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INVESTIGATIONS OF RED-COLOURED SPEED HUMPS INSTALLED ACROSS THE ENTIRE WIDTH OF THE CARRIAGEWAY

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Abstract

Pedestrians and cyclists are defined as vulnerable road users and are particularly at risk in traffic accidents in urban areas. A common speeding prevention measure used worldwide to protect vulnerable road users and ensure their safety in urban areas is the use of vertical traffic calming devices, i.e. speed humps and speed bumps. This article deals with red-coloured speed humps that are installed across the entire width of the carriageway. The geometric characteristics of such speed humps, the materials from which they are made and the installation and marking procedures are described. The reasons for their increasing use in the installation of new and replacement of existing vertical traffic calming devices in Croatia are also discussed. Finally, a short survey was conducted at two locations in Zagreb, the capital of Croatia, where two different types of these speed humps are installed: the speed hump installed immediately before the crosswalk and the speed hump on which a crosswalk is marked. A total of 60 road users (drivers, pedestrians, and cyclists) were interviewed to find out their opinions and satisfaction with these devices.

Keywords: traffic calming, speed humps, characteristics, application, survey

1 Introduction

The most common cause of road accidents is excessive speed [1], and the number of people died in road accidents continues to increase worldwide [2]. Compared to the global situation, Europe is doing relatively well thanks to measures taken at national, regional, and local levels. Statistics for the European Union (EU) show that the number of traffic fatalities decreased by 43% between 2001 and 2010, and by another 21% between 2010 and 2018 [3]. Unfortunately, progress in reducing road deaths and injuries in the EU has stagnated in recent years, and in some countries with satisfactory road safety statistics, the number of road deaths has recently increased again [4]. In 2020, 40% of all fatal road accidents in the EU occurred on urban roads, and up to 50% of these road accidents involved vulnerable road users (pedestrians and cyclists) [5]. For this reason, the EU has adopted the “Vision Zero” and the “Safe System” approach to reduce the number of fatalities and serious injuries on European roads [6]. This approach refocuses road safety policy by emphasizing the prevention of fatalities and serious injuries. It offers a combination of measures to reduce road fatalities, such as safer road infrastructure, safer vehicles, and measures to address speeding.
A common speeding prevention measure used worldwide to protect vulnerable road users and ensure their safety in urban areas is the use of vertical traffic calming devices, i.e. speed humps and speed bumps [7] (Fig. 1). Numerous studies have shown that the use of such devices at critical locations in residential areas significantly reduces vehicle speeds and thus also the number and consequences of road accidents involving vulnerable road users [8].

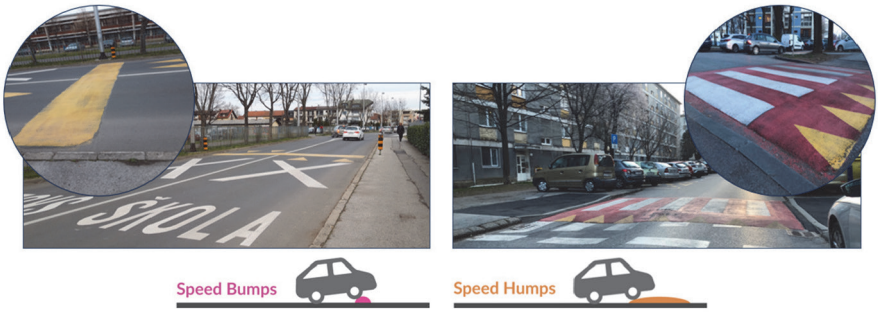


Figure 1 Vertical traffic calming devices: a) speed bump, b) speed hump

The parameters of vertical traffic calming device that most influence the reduction in vehicle speed are ramp length and ramp height: the longer the ramp, the lower the speed over the device [9]; raising the device by 1 cm leads to a speed reduction of 1 km/h [10]. It is also very important that the device is made of suitable materials to prevent the vehicles from skidding, that it is manufactured with minimum deviations from the prescribed dimensions, that it is properly labelled with appropriate signs and markings, that it is placed at an appropriate distance from road crossings and crosswalks, and that it is visible from a sufficient distance [11]. This study deals with red-coloured speed humps that are installed across the entire width of the carriageway. This is a speed hump that is increasingly being used when installing new and replacing existing vertical traffic calming devices in Croatia.

2 Red-coloured speed humps

According to the Croatian Regulation on Traffic Signs, Signalisation and Road Equipment [12], speed humps are constructed surfaces with a trapezoidal profile for enforced speed reduction. They are placed either individually or in a row, usually on local and unclassified roads in the settlement near public buildings and spaces (schools, kindergartens, playgrounds, etc.) where it is necessary to slow down motor vehicles for road safety reasons. The use of these devices is not permitted on roads and streets frequently used by emergency vehicles (e.g. access roads to hospitals). The height of the speed hump (h) is 7.5 cm, the slope of the access ramp (1:n) is 1:15 to 1:20 and the length of the access ramp (l_{ar}) is approx. 100 cm (Fig. 2). They must not have any sharp edges at the connection with the pavement in the direction transverse to the driving direction. They must stand out from the road in terms of colour so that they are clearly visible both day and night, and they must be marked with appropriate horizontal and vertical traffic signalization. Their surface must be made of non-slip material and marked with durable reflective material on the side from which the vehicle is approaching. Adequate drainage measures must be implemented in the zone of these devices.

There are two different types of red-coloured speed humps installed across the entire width of the carriageway in Croatia: the speed hump on which a crosswalk is marked (Fig. 3a) and the speed hump installed immediately in front the crosswalk (or in rows) (Fig. 3b).

The Croatian Regulation [12] does not stipulate when a speed hump installed across the entire width of the carriageway should have marked crosswalk on it, and when the speed hump must be placed in front of the crosswalk. However, during a site visit to a number of locations where such devices have been installed, it was noticed that crosswalks are manly drawn at speed humps in front of public buildings such as schools and kindergartens. In this way, better visibility of the most vulnerable road users (children) is achieved at raised crosswalks. On the other hand, there is rarely a marked crosswalk on a series of speed humps. Namely, such devices are often installed on access roads next to car parks, playgrounds, etc. to reduce driving speeds on longer stretches of road.

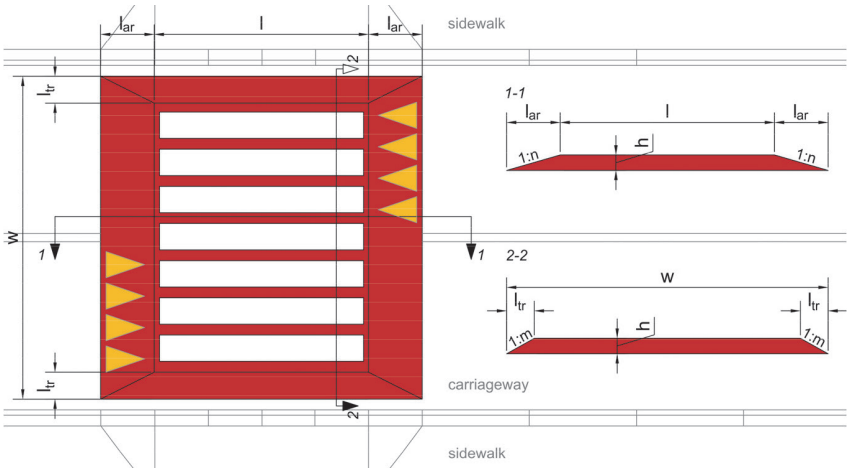


Figure 2 A detail of the red-coloured speed hump

As already mentioned, the height of the speed hump (h) as well as the slope (1:n) and length of the access ramp (l_{ar}) are specified in the regulations [12] (Fig. 2). Slightly shorter transition ramps (l_{tr}) are built transverse to the road axis, the slope of which (1:m) is not prescribed, but which are also necessary, both for the drainage of rainwater and for easier crossing from the sidewalk (dropped kerb) to the speed hump. The width of the speed hump (w) is not prescribed and depends on the width of the carriageway. It should be noted that the speed hump is often about 20 cm away from the edge of the carriageway, also to allow rainwater to drain away more easily. The length of the speed hump (l) between the access ramps is also not prescribed. However, experience has shown that this part of the speed hump should be approx. 4 metres long, i.e. longer than the wheelbase of passenger cars [13]. In addition, the length of the speed hump with marked crosswalk also depends on the width of the crosswalk, which is at least 3 m according to [12].

The rainwater from the speed humps pours over the ramps onto the carriageway and continues to flow along the longitudinal and transverse slope of the road towards the road drains. When choosing the location for the installation of these speed humps, care must be taken to ensure that the existing water drainage from the carriageway is not interrupted.

These speed humps are usually made of asphalt or poured concrete. There are no specific guidelines and rules for choosing one or the other material, as each of them has certain advantages and disadvantages. Asphalt speed humps, for example, are cheaper, more flexible and can be installed and used more quickly than concrete speed humps. On the other hand, the flexibility makes an asphalt speed hump more sensitive to high temperatures, which can lead to rutting in summer. Concrete speed humps are somewhat more expensive, but also more durable. They withstand high temperatures well, but can be damaged at low temperatures when water freezes in small cracks in winter. Once the speed hump is installed, it will be painted with red reflective paint and marked with yellow arrows on the access ramps.

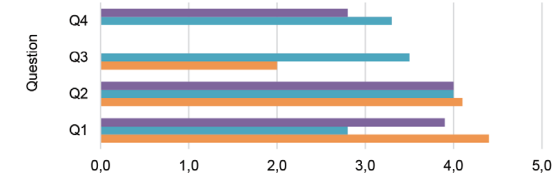
3 Survey on user opinion and satisfaction

A short survey was conducted at two locations in Zagreb, the capital of Croatia, where two different types of red-coloured speed humps are installed: with a marked crosswalk (location L1 in Fig. 3a) and without crosswalk (location L2 in Fig. 3b). The roads observed were two-lane roads with two-way traffic and sidewalks on both sides. The speed limit was 40 km/h.

Figure 3 Red-coloured speed hump installed across the entire width of the carriageway at: a) location L1, b) location L2

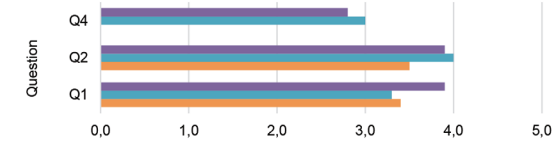
A total of 60 randomly selected passers-by of all ages were interviewed, including 10 pedestrians, 10 cyclists and 10 car drivers at each location. As can be seen from Table 1, certain questions have been adapted to the individual user categories. Questions Q1, Q2, Q3 and Q4 were related to the general satisfaction of users with the speed humps in question and their effectiveness and comfort. Questions Q5 and Q6 were related to users' opinions on pedestrian safety at/near these speed humps and question Q7 to their preferences for the type of vertical traffic calming device.

The survey results showed that all user groups were generally satisfied with the two types of red-coloured speed humps examined and considered them to be effective (Fig. 4 and Fig. 5). However, it should be noted that cyclists were the least satisfied group with these speed humps, and that pedestrians were notably more satisfied with the speed hump with marked crosswalk. Furthermore, car drivers found both speed humps moderately to very uncomfortable, and cyclists found them moderately to slightly uncomfortable. Pedestrians, on the other hand, found the speed hump with the marked crosswalk very uncomfortable.



	Q1	Q2	Q3	Q4
Drivers	3,9	4,0	0,0	2,8
Cyclists	2,8	4,0	3,5	3,3
Pedestrians	4,4	4,1	2,0	0,0

Figure 4 Average rating of the red-coloured speed hump on which a crosswalk is marked: a) user satisfaction (Q1), b) efficiency (Q2), c) user discomfort when crossing the road (Q3), d) user discomfort on the carriageway (Q4)



	Q1	Q2	Q4
Drivers	3,9	3,9	2,8
Cyclists	3,3	4,0	3,0
Pedestrians	3,4	3,5	0,0

Figure 5 Average rating of the red-coloured speed hump installed immediately before the crosswalk: a) user satisfaction (Q1), b) efficiency (Q2), c) user discomfort on the carriageway (Q4)

Table 1 Survey of users' opinions on red-coloured speed hump installed across the entire width of the carriageway

Q no.	Questions	User responses	Examined users
Q1	How satisfied are you with this type of speed hump?	very dissatisfied (1) dissatisfied (2) neutral (3) satisfied (4) very satisfied (5)	pedestrians cyclists drivers
Q2	Do you think they are effective?	very ineffective (1) ineffective (2) neutral (3) effective (4) very effective (5)	pedestrians cyclists drivers
Q3	How much discomfort do they cause you when you cross them from sidewalks?	extreme discomfort (1) very discomfort (2) moderate discomfort (3) slight discomfort (4) no discomfort (5)	pedestrians cyclists
Q4	How much discomfort do they cause you when you cross them from carriageway?	extreme discomfort (1) very discomfort (2) moderate discomfort (3) slight discomfort (4) no discomfort (5)	cyclists drivers
Q5	At which crosswalk do you feel safer?	a) at crosswalk marked at speed hump b) at crosswalk marked near the speed hump	pedestrians
Q6	How can you recognise pedestrians better?	a) at crosswalk marked at speed hump b) at crosswalk marked near the speed hump	drivers
Q7	What type of vertical traffic calming devices should be installed most frequently in your city?	a) red-coloured speed hump installed across the entire width of the carriageway b) narrow concrete speed bump c) trapezoidal rubber modular speed hump	pedestrians cyclists drivers

The assessment of pedestrian safety at/near the investigated red-coloured speed humps showed that pedestrians feel safer at speed hump with a marked crosswalk and that drivers perceive pedestrians significantly better at the same speed hump (Fig. 6).

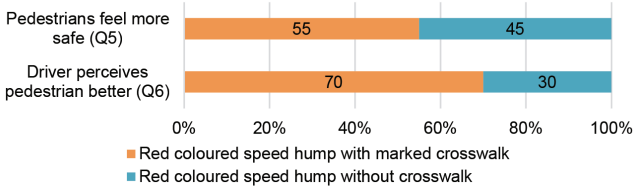


Figure 6 Assessment of pedestrian safety at/near the different types of red-coloured speed humps installed across the entire width of the carriageway (Q5, Q6)

The answers to the last question, relating to users' preferences for the type of vertical traffic calming device (Fig. 7), showed that pedestrians and drivers most preferred the red-coloured speed humps and cyclists the trapezoidal modular rubber speed humps. All users surveyed found the narrow concrete speed bumps the least desirable.

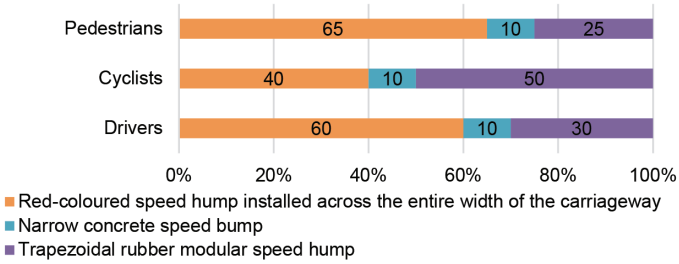


Figure 7 Percentage of different road users that prefer certain type of vertical traffic calming devices (Q7)

4 Conclusions

Red-coloured speed humps, which are installed across the entire width of the carriageway, have been used more and more frequently in Croatia in recent years when installing new and replacing existing vertical traffic calming devices. They are durable, easy to install and highly visible both day and night. The survey carried out as part of this study showed that all user groups analysed (pedestrians, cyclists and car drivers) were generally satisfied with these speed humps and considered them to be effective. Drivers found them moderately to very uncomfortable, while cyclists found them moderately to slightly uncomfortable. Pedestrians, on the other hand, found the speed hump with the marked crosswalk very uncomfortable, but also stated that they felt safer on it than on the classic crosswalk marked on the carriageway.

In the light of the above considerations, the authors of this paper are of the opinion that the red-coloured speed humps installed across the entire width of the carriageway are a good solution for traffic calming in urban areas in Croatia, but clear recommendations for their installation should be defined. In fact, many different types of speed humps and speed bumps are installed in this country, and it is obvious that those responsible in local authorities do not coordinate their choice. One possible problem could be that there are no universal guidelines to help select the appropriate type of traffic calming device in a particular location, and only a relatively small number of previous studies have focussed on assessing their effectiveness and safety benefits.

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