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# Influence of Cycling Infrastructure on the Transformations of Public Spaces in Cities and Agglomerations

Andrzej Zalewski <sup>1</sup>, Joanna Fiszer-Sozanska <sup>1</sup>

<sup>1</sup> UTP University of Science and Technology, Faculty of Civil, Environmental Engineering and Architecture, Prof. S. Kaliskiego Avenue 7, 85-796 Bydgoszcz, Poland

andrzej.zalewski2205@gmail.com

**Abstract.** The aim of the article is presentation of influence of cycling infrastructure on the diversity of transformations in public spaces in cities and agglomerations. Transformation of street sections make changes in the organization of traffic and the transport service system of the area. As a rule, cycling and heavy vehicles are separated. In some situations, it is necessary to transfer some of the traffic or parking of the cars to the neighbouring streets. New cycling infrastructure in the street section at intersections and interchanges causes transformation in the division of the street public area, implementation of linear or point development and often the necessity of implementation of traffic lights. The cycling infrastructure in the traffic calming zones make changes in the division of the street public space and the implementation of physical impediments to reduce speed of traffic - these restrictions should not apply to bicycle traffic. In sections streets between the junctions, the implementation of cycling infrastructure into a street cross-section causes changes in the division of the street cross-section, taking into account the priorities and horizontal and vertical segregation of bicycle traffic from other road users and the functional and elevation shape of the terrain between the boundary lines and the carriageway. Roads and bicycles parking may be one elements of the interior design of streets and squares and the aspect of their urban and architectural shaping should be given special attention. Impacts of cycling infrastructure into transformation of public spaces will be present on selected examples from Polish towns and agglomerations (Warsaw, Lublin, Kutno and Tomaszow Mazowiecki).

## 1. Introduction - bicycle infrastructure in the classification of city roads and the principles of functional shaping of a street cross-section

The infrastructure for the bicycle as a transportation mode is included in the classification of city roads. For a bicycle, in addition to the possibility of cycling on general principles in mixed traffic, including mechanical or electric transport mode, due to its functional and technical characteristics (lack of protection in the event of collision with other transportation means and speed, often insufficient knowledge of traffic regulations) by cyclists), an infrastructure dedicated only to bicycle traffic is envisaged. Many interesting information regarding the bicycle function in urban and categories of urban roads, including a special category of urban roads for bicycles only provides a classification of urban roads of the World Road Congress (now the World Road Association) from 1991 [1]. According to the functional and technical characteristics, it is assumed that the bicycle in the motor aspect may be used for both transit transport and spatial development services. In the urban context, the design of the infrastructure for bicycles should take into account the architectural structure of the space and the impact on the aesthetics of urban roads and infrastructure in terms of orientation of cyclists. In the aspect of the social function of city roads, the bike can be used both in everyday and recreational movements. Bicycle infrastructure routes intended for everyday travel should be kept as short as possible. In the street space for cyclists, the microclimate that prevails on the route they move



is of great importance. In the urban context, the design of the infrastructure for bicycles should take into account the architectural structure of the space and the impact on the aesthetics of urban roads and infrastructure in terms of orientation of cyclists<sup>1</sup>. In the aspect of the social function of city roads, the bike can be used both in everyday and recreational traffic. Bicycle infrastructure routes intended for everyday travel should be kept as short as possible. In street space, the microclimate that prevails on the course that cyclists move is important.

A place for a bicycle is classified according to the AIPCR / PIARC classification in five out of six urban road categories, i.e. .:

- Class II - roads for all transportation modes with segregation of traffic and speed allowed up to 50 km/h,
- Class III - roads for all transportation modes with traffic integration and speed allowed up to 30 km/h (itineraries or zones of traffic calming - tempo "30", residence zone, woonerf),
- Class V - roads for bicycles that are intended only for cyclists,

In addition, according to the authors, cycling can take place on class IV roads - roads for public transport<sup>2</sup> and on class VI roads - pedestrian routes, where bicycle traffic is subordinated to pedestrian traffic. The possibility of cycling traffic above the category of city streets means that solutions for bicycle traffic can have a very different form, in the field of street-side switching and various priorities for bicycles. In street cross-sections should be protected by the efficient and safe operation of the transportation modes that are admitted to traffic and parking. The diagram of mutual connections between elements of transportation infrastructure in the street cross-section and transportation modes and functions of the public street space, taking into account the aspect of traffic safety, is presented in Table 1. The implementation of the bike into the street space interferes significantly in its earlier use.

The bike as a transportation mode is associated with the carriageway intended for the traffic of wheeled vehicles, including primarily motor vehicles and with pedestrian space. The street cross-section should take into account the possibility of parking bicycles. Bicycle infrastructure is an element of the use of space, which should be arranged in an appropriate manner to positively affect the aesthetics of the street and does not pose hazards in the safe and efficient use of cross-section elements intended for other transportation modes. The designation of places (sockets) for parking bicycles prevents chaos in the public space caused by uninhibited bicycles.

**Table 1.** Scheme of functional connections of the land use elements and transportation modes in street cross-section

	traffic				using	arrangement of public space
	cars	public transport	bike	pedestrian		
space for pedestrians						
cycling infrastructure						
carriageway						
car parking places						
bike parking places						
middle belt						
separated track for public transport						

Designations:  strong relationship;  medium relationship;  weak relationship.

## 2. Possibilities of location of bike in the space of streets and roads

Bike as a transportation and recreation mode in the era of universal policy of sustainable development in spatial development and transport has become present in the public space of the streets of many cities and agglomerations in Europe. A similar situation takes place also in Poland, where in the last

<sup>1</sup> Cyclists in daily travels prefer the shortest routes in its course.

<sup>2</sup> Common bike-bus-taxi or tram-bike lanes.

several years the use of a bicycle has become more and more popular and infrastructure is being developed. This makes it necessary transformations in the streets and squares. The street space in the lines delimiting the spatial development or in the lines of building streets and squares is very limited and the possibilities of introducing infrastructure for bicycles into this space are very limited. In addition, many streets have narrow cross-sections, where it is impossible to place infrastructure for bicycles, due to spatial restrictions and conservator protection.

Literature review [1-9] and authors' own experiences [10-12] show that the possibilities of placing a bicycle in the space of streets and roads are very diverse:

- Bicycle as a free vehicle
- Bicycle traffic treated as similar to pedestrian traffic
- Bicycle traffic as independent
- Bicycle traffic on general terms (with possible speed limits and availability for selected categories of traffic participants)
- Segregation of pedestrian and vehicular traffic,
- Integration of pedestrian and vehicular traffic on a common surface.

When a bicycle is treated as a slow vehicle, road equipment and traffic organization must be adapted to receive it. In terms of types of cycling infrastructure, the following solutions can be distinguished on the sections between intersections: a separate bicycle road, a bike lane and/or a recommended traffic lane, paved roadside, a pedestrian-bicycle route), a bicycle and bus corridor or a bicycle-bus-taxi lane and a lane bicycle on the road in the direction opposite to the direction of traffic on the road (contra-lane) and/or the recommended lane<sup>3</sup> on the road.

The bicycle as a pedestrian-like route layout and traffic organization must be adapted to the requirements of pedestrian and bicycle traffic (pedestrian-bicycle route, one- and two-way bicycle path run next to the pedestrian walkway without physical separation).

If bicycle traffic is treated as independent, it is isolated in the form of independent bicycle routes, run parallel or in the distance from the existing element of the road and street system (a separate bicycle path on the former railroad track).

If cycling is done on general road traffic principles (with optional speed limits and availability for selected categories of road users - maintaining traffic segregation - street bike, the route recommended street traffic calming "speed 30" or "rate of 40," traffic calming or on the principle of integration traffic of various transportation modes in the form of a "woonerf", pedestrian-traffic itineraries, or bicycle-bus-taxi or tram-bike corridors.

### **3. Transformation of the public space of roads and streets after the implementation of infrastructure for bicycles**

The implementation of a separate infrastructure for bicycles in the public space of streets causes numerous and various changes. Transformations of street sections entail changes in the organization of traffic and the transportation service system of the area. As a rule, cycling and heavy vehicles are separated. In some situations, it is necessary to transfer some of the traffic or parking to the neighbouring streets.

The implementation of cycling infrastructure in the street section at intersections and road interchanges results in:

- changing the division of the street transportation area,
- implementation of linear or point development,

Implementation of cycling in the zones of traffic calming causes:

- changing the division of the street transportation area,
- implementation of physical impediments to speed limit - these restrictions should not apply to bicycle traffic,

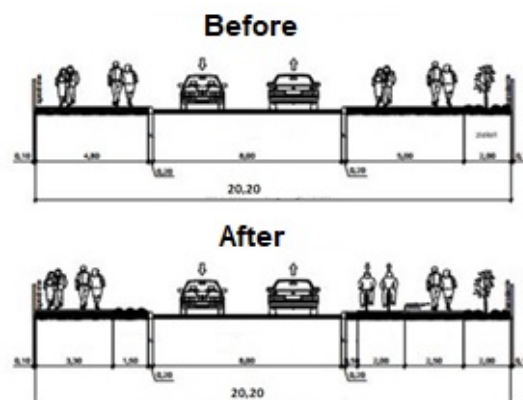
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<sup>3</sup> Recommended lane for bicycles - shared by bicycles and cars with priority for bicycles. When there is no bicycle, the car can use the entire width of the lane

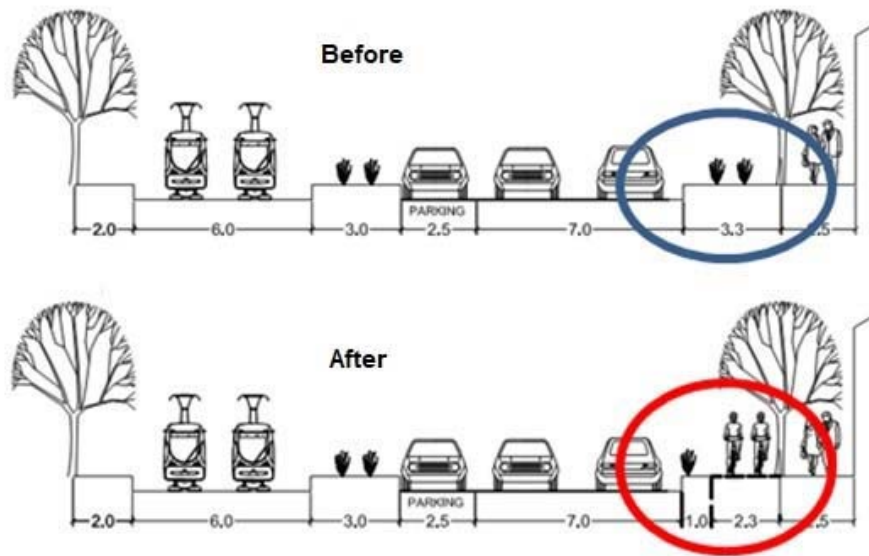
- on sections of intersection between crossroads, the implementation of cycling infrastructure into a cross-section street causes changes:
- division of the street transportation area, including priorities and horizontal and vertical - segregation of bicycle traffic from other road users,
- functional and elevational shape of the area between the boundary lines and the roadway.

#### 4. Examples transformations of street cross-sections in the aspect of implementation infrastructure for bicycles

Based on the authors' experiences (design and implementation), below are selected transformations of street cross-sections in street bounding lines (figures 1-10) on examples from Polish cities: Warsaw [10], Kutno [11], Lublin [12] and Tomaszow Mazowiecki [3]. The cross-sections presented above relate mainly to transformations consisting of: separating the bike from the roadway and marking between the road and the dividing line of the two-way bicycle path (figure 1 and 2), one-way paths (figure 3), pedestrian and bicycle paths (figure 4), separation on the road: a two-way bicycle path in place of one car lane (figure 5), one-way bicycle lanes (figure 6), recommended lanes for bicycles or bike lanes on carriageway (figure 7), contra-lane on a one-way street with simultaneous transformation of the street into a "bicycle street" with mixed cycling and car traffic and speed limit up to 30 km/h (figure 8). At figure 9 is showed the transformation of a street cross-section, where previously unidirectional bicycle paths of understated width were located on the sidewalks and bike path, which was very dangerous for cyclists and pedestrians. Therefore, it was proposed to transform the street into a "bicycle street" with an authorized speed of up to 30 km / h. This solution should improve traffic conditions and safety of the above-mentioned groups of traffic participants. Figure 10 shows variant transformations of a street cross-section, when a planned bicycle path is run on a bridge - variant I (a staged solution) provides on one side of the road to be covered by bicycles, which was previously intended for pedestrian traffic), and variant II (final solution) to build a footbridge for cyclists across the river.



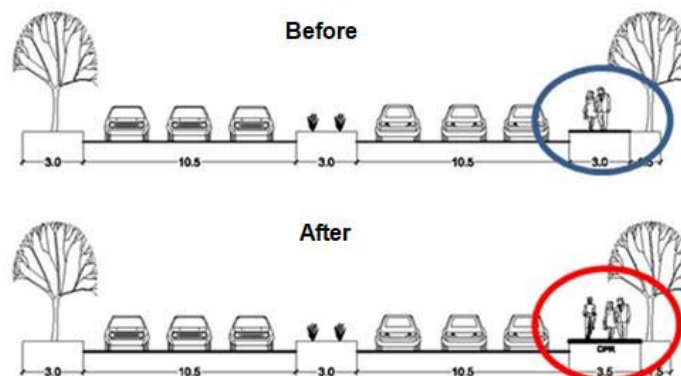
**Figure 1.** Transforming the street cross-section by separating bicycle traffic from the carriageway and separating a two-way bicycle path from the sidewalk 2.5 m wide with a band 0.5 m and from the sidewalk with a belt - a width separator of 0.5 m [11].



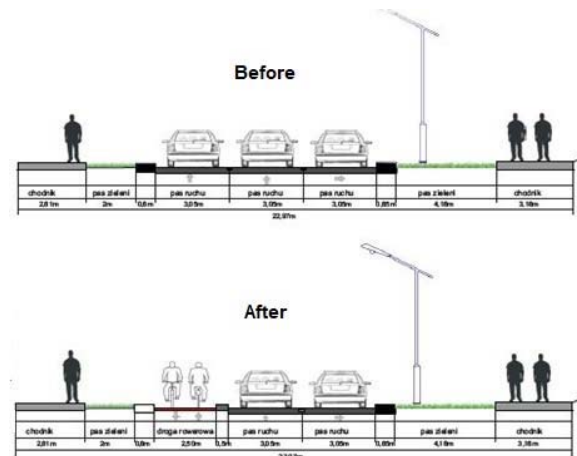
**Figure 2.** Separation of the bike from the roadway by dividing the carriageway into a bike-path and the accompanying sidewalk. Bike-path is located in the place of the green area [10]



**Figure 3.** Rebuilding of street a cross-section by reducing the width of the sidewalk and construction of a one-way bike- path, width 1.5 m, and a lane separating the bike path from the carriageway 2 m and a strip separating from the sidewalk, 1.5 m wide [3]



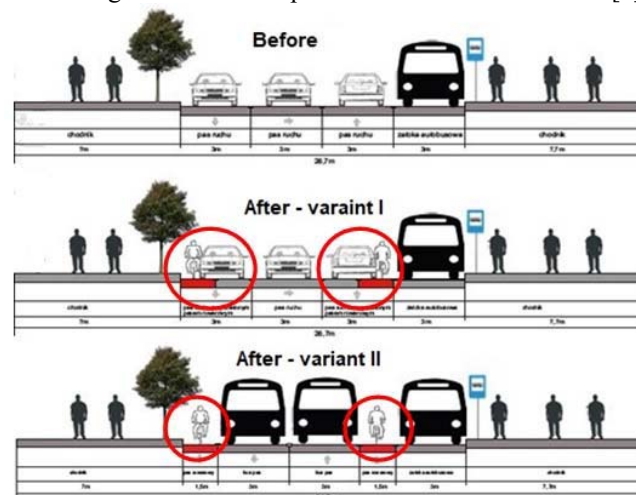
**Figure 4.** Separation of the bicycle on the roadway of the two-street street by and transforming the pavement into a pedestrian-bicycle route with possible reduction of the width of the green area [10]



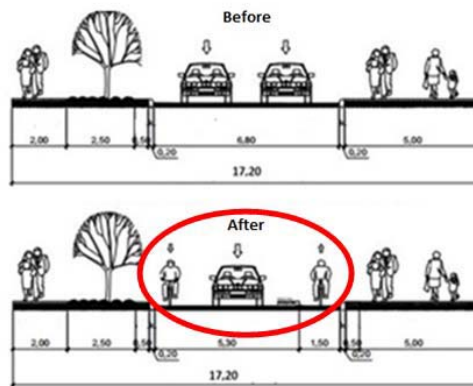
**Figure 5.** Proposal of transformations of the cross-section of a one-way three-lane street by transforming the lane into a two-way bicycle path separated from the carriageway by a separator (a curb width of 0.5 m) [12]



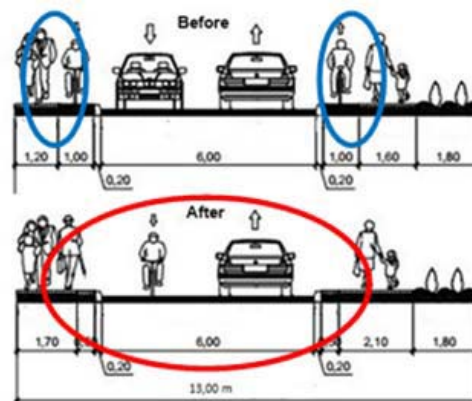
**Figure 6.** Transforming the street cross-section by changing the use of extreme lanes for parallel parking lanes and lanes for bicycles on the carriageway. Pedestrian traffic is on the sidewalks along the building line and on the promenade on the central belt [3].



**Figure 7.** A variant proposition of transformations of the cross-section of a two-way street with strong bus traffic: variant I - implementation of recommended lane for bicycles (shared by bicycles and cars with priority for bicycles); variant II – one way bike lanes – in both variants width of bike lanes 1.5 m [12].



**Figure 8.** Transforming the cross-section of a two-way on-way street into a one-way street with an extended lane width of 4.30 m and limited speed up to 30 km/h and contra-lane of bike of 1.5 m wide; traffic directions are separated by a 1.0m wide separator [11].



**Figure 9.** Liquidation of one-way bicycle paths on the pedestrian walkway and creation of a bicycle street - bicycle traffic on general terms and speed limit of 30 km/h and directional signs for bicycles [11]

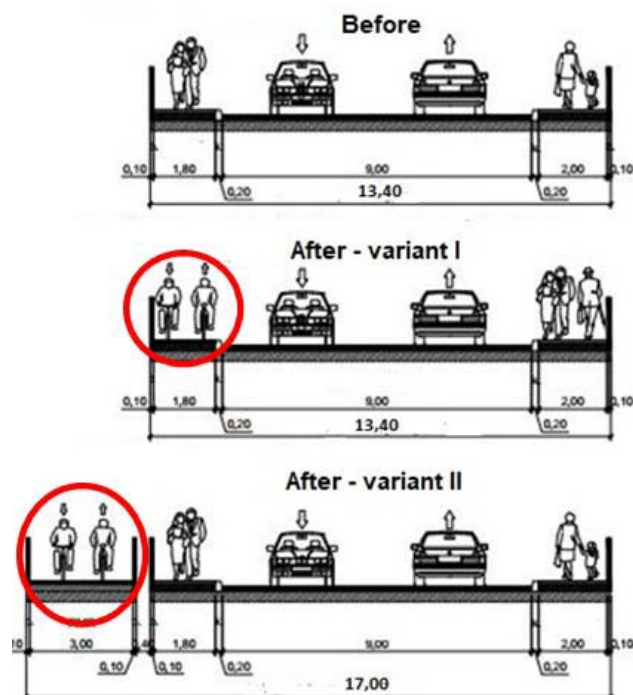
## 5. Conclusions

The multitude of spatial and functional limitations as well as economic limitations in connection with the habits of users prevent in the urban practice application of model bicycle segregation solutions from other users of the transportation space. This makes necessary to consistently use different models of bicycle positioning in the street transportation space, taking into account the adaptability of the bicycle infrastructure types in individual urban areas.

In the new cities and newly built areas limitations are considerably less conditions for the implementation of bikeway systems than in old cities, especially in their historical fragments, due to the smaller constraints on the transformation of spatial structures and the transportation space of the streets of these cities.

The implementation of a cycling network (in various organizational and technical forms) in most cases requires changes to the existing traffic and parking arrangement. That is why it is good when it takes place simultaneously in conducting other transformations in the organization and parking of other modes of transport.





**Figure 10.** A variant proposal of transformations of a street cross section on a bridge: variant I - implementation of two-way bicycle traffic on one of the sidewalks with a width 2.0 m, a sidewalk on the other side is intended for pedestrians; variant II - leaving the cross-section of the street on the bridge - no changes and adding a 3.0 m bike bridge parallel to the bridge (two-way traffic) [11]

In the new cities and newly built-up areas, there are considerably less conditions for the implementation of bicycle path systems than in old cities, and especially in their historical fragments, due to the smaller constraints on the transformation of spatial structures and the transport space of the streets of these cities.

Linear infrastructure of cycleway and equipment for bicycle parking may be one of the elements of composition design of streets and squares and the aspect of their urban - architectural shaping should be given particular attention.

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