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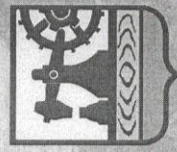
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CITY OF BITOLA TOWARD TRAFFIC CALMING AND STREET NETWORK RE-DESIGN

Summary. The current urban planning principles are based on the renewal and use of the cities' available potentials, with the aim of their sustainable urban mobility development. Today, as many authors have stated, there is no doubt that urban reconstruction is a much better direction for the development of smart cities since numerous challenges threaten the ability of cities to become viable pillars of sustainable development. The main objective of this paper is to adopt recently developed methodology for the analysis and selection of pedestrian crossing types on the case study location example regarding first phase of building and introducing urban sustainability directions of the city of Bitola, North Macedonia, on its road towards development as a compact city, as well as to underline the principles and assessment procedure for the re-design of urban network in Bitola as a sustainable urban form

1. INTRODUCTION

Pedestrians are the most vulnerable road users. In many countries, collisions with pedestrians are a leading cause of death and injury, and over half of all road deaths are caused by collisions between vehicles and pedestrians, that occur in a number of situations, especially including walking while trying to cross the road. Road traffic crashes kill 1.25 million people every year, almost 90% of road traffic deaths occur in low- and middle-income countries, road traffic injuries are the #1 cause of death for people aged 15-29 years, road traffic crashes cost countries around 3% of their GDP. Moreover, according to Principle 2 of the Declaration of the Rights of the Child, "The child shall enjoy special protection, and shall be given opportunities and facilities, by law and by other means, to enable him/her to develop physically, mentally, morally, spiritually and socially in a healthy and normal manner and in conditions of freedom and dignity"[1].

Since the current urban planning principles are based on the renewal and use of the cities' available potentials, with the aim of their sustainable development, the general aim of our work is to emphasized that SUMP (Sustainable Urban Mobility Plan) components: safety and security are a core components in creating sustainable urban mobility, and are primary areas of action, particularly in making roads safer and more secure for 'vulnerable' road users. Improving the safety and security of modes can be an extremely important step in encouraging users to change (or even try) alternative modes, especially when they are perceived as 'unsafe'. One of the urban mobility measures and management is traffic calming. It is a combination of a plurality of physical measures, which aim to reduce the negative effects of the use of motor vehicles, bringing to change driver behavior and reduce the maximum speed of which would achieve greater traffic safety. Traffic calming is defined as a concept of transport policy that includes promotion of traffic to pedestrians, cyclists and public transport, and a reduction in average speeds for vehicles in residential areas. The same so in calming traffic applied to

the control of speeds vehicles in recreative zones. In its early development in the UK in the 1930s, traffic calming was based on the idea of residential areas protected from through traffic. Subsequently, it was mainly justified on the grounds of pedestrian safety and reduction of the noise and local air pollution that traffic produces. However, car traffic severely impairs the social and recreational functions that streets are now recognized to have. The Livable Streets study by Donald Appleyard (1981) found that residents of streets with light traffic had, on average, three more friends and twice as many acquaintances as the people on streets with heavy traffic which was otherwise similar in dimensions, income. For much of the twentieth century, streets were designed by engineers who were charged only with ensuring smooth traffic flow and not with fostering the other functions of streets. The basis for traffic calming is broadening traffic engineering to include designing for these functions.

1.1. Elements of traffic calming

Useful definition is that they are solutions that reduce the behavior of the driver to reduce the vehicle speed or to improve the safety of pedestrians.

Frequently used items in the projects for traffic calming are the following:

- Bumps on the road;
- Boards (panels) in the form of a trapezoid;
- Tightening;
- Chicanes;
- Treatment of entry;
- Other elements;
- Area housing.

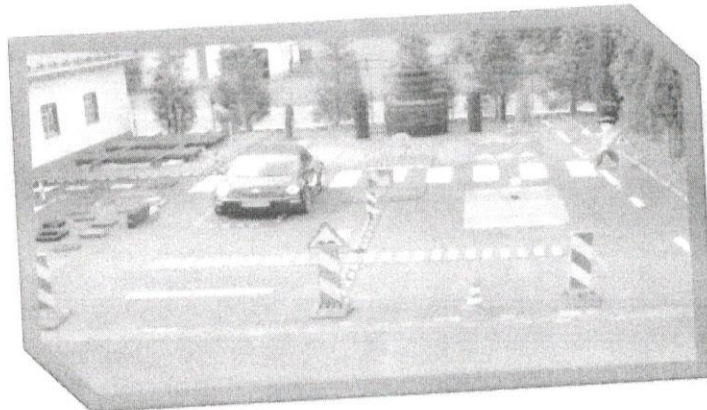


Fig. 1. Traffic calming items

Bumps on the road are the most effective measures to reduce the breeze of the vehicles. There are different designs bumps in different countries. In general can be given as narrow and wide, narrower bumps to spend less time while the extended bumps result in less effect of "reducing speed". The height of the Bump is between a minimum of 50 mm to a maximum of 100mm. The amount of bumps change depending on the scheme of traffic calming. Bump, with a height of 50 to 70 mm can be placed on roads in moving vehicles or vehicles of public transport emergency. The height of 100mm gives better cuts than lower speed bumps for a given spacing.

The downsides of these bumps are:

- They are not accepted by the companies of public transport and emergency services;
- Cyclists have circumvented;
- Leading to increased traffic on adjacent roads;
- Low vehicles and vehicles with large distance between axles can touch the ground on the vehicle;

- It requires a lot of bumps on a long road.

From an environmental perspective bumps which shaped plate is acceptable for pedestrians, given that provide flat crossings from curb to curb.

The amount ranges from 50 mm to 100mm.

They are useful at:

- For local and collector streets;
- Roads passing through small settlements;
- For entry into the zone at a speed of 32 km / h.

They are useful for:

- Local and collector streets;
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- The Port of Entry in zone at a speed of 32 km/h.

The pads to limit the breeze are quite friendly to buses, cyclists and vehicles. Emergency interventions, rather than ask curb to curb, cushion can be incorporated into the lane at a distance of 1m from the curb. If it is higher than 7.5 cm it can present a problem for sport vehicles. The recommended length of these bags is from 2 to 3.7 m.

Tightening are extensions of the sidewalk or islands on one or both sides of the street, which on this spot narrow street. The expansion may be a footpath or green space with vegetation. An effective result is achieved with a combination of extended walkway and flat hump. The road where the traffic is in two directions, the tightening is performed at 20 feet (6 meters), typically dodge width of 13 to 17 feet (4 to 5 meters).



Fig. 2. Tightening the path from the left and the right



Fig. 3. Tightening the path from both sides

The Effects of such tightening are:

- The speeds will be reduced to 4% if the tightening is on one side, 14% if there is a tightening on both sides of the street;
- Reduce the passage of travellers through the wide streets and places to secure better visibility for them;
- Provide better view of the street with greenery on the islands at the ends of the streets.

Chicanes represent a series of alternating tapers or deformation of the edge that extends from one side to the other side of the street forming an "S" turns. If the narrowing is performed at 10 to 15 m, they can be effective in reducing speed. Apply in places where there is an equivalent flow of vehicles in both directions. Not admitted to the difficulty of manoeuvring the buses.

Treatment of entry used in environments where the driver should be observed informs that changing the character of the road, starting zone for traffic calming or join in the settlement.

The method uses structures - granite sets a different texture of the road surface in order to provide input or output image, while reducing speed combined with physical and psychological means of transport.

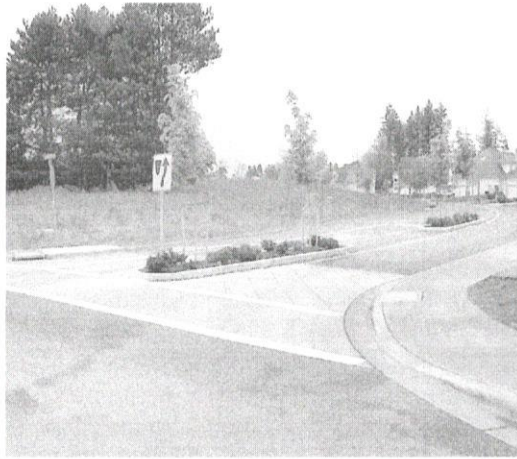


Fig. 4 Treatment of entry

Other elements are for example, ecological sealing off streets - closings, that can be **derived as:**

- ✓ Diagonally diverting - barriers, diagonally placed on the intersections, blocking movement, sometimes called diagonal closure of the road;
- ✓ Half way closing - barrier, closing travel in one direction over short sections of roads that are two-way.

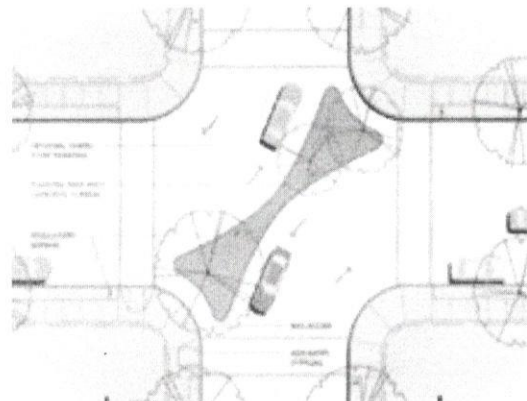


Fig. 5. Diagonally diverting

Tightening the island in the middle of the road is raised island located along the central axis of which narrow the street. With this measure it provides safe crossings for pedestrians even on the central points of the road.



Fig. 6a. Tightening the island in the middle of the road

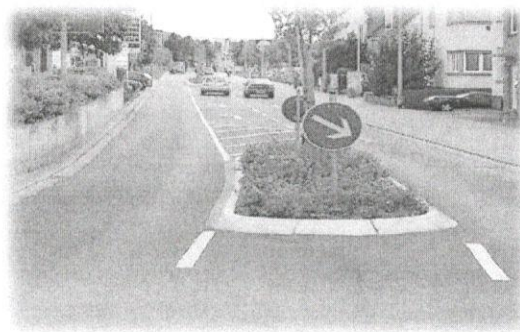


Fig. 6b. Tightening the island in the middle of the road

2. GEOMORPHOLOGICAL POSITION OF BITOLA AND URBAN STREET NETWORK

Since the primary focus of the National Strategy on the Sustainable Development in our country, is placed on systematic and better management of urbanization through sustainable land use policies and tools, the idea to analyze the need and possibilities for introducing the concept by using new simulation tool seems logical and necessary. Thus, bearing in mind that the vision of local public authorities, specifically those in the field of traffic and urban planning is highly important for generating sustainable urban development strategies, the main aim of this paper is transfer the scientific knowledge to the local level through the use of 2D simulation of urban streetscape and traffic flow. Namely, the City of Bitola case study illustrates how a city can address a nationwide problem at the local level. Bitola (Figure 6) is the economic and industrial centre. The Pelagonia agricultural combine is the largest producer of food in the country. The Strezevo water system is the largest in our country and has the best technological facilities. The three thermoelectric power stations produce nearly 80% of electricity in the state. Bitola also has significant capacity in the textile and food industries. Bitola is also home to twelve consulates, which gives the city the nickname "the city of consuls." Covering an area of 1,798 km² and with a population of 74,550 (2002), Bitola is an important industrial, agricultural, commercial, educational, and cultural centre. It represents an important junction that connects the Adriatic Sea to the south with the Aegean Sea and Central Europe, as in [3].



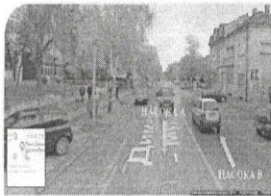
2.1. City of Bitola and the local mobility

3. LOCATION ANALYSIS

The main objective of this analysis is to use recently developed methodology regarding the selection of the most suitable pedestrian crossing type for the city of Bitola, North Macedonia, and the most important aim is directed towards obtaining pedestrian safety, bearing in mind the role of pedestrian safety within the current safety goals [3].

For the analysis of the selected location, one-hour traffic counts were fulfilled. Data were collected, analyzed and synthesized in the Table 2.

Tab. 1

	<i>A1 - signalized pedestrian crossing</i>	<i>A2 - pedestrian crossing with refuge median island</i>	<i>A3 – pedestrian overpass</i>	<i>Studied location</i>
K1- Safety Criterion	<i>sub criterion: driving speed (N,1.1)</i> <i>sub criterion: traffic flow (N,1.2)</i> <i>sub criterion: length of the pedestrian crossing (road width) (N,1.3)</i>			
K2 - Price Criterion	<i>sub criterion: price of design (N,2.1)</i> <i>sub criterion: price of construction (N,2.2)</i> <i>sub criterion: price of maintenance (N,2.3)</i>			
K3- Environment & Comfort Criterion	<i>sub criterion: noise and environmental impact (N,3.1)</i> <i>sub criterion: comfort (N,3.2)</i> <i>sub criterion: access for the disabled (N,3.3)</i>			

Source: authors

Tab. 2

Total hourly number of traffic users

	PEDESTRIANS	MOTOCICLES	PC	BUS	Heavy duty vehicles		
					LDV	DV	HDV
DIRECTION A	93	5	190	3	11	4	/
DIRECTION B		3	148	/	8	2	/
Total:	93	8	338	3	19	6	/

Source: authors

Through traffic calming is genetic expression to describe changes in the horizontal and vertical profile of existing roads in residential or school areas of trade or purchase, in order to reduce restrictions, and to improve safety of passengers and cyclists, based on the analysis we proposed tightening the path from the left, the right and both sides.

4. CONCLSION

Safety is a condition in which a pedestrian can normally cross a pedestrian crossing, with the process not being disturbed nor degraded due to various threats and dangers. Driving speed has been identified as a key risk factor in road traffic injuries, influencing both the risk of a road crash as well as the severity of the injuries that result from crashes. The length of the pedestrian crossing is in correlation with traffic safety. The crossing time using a longer pedestrian crossing means longer stay of the pedestrian on the roadway and higher risk of getting injured. On a multi-lane road the vehicles moving along the right kerb often obscure the view of vehicles that move along the farther lane. This phenomenon is especially noted in cases when small children want to cross the street and the motorists fail to notice them on time. This problem is especially emphasized in the vicinity of schools. Exposure to noise in everyday urban life is considered to be an environmental stressor. A specific outcome of reactions to environmental stress is a fast pace of life that also includes a faster pedestrian walking speed. On zebra crossings and signalized crossings pedestrians are exposed at great noise level, whereas in underpasses and overpasses they are much better protected. The influence of noise is greater the closer the vehicles are to the pedestrian crossing and the larger their number. This influence

is most expressed in peak hours when the highest number of vehicles is on the road, as well as pedestrians. Aesthetics and environment considers the negative impacts of pedestrian crossing construction on the environment, changes of the streetscape, unpleasant experiences as well as a feeling of personal protection. The methodology of selecting a pedestrian crossing proposed by this research is comprehensive. For this purpose, adopted AHP excel software tool has been tested. Analysis results shows that median islands as well as tightening the street profile are recommended.

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