Respecting a speed limit and its effectiveness in a traffic calming zone

Jan Kempa

1University of Science and Technology in Bydgoszcz, Poland

Abstract. The purpose of the study was to test the level of respecting the speed limit by drivers of vehicles in a traffic-calming zone that was not formally designated, located in a part of an old city in a middle of the Polish city. Due to the historic assets in that location, the applied means of traffic calming included only legal-organizational means, i.e. local speed limit signs. The analysis was carried out of vehicles speed in selected measuring sections; next, the level of respecting speed limits by drivers was determined. The results proved that just installing the speed limit signs at entrances to zones or at priority to the right intersections are insufficient to obtain the required speeds. The tests revealed that in all tested sections, drivers exceeded the speed limit of 30 km/h. An average speed varied from 32.1 km/h to 37.1 km/h, with the 85% quantile of speed amounting from 36.1 km/h to 42.7 km/h. A large percentage of drivers who exceed the speed limit was recorded, which was from 35% to 90%. The lowest percentage of drivers exceeding the maximum speed was recorded in sections where the surface was made of cobblestone (only 10%). This stemmed from the fact that in order to obtain the driving comfort, the drivers were forced to reduce the speed significantly. The results of tests show explicitly that in order to obtain desired traffic conditions from the safety perspective, it is necessary to apply physical means of traffic calming that force drivers to reduce speed. Such measures should include: an adjustment of the traffic corridor geometry in a general layout, narrowing a lane, speed bumps, raised speed tables at intersections, and raised pedestrian crossings. The applied traffic calming measures, including but not limited to areas that are subjects to the conserver’s supervision, should meet high functional, engineering, and visual standards, and be a harmonious part of the historic surrounding.

1. Introduction

The problems of applying speed limits on Polish roads have always been a subject of heated debates, primarily among road users, traffic engineers, road and traffic managers, state and local government authorities, persons involved in road education, driver instructors, etc. This issue occurs regularly in various social media, in particular in the context of major road accidents or transport disasters that involve fatalities. Hazards in traffic are also a topic of numerous social campaigns aimed at promoting safe transport behaviours, including but not limited to driving with safe speeds and effects of their exceeding.

The purpose of this study is to present selected results of research that concerns respecting local speed limits by drivers of vehicles in a traffic-calming zone that was not arranged, i.e. the effectiveness of traffic organization measures only. The zone is located in the centre of a large city (with a population of almost 400 thousand), in its oldest part, i.e. the Old City. Due to the very high
intensity of pedestrian and cyclist traffic and the necessity to raise the sense of safety among unprotected road users, the road manager decided to introduce a traffic-calming zone in this part of the city. The geometry of the street system in the analysed area of the city has existed for a few hundred years, and when creating the zone, a decision was taken not to change it. Neither was the zone provided with equipment or structural means of traffic calming. It was assumed that the spatial development and its characteristics (e.g. old, often historic and dense developments) as well as standard vertical markings would automatically influence the driving way and style of drivers. Therefore, it is quite interesting from an engineering point of view to see how fast drivers will drive in the zone that is fitted with only local speed limit signs (this type of limit applies to drivers up to a location of a sign that revokes the limit). Is it enough to fix such signs, or will it be necessary in the future to erect structural traffic-calming measures that force drivers to move with desired speeds and thus to provide the adequate level of traffic safety?

Importantly, ‘traffic calming is a planning concept that has had a major impact on developing spatial structures and transport systems in urbanised areas at the end of the 20th and beginning of 21st centuries’ [1]. Traffic calming is to be understood as ‘methods aimed, using various measures (referred to as baffles), at calming traffic that goes through a town, resulting in the reduction of accident figures. The lower number of accidents is the outcome not only of traffic calming, but also of the application of measures that result in emphasizing hazardous points’ [2]. According to the American Institute of Transportation Engineers ‘traffic calming is an attempt at achieving balance between the traffic of vehicles and all other road users: pedestrians, cyclists, entrepreneurs, and local residents’ [3]. According to documents of the European Union, traffic calming is called a process of slowing down traffic that makes a street safer and friendlier to pedestrians, cyclists, and local community life [4]. According to [1]: ‘traffic calming involves ordering and adapting traffic services in the area to their basic functions and functional, cultural, and ecological characteristics. Traffic calming is an organizational, civil engineering, and legal solution, which reduces the burden of traffic by imposing limitations and changing transport services in selected areas, e.g. residential zones areas, city centres, and commercial streets, by waiving the principle of full and free using of car and reducing the level of area penetration by traffic’.

In Poland, a large number of institutions and organizations, both central and local ones, have attributed great importance to road safety. Therefore, it should imply that in numerous areas of Polish cities, towns and other areas, not necessarily urbanised ones, traffic calming zones will dominate as forms of their transport service. There is extensive literature available on this subject, but it is generally based on data and information derived from foreign studies, in particular from Denmark [5] and the Netherlands [6]. Therefore, there is a shortage of domestic studies concerning the effectiveness of introduced traffic calming measures. Consequently, in the course of their designing and developing, urban planners and designers use foreign experiences or own experience and intuition.

2. Characteristics of studied sections
The studied sections (7 in total) located in the analysed zone have been selected in such a way to make sure that they are different in terms of geometry, a type of surface, the number of crossroads, and connected road facilities (car parks) as well as applied traffic organization measures (right of way or priority to the right intersections). The characteristics of the studied sections of streets have been described in Table 1. Moreover, there were stopping restrictions and no parking in all sections and no road markings.

Speed measurements were carried out during a day, from 10.00 a.m. to 2 p.m. Atmospheric conditions: good weather, no wind, dry surface, temperature 10°C. It is noteworthy that traffic volume in streets located in the analysed zone, both in the existing and forecast condition (2035), is not heavy.
and fluctuates from several dozen to several hundred vehicles during rush hours. Traffic volume is illustrated by maps presented in Figures 1 and 2 [7].

The views of selected sections of streets in which speed measurements were carried out are presented in Figure 3. They present the type of developments in the analysed traffic calming zone as well as standard existing road infrastructure elements.

| Section number | Applied traffic calming measure | Normal profile | Width of roadway and type of surface | Traffic organization and section geometry |
|----------------|---------------------------------|----------------|--------------------------------------|------------------------------------------|
| 1              | A bus stop without a bay; 3 priority to the right intersections; an average distance between them ~100.0 m | Two traffic lanes; pavements on both sides | 5.5 m along ~75.0 m 9.0 m along ~125.0 m; asphalt | A single traffic direction; a straight road, ~200.0 m long |
| 2              | Cobblestone surface 5 priority to the right intersections; an average distance between them ~60.0 m | A single traffic lane; pavements on both sides | 5.0 m; granite cobblestone | A single traffic direction; a straight road, ~250.0 m long |
| 3              | 3 priority to the right intersections; an average distance between them ~100 m | Two traffic lanes; pavements on both sides | 7.0 ÷ 7.5 m; asphalt | Two traffic directions; a straight road, ~200.0 m long and a curve, radius 200 m, turn angle ~14° |
| 4              | 3 priority to the right intersections; an average distance between them ~100 m; 2 entrances to and 2 exits from car parks | Two traffic lanes; pavements on both sides | 7.0 ÷ 7.5 m; asphalt | Two traffic directions; a straight road, ~200.0 m long |
| 5              | 2 priority to the right intersections; an average distance between them ~400 m; there are residential buildings close to the roadway and the resulting limited visibility conditions | A single traffic lane; pavement on one side | 4.0 m; asphalt | A single traffic direction; initially a curve (right), radius 55.0 m, a turn angle ~40°, next to a straight section, ~175.0 m long |
| 6              | 4 intersections (1 with the right of priority, the other with priority to the right) an average distance between them ~60 m; an entry to and exit from a car park | Two traffic lanes; pavements on both sides | 8.0 m; asphalt | Two traffic directions; a straight road, ~200.0 m long |
| 7              | 4 intersections (1 with the right of priority, the other with priority to the right); an entry to and exit from a car park; a taxi rank (at a curb) at the beginning of the street, length ~50 m | Two traffic lanes; pavements on both sides | 8.0 m; asphalt | Two traffic directions; a straight road, ~200.0 m long |
**Figure 1.** Traffic volume map – present condition

**Figure 2.** Traffic volume map – forecast condition in 2035
3. The outcome of speed measurements

Speed measurements were conducted with radar and they were arranged and concealed so that they
draw absolutely no attention of drivers and would not make them drive slower than usual. Only
passenger cars driven in free traffic conditions (no jams) were subject to measurements. Based on the
preliminary outcome of speed measurement results, the number of samples was calculated, as
necessary for the purpose of mathematical statistics. The calculation revealed that the sample of
approximately 50 cars fulfilled such requirements; nevertheless, in each measurement section, the
speed of more than 70 vehicles was measured. The values of the examined traffic characteristics are
presented in Table 2.

| Section number | Average speed [km/h] | Standard speed deviation [km/h] | Average speed quantile [%] | 85% quantile speed [km/h] | Share of drivers respecting the speed limit [%] |
|----------------|----------------------|---------------------------------|---------------------------|--------------------------|-----------------------------------------------|
| 1              | 36.9                 | 4.9                             | 55.3                      | 42.7                     | 12.9                                          |
| 2              | 32.1                 | 4.6                             | 73.0                      | 36.1                     | 65.7                                          |
| 3              | 34.6                 | 4.2                             | 58.5                      | 39.1                     | 24.3                                          |
| 4              | 37.1                 | 4.9                             | 52.4                      | 42.2                     | 10.0                                          |
| 5              | 33.2                 | 2.7                             | 55.6                      | 36.9                     | 22.9                                          |
| 6              | 34.9                 | 4.2                             | 66.0                      | 39.8                     | 14.3                                          |
| 7              | 35.9                 | 5.5                             | 59.5                      | 40.9                     | 21.4                                          |
According to the analysis of data given in the above table, in each of the analysed measurement sections, drivers exceeded the speed limit of 30 km/h. The speed was exceeded by most drivers in the section No 4, where only 10% of drivers respected the speed limit, while others, namely 90%, drove faster than 30 km/h. The average speed in this section was also highest and amounted to 37.1 km/h. In the opposite direction (i.e. section No 3), the share of drivers respecting the speed limit amounted to 24.3%, and the average speed was at 34.6 km/h. The above differences may result from the fact that drivers going in section No 3 (the opposite direction to driving in section No 4) drove next to an entry to and exit from a car park, which were about 50 m apart. Many of them took into consideration the hazard of a collision with vehicles leaving the car park and, therefore, reduced not only their speed but drove very close to the roadway centre as well.

In section 1, the percentage of drivers respecting the speed limit was slightly higher than in section No 4 and amounted to 12.9%. An average speed of vehicles in this section amounted to 36.9 km/h. The traffic calming measure applied in this street was a bus stop without a bay. However, it did not force drivers to reduce speed, because the width of roadway (two lanes in one direction) made it possible to avoid a bus without any additional manoeuvres.

In the measurement section No 5 the percentage of drivers who respected the speed limit was 22.9%, while an average speed was 33.2 km/h. Drivers were made to reduce their speed due to a curve in the road plane and the limited visibility conditions that resulted from the location of buildings at the edge of the roadway.

In section No 6, likewise in section No 3, the applied traffic calming measures were a priority to the right intersections as well as an entry to and exit from a car park. According to data analysis, drivers of vehicles who drove along this section respected the speed limit more than drivers driving in the same street, but in the opposite direction (section No 7). In the former instance, the share of drivers respecting the speed limit was at 14.3% (section No 6), and in the latter, it was at 21.4% (section No 7). The difference between average speeds was only 1.0 km/h. In section No 7, drivers took account of the possibility of vehicles leaving a car park and probably this factor made the share of drivers respecting the speed limit higher by more than 7% than in section No 6.

The most effective traffic calming measure proved to be the cobblestone surface in section No 2. The percentage of drivers who drove with speed lower or equal to the speed limit amounted to 65.7%, while an average speed was lowest out of all registered and amounted to 32.1 km/h.

According to the analysis of data from measurements, the percentage of drivers moving with an average speed, which in all studied sections exceeded the value of speed limit, fluctuated from 52.4% to 73% (table 1, column 4).

Table 2 presents also the speeds of vehicles that correspond to the position measurement of the speed distribution, which is used very often in traffic engineering, i.e. 85% quantile. In five out of seven analysed sections, its value was close to 40 km/h or was slightly higher. It can be concluded, in general, that exceeding a speed limit by about 10 km/h is very significant in view of pedestrian safety. According to the Institute of Motor Vehicle Transportation, if a pedestrian is knocked down by a vehicle going at 40 km/h, the probability of fatal injuries is 15% higher than in the event of 30 km/h. There are also documented instances where serious disabilities, and often fatalities, occur as a result of being hit by a car driven at 40 km/h.
It has to be emphasized that before the introduction of the above-mentioned zone, average speeds of vehicles in street sections fluctuated from 38.5% to 47.5 km/h. Therefore, the results indicate that the introduction of the zone did contribute to the speed reduction, although not adequately.

4. Conclusions

The author has chosen to test the level of respecting speed limits by drivers moving in a traffic calming zone within the Old City without special calming arrangements, as a topic of his study. According to the results, the introduction of the zone has contributed to the speed reduction, however not sufficiently. The most effective measure of traffic calming in the analysed calming zone was the cobblestone surface in section No 2. In this measurement section, more than 65% of drivers respected the speed limit of 30 km/h. In other sections, the share of drivers who respected the speed limit amounted from 10% to 24%.

Based on the analysis of study results, it can be concluded that the cause of exceeding the speed limit was the inadequate type of applied traffic calming measures. It has turned out that the installation of speed limit signs alone at entrances to the zone and priority to the right intersections inside the zone was not sufficient to achieve the desired speed reduction. According to the author, first of all, it will be necessary to reduce the width of a roadway or even to narrow down the roadway to a single lane and apply engineering measures that force drivers to respect the speed limit, which is aimed at safeguarding unprotected road users. Moreover, other introduced measures should involve intersections with a raised table, clear marking of exits from car parks (with a different and contrasting colour of the surface compared to the roadway pavement), speed bumps at distances that prevent drivers from reaching speeds above the limit, etc.

It is generally known that to achieve safe traffic conditions, substantial funds have to be committed. However, according to experiences and practice, the volume of such funds is not commensurate to expected effects, i.e. the reduction of the road incident numbers, and primarily their effects, that is the number of fatalities and injuries. The way of arranging and the visual aspects of all the traffic calming zones are not insignificant either. The analysed zone leaves much to be desired in this respect. It is situated in the oldest part of the city. Therefore, not only the historic buildings but also elements of road infrastructure should be the pride of the city.

Experiences in the arrangement of traffic-calming zones in Poland are quite rich. Such zones are more and more commonly built and arranged according to best practices in engineering. Results of Polish research confirm the favourable impact of constructing and operating traffic calming zones on the road safety as well as the improved quality of public spaces, which is very important. Such zones more and more often meet also high functional standards and, equally important, visual requirements. The latter element is of a great importance from the perception of traffic calming zones, in particular among the city dwellers. Residents feel comfortable in well-arranged and visually attractive zones, as they can see and feel that the zone has been created for them. Moreover, it is obvious that such conditions impose on users the duty to behave correctly and responsibly in traffic. A very important measure of traffic calming in the historic zones of cities ‘is to maintain the historic surfaces of streets or to introduce new ones, whose form and material copy the style of historic heritage in the area and raise the value of public space’ [1].

In the historic areas, there certainly are limitations in introducing numerous traffic calming measures. The most commonly used limitations are legal and organizational measures. However, the results of studies show that their effectiveness is quite limited. Numerous new solutions appear which on the one hand, contribute to the major improvement of road safety, and on the other hand, harmonize with the climate of historic parts of the city.
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