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2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



Organizer
University of Zagreb
Faculty of Civil Engineering
Department of Transportation



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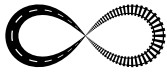
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REQUIREMENTS FOR HIGH QUALITY CYCLING INFRASTRUCTURE DESIGN

Tadej Brezina¹, Nikolaus Ibesich², Martin Niegler³, Helmut Lemmerer¹

¹ Vienna University of Technology, Institute of Transportation,
Research Center of Transport Planning and Traffic Engineering, Vienna, Austria.

² Umweltbundesamt GmbH, Department Transport and Noise, Vienna, Austria.

³ Komobile w7 GmbH, Vienna, Austria.

Abstract

Cycling is increasingly recognized as a significant component of an integrated urban transport system. Following leading bike cities like Copenhagen or Amsterdam, many other European cities have been working to improve conditions for cycling. Thus, two trends can be observed: a) a general increase of bicycle use and b) in particular an increase of pedelecs. The rising popularity of cycling calls for an appropriate infrastructure supporting both intra-city cycling and suburbia-city commuting.

This paper presents two results from an Austrian research project on new perspectives for cycling in the suburban-urban relation [1]. On the one hand this paper presents requirements for providing a high quality cycling infrastructure, on the other hand it introduces a new organizational element for road junctions – the 'Viennese diagonal'.

The design and construction requirements focus on capacity, speed and curve radii and the effects of surface quality on body energy expenditure.

The 'Viennese diagonal' is especially aimed at top-level high capacity cycling routes and allows a 'one-step crossing' in contrast to the traditional and widespread 'two-step-crossing', where cyclists need to wait at least one period at traffic lights, are being confronted with limited space and sharp turns before they can go on, because the cycling infrastructure continues on the other side of the road – similar to pedestrians.

Keywords: cycling infrastructure; pedelecs; design requirements; intersection design; cycling improvement

1 Introduction

Many city transport concepts proclaim that cycling will play an important role in their future transport regimes, e.g. the Vienna Transport Masterplan 2003 [2].

As the bicycle traffic shares of Vienna have increased in recent years, also the average daily traffic (ADT) of cyclists is considerably high and, for example, counts more than 5,000 bikes at the bikeway next to Vienna Opernring. (Fig. 1); by comparison: the main road's ADT counted 27,300 motorized vehicles. The latest impact of electrically assisted cycling is, among others, one of the reasons for this upward trend as Pedelec sellings for Austria show (Fig. 2).

Pedelecs are attractive because they reduce body energy expenditure by utilizing electric power as a support. The path-time diagram shows the pedelec's ability to improve a regular bike's range of attractiveness. This improvement is about a factor of 3.3 (Fig. 3) and results from the equal modal access distance but an improved average speed (from 15 to 20 km/h) due to external power.

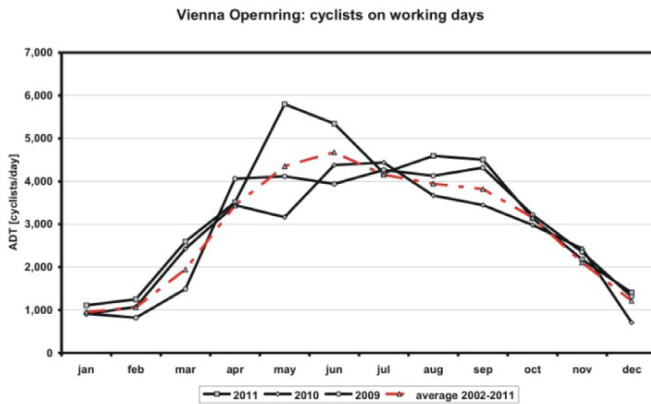


Figure 1 ADT of cyclists on Vienna Operring route from 2009 to 2011. Data: www.nast.at.

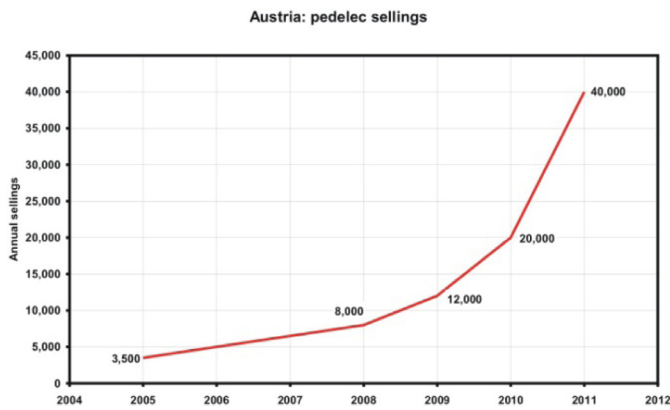


Figure 2 Recent Austrian pedelec sellings, 2011 data is preliminary. Data: BMVIT & WKÖ.

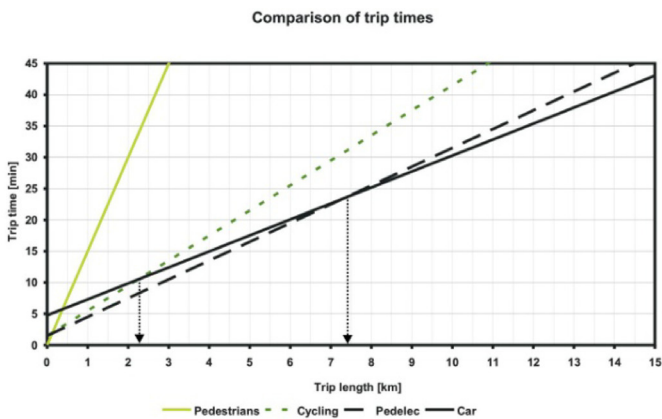


Figure 3 Trip time comparison of regular bikes and pedelecs with other cars and pedestrians. Modified after [3–5].

Apart from a convenient gear, be it bike or pedelec, an appropriate infrastructure enhances cycling popularity.

2 High quality cycling infrastructures

To experience cycling as a useful and pleasurable means of transport, cyclists frequently express infrastructural needs and preferences such as sufficient manoeuvre space, dense route network, steady cruising speed level, no sharp turns or obstacles [6–10] Sufficient lane width is top ranked [11]. Furthermore, cyclists don't like diversions, they prefer direct routings and thus often even choose major road routes over off-road paths [12]. Although these cyclists' needs are well published, easy to understand when actually riding a bike, and transport engineers are trained in vehicular dynamics, the solutions they provide leave a lot to be desired. Fajans and Curry proposed that city administrations should buy bikes for their traffic planners' commute to experience cyclist needs from first hand [13]. Here we focus on three basic infrastructural requirements: capacity, design speed and radii and surface quality.

2.1 Capacity

Western capacity values usually include less than 3.5 m wide paths – real cycling highways rarely exist. We utilized density measurements from Asian roads (almost exclusively used by bikes and mopeds under slow speeds) for two-wheel capacity values of wider bicycle paths (Fig. 4). This diagram perfectly illustrates that a width of 4 m is able to cater for 5,000 to 6,000 bikes per hour.

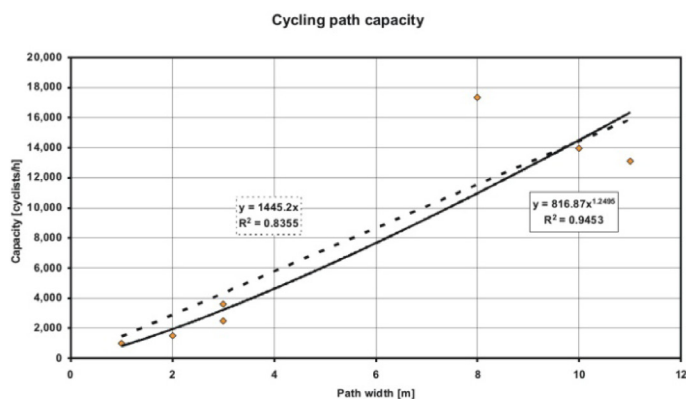


Figure 4 Bicycle path capacity, European sources and Asian measurements. Source: [14].

2.2 Speed and curve radii

Fig. 5 shows the radius–speed relationship for asphalt and water–bound surfaces according to selected sources. A reasonable design speed for intra–urban cycling infrastructure is 30 km/h leading to 22 m and about 38 m of inner curve radius depending on the surface.

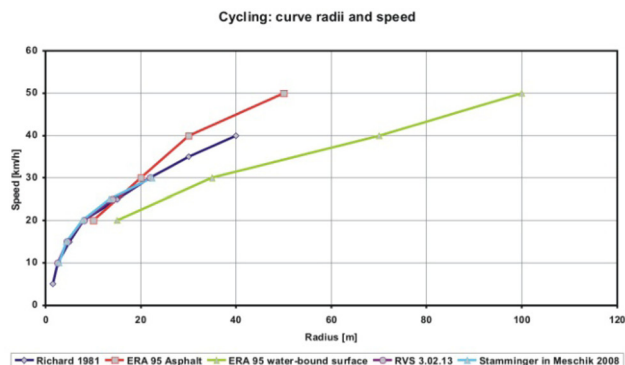


Figure 5 Speeds–curve radii relation for asphalt and water–bound surfaces. Data sources: [15–18].

2.3 Surface quality

Cycling is a mode of transportation closely related to body energy expenditure and it provides energy savings over pedestrians. Good surface quality is of great importance – bad quality imposes a constant stimulus on riders and thus reduces comfort and design speed remarkably. Fig. 6 shows the influence of surface quality on the rider's energy expenditure – spanning a range of 220 %. In his survey, Utkin points out that besides the increased energy use, coarse or badly maintained surfaces superpose vibrations on cyclists that are similar to the usage of construction machinery like jackhammers. Ongoing exposure to intense vibration can cause health issues for riders. Therefore a well designed and maintained surface is necessary for premium cycling conditions [19].

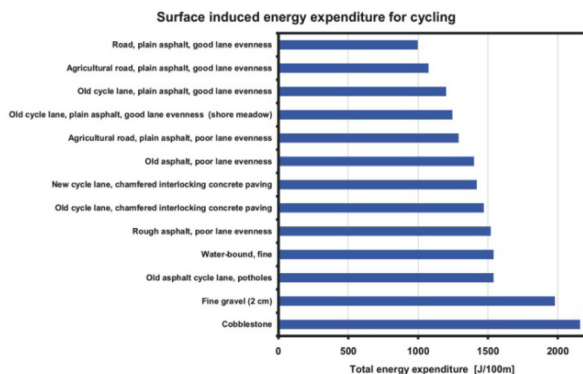


Figure 6 Surface induced energy expenditure for cycling ranging from 1,000 J for smooth asphalt to 2,200 J for a cobble stone cover. Source: [20].

3 The Viennese Diagonal

3.1 The principle

High quality and high priority bicycle connections are frequently issued demands by cyclists – and hardly ever met with current intersection situations and changes in bike infrastructure setups.

Generally, two types of routings can be distinguished: two-sided and mono-directional vs. one-sided and bi-directional. External boundary conditions, e.g. topography or space constraints, often lead to changes from one type to the other or one side to the other along one route. At intersections, they are very often connected with 'two-step crossings' which reduce comfort due to sharp turns, little space and travel delays for cyclists (Fig. 7a).

We therefore propose the Viennese diagonal as a comfortable and viable solution for providing high quality cycling routes. The Viennese diagonal is a diagonal cycle lane alignment and aims at high priority bike routes with a large number of cyclists in comparison to normal numbers of cyclists and cars, e.g. the cycling super highways being introduced to London [21]. Such high priority bike routes may incorporate progressive signalling schemes ('green waves') and counting devices with displays as already existing in Denmark and South Tyrol. The Viennese diagonal's principle given in Fig. 7c is a well-established layout known to transport systems design, e.g. from railroads changing sides of a road (Fig. 8).

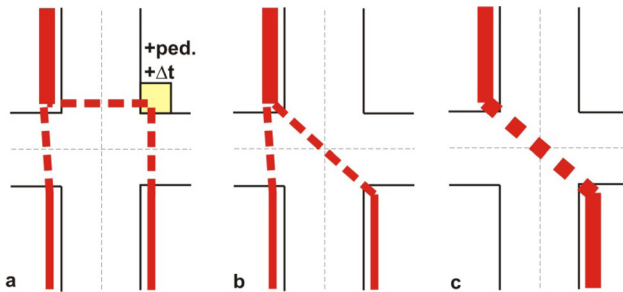


Figure 7 Intersection with regular two-step crossing (a) and two variants of the Viennese diagonal (b, c).



Figure 8 Two-track light rail changing sides of a road (Badener Bahn at LB17, Traiskirchen, Austria). Photo: T.Brezina.

3.2 Capacity case study

We took a standard four-way intersection with a standard two-step crossing and calculated the signalling programme and performance for a 90 seconds interval. Then we modified the intersection with a Viennese diagonal and redid the calculations (Fig. 9). With the introduction of a third phase for the Viennese diagonal, the grade of saturation increases but remains below one (Fig. 10).

To sum it up, the newly introduced bicycle infrastructure entails the following

- Benefits: It is a highly visible and present prioritization of cycling without (significant) reduction of road-flow utilizing similarities to public transport prioritization schemes;
- Challenges: It is a new concept and not yet introduced to the road code or professional's guidelines in Austria and elsewhere;
- Minor disadvantages: additional traffic light programming and roadway maintenance for on-pavement markings are necessary.

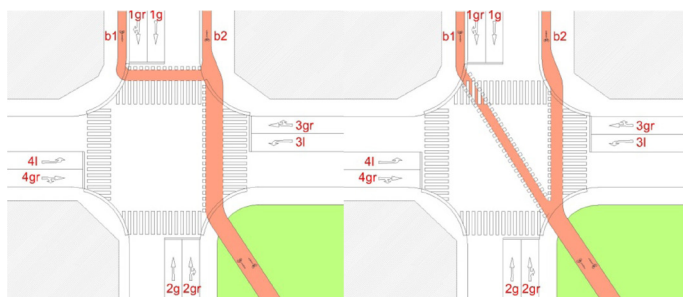


Figure 9 Diagram of two-step crossing (left) vs. diagonal layout (right).

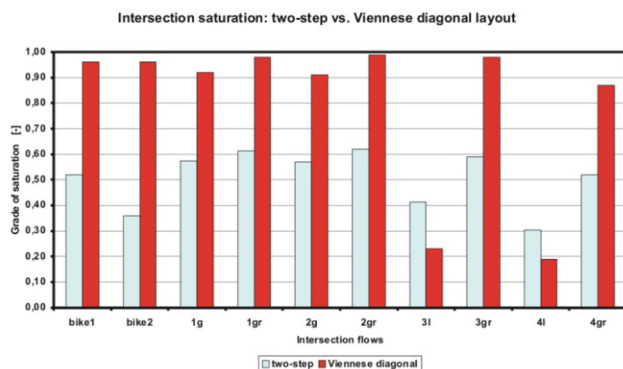


Figure 10 Diagram of intersection saturation, two-step vs. Viennese diagonal.

4 Conclusion

A local, high quality infrastructure is needed so cyclists can profit from their vehicular dynamics instead of being forced into pedestrian movement patterns. A dedicated cycling infrastructure needs to be optimized for cycling to tap the full potential. We introduce the Viennese diagonal as such a prioritization measure for already well used cycling routes. It is a promising idea in need of further research and pilot projects before an introduction into road traffic regulations can be considered.

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