

PAPER • OPEN ACCESS

Traffic Calming as a Comprehensive Solution Improving Traffic Road Safety

To cite this article: Andrzej Zalewski and Jan Kempa 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **471** 062035

View the [article online](#) for updates and enhancements.



IOP | ebooks™

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the [collection](#) - download the first chapter of every title for free.

Traffic Calming as a Comprehensive Solution Improving Traffic Road Safety

Andrzej Zalewski ¹, Jan Kempa ¹

¹ University of Science and Technology in Bydgoszcz (Poland), Faculty of Civil and Environmental Engineering and Architecture, Prof. S. Kaliskiego Avenue 7, 85-796 Bydgoszcz, Poland

andrzej.zalewski2205@gmail.com

Abstract. The purpose of the article is presentation of various aspects of improvement of traffic calming solutions on traffic safety and the results of implementations of these solutions. The paper is a review of methods and measures on improving traffic safety. The main implementation criterion of traffic calming solutions to improve the state is often urban traffic safety. Traffic calming solutions significantly reduce the number of accident victims (ie. fatalities and serious injuries). The key to achieving these effects is reducing speed, adjusting speed to street character and function, and transforming road and street infrastructure, which forces to drive slower and improves the quality of the urban environment. The implementation of the area conception of traffic calming is often linked to the process of urban transformation and revitalization of the area. Solutions of traffic calming in Poland in all forms including: zones 50, zones 30-40, inhabitant zones (20 km/h) as well as shared spaces improve the traffic safety, reduce the accident risk and simultaneously improve the environmental conditions of residential areas, promote the increasing of cycling, public transport and pedestrian traffic as well the aesthetics of the urban landscape. The best results bring solutions of traffic calming on the implementation on the transit roads passing through the small cities and in urban centres. The effectiveness of solutions of traffic calming in the aspect of safety must be systematically evaluated, due to their relaxation, because drivers get used to it and increase the speed of travel.

1. Introduction

The idea of calming road traffic combines numerous aspects of the functioning of urbanized areas, including urban planning, transport, road safety (road safety) and social aspects. Traffic calming can be defined as "a solution of organizational, construction and legal nature, reducing the nuisance of car traffic through restrictions imposed on it and changing the transportation service of selected areas, e.g. residential areas, city centres', shopping streets. These activities assume a departure from the principle of full freedom of use of the car and reduce the degree of penetration of the area by traffic." [1]¹. Traffic calming measures may have the character of planning and structural solutions as well as detailed solutions of road elements and traffic organization. By implementing solutions for traffic calming, you can achieve both goals related to improving traffic safety, as well as organizing traffic areas, improving the urban landscape, environmental conditions, facilitating internal transportation"

Traffic calming solutions significantly reduce the number of accidents and their victims. The key to achieving these effects is reducing speed and adapt it to the permitted speed, which in turn should result from the character and function of the street and the transformation of road and street infrastructure that forces drivers to drive slower. Such actions further improve the quality of the urban

¹ Following the definition of O. Gunnarson [1] in an identical way to calm traffic calming, the defined authors of the Integrated Program for Improving Traffic Safety in Poland "Gambit" (1996) [2].



environment. The implementation of the traffic calming area solution is often connected with the process of urban transformation and revitalization of a given area.

The genesis of traffic calming as an urban concept related to the integration of various measures of transport in the street space and activities for the hierarchisation of the road and street system in the town can be found in many urban concepts at the turn of the 19th and 20th century [3], including, among others Neighbourhood Unit of Clarence A. Perry [4], the concept of Cellular Structure of A. Tripp [5]. The origin of the idea of traffic calming is considered to be the independently created: a project of changes the transportation service system of the historical city of Norwich in England elaborated by C. Buchanan [6] and the concept of "traffic replanning" developed at the turn of the sixties and seventies of XX century by the Institute of Urban Planning - Chalmers University of Technology in Gothenburg by the SCAFT group, where it also found one of the first implementations in the downtown area [1]. Both of these pioneering solutions have consisted in changes to the public street network to improve road safety, reduce the nuisance and improve the environment in general. They recommended simple methods of traffic organization, including:

- implementation changes and appropriate division of the street profile,
- disabling transit traffic in relation to the analyzed unit outside by construction of peripheral roads and special itineraries for heavy traffic,
- total or periodic closure of streets for vehicular traffic,
- implementation of special pedestrian routes,
- introduction of bicycle routes,
- priority for public transit,
- organization of the traffic delivery,
- limitation of parking along the curbs.

In 1970, Dutch planners H.G. Vahl i J. Giskes [7] in the Delft in the Netherlands implemented the first solution according to the Woonerf concept. It solution is to be considered the archetype model of the "modern traffic calming", as well as the concept of the first generation of modern traffic calming. This concept quickly became very popular and is now widely implemented. The idea of woonerf, currently considered as a shared space solution, stems from the desire to improve the living conditions of its inhabitants, mainly of downtown large districts and big cities. Functional and spatial forms of traffic calming solutions result from allowed speeds on the streets of various classes. The urban space model of O. Gunnarsson, with supplements by A. Zalewski [8], and also taking into account the permitted speeds is shown in figure 1. Public spaces for road traffic can be divided into:

- pedestrian zone (F) – speed to 7 km/h,
- integrated pedestrian and car traffic zone (F/C) – speed to 20 km/h,
- traffic calming (C) – speed to 30 – 40 km/h,
- integrated traffic calming and through (C/T) - speed to 50 km/h,
- traffic car zone (T) – speed more than 50 km/h.

In 1991, Monderman [9] proposed to extend the idea of woonerf to other functional and technical forms of the traffic zones, as so-called. shared space, in which the segregating elements of traffic participants (such as curbs or horizontal signs) are abolished or minimized, and significant attention is paid to aspects of aesthetics of the transformed street space. According to Zalewski, this applies to both pedestrian and walking zones - cycle routes (7-10 km/h), restricted speed zones 30-40 km/h, as well as environmentally friendly streets (50 km/h). In addition to the functional and technical forms mentioned above, attention should also be paid to the solutions of traffic sequences calmed on non-urban roads (permitted speed up to 60 km/h) and point solutions of traffic calming, including but not limited to: mini, small, spiral and turbine roundabouts.

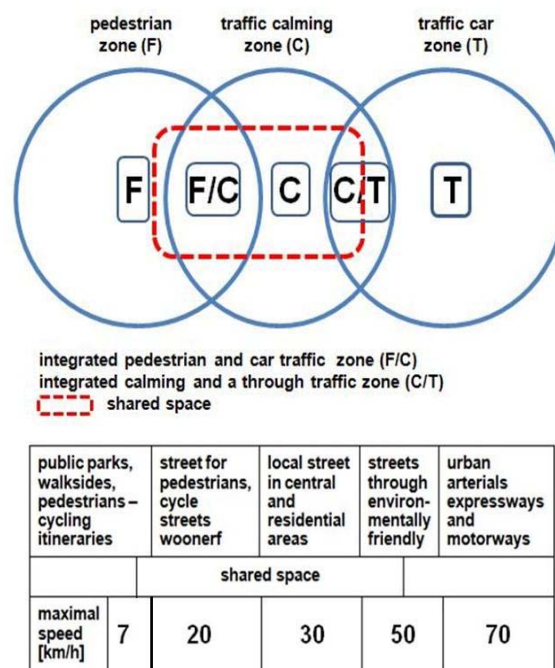


Figure 1. Types of urban space in the city model according to Gunnarsson with supplements by A. Zalewski [8]

Reducing the road traffic safety hazards can be achieved by implementing a variety of technical and organizational solutions, with the key in this aspect being the speed reduction. Traffic calming clearly contributes to the improvement of traffic safety. For example, decreasing the speed from 80 to 40 km/h reduces the risk of fatal pedestrian accident, up 3.3 times, while from 60 km/h (reduction in built-up areas in Poland) to 40 km/h 2.15 times [10]. Traffic safety is improving mainly as a result of reducing the severity of accidents and these are very important data from a social point of view. Lowering the speed reduces the braking distance of the car, which should also potentially improve the traffic safety. The speed limit from 50 to 30 km/h reduces the braking distance from 34 m to 15 m [11]. At low vehicle speed, the angle of view of the vehicle driver is increased, which also improves road safety.

Another important element of traffic safety in traffic calming solutions is the shaping of the road cross-section to prevent vehicle drivers from driving above the permitted speed. At a speed of 50 km/h, it is recommended in countries applying the "tempo 50", for the streets of the basic layout, the width of the lane is 3.0 m, which is 0.5 m lower than recommended in Poland for documents of technical nature and design guidelines [12,13]. An example of taking into account the aspects of safe cross-sectional shape is the solution recommended under German conditions for a speed of 50 km/h, which, due to the width of two-way carriage 6.25 m, creates favourable conditions for two lorries to change, while with a limit of 40 km/h, only the width of the road 5.5 m is sufficient [14].

In order to increase traffic safety in the scale of the whole city in the aspect of traffic calming, it is necessary to implement a modulation of speed on the whole street network adequate to the functional and technical classes of streets, taking into account their location in urban structures. In the adopted on 27.09.2011, The European Parliament Resolution on Road Safety in Europe 2011-2020 (2010/2235 (INI)) [15] states, among others, that "a strong recommendation is required that the responsible authorities set a speed limit of 30 km/h on housing areas and on all single-lane roads in urban areas, which do not have a separate lane for cyclists, in order to better protect weaker road users", and hence one of the forms of traffic calming. The recommendations of the above European Parliament resolution are included in the National Road Safety Improvement Program in Poland [16].

2. Principles for calming traffic in urban space

The following principles should be followed in solutions of traffic calming zones [17, 18]:

- **The principle of safe solutions** - consists in ensuring their functioning, without causing traffic dangers.
- **The principle of elimination (if possible) of traffic unrelated to the area** - consists in limiting the access to a calmed area or road-street itinerary, so that the volume of car traffic reduced to the necessary minimum. This mainly concerns the elimination of oppressive transit traffic (long-distance and local), which absolutely should not penetrate the traffic calming zone.
- **The principle of warning when entering a different character of the area** - consists in such information being given outside the calming zone or at least on its border or the road-street itinerary, so that drivers are timely advised about the need to drive further at reduced speed.
- **The principle of preferences for pedestrian and bicycle traffic, public mass transport (if any) and emergency services.** Preferences should be a viable alternative to implementing on individual car traffic. The preferences for the traffic of emergency vehicles concern the assurance of the passability of calmed streets by these vehicles and municipal service vehicles.
- **The principle of stabilizing vehicle speeds at the desired level** - it consists of such street management, to force drivers to maintain the speed implemented by limitations, without excessive fluctuations, including without sudden braking and acceleration. The implementation of traffic calming management should be homogeneous, from the point of view of the speed being developed, throughout the calmed area or road-street itinerary.

The application of the above principles should ensure safe and efficient operation of the road and street system.

3. The impact of methods and measures of traffic calming on improving traffic safety

The impact of methods and measures of traffic calming on improving traffic safety is one of the basic research fields in traffic engineering. Traffic calming measures have a diverse character and form. They can be divided into three basic groups: legal, organizational and physical. In recent years, a fourth group has been added, the so-called measures influencing the psyche of road users. The first group - legal measures is of fundamental importance as it allows the use of other groups in legal terms. The group of organizational means makes it possible to apply these funds from the point of view of the principles of organization of the street and road network. The third group - physical measures is a form of physical execution of traffic calming objectives, including improving safety by forcing a speed limit of vehicles. On the other hand, the fourth group, i.e. calming measures that affect the psyche, are designed to induce drivers to feel the increased risk of a road accident or reduce the comfort of driving at a higher speed (e.g. paved surfaces) or to fear the penalty for driving with excessive speed (photoradars).

The research on the measures of calming the traffic and their effectiveness has been done by many research and scientific centres, including among others: Danish Directorate of National Roads [19], French Center for Research on Transport in Cities – CETUR [20-22], University of Karlsruhe in Germany [23], CROW in Netherland [24,25], Institute of Road Safety in Belgium [26,27] Department of Transportation of Federal Highway Administration and Institute of Transportation Engineers in USA [28], international organizations as: European Commission [29], World Road Association [30], and in Poland: National Road Safety Council [2,15,31-34], Gdansk University of Technology [2,35], University of Science and Technology in Bydgoszcz [36], Lodz University of Technology [3]. Danish Directorate of National Roads [19] presented a list of selected physical measures of traffic calming depending on the nature of the road (street, local street), allowed speed (≥ 60 , 50 , ≤ 40 km/h) and average annual traffic volume (> 3000 P/d, ≤ 3000 P/d). The collection of traffic calming measures in terms of the possibility of their use has been developed by research workers of the University of Technology and Life Sciences in Bydgoszcz in their work on traffic safety in cities [36]. They presented an expanded list of 42 means of slowing down traffic, which is a continuation of the Danish list. This list of traffic calming measures includes both technical and physical measures as well as formal and legal solutions (eg. vertical marking, traffic lights, persons supervising the pedestrian crossing) and measures affecting the drivers' psyche.

The analysis of the results of the above works indicates that the methods and means of traffic calming used in a significant way contribute to reducing the accident risk as well as road and traffic parameters that are the cause of accidents. This is expressed by the reduction in the number of accidents and their consequences, which are the result of reduced speed and reduced traffic. In order to determine the effectiveness of measures in the aspect of calming the traffic, it is necessary to take into account the traffic and road context as well as the spatial conditions of their implementation.

From the technical side, in the solutions calming traffic, it is introduced for the speed limit (up to 30-50 in cities and up to (60) km / h outside of cities) and the geometry and cross-section of routes and streets are adapted to the introduced transformations. It should be noted that there is a specificity of the solutions used for traffic calming in cities and they differ from those used along road routes passing through small towns and villages. There is also a difference in the forms used, depending on the function of the area in which sedation is introduced.

The best results are coherent and consistent use of various types of traffic organization measures, taking into account the projected speed limit and the expected traffic volume. Experience has shown that the criterion for the use of sedatives is the dominant function of the road (transit or handling the environment) and the level of traffic (3000 vh/day). These criteria determine the possibility of using specific types of traffic sedatives. It is important that on road routes with significant traffic, ie. > 3,000 vh/d, one can't use releasing thresholds, which in turn can be one of the basic measures on low-speed streets, less than 40 km/h and intensities lower than given. Traffic calming promotes pedestrian and bicycle traffic conditions, primarily by limiting the permitted speed to a level that reduces the accident risk of these two weakest road users and in some cases also by horizontal segregation in the form of separation of routes for bicycles and pedestrians parallel to the roadway (in the form of paths or belts for bicycles and sidewalks), or the introduction of a bicycle to the sidewalks and transforming them into footpaths - cycle routes.

Brilon and Blanke [23] examined the impact of traffic calming measures on road safety improvement in selected German cities, where pioneering implementations were carried out, including: Berlin (Moabit district), Borgentreich, Bextehunde, Esslingen, Ingolstadt, Maiz – Batzenheim and Hamburg (zones „tempo 30“). The implementation of traffic zones on a scale of whole cities or selected districts brought positive effects in terms of reducing the hazard of road safety. The examples on the basis of which the efficiency of traffic calming solutions were evaluated were selected in such a way that they were representative and concerned various forms of sedation and were located under different spatial conditions. On average, all of the study sites included include:

- 34% reduction in the number of serious accidents
- 16% reduction in accident costs
- 54% reduction in the number of accidents caused by motorcyclists
- 34% reduction of accidents caused by pedestrians.

French experience indicates the high efficiency of comprehensive and consistent implementation of traffic calming solutions, as well as the phenomenon of relaxation, ie the reduction of efficiency with the passage of time and the need for a new look at the analyzed place along with the possible introduction of changes [21,22].

Polish experiences [3] indicate that at the crossings of national roads through villages and small towns, the majority of implemented solutions significantly reduced the accident risk ratio and, what is also very important, the severity of accidents. The reduction in the risk level, excluding Garwolin crossing, ranged from 70% (Serock) to 100% (Kobylnica, Pultusk).

The implementation of national road crossings by villages and towns confirms that traffic calming has generally reduced:

- number of accidents, including pedestrians,
- speed of the transit traffic pipeline (V_{85}),
- number of dangerous and unlawful manoeuvres on the road,
- ordered the pedestrian traffic along and across the calmed roadway.

Moreover, in the solutions that take into account the aspect of traffic calming, the conditions and safety of bicycle traffic (Kobylnica and Koscierzyzna) have been ordered and improved.

According to the data of the Polish National Road Safety Council [33], based on the experience of Western European countries and the United States, the most effective means of reducing the number of accidents, injuries and deaths are considered in relation to car traffic:

- for extension of the elevated dividing lane by crossing (leaving the relation only to the right for side inlets) - 100%,
- construction of a separate dividing lane on an existing roadway - 90%,
- for removing permanent obstacles from the environment of the road, e.g trees, poles, etc. - 80%,
- for reconstruction of the intersection to the roundabout - 76%.

Most road safety improvement measures that are used in traffic calming measures simultaneously reduce the risk of pedestrians, cyclists and car traffic. Belong to them:

- improvement of surface roughness at the intersection - up to 57%,
- extension of the elevated dividing belt by crossing (leaving the relation only to the right for side inlets) - 50% and 100% respectively,
- construction of a separate dividing lane on an existing roadway - 50% and 90% respectively, traffic calming by:
 - for speeding thresholds and elevated intersections causing physical speed reduction - 46% and 65% respectively,
 - physically enforce the deflection of the driving path by installing central or side elements and or change the geometry of the road by 46% respectively.

The list of the above measures indicates that in relation to pedestrian and bicycle traffic, road safety improvement, also in traffic calming solutions, can be achieved by applying physical measures to reduce the risk of car traffic safety. Another effective physical means whose application can significantly improve the condition of pedestrians and cyclists is a speed camera (50%), which by enforcing the speed limit of the car contributes to the improvement of safety of all road users.

It should also be noted that the introduction of a speed limit in the form of prohibition road signs, from 60 km/h to 50 km/h and from 50 km/h to 40 km/h has a relatively small impact on road safety improvement for all road users. This means that in order to ensure that the traffic calming effect effectively improves the road safety condition, in addition to the speed limit in the form of road signs, it should be supported by other measures calming the traffic and at the same time reducing the accident risk.

An example of a model solution for traffic calming in the so-called The Dutch town in Pulawy Wlostowice is shown in Fig. 2. A comprehensive traffic calming solution was implemented in the single-family housing area, where various technical and legal measures were applied for speeds limited to 30 km/h and up to 20 km/h. On the urban streets of principal network, traffic calming has been implemented with a speed limit of 40 or 50 km/h. Figure 3 shows a scheme of part layout of a fragment of the urban street which is also a Provincial Road DW 824. In addition to the speed limit to 40 km/h, the various physical of traffic calming measures were used, including the changes geometry of the street cross-section, the narrow widths of lanes to 3.00 m and less, pavement separating traffic directions, cycling routes outside of carriageway, plateaus at intersections and pedestrian crossings. The developed solution according to the concept of the Dutch DHV office significantly improved traffic safety and the condition of public space in this part of the city.

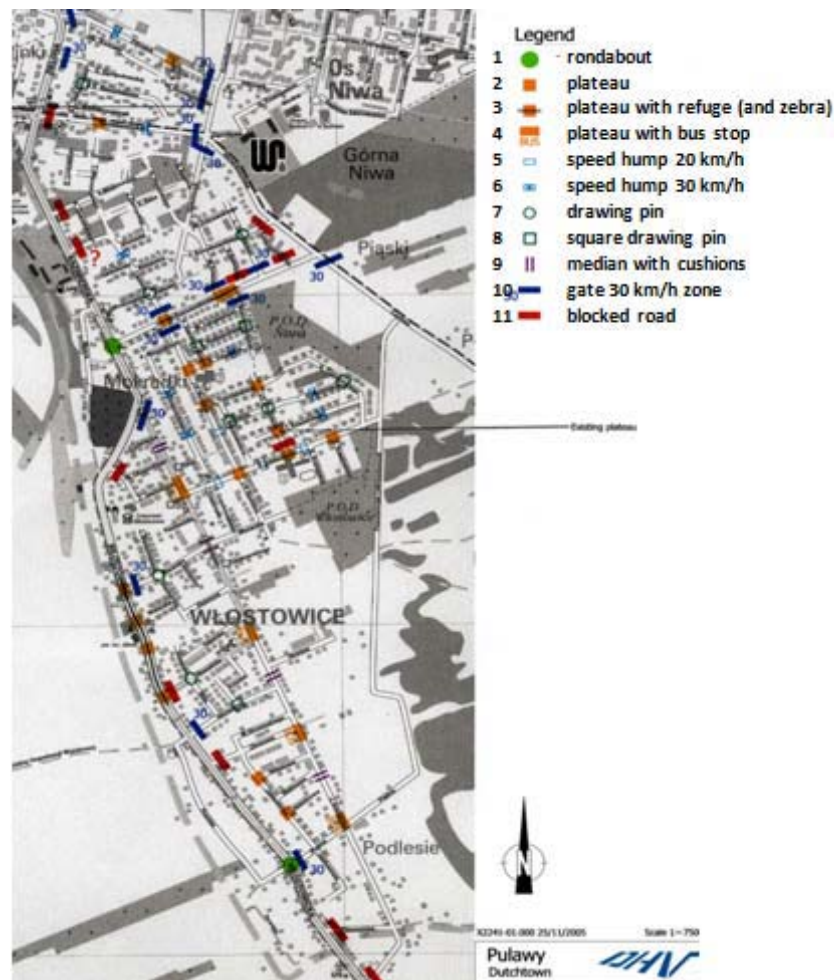


Figure 2. Pulawy Wlostowice (Pulawy Dutch Town) – concept of traffic calming zone single-family housing area and through Provincial Road DW 824 [37]

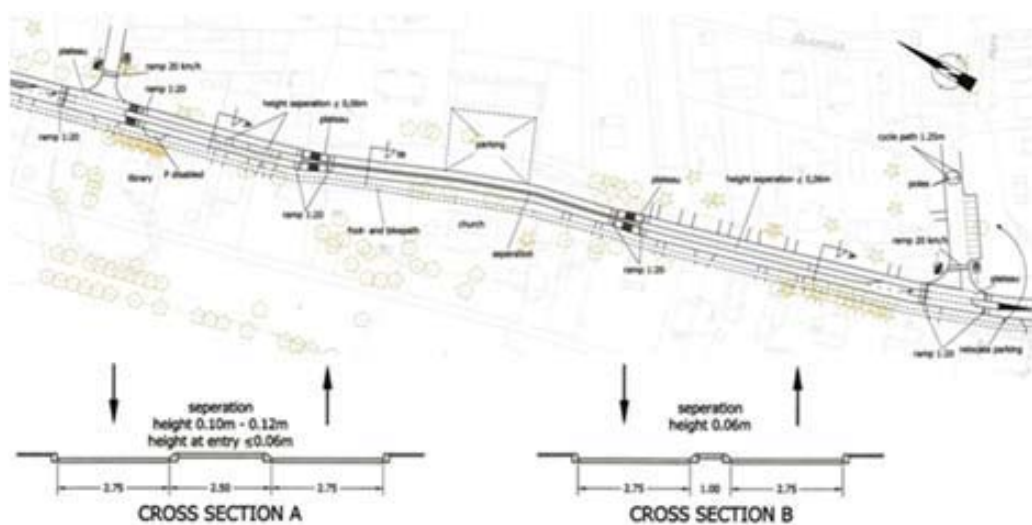


Figure 3. Pulawy Wlostowice (Pulawy Dutch Town) - scheme of part layout of a part of the urban street - Provincial Road DW 824 [37]

4. Conclusions

Traffic calming in towns and agglomerations is interdisciplinary, comprehensive and creative solution. The beginnings of the idea of traffic calming can be sought in urban planning concepts from the beginning of the 20th century. Today, in the second decade of the 21st century, traffic calming is:

- a global trend,
- a solution proven in many countries and confirmed by many positive experiences, especially in urban areas and in various transport service conditions as well as in various road and traffic conditions,
- the activity commonly used in high-powered countries, which can be implemented in many areas and road and street routes in urban areas.

Review of the literature and the implemented transportation service solutions, including traffic calming, indicates that the functioning of these solutions is based on reducing the speed of motor vehicles, which is the key to achieving improvement of the traffic safety. Speed management in a manner adequate to the implemented restrictions, supported by physical measures enforcing this limitation on the participants of the traffic, leads to achieving the desired effects of various character, including, above all, improving the state of road safety.

The implementation of universal speed limits in urban traffic to 50 km/h does not mean that in towns on traffic itineraries, where this limit applies, traffic is calmed. In order to achieve the desired calming effects, it is necessary to apply of physical means in cross-sections enforcing the speed limit applied. The emerging phenomenon of relaxation of traffic calming solutions makes them require systematic monitoring and investigation of the causes of this phenomenon. In the case of relaxation, measures and measures should be taken that are adequate to the changed road and traffic conditions, so that they can still be effective, safe and functional.

It is necessary to search for optimal types of traffic calming measures while maintaining their effective impact on speed reduction and maximizing users' convenience, taking into account the aesthetic and visual context.

Integration of the problems of traffic calming and sustainable traffic safety with urban planning and design is indispensable.

References

- [1] O.Gunnarsson, "Urban Traffic Network Design – A Spatial Approach", *VTI/BAST International Conference*, Göteborg 1990.
- [2] R. Krystek and team, "'Gambit' Integrated Programme for Safety Improvement in Poland, Final Report 1994-1996", *Ministry of Transportation and Maritime Economy and National Road Safety Council*. Warsaw, 1996.
- [3] A. Zalewski, „Traffic Calming as a Urban Planning Problem”, Publisher Technical University of Lodz, 1104. Scientific Papers, Scientific Dissertation No 414, 2011. Lodz, (in Polish).
- [4] C. Perry, "Sustainable Neighborhood Planning for Region Nieghborhood Scale" *Treasure Coast Regional Planning Council February 2004*, http://www.tcrpc.org/orientation/02_neighborhood_scale/2_neighborhood_scale_print.pdf; [access (VIII.2010)]
- [5] A. Gawlikowski, *Ulica w strukturze miasta, Street in the city structure*, IUPP PW, Warszawa 1993, (in Polish)
- [6] C. Buchanan, "Traffic in the Towns", *Crown Edit.*, London, 1963.
- [7] H.G. Vahl i J. Giskes, "Urbanisme et trafic de la guerre à la paix", *CETUR*, Bagneux, 1989.
- [8] A. Zalewski, "Shared Spaces in Poland", *Transportation Research Arena European Conference*, poster, Warsaw, 2016.
- [9] H. Monderman, "Project for Public Space", <https://www.pps.org/article/hans-monderman> [access 01.02.2014]
- [10] S. Gaca, W. Suchorzewski, M. Tracz, „Road Traffic Engineering – Theory and Practice”, *WKiŁ*, Warszawa, 2009. (in Polish)
- [11] Amarcande, "La rue – un es pace a mieux partager", Paris, 1990.
- [12] Gazette Republic of Poland, "Ordinance of the Minister of Transport and Maritime Economy of March 2, 1999, regarding the technical conditions that the public road and their location should meet", No. 43 of March 5, 1999, pos. 430, (in Polish).

- [13] General Directory of Public Roads, "Recommendation of designing streets", Warsaw, 1992, (in Polish).
- [14] P. Neufert, "Architectural and construction design manual", Arkady, Warsaw, 1998, (in Polish).
- [15] Resolution on Road Safety in Europe 2011-2020 (2010/2235 (INI)), The European Parliament, accepted at 27.09.2011, Brussels.
- [16] Ministry of Infrastructure and National Road Traffic Council, "National Program of Road Traffic Safety Improvement in Poland", Gambit 2005, Urban and Regional Transport 8-9/2005 and www.krbrd.gov.pl, [access (28.03.2018)].
- [17] A. Sambor, M. Więckowski, A. Zalewski Sambor A., "Traffic organization and parking in historical areas", *Institute of Roads and Bridges, Warsaw University of Technology*, manuscript, Warsaw 1984, (in Polish).
- [18] M. Więckowski, "Traffic calming in inhabitant areas", *Polish Roads, insertion "Safety and Traffic Road Engineering"*, pp. XIV – XXII, 7-8/2002, (in Polish).
- [19] Road Directorate, Denmark Ministry of Transport, "An Improved Traffic Environment catalogue of Ideas", *Road Data Laboratory Road Standard Division*, Report 106, Herlev, 1993.
- [20] CETUR, « Ville plus sûre, Quartiers sans accidents - Savoir faire et technique », *MELATT Comité Interministeriel pour les Villes Bagneux*, 1990
- [21] CETUR, Guide zone 30, Méthodologie & Recommandations, *MELATT*, Bagneux, 1992
- [22] CETUR, Ville plus sûre, Quartiers sans accidents - Réalisations, évaluations, *METT, Bagneux*, 1994.
- [23] W. Brilon, H. Blanke, "Extensive Traffic Calming: Results of the Accident Analysis in 6 Model Towns", *Institute of Transportation Engineers, ITE Publications* no PP-037, Washington DC pp. 119-123, Compendium of Technical Paper, (1993),
- [24] CROW, Recommendations for traffic provision in built-up areas", *ASVV*, Ede, 1998.
- [25] CROW, "Road Safety Manual", *ASVV*, Ede, 2009.
- [26] Institute Belgian Pour La Sécurité Routière, ASBL, Ministère des Communications et de l'Infrastructure, "Politique Communale de Sécurité Routière Vademecum", Bruxelles, 1993.
- [27] Institute Belgian Pour La Sécurité Routière, "Zones 30 – 3 ans après, premier aperçu", Bruxelles, 1996
- [28] R. Ewing, "Traffic Calming: State of the Practice", *U.S. Department of Transportation, Federal Highway Administration, Institute of Transportation Engineers*, Washington D.C. ISBN 0-935403-36-1, 1999
- [29] F. Kustner, C. Laurence, R. Geffen, Halving injury and fatality rates for cyclists by 2020, ECF Chapter on the 4th EU Road Safety Action Programme, 2011-2020, EU, Brussels. 2010.
- [30] AIPCR/PIARC, "Circulation de transit dans les Petites Agglomérations - Sécurité et Environnement", Rapport 04.03.B, *Comité Technique de Routes Interurbaines et de la Route en Milieu Urbain*, Paris, 1991
- [31] AIPCR/PIARC, "Conception des Réseaux de Voiries Urbaines - Nouvelles approches" Rapport 10.04.B, *Comité Techniques de Route en Milieu Urbain*, Paris, 1991
- [32] National Road Safety Council, Ministry of Infrastructure, "Program for the elimination of dangerous places - II edition", <http://www.krbrd.mi.gov.pl>; Warsaw, 2005, [access XI.2007].
- [33] National Road Safety Council, Ministry of Infrastructure, "Traffic Calming Programme", Warsaw, 2009, www.krbrd.mi.gov.pl; [access XI.2009].
- [34] National Road Safety Council, Ministry of Infrastructure, National Road Safety Programme 2013–2020, Document adopted by the National Road Safety Council on 20.06.2013, <http://www.krbrd.gov.pl/files/file/Programy/KRBRD-Program-P1a-20140422-S2-K3d-EN.pdf>; [access 01.02.2014]
- [35] Jamroz K. and team, „Principles of Traffic Calming on the Roads of Pomeranian Province”, Pomeranian Gambit, part. I.- Street Networks, cz II – „Transit Roads Through Small Towns and Villages”, *Pomeranian Road Traffic Safety and Gdansk University of Technology*, Gdansk, 2004, www.prbrd.pl [access XI.2004], (in Polish).
- [36] T. Szczuraszek (red.), „Urban traffic safety”, *WKiŁ*, Warsaw 2005, (in Polish).
- [37] DHV Project of Pulawy Dutch Town, DHV Amersfoort-Warsaw, 2005.