DESIGNING THE CROSS-SECTION OF URBAN STREETS FROM THE PRIMARY URBAN NETWORK: BOULEVARD “ST. CLEMENT OF OHRID” – SKOPJE

Kristina Ickovska
MSc in Civil Engineering
Ss. Cyril and Methodius University in Skopje
Faculty of Civil Engineering
N. Macedonia
ickovska@outlook.com

Slobodan Ognjenovic
PhD, Professor
Ss. Cyril and Methodius University in Skopje
Faculty of Civil Engineering
N. Macedonia
0000-0002-4242-9169

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This study analyzes the dimensioning of the cross-section profile of urban streets within the primary street network, using the example of Boulevard "St. Clement of Ohrid" in Skopje as a case study. It emphasizes that the basis for determining the cross-section is the comparison between the expected traffic load and the permitted traffic flow per lane. The number and width of lanes must be adapted not only for motor vehicles but also for public transport, cyclists, and pedestrians, ensuring safe and efficient movement for all users.

A major concern addressed is that street cross-sections are frequently designed mainly to accommodate motor vehicles, with remaining space only minimally allocated to pedestrians and cyclists. This practice overlooks the wider urban context and can negatively impact the overall quality of urban life. This study emphasizes the importance of adopting a holistic design approach that promotes non-motorized transportation and public transit to foster safer and more livable city environments.

Keywords: traffic lanes, safety, urban mobility, cyclists, pedestrians

1. INTRODUCTION

The basis for dimensioning the cross-section of a urban streets lies in comparing the design traffic load with the permissible traffic flow per traffic lane, i.e., the number of driving lanes is calculated as $n=Q_m/Q_i$. Attention must be paid to the traffic conditions (continuous or interrupted traffic flow), as the allowable traffic load per lane significantly varies depending on these conditions. Besides defining the number of lanes for motor vehicles, it is crucial to recognize that the cross-section includes other modes of transport that require a similar approach. Therefore, evaluating the capacity and level of service is a necessary process for public transport vehicles, cyclists, and pedestrians.

In reality, cross-sections are often dimensioned primarily for motor traffic, while the remaining space is distributed to pedestrian and bicycle traffic, as well as to central and lateral safety zones. Traffic issues must be addressed with a comprehensive approach based on the rational use of private motor vehicles while simultaneously promoting non-motorized transport and public transport. Otherwise, the uncontrolled and excessive use of private vehicles will completely devalue the essence of urban life and destroy space intended for people.

In the Dutch Road Safety Manual (CROW), streets that exhibit a mismatch between their function and designed geometric characteristics are called “grey streets” (grey roads). For example, a collector street intended to balance traffic flow and speed with the safety of all users and access to surrounding facilities, but designed with geometric and cross-section elements typical of an urban arterial street. This creates significant tension between the traffic function and all surrounding urban elements. To balance the designed elements with the function of the street, adjusting its cross-section is often the only viable option.

2. FUNCTIONAL ELEMENTS OF THE CROSS-SECTION

The cross-section represents the initial projection of the street through which the basic programmatic requirements are defined and the first physical contours of the future traffic space are shaped. It consists of a collection of various functional and structural elements. Their number, dimensions, and interrelationships depend on the functional classification of the street, the user structure, and the operational indicators.

Urban planners and designers must carefully adapt the widths of the cross-section elements to ensure that everything aligns with urban planning conditions, the specific types of urban traffic, and the spatial and environmental needs.

2.1 TRAFFIC LANES

The width of traffic lanes depends on the design speed, while their number is determined by the relevant traffic load and the level of service. The minimum width of a traffic lane is directly related to the width of the vehicle (maximum 2.50 m) and the lateral safety distance between vehicles. To ensure fast and safe passing of vehicles, there must be a protective distance between the vehicles themselves and between the edge of the roadway and the vehicle.

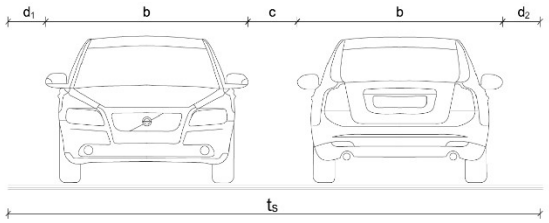

Figure 1. Carriageway width

Table 1. Traffic lane width

Design Speed V [km/h]	Lane width b [m]	2 × b = 2 × 2.50	
		c [m]	d [m]
≥ 100	**3.75**	1.70	0.40
80 ≤ V < 100	**3.50**	1.30	0.35
60 < V < 80	**3.25**	1.00	0.25
40 < V ≤ 60	**3.00**	0.80	0.10
Vr ≤ 40	**2.75**	0.30	0.10

, whereas:

$$t_s = d_1+2b+c+d_2 \quad (1)$$

$$c = 0.400+0.005*(V_1+V_2) \quad (2)$$

$$d = 0.200+0.005*V_{1,2} \quad (3)$$

2.2 PEDESTRIAN PATHS

Pedestrian paths must have sufficient width not only to allow movement, but also to support free activities, the overall potential, and the attractiveness of the outdoor space. They have a key impact on urban life and accessibility for residents. They should be designed in a way that provides full physical protection from traffic lanes. In this sense, a sidewalk placed directly next to the edge of the roadway without a protective zone is, in every respect, the least safe solution. Pedestrians are highly sensitive to so-called “lateral obstacles,” which must be taken into account when defining the effective width of the path. The effective width of the path or the unobstructed pedestrian movement zone, directly depends on the physical and/or psychological barriers located on both sides of the path.

The minimum sidewalk width on streets within the primary urban network is **4.50 meters**.

Figure 2. Sidewalk zones

2.3 CYCLING PATHS AND LANES

The operating envelope of a cycling surface consists of the width of the bicycle (0.60 m) and the maneuvering space required on both sides (0.20 m each), totaling 1.00 m. The clearance envelope includes the operating envelope plus safety clearances on both sides of the bicycle, with a minimum of 0.25 m each. The safety distance between the bicycle's operating envelope and fences, street furniture, or greenery should be 0.25 m. The safety distance between the bicycle's operating envelope and the carriageway should range from 0.25 to 0.75 m for motor traffic speeds between 30 and 50 km/h. If there is parallel parking adjacent to the edge of the carriageway, this safety distance should be 0.75 m. On the primary urban street network, physical separation between bicycle and motor traffic is required. According to the European Cyclists' Federation (ECF), segregation of motor and bicycle traffic is necessary wherever motor traffic speeds are ≥ 50 km/h.

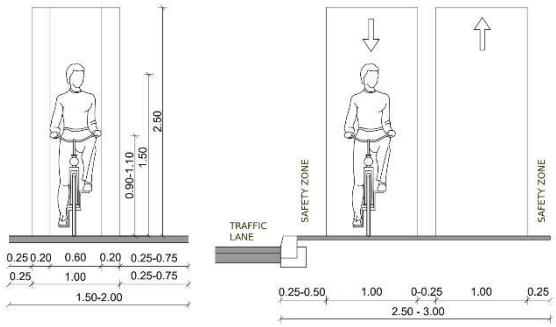

Figure 3. Cycling path, lane width

3. BOULEVARD "ST. CLEMENT OF OHRID" – SKOPJE

A typical example of a "grey street" is Boulevard "St. Clement of Ohrid" in Skopje. The boulevard is part of the primary urban street network of the City of Skopje, with a total length of approximately 917 meters. According to the functional classification of streets in the General Urban Plan (GUP) 2012–2022 of the City of Skopje, the boulevard is designated as an urban arterial street with a variable width ranging from 36 to 40 meters. This includes 2 x 10.50 m carriageways, a 5.00 m central green median, and sidewalks with variable widths ranging from 5.00 to 7.00 meters.

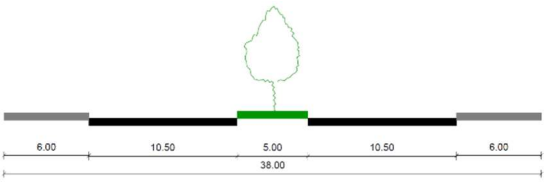

Figure 4. Cross-section of the boulevard according to the City of Skopje GUP 2012-2022

3.1 HISTORY OF THE BOULEVARD

The boulevard "St. Clement of Ohrid" is one of the oldest streets in the city, planned in the General Regulation Plan by architect Dimitrije T. Leko from 1914. In this plan, the areas on the left and right sides of the Stone Bridge are encircled by a boulevard called "Czar Dušan's Ring," which passes under the fortress through a tunnel. In the 1920s, street-related construction activities focused on expanding the existing street network and partially breaking through the "Czar Dušan" ring (today's "St. Clement of Ohrid" Boulevard).

Figure 5. "Czar Dušan's Ring" boulevard in the 1930s

In the period after World War II, the boulevard was preserved but underwent significant transformation of its surroundings with the construction of new residential and administrative buildings. It was renamed JNA Boulevard.

Figure 6. Cross-section of the boulevard up to 2011

In June 2011, a major reconstruction was carried out on the boulevard. An additional traffic lane was added at the expense of the central green strip, resulting in three traffic lanes per direction with a total width of 10.50 m. The two carriageway lanes are separated by a central green strip 5.00 m wide. The reconstruction also reorganized the existing intersections, creating dedicated left-turn lanes. At the intersection with Dimitrija Chupovski Street, the left-turn lanes were constructed, but left turns are prohibited.

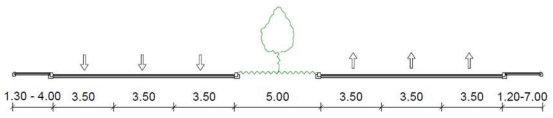

Figure 7. Cross-section of the boulevard up to 2011

In 2017, as part of the implementation of the new cycling infrastructure project "Skopje – Velograd," the width of the traffic lanes on a section of "St. Clement of Ohrid" Boulevard was reduced from 3.50 m to 3.00 m, enabling the introduction of one-way bicycle lanes in both directions with a width of 1.50 m each. "St. Clement of Ohrid" boulevard serves as one of the main connectors between routes 1, 2, and 3 of the "Skopje – Velograd" project.

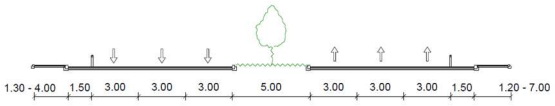

Figure 8. Cross-section of the boulevard from 2017 to the present

3.2 THE BOULEVARD TODAY

Although this boulevard is classified as an urban arterial street in the General Urban Plan of the City of Skopje, its cross-section does not correspond to its function.

CHARACTERISTICS OF AN URBAN ARTERIAL STREET	BOULEVARD "ST. CLEMENT OF OHRID"
They connect active areas of a city: residential zones with business districts, industrial zones, residential areas with the central urban area, and so on.	✗ connects individual parts of the central urban area.
They play a key role in public transport management.	✗ The boulevard plays a secondary role in the management of public urban transport.
Continuous traffic flow	✗ Interrupted traffic flow
Divided carriageways with at least two traffic lanes	▨ Divided carriageways with three traffic lanes
Pedestrian and bicycle paths separated from the carriageway by a planted curb strip	✗ Bicycle lanes on the carriageway and curb-separated bicycle and pedestrian paths
Urban buildings and facilities protected from noise and air pollution by a protective green strip.	✗ Curb built-up area

From the above, we can conclude that the cross-section of "St. Clement of Ohrid" Boulevard makes it a "grey street". Along and near the boulevard are located a university, cultural center, high school, cathedral, edge residential and business facilities, while at the same time it serves as a connection between Vodno and the Vardar River promenade, making it extremely important for pedestrian and bicycle traffic. Streets in the primary street network need to have a high-quality ambient function, which is especially important both for boulevard users and for the residents in its vicinity.

Figure 9. St. Clement of Ohrid Boulevard – Grey Street

Given the current situation, it is evident that the boulevard requires reconstruction aimed at increasing the safety of pedestrian and bicycle traffic, expanding urban greenery, reducing noise and air pollution, improving the boulevard's ambient function, and aligning the cross-section with its role in the street network. One way to achieve this goal is to reduce the number of traffic lanes to create space for protective curb green strips, two-way bicycle paths on both sides of the boulevard, and to widen pedestrian sidewalks where necessary.

3.3 CONCEPTUAL DESIGN

Typical cross-section of St. Clement of Ohrid Boulevard:
– Traffic lanes: 2 x 2 x 3.00 m
– Central median green strip: 3.00 m
– Bicycle paths: 2 x 2.50 – 2.75 m
– Curb green strips: 2 x 2.50 – 3.00 m
– Pedestrian sidewalks: 2 x 2.00 – 5.50 m

3.3.1 Intersections

At the intersection with Ilinden Boulevard, right-turn channelization has been eliminated to reduce crossing time for pedestrians and cyclists. Roughened surfaces are provided at the right-turn radii to slow down passenger vehicles while allowing larger motor vehicles—such as fire trucks, utility vehicles, ambulances, and similar to make turns. Within the intersection zone, continuous bicycle movements are ensured using a minimum turning radius of R = 3.00 m.

Figure 10. Pedestrian and bicycle crossing at the intersection with Ilinden Boulevard

For the intersection with Partizanski Odredi Boulevard, a solution has been developed involving the introduction of public transport on Partizanski Odredi Boulevard. The proposal includes implementing tramway public transport in the central part of the boulevard's cross-section. A tramway solution is presented, physically separated from the traffic lanes. Protective islands are planned between the right turns of motor vehicles and the bicycle lanes.

Figure 11. Intersection with Partizanski Odredi Boulevard

4. CONCLUSION

Modern urban street design represents a complex and comprehensive approach that prioritizes the needs of all users while integrating various elements to create safe, accessible, and vibrant public spaces. This entails creating conditions for multimodal transport, ensuring that streets provide safe motorized, pedestrian, and bicycle traffic.

Analyzing the current regulations in Macedonia and the widths of traffic lanes on urban roads in the country, especially in the city of Skopje, it is concluded that the lane widths rarely correspond to the maximum permitted speed in urban areas (50 km/h) and are most often dimensioned for higher speeds. In the General Urban Plan of the City of Skopje (2012–2022), 97% of the primary urban street network is planned with lane widths of 3.50 m, a width appropriate for speeds of 80–100 km/h. This data indicates that the city of Skopje needs to reduce the width of traffic lanes both in planning documentation and on existing roads to align the lane width with the maximum allowed speed of motor vehicles. Specifically, the lane widths on streets with at-grade intersections in urban areas should not exceed 3.00 m.

This adjustment will contribute to increased safety for all traffic participants, including pedestrians and cyclists, as well as drivers and passengers in motor vehicles.

In addition to increasing the safety of all types of traffic, reducing the width of traffic lanes on urban streets will also enable more rational dimensioning of the elements in the cross-section. The space gained by narrowing the traffic lanes can be used to introduce bicycle lanes or paths, widen pedestrian sidewalks, and increase green strips and areas, depending on the specific needs of the street. An indirect benefit of reducing lane widths is the reduction of asphalt surfaces, which contribute to the formation of urban heat islands and the increase of air temperature near the streets.

Figure 12. Transformation of St. Clement of Ohrid Boulevard

The historical changes to the cross-section of “St. Clement of Ohrid” Boulevard and the proposed solution can be seen in Figure 12 and reference [10].

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