České vysoké učení technické v Praze, Fakulta stavební

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Zásady návrhu dopravního zklidňování na místních komunikacích (15 let vývoje v ČR)

Principles of Traffic Calming Design on Urban Raods (15 years of development in the Czech Republic)

Summary

Urban road spaces are the most important public places in cities and settlements. To a great extent, they give the municipality its unique character and perception of the surrounding environment. These spaces not only serve for transport, but also provide a framework for other diverse life activities, which is reflected by various requirements and functions (with considerable, even conflicting differences in the interests and needs of individual users of urban road spaces). The fulfilment of all these functions, in particular, is the reason for designing and building urban roads with the aim of removing the superiority of car traffic in the use of urban roads, enhancing road traffic safety, creating better conditions for pedestrians and cyclists and generally improving the living environment.

These targets are reached through “traffic calming” whose main principles and procedures are the subject of this article. Together with them, the article presents the development and implementation process of principal legislative rules and regulations governing traffic calming strategies in the Czech Republic. It also includes recommendations for the selection of traffic calming measures suitable for specific design conditions.

Souhrn

Prostory místních komunikací jsou nejdůležitější veřejná místa ve městech a obcích. Ve velké míře vtiskují sídlu jeho jedinečnost a prožitek daného okolního prostředí. Tyto prostory neslouží jenom dopravě, nýbrž poskytují také rámec rozmanitým jiným projevům života, což se projevuje nejrůznějšími požadavky a funkcemi (přitom různost zájmů a potřeb jednotlivých uživatelů prostorů místních komunikací je značná, mnohdy až protichůdná). A právě naplnění všech těchto funkcí je důvodem k tomu, aby místní komunikace byly projektovány a stavěny s cílem odstranění nadřazenosti automobilové dopravy ve využívání místních komunikací, zvýšení bezpečnosti silničního provozu, vytvoření lepších podmínek pro chodce a cyklisty a celkovém zlepšení životního prostředí vůbec.

K dosažení těchto cílů slouží tzv. „zklidňování dopravy, jehož hlavní zásady a postupy jsou v tomto článku popsány. Spolu s tím je popsána i geneze tvorby a zavádění hlavních legislativních předpisů, které problematiku zklidňování dopravy v ČR řeší. Článek obsahuje i doporučení k výběru typu zklidňovacího prvku vhodného pro určité návrhové podmínky.

Klíčová slova: doprava, intenzita, kapacita, nehodovost, zklidňování dopravy

Keywords: traffic, traffic volumes, capacity, accident rate, traffic calming

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Contents

1 Introduction

The design of urban road (hereinafter UR) spaces is of vital importance in tackling the problems of the built-up environment, and therefore road design inside developed areas is closely related to urban planning and architectural concepts of designing urban zones (see Fig. 1). UR design in built-up areas must always be perceived as a complex activity.

Fig. 1 – Example of traffic space humanization

2 What is "traffic calming"

- Under terminological standard: "Specific measures for the protection of living conditions mainly in municipalities and their areas of interest".
- Under TP 132 : "Measures for removing general superiority of car traffic in the network of selected UR and creation of better conditions for pedestrian and cycle traffic, enhancement of road traffic safety and improvement of the environment".
- Or also: "Humanization of traffic".

3 Input conditions for traffic calming

The growing volumes of motorized traffic and related unfavourable consequences on the environment and the quality of life in general lead to seeking ways of how to mitigate or compensate these negative effects. In the Czech Republic, this phenomenon appeared in its acute form at the start of the 1990s together with a rapid growth in road traffic. Due to the fact that the existing road network was not ready to accommodate such growing traffic volumes, it suffered from relative overloading and resulting increased numbers of road accidents.

This problem was manifested in its most acute form mainly within municipalities, requiring an adequate response and introduction of some reasonable traffic "slow-down" measures. Initial conditions for traffic calming include:

- road network condition in municipalities,
- growth in car numbers, traffic volumes and capacities,
- growth in "aggressiveness" of car drivers,
- growth in numbers of car accidents – and their aggravated consequences.

☞ Road network condition in municipalities

A large percentage of roads within municipalities do not have the attributes of "urban roads", but rather roads in "rural areas" (wide carriageways, ditches, absence of pavements etc.) - highways. The resulting psychological impact on drivers is that they "do not have any reason for changing their driving mode"!

☞ Growth in car numbers, traffic volumes and capacities

Since the start of the 1990s, a significant growth in the numbers of cars in the Czech Republic has started – between 1990 and 1995, for example, the number of passenger cars grew by ca 670 ths. (i.e. by ca 30 %), while between 1990 and 2005 the number of passenger cars rose by ca 1.594 million (i.e. by ca 70 %) – see Fig. 2.

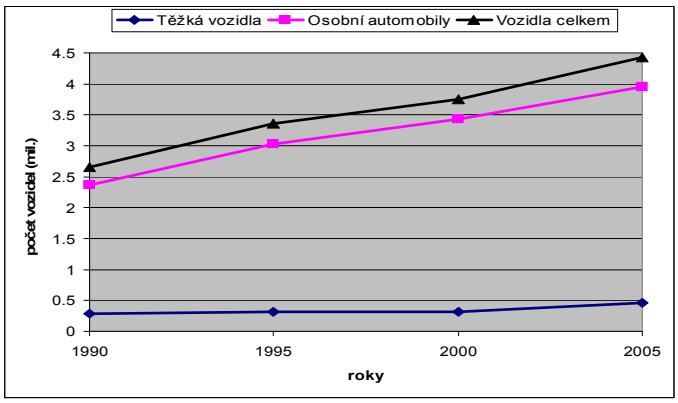

Fig. 2 – Growing numbers of vehicles in CR in 1990-2005

The magnitude of traffic volumes and traffic capacities developed in a similar way, e.g. in Prague traffic volumes grew by ca 5.6 "vehicle/kilometres" (i.e. by ca 80 %) between 1990 to 1995, and by 9.3 million (i.e. by ca 130 %) between 1990 to 2000 – see Fig. 3.

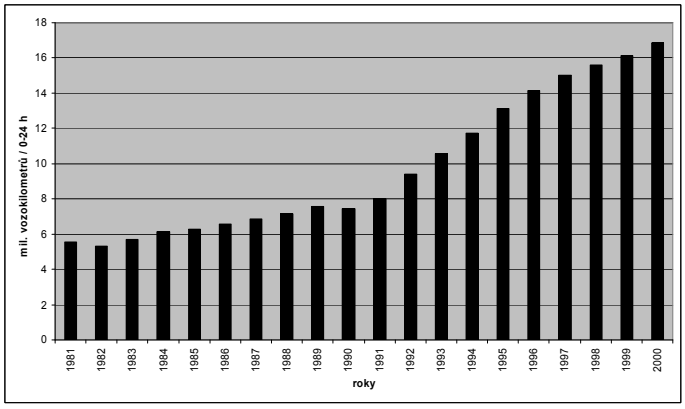

Fig. 3 – Development of traffic capacities of car traffic in Prague

☞ Growth in "aggressiveness" of car drivers and numbers of car accidents

Serious negative effects of the car traffic development after November 1989 included growing aggresiveness of drivers – particularly of passenger cars. This fact was, unfortunately, also reflected by statistical data related to traffic accidents and, in particular, their consequences. This statistical data (see Fig. 4) show that between 1990 and 1995 the following quantitative growth was recorded:

- traffic accidents by ca 85 % ,
- persons with light injuries by ca 30 % ,
- persons with serious injuries by ca 40 % and
- persons with fatal injuries by ca 20 % .

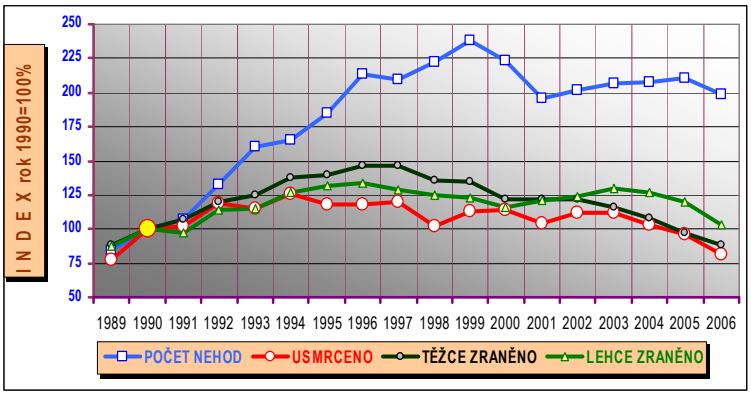

Fig. 4 – Growing numbers of traffic accidents in CR and their consequences

4 Traffic calming development in the Czech Republic

The facts above, in particular the growing numbers of traffic accidents, called for immediate action. At the very start of the 1990s, therefore, the first proposals for improving the unfavourable situation on Czech roads started to appear. These proposals were mostly based on the experience in dealing with these issues taken over from neighbouring, economically developed countries, such as Germany, Austria and others. In order to successfully launch traffic calming policies, their legislative support needed to be enforced first, i.e. there was a need for the design of relevant technical regulations, which would allow successive practical implementation of traffic calming.

4.1 TP 85 Road humps

As state administration called for immediate solutions to the problem, the first regulation to be issued were technical conditions (hereinafter TC) of the Ministry of Transport of the Czech Republic, TP 85 Road humps[1)] [1].

TP 85 regulated the possibility of using road humps only on UR classified into functional groups "D" (with eliminated car traffic or with mixed traffic) and mainly "C" (service roads). In justified cases, they may also be used on UR classified into functional group "B" (connecting roads) or on transit roads of class III.

The road hump is a technical and traffic device designed mainly for reducing the speed of passing vehicles. It affects drivers not only optically (and acoustically), but above all physically – by an artificial change in height conditions on the road. The road hump acts physically mainly by the hump height, a change in the longitudinal drive-on gradient (the road hump threshold ramp), the road hump length or the combination of all these parameters.

TP introduced classification of road humps into:

- transversal road humps - narrow
  - wide (or incorporating a pedestrian crossing)
- raised surfaces and
- speed cushions.

Due to the fact that TP 85 regulate only one partial traffic calming method, their publication caused an illogical situation where TC had come out earlier than the regulation treating traffic calming problems in a complex way. Moreover, this umbrella regulation was issued with a 4-year lag which caused that in the meantime road humps had become a kind of "synonym" for practical traffic calming solutions. This problem has been encountered till the present day resulting in frequent explanations that for some practical

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[1)] These TC were designed by a team of authors from the Department of Road Structures of the Faculty of Civil Engineering, CTU, including the author of this dissertation thesis.

situations road humps represent a wrong option (when the vehicle passes over it the road hump e.g. becomes a source of noise and vibrations) and that there are alternative, better solutions to the problem. They involve, in particular, the application of prefabricated narrow transverse road humps whose main advantages for the investor are the price and fast installation speed (or potential simple removal).

On the other hand, however, it must be pointed out that these road humps are not able to make undisciplined drivers change their behaviour with adequate fierceness (allowing, for example, passage at greater than design speeds or sometimes even by-passing) and, besides, they are soon damaged.

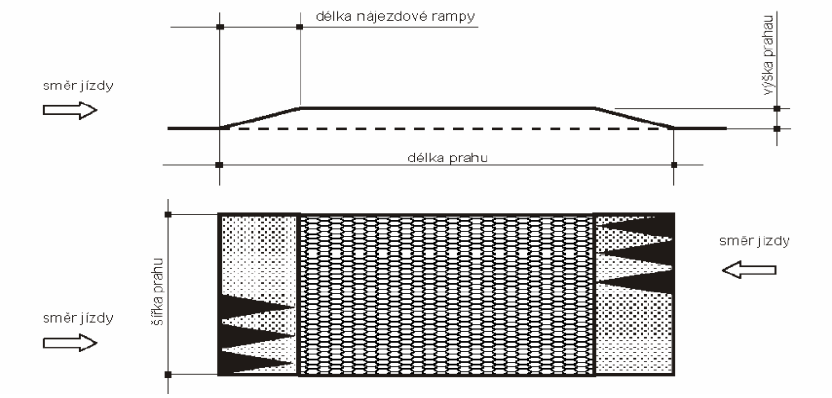


Fig. 5 – Diagram of wide transverse road hump

In terms of function (more fierce effect on vehicles, better protection of pedestrians) and long-term perspective, therefore, wide transverse road humps seem a more convenient solution. The most frequently applied type are road humps of "trapezoidal" shape – for diagram see Fig. 5. Less frequently, wide transverse road humps are also designed as circular-shaped or stepped-shaped. One of the greatest advantages of the wide transverse road hump is its potential connection with the pedestrian crossing. The minimum ramp length then is 1.0 m, and the minimum length of the whole hump is 5.0 m. The recommended hump height is 70 - 120 (150) mm. The hump height, as it is, has a lower effect on the highest allowed vehicle speed than the drive-on ramp gradient.

Another, recently more commonly designed traffic calming element are raised surfaces – usually serving as junction tables. This type of traffic calming is well applicable mainly on UR of functional group "D", or on UR of group "C" serving as links inside residential zones. In order to differentiate them from the surfaces of other areas, the raised table is recommended to be highlighted either by a different colour or different road surfacing – see Fig. 6.

The last type of road humps are speed cushions which, however, have not been widely applied in the Czech Republic yet.

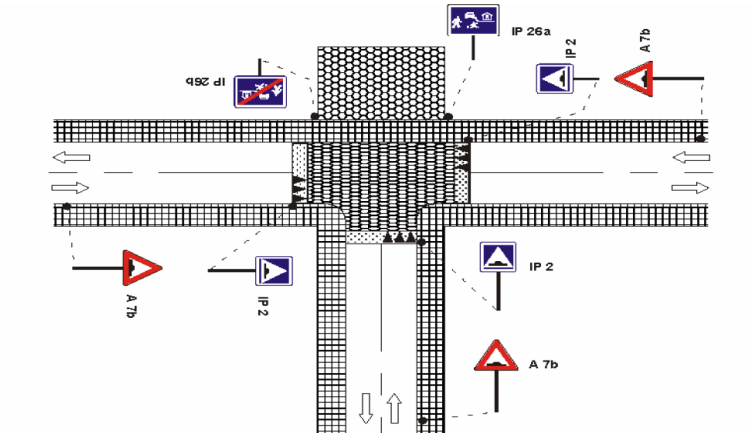


Fig. 6 – Raised junction table

4.2 TP 132 Design principles of traffic calming on UR

In the period of 1996 – 1999, the first significant research project focused on traffic calming problems was carried out. It was the Ministry of Transport CR project No. S602120604 "Research of technical and operational conditions on urban roads combining motorized, pedestrian and cycle traffic“ whose senior researcher was the author of this dissertation thesis.

The material output of this project consisted in three important technical regulations[2)] dealing with traffic calming problems, in particular:

- TP 132 Design principles of traffic calming on UR [3],
- VL 7 Selected elements of UR for traffic calming [4] and
- TP 145 Design principles for modifications of transit routes passing through municipalities [5].

TP 132 represents an umbrella regulation for wider implementation of traffic calming on UR, which not only defines the area of its relevant application, but also contains methods of setting up its targets and the necessary steps for their fulfilment. TP regulates traffic calming on UR of functional groups B and C applying also to newly built and reconstructed roads. The direct follow-up to TP 132 are TP 145 and model data sheets VL 7, which further expand and specify the material contained in TP 132.

[2)] Apart from them, the project’s output included background material for reviewing the basic standard for urban road design ČSN 73 6110 [2].

TC regulate traffic calming design principles (the diversity of interests and needs of individual users of UR spaces is shown in Fig. 7), specify the classification and description of traffic calming elements suitable for reducing traffic volumes and mainly the speed of vehicles passing through the calmed area. In terms of the implementation method, the purpose and impact on drivers, the following categories exist:

- psychological or physically-psychological elements,
- physical elements,
- combined elements,
- elements for the protection of non-motorized participants of road traffic and
- elements at junctions.

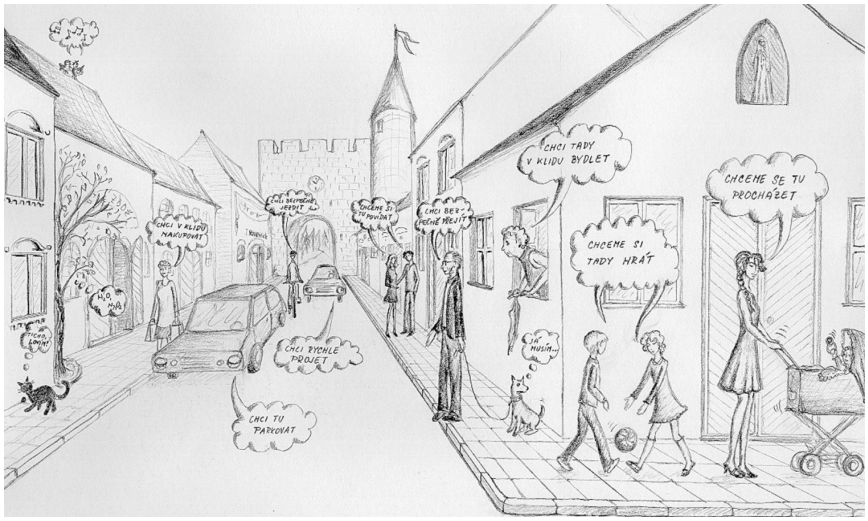


Fig. 7 – Diversity of interests and needs of individual UR space users

4.2.1 Psychological elements

Their purpose is to alert drivers of a change in the traffic mode and motivate them to be more concentrated and reduce the driving speed. They have the form of traffic signs, mostly in combination with other optical or even physical elements. The following elements are used:

- repetition of vertical signs on the roadway or highlighting of vertical signs e.g. by retroreflex foil (or flashing light),
- speed check warning - radar, dummy policeman etc.,
- optical brakes – transverse lines with shortening mutual distances,
- different roadway surface – different colour, surface texture or material,
- special lighting and others.

4.2.2 Physical elements

Basic physical traffic calming elements include:

- road humps (see 4.1),
- roadway narrowing,
- chicanes.

Roadway narrowing - a construction measure aimed at reducing the speed and traffic volume of motor vehicles and at enhancing conditions for pedestrians and parking vehicles. Narrowing produces the effect where the driver subconsciously or consciously moves away from side barriers reducing automatically the driving speed.

The design of roadway narrowing must be based on actual demands of "design vehicles" for which the respective UR serves – see Fig. 8.

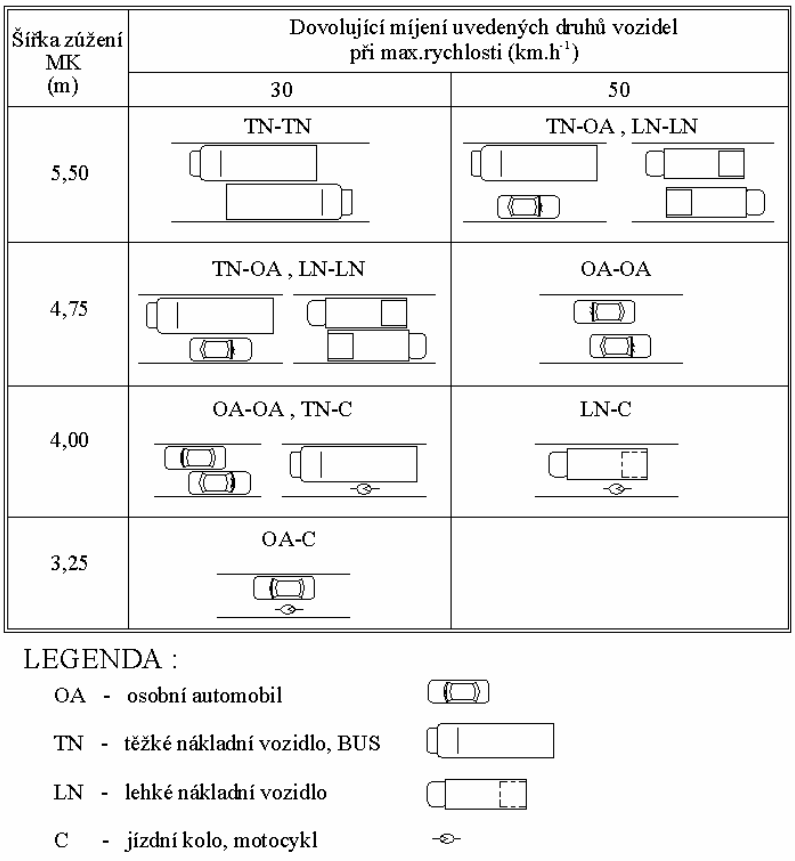


Fig. 8 – Spatial demands allowing passing of different vehicles

By physical means, road narrowing is created by:

- ♦ reducing the roadway width between curbs,
- ♦ inserting raised surfaces (in combination with parking lanes).
- ♦ inserting central traffic islands or strips.

In the case that raised pavement surfaces are used in junction areas, the result are shortened lengths of pedestrian crossings and thus increased safety of pedestrians - see Fig. 9.

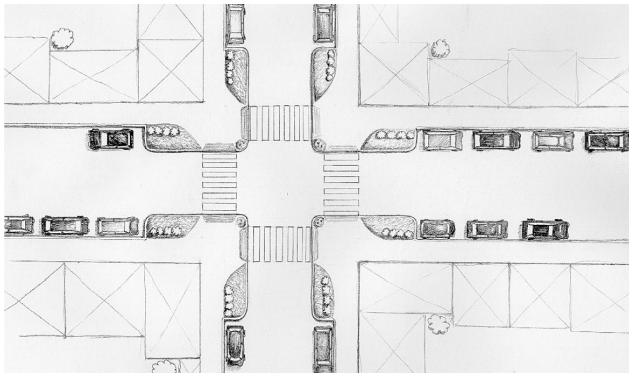


Fig. 9 – Diagram of pedestrian crossing shortening by raised pavement surfaces

Roadway narrowing is frequently also carried out by inserting a central traffic island or strip. This measure serves mainly as:

- ❑ so-called "gate" at the entry into a municipality or calmed area,
- ❑ street refuge for pedestrian protection and easier crossing – see Fig. 10.

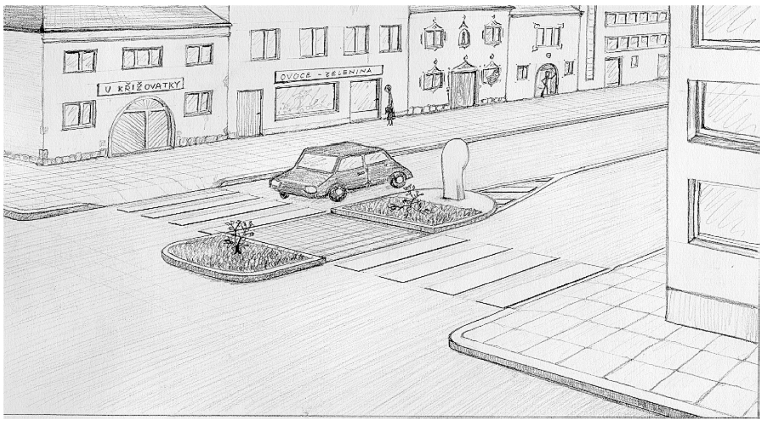


Fig. 10 – Diagram of street refuge for pedestrian protection

As street refuges act only as "points", in order to ensure the required speed limit along the whole road section central traffic separating strips may be designed in various modifications (paved, grass covered, separated etc.).

Chicanes – are formed by transverse shift of the lane. It forces drivers to change the direction and thus to reduce the speed frequently also restricting the straight, unblocked view of the road, which psychologically urges to drive at a faster speed.

Transverse shift is achieved in the following ways:

- by inserting raised surfaces or traffic islands,
- by deliberate shift of curbs during road construction,
- by alternating side parking (see Fig. 11).

The chicane may also be formed by designing the "stop bay" where the original traffic lane is interrupted by a raised pavement surface at the point of a public transport stop (suitable only for UR with low traffic load). The chicane and roadway narrowing are often accompanied by "uneven" trafficked roadway parts along the curbs which allow the passage of oversize vehicles, but whose uneven surface discourages passenger cars from driving on them.

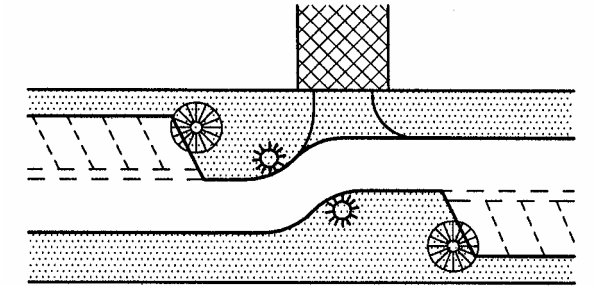


Fig. 11 – Chicane formed by raised surfaces forming parking lanes

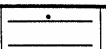
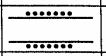
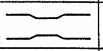
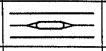
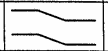
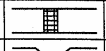
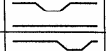
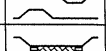
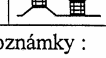
4.3 Combined elements

The combination of two or more traffic calming elements multiplies their effects on speed reduction and enhanced safety of pedestrians. The most frequent solution consists in combining the psychological element with some of the physical ones. On service UR the common applications are mainly combinations of transverse road humps (or raised surfaces) with road lowering or the chicane. Each individual combination case has a different "fierceness of impact" and is suitable for specific conditions.

TP introduced recommendations for the selection of appropriate types of traffic calming (or their combinations) suitable for the required design

conditions. The selection is made according to the type of the calmed road use, or the required vehicle speed on it – see Tab. 1.

Tab. 1 - Recommended application of various types of traffic calming elements

	Hlavní typy prvků		Způsob využití komunikace				Žádoucí rychlost ($km.h^{-1}$)		
			B1, B2	B3	C1	C2, C3			
			převážně dopravní	obslužně dopravní	dopravně obslužná	obslužná	50	40	≤ 30
1		Předsazené značení - varování	x	(x)			x	(x)	
2		Brány	x	(x)			x	(x)	
3		Zúžení vozovky vysazenými plochami	[x]	x	x	x		x	x
4		Zúžení vozovky středním dělicím ostrůvkem	(x)	x	x	x	(x)	x	x
5		Šikany		(x)	x	x		x	x
6		Zvýšené plochy		(x)	x	x			x
7		Šikany se zvýšenou plochou		[x]	(x)	x		x	x
8		Příčné prahy		[x]	(x)	x	(x)	x	x
9		Zúžení vozovky na 1 pruh			(x)	x		(x)	x
10		Šikany se zúžením na 1 pruh			(x)	x		(x)	x
11		Zúžení vozovky na 1 pruh se zvýšenou plochou			[x]	x		[x]	x
12		Šikany se zúžením vozovky na 1 pruh a zvýšenou plochou			[x]	x		[x]	x
13		Zúžení vozovky na 1 pruh s příčným prahem				x			x
14		Šikany se zúžením vozovky na 1 pruh a příčným prahem				x			x

Poznámky :
x Doporučené použití,
(x) Používá se pouze v případech vysoké intenzity provozu motorové **nebo** pěší dopravy,
[x] Používá se pouze v případech vysoké intenzity provozu motorové **a zároveň** pěší dopravy,
❑ U prvků č. 3, 4, 5, 8, 9, 10, 13 a 14 je možná kombinace s přechodem pro pěší.

4.4 Elements at junctions

Traffic calming of junction areas applies either traffic or construction elements.

Traffic elements allow increasing the spaces for non-motorized traffic and parking at the expense of spaces for car traffic by means of undemanding modifications (traffic signs) without any construction interventions. It is,

however, a fact that they do not represent unsurmountable obstacles for undisciplined drivers.

One of the possibilities of reducing the speed of cars is also return to junctions with no marked priority – this method is currently implemented in many European countries with good results (being cost-effective as well).

Construction elements, on the contrary, impact on undisciplined drivers, too, with a degree of fierceness corresponding to the type of designed measures. It is advisable to design such construction modifications that prevent fast vehicle passage across the junction. The following measures are used:

- narrowing entries to junctions,
- reducing junction spaces,
- forming chicanes in the junction,
- raising the total junction surface to the pavement level.

A separate type of traffic calming elements are roundabouts. The purpose of this measure is to make drivers reduce the speed while driving across the junction. This is achieved by the right shape and dimensions of the junction, which must:

- avoid straight passage (and straight view) by placing a central island into originally straight routes,
- ensure the passage of oversize vehicles across the junction.

By their arrangement, roundabouts are classified[3)] into:

- roundabouts with a central untrafficked island (one or more traffic lanes creating a circular strip) and
- miniroundabouts (with a trafficked central island).

The use of roundabouts with untrafficked central islands is advisable mainly on entering municipalities (or calmed areas), in particular on roads with high traffic load (e.g. transit routes). This type of junctions clearly alerts drivers by physical means that the environment and thus the driving mode have changed. This mission is best fulfilled by roundabouts with dominant central islands which form an unsurmountable obstacle to visibility in the straight direction.

Miniroundabouts are less demanding for spatial needs. In order to allow the passage of oversize vehicles across this junction, however, a possibility of

[3)] Under ČSN 73 6102 [6]. The terms used until recently were "large", "small" or "mini" roundabouts.

complete trafficking of the central island by these vehicles must be ensured. But the shape of the central island must be designed so that its trafficking is not "interesting" for passenger car drivers, too. The island shape may be e.g. lentil-shaped, flat cone-shaped or stepped. The designed island height against the roadway is ca 0.10 - 0,20 m.

Nevertheless, it is true that for undisciplined drivers direct passage across the central island does not represent an unsurmountable obstacle.

5 Conclusion

Traffic calming is increasingly more applied in all economically developed countries. Traffic calming was originally the domain of service roads, or zones with limited traffic (e.g. residential zones). At present, however, traffic calming is increasingly introduced on connecting UR or on transit routes passing through municipalities, being proportional to their growing load and related problems (noise, emissions, accident rate, visual appearance and others). We may conclude that traffic calming of these important UR in particular is the most urgent issue of today as these roads pose major problems to local governments.

References:

[1] TP 85 Road humps, MD ČR, 1996.

[2] ČSN 73 6110 Design of urban roads, ČNI, 2006.

[3] TP 132 Design principles of traffic calming on urban roads, MD ČR, 2000.

[4] VL 7 Selected elements of urban roads for traffic calming, MD ČR, 2001.

[5] TP 145 Design principles for modifications of transit routes passing through municipalities, MD ČR, 2001.

[6] ČSN 73 6102 Design of road junctions, ČNI, 2008.

Ing. Ludvík Vébr, CSc.

Qualifications:

- 1979 - 1984: Study at the Faculty of Civil Engineering, CTU in Prague, study branch of Constructions and transportation structures. He graduated from the Department of Road Structures by defending the diploma thesis entitled "Design problems and structural assessment of flexible pavements"
- 1999: degree of CSc. at CTU in Prague - branch "Theory and constructions of engineering structures"

Fellowships:

- 1987 : Pragoprojekt – 10 months
- 1992 : TU Delft – Faculty of Civil Engineering - 3 months

Professional practice:

- 1984 : Pražský projektový ústav/Prague Design Institute – designer
- 1984 - 1985: Site manager at the site of Dukovany Nuclear Power Plant
- 1985 - 1987 : Faculty of Civil Engineering, CTU - lecturer
- 1987 - now : Faculty of Civil Engineering, CTU – assistant professor
- 2004 - 2006 : Deputy Head of Department of Road Structures
- 2007 - now : Head of Department of Road Structures

Participation in grants and research projects (last 5 years):

- Research plan No. 1 MSM 6840770001 – "Reliability, optimization and durability of building materials and structures",
- MŠM 1M6840770001 – CIDEAS Research Centre,
- MD ČR project No. 803/120/117 "Asphalt pavements of a new generation in the Czech Republic“ – joint researcher,
- MD ČR project No. 1F52I/077/120 "Accurate prediction of road surface service life. Determination of total weight, axle load and vehicle speed without traffic volume limitations and investigation of their characteristics" – researcher of partial project task "Specification of the flexible pavement physical model based on the assessment of measurement results achieved by the WIM system",

- GAČR project No. 103/05/2133 "Optimization of the effect of the subbase system of road pavements on their service performance" - joint researcher,
- GAČR project No. 103/02/0396 "Fatigue of asphalt mixes and optimization of flexible road pavement design" - joint researcher,
- MŠMT Transformation and development programme No. 61/2004 "PC graphics workplace" - researcher,
- FRVŠ grant project No. A 1913 "Innovation of a specialized workplace for teaching AIP systems in road construction" - researcher.

Pedagogic activity (lectures, current teaching load):

- Road structures 1 - branch K (136SS1)
- Road structures - branch C (136DOST)
- Highways - branch G (136POKG)
- Road pavement mechanics - branch K (136YMVZ)
- CAD project - branch K (136YPC)
- Road software - branch K (136YSSO)