turning at the junction (Figure 12).
A 50 m long raised junction with cobblestone surface was provided also on the test section No. 5 (Figure 13). The test section is entered after leaving a signalled junction. The raised junction entry ramp is located ca. 114 m from the junction exit. The speed distribution was largely influenced by the signal phase, determining the speed of most of the vehicles entering the Tempo–30 zone. On the section leading to the raised junction there is an bus lay-by adjacent to the traffic lane (Figure 14). The opposite traffic lanes are separated with P-21 hatched area pavement marking.

With only one traffic-calming treatment provided on this section, only four test stations were sited there. The percentages of the speed ranges in consideration, estimated before and after the respective traffic calming measures are presented in Figure 15, together with a diagram showing siting of the test stations. The percentages of the speed ranges in consideration obtained from the measurements taken on the test section No. 4 (Figure 15) allow us to conclude that a signalled junction preceding the entry
to Tempo–30 zone did not have any speed-reducing effect since 100% of vehicles entered the Tempo–30 zone travelling faster than 30 km/h. On the section leading to the raised junction only a minor portion, namely 13% of vehicles travelled at a speed below 30 km/h. On the other hand, as much as 46% of drivers slowed down to below 30 km/h on the raised junction section between the two pedestrian crossings (Figure 15).

![Figure 13. Aerial view of the test section No. 5](image1)

![Figure 14. Raised junction, 50 m long, elevated 14 cm above adjacent surface](image2)

![Figure 15. Percentages of speed ranges measured on the test stations sited on the test section No. 5 at the entry to Tempo–30 zone starting after signalled junction](image3)

4. Conclusions
Considering the above-presented speed distributions obtained on the five test sections we can state that speed reducing effect at the entry to the Tempo–30 zone can be obtained by using various speed control treatments, both vertical, designed to change the road surface elevation and horizontal, designed to
deflect the path of travel. This said, the most effective traffic-calming treatment before the entry to the Tempo–30 zone were the devices changing the road surface elevation.

However, speed reduction was not significant if these treatments were used alone and this irrespective of their length – 50 m or 86 m in the cases under analysis. Only when combined with a speed hump/bump at the end they do influence the drivers’ perception, making them slow down. Speed humps must be engineered with a great care, considering all the aspects related to change of the road surface elevation. One must bear in mind that excessive difference of elevation over a short length may cause scraping of the undersides of cars passing through the hump and, besides, premature deterioration of the hump itself, as it can be seen very clearly in Figure 2.

A traffic circle or mini roundabout were found to have only a small speed-reducing effect. In the analysed case the length of influence of traffic circle was particularly small. A mini roundabout with exit leading to the Tempo–30 zone did not reduce speeds of travel to the desired level of 30 km/h, i.e. the permitted speed. Also horizontal deflections on the section leading to the raised junction had little effect, since on average 40% of drivers exceeded the speed limit of 30 km/h there.

A signalled junction before the entry to the Tempo–30 zone was found to be ineffective either, since the drivers tended to slow down no sooner than at the raised junction.

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