Walking as the Most Sustainable Urban Transport Mode

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Abstract. Sustainable development of urban areas requires promoting economical transport modes such as walking, cycling, or public transport, particularly through building appropriate transport infrastructure. Urban pedestrianisation and walkability is a principal concept in sustainable planning and design. All over the world professionals try to design cities, neighbourhoods and places not around cars but for people. Walking, as pedestrian transportation became the main topic of multidisciplinary urban studies, projects and policies. To encourage walking the built environment must be adapted to the needs of users, of which the feeling of security is one of the most important. In every walkability measurement the safety is present. However, making cities socially and physically safe is one of the most important fundamentals of walkability, likeability, liveability and sustainability. The main objective of our research is to provide an essential contribution to systems knowledge of pedestrians' needs, thus stimulating structural and functional interventions, policy making and regulation to support the walking quality conditions across the Czech Republic. In urban planning, transport planning and traffic safety sciences a comprehensive, integrated systems approach is now needed. This attitude follows that path to determine pedestrians' needs with regard to the quality of physical and social environments, the transport system, and policymaking and implementation for a safe and healthy mobility of pedestrians. This study is conducted from 3 perspectives: transport and urban functionality, user´s perception, durability and future prospects. Special attention is given to the coherence and integration of these perspectives. The focus is on pedestrians' needs with regard to the strategic, tactical and operational levels of travel and sojourn decisions of pedestrians, particularly in city outskirts.

1. Introduction

Present day offers many kinds of means of transport and ways how to move fast even at a long distance in the global world. Fascination by this previously unknown possibility - to travel all over the world in a relatively short time - often diverts attention from the most natural and also the healthiest modes of transport. Walking indeed is the first and basic transport mode, and when extreme cases such as the handicapped, injured and for other reasons walking - incapable people are left out, it is also the healthiest and most typical transport mode of human beings. Unfortunately, the benefit of walking is nowadays often disregarded and replaced with other means of transport - most frequently individual car traffic. Present - day cities have changed into car areas in which pedestrians are pushed out by danger, noise, and combustion gases produced by columns of stopping and starting vehicles. Parking cars obstruct pedestrians' view and movement. The liberty of walking in city centres can be regarded as an attribute of a free personality according to The Charter of Fundamental Rights and Freedoms.

Figure 1 Recently pedestrianised street in Bautzen, Germany and St. Pölten, Austria

2. Benefits of walking

Walking can be beneficial for all sectors of society, trade and business, environment and health and safety of residents. Walking is a universal way of transport and for many people it is the only transportation possibility. There are three arguments that maintain the importance of walkability. The economic one says that in a walking city inhabitants spend less money on transportation and invest more on housing and local recreational opportunity etc. People want to be there. Human friendly urban spaces represent a new lifestyle and allow education, commerce and tourism to develop. The environmental impact of walkability is evident if we compare the carbon mapping of dense walking centres and suburbs. Nevertheless, the walking environment has a great impact on society, social cohesion seems stronger, and the city is for everyone: children, the elderly, PSN – people with special needs and low income people can also use it. At the same time, walking works against inactivity which is a real factor of the Czech and European healthcare and mental caused by obesity.

Walking is beneficial for health of walkers, it decreases the risk of cardiac diseases and heart attack, and at the same time it develops the quality of environment. Reduction of the number of streets with the prevalence of road traffic improved the level of noisiness and air pollution, and on the top of that it contributed to the improvement of social life. Human and economic losses incurred during traffic accidents and their prevention can be reduced, if more people use walking instead of driving motor vehicles. Walking makes people get closer quietly, quickly and cleanly.

3. Historical heritage

In the last hundred years there appeared a very significant new element in the streets – a personal vehicle. Regarding appearance, character and function of street space this event has caused changes, the extent, depth and consequences of which have not been, regardless the increased number of critical voices, dully appreciated yet. Still, many people have not realized how important this change was. Already in the 20's of the 20th century, it means in the period of beginning of modern movement - functionalism, there appeared uncritical fascination by a vehicle, considered to be a symbol of progress and prosperity, whereas its negative aspects, emerging along with the development of automotive industry in larger extent, are neglected. Since then the vehicle has become the standard for planning and designing the settlements – to attain a full utilization of its technical parameters, the vehicle must be given maximum space and roads must be adapted. These conceptions were in particular implemented in the aftermath of World War II, when the planners used the opportunities and rebuilt damaged and bombed out towns of Western Europe in line with their ideas on modern road network.

A massive construction of road network was implemented in the West Europe twenty years earlier than a real boom of automotive industry emerged and thus stimulated it significantly. At the same time the public transport systems collapsed. In the periods when public transport had a share of 80-90% of the total traffic capacity, only 10-20% of the total capacity of funds designed for traffic was invested in it. When in the 70'Th, in particular in Western Europe, due to the increased standard of living and systematic economic favouritism of motor transportation, the automotive industry experienced a great boom, the existing roads failed to be sufficient. Although these roads were designed generously at that time, jams and traffic collapses became an everyday nuisance. Therefore further roads and flyovers are built more frequently now, obviously with larger capacity and higher investments. However, the increased level of motorization and increased volume of traffic quickly exhaust the capacity of recently constructed roads, and the traffic situation is becoming worse despite higher investments. This trend is ongoing even today.

4. Land use planning

Land use planning plays a key role in urban mobility concepts. Land use planning may make the car use absolutely necessary (large suburbs of American agglomerations), or on the other hand completely minimize the necessity to satisfy mobility through individual car transport (building residential areas with the exclusion of car traffic). Typical examples of land use planning failure related to transport is the uncontrollable growth of towns and cities, or suburbs respectively (so-called urban sprawl), but also the development of large business centres at the edges of large towns and cities which induce considerable traffic volumes. In contrast, the ideal urban structure which does not induce excessive car traffic is considered to be the existence of multi-function urban units, where the social facilities (schools, shops, etc.) and jobs are found within a walking distance. The planning needs to take into account the well-known fact today that higher offer of infrastructure for car transport usually aggravate the situation with excessive car transport, since it induces demand for this transport mode.

5. Creation of walkable urban space

Spatial mobility is a basic human need for movement that influences the overall development and design of urban areas. Municipalities with good environment for pedestrians support gatherings and social life; they flourish with life and are often visited. On the contrary, shopping avenues choked up with motor traffic discourage people from visiting. The improvement of conditions for pedestrians' supports local economy brings more activities to municipal centres and enhances access to local stores, libraries and other facilities. Safer streets allow parents or guardians to give children more freedom, and thus also room for social communication and physical and spiritual development.

Walking cannot be considered to be only a special type of transportation and should not be perceived separately. Development of better environment for pedestrians can make more people start walking, and through higher level of awareness it can retrospectively support the development of such environment not only for pedestrians, but for the others as well. Walking can improve the quality of life for everybody. It can improve social relationships in the neighbourhood, local economy as well as prosperity. Compared to the costs expended on construction of new roads or railways walking is not so much demanding.

What is common for all forms of transportation on foot is a set of physically and physiologically determined requirements regarding external environment.

5.1. Walking Barriers

Walkonomics rating system combines eight factors: road safety and ease of crossing in relation to the transport, sidewalk quality, smart solution and attractiveness as a design and maintenance question, hilliness according to accessibility, navigation by signalisation, fun and relaxing functions, and last but not least the fear of crime is measured by crime statistics, the presence of police, lighting and the signs

of vandalism. The Walk Score, a successful company that provides a numerical walkability index for "live where you love", plays an important role in the real estate market. Data are available about walking, transit, biking, travel time, public transport, car and bike sharing in the neighbourhood, points of interest and people friendliness. Obstructions preventing walking can be divided into three general areas. These factors influence the stance and decision regarding choice of transportation means for planned journey:

- Social environment and its features
- Physical environment
- Travelling distance and needed time

Social environment comprises a range of walking obstacles that can have personal character, such as for instance age, sex, physical shape or financial possibilities. Walking can be perceived as a dangerous activity: speed of vehicles, danger from other people, dangerous bikers and skaters, problems regarding vulnerable groups. Walking is regarded to be somewhat commonplace activity; it is one of the first activities that we learn and one of the last that we need to give up as older people, however between these extremes it is generally ignored as a function. Walking is a slow process, and time or lack of time is a huge drive, which governs our lives and is a reason why we accomplish as shortest and fastest journeys as possible. "The automotive culture" and its emotional marketing support this image and along with a basic investment made into the purchase of a car it supports a negative perception of walking. Walking is considered to be of a secondary importance compared to a car, and when designing various equipment it was always the car, which was prioritised. Pedestrians are perceived as shabby people with heavy boots compared to people in branded suits with polished shoes. Bad conditions of many pavements, which are quite often very narrow as well, link social attitudes and physical environment. The main concerns are as follows:

- Lack of safe and convenient places for crossing
- Narrow pavements and fast-moving vehicles increasing noise, air and water pollution and danger
- Obstacles caused not only by street facilities but also by parking vehicles
- Damaged surface of pavements caused by heavy traffic and bad maintenance
- Bad street lighting (inappropriate intensity, colour, direction)
- Badly designed pavements that are inconvenient, narrow or are poorly designed, which leads to the nervousness of the participants; vehicles parking on the road in such a way that road cannot be crossed
- Insufficient cleaning, graffiti removing and stop vandalism
- Terrestrial plans preventing direct access among residential, work and leisure areas
- Weather and consequences of climate change (too hot, cold, windy or wet)
- Lack of time or facilities for garment changing, safekeeping and cleaning after the end of the journey
- Criminality and hooliganism causing a close down of the pavements between public social facilities and residential areas etc. and the networks of public roads on plot of lands of other people
- Bad signs and maintenance outside public roads.
- The distance and time spent on walking noticeably influences a combination of the impact of social and physical obstacles. The individuals will make decisions regarding when and where to go in accordance with the fact if their journey is leisure or not.

6. Walking and environment requirements

The target is to provide the citizens with quality environment without any jeopardy caused by traffic noise and air pollution, and to secure the most important requirements: safety (i.e. protection against traffic accidents and risks and safety as a protection against sudden events), access (i.e. full

accessibility of places), services, facilities and public transport stops. Convenience is needed as a basis of physical and mental status, and as a prerequisite for movement and rest. If we focus on the development of these requirements as the citizens formulate them, the analysis state that the mobility is connected with life style.

This is linked to the necessity to concentrate on achievement of individual goals in the town, i.e. to map attractive locations and destinations of the most frequent arterial roads. Besides this it is necessary to identify dangerous places from the perspective of movement and traffic, and along with other aspects, such as unevenness of pedestrian paths, unsuitable lighting, these all have a negative impact on safety and do not generate any positive results regarding attainability, safety and convenience. It is necessary to focus the attention on regeneration of public urban premises so that the continuous pedestrian network along which we can move around the town can be developed. In addition to the general function, which is accessibility of the premises, safety and other values such as better special convenience, good identity with the place and feeling of common ownership are necessary. Such pedestrian routes promote only walking but encounters of people and rest in public places as well. The pilot projects were testing various solutions and technical procedures. When attaining the quality of urban premises the basis is to achieve an optimum level for all users because everybody cannot achieve maximum satisfaction.

We can feel the increasing interest to regenerate the towns so that the conditions and quality of life of city dwellers and pedestrians can be improved through identification of the best-implemented solutions and development of new facilities and solutions. We expect the increase in the level of traffic and safety of pedestrians in the towns, which presupposes, apart from others, the following:

Promotion of various methods of non-motor transportation and utilization of public traffic instead of private cars,

Minimization of negative impacts of traffic on environment,
Improvement of pass ability and accessibility of public premises,
Improvement of citizens' health and quality of life thanks to reduced emissions, noise and pollution
Better evenness of streets, which also applies for motor traffic,

Reduction of costs in the transport infrastructure in terms of construction of new roads and repairs, cost reduction aimed at elimination of air pollution as well as costs incurred due to traffic accidents and health care.

7. Urban space

In the 20th century motorisation based development transformed the urban landscape; in consequence the majority of the population became car-dependent. Cars give them the feeling of freedom and security. However, in the 60's, problems were recognised. The pedestrianisation of European historic city centres started and in Venice, at the 1st International Making Cities Liveable Conference in 1985, walkability as one prerequisite of liveable city was named.

Walking is the most elementary human movement. Walking requires space. The man must have an option to walk at corresponding speed, without any botheration, without being squeezed and without the need to manoeuvre too much. The problem is to define human level of tolerance regarding obstacles appearing during walking, the space must be narrow enough and rich in experience, however still wide enough to have sufficient space for manoeuvre. The tolerance and requirements regarding space differ a lot when it comes to different persons, dependence on group of people or situation.

In situation when the level of space crowded with people can be determined, the indication is that the upper limit to accept admissible density of people in the streets and on the pavements with two-directional pedestrian traffic is approximately 10-15 pedestrians per minute per one meter of street width. It corresponds to the flow of about one hundred people per minute per 10 meters of the street width. If the intensity continues to grow we can see a clear tendency of streams. Due to this fact the pedestrians must keep right to pass the street and the freedom of movement more or less disappears. Then people do not meet each other in the streets, but they are going in the crowd, one after another. The squeeze is too high. If the stream of pedestrians is too limited, the streets can be adequately narrow. The lanes in old towns as well as inside passages in the houses are rarely wider than one meter and rural footpaths are seldom wider than 30 cm.

Special requirements for space are attributed to traffic “with wheels"': prams, wheel chairs, shopping trolleys etc. To respect this kind of traffic there must be a general request concerning determination of larger dimensions than stipulated. The idea what space can be required if there are prams moving around was identified when the main street in Copenhagen was converted from standard street comprising automotive traffic and narrow pavements to the street with pedestrian zone that was four times wider. Whilst the number of pedestrians increases during the first year approximately by 35%, the number of prams increased by 400%.

7.1. Surface for pedestrians, streets, squares

Foot traffic is very sensitive regarding paving and street surface. Stone block paving, sand, bulk gravel and uneven surface are inconvenient in particular for those who walk with difficulties. The inconvenient type of street surface negatively influences overall foot traffic. People tend to avoid wet and slippery paving, water, snow and mud wherever possible. Those who have difficulties with walking are bothered by such conditions even more.

7.2. Pedestrian infrastructure

Responsible institutions should monitor the following targets:

- Traffic should not be the only prioritized function of street space, as still the street has many other functions that have the same level of importance,
- Motor traffic should not be prioritized to other types of traffic,
- Motor traffic should adapt to the settlements, it means that the speed of passing vehicles should be reduced and the space demand of vehicle traffic should be reduced in both, stationary and street space,
- To reduce the road load to a level acceptable for given territory,
- To increase the safety of traffic and in particular the safety of those participant groups who are, for various reasons, more jeopardized by traffic accidents - children, senior citizens, mothers with prams, PSN - people with low mobility and cyclists,
- To improve the attractiveness and aesthetics of public space,
- To perceive the solution of street and public space in a comprehensive way and to adapt it so that it suits the needs of all of its users and all of its functions – not only traffic ones. This can be achieved only in case we adopt a multi-branch approach and involve general public in the planning process.

8. Public space guidelines

Space is generally one of those key elements forming the settlements. Their general functions are as follows:

Compositional and structural – settlement segmentation, development of structure and layout,

- Space-creative – creation and restriction of settlement premises,
- Esthetical – general element of perception of settlement and its architecture, esthetical impression,

- Residential – living space for inhabitants, place for children games,
- Social and cultural – space for encounters and establishment of social contacts,
- Business – space in which business relations and retail take place,
- Traffic – provision of territorial residential traffic,
- Hygienic – provides for lighting, insolation and ventilation,
- Adjacent buildings, place for greenery,
- Technical equipment – space for engineering utility network and their connection to the development.

9. Pedestrian needs

Movement of pedestrians differs from all other types of traffic in particular due to its irregularity, flexibility and spontaneous ness. It is the most natural and the most frequent type of movement as far as the frequency is concerned. However the pedestrians are the most vulnerable participants of road traffic. And therefore they have to be prioritized and protected. The intensity of pedestrian movement depends on the length of the journey and especially on its attractiveness. This is indicated not only by its safety parameters, i.e. the level of safety against a collision with motor traffic, but in particular by its psychological attractiveness - architectonic solution, number and diversity of different perceptions, frequency of interaction with other people and last but not least by personal safety feeling, especially at night. The composition of pedestrian stream is very non-homogeneous. The stream of pedestrians in the streets comprises all age categories – starting from playing children, through adults travelling to work and ending up with strolling senior citizens and persons with lower mobility. As for the purpose of the journey the composition of pedestrians is also non-homogeneous and dependent on local conditions. The same area is often used by pedestrians who move somewhere intentionally (typically hurry to work) and pedestrians who link movement with other activity – shopping, window-shopping, establishing contacts, in case of children a game etc. in accordance with a specific situation the solution of pedestrian movement must therefore correspond to different requirements of both groups (direct and fast movement versus possibility for an uninterrupted stay within the street space) and enable their coexistence. The general aspect when giving preference to pedestrian traffic is the enhancement of its convenience. How do pedestrians behave and what is a condition for their safety?

- Within local roads we can find even small children moving around on their own - 50% of children from the age of six regularly participate in motor traffic.
- Depending on the type of executed journey and pedestrian age the movement speed is within 1.8-6.5 km/h.
- Compared to motor traffic the pedestrians spend longer time within the street. The ability to perceive surroundings and its details is markedly higher in case of pedestrians than motorists. Concurrently the pedestrian does not like dull and monotonous spaces, which is not boring for a motorist.
- Visual striking ness of a pedestrian is low. Especially at night, if pedestrian's clothes are not equipped with reflective elements, the pedestrian blends with surroundings. Another issue is so called "hiding", when all of sudden the pedestrian can appear on the road from behind the corner of the building or bus standing in the stop.
- From psychological perspective there is generally very low willingness of pedestrians to wait. Even after half a minute waiting at the crossroads when the light is red, the pedestrians start risky crossing.
- The pedestrians are also not willing to accept any detours; nevertheless it depends on age and purpose of the journey. The straightest routes are preferred, regardless the risk. Even small detours are not accepted. What is particularly disturbing is a detour longer than 60 m.
- On the roads of higher functional classes in certain cases we can apply flyovers between motor traffic and foot traffic. However it must be emphasized that subways (often dark and untidy places)

and foot bridges (route extension) are not given preferences by most pedestrians, and if at least slightly possible they try to avoid them. Due to this reason many towns have already started to replace the already existing subways with grade crossing

10. City for Pedestrians

General principles for urban design are:

- To provide for pedestrian access to and clear routes across all parts of the city
- To assert comfortable routes both from the technical parameters point of view and with regard to user friendliness of the proposed solutions
- To give preference to single level crossings inside the city with application of modern safety and calming down elements. Even though single level crossings reduce automobile traffic fluency they provide to pedestrians the needed user comfort and safety if designed correctly
- Multilevel crossings should be designed to minimise loss drops and provide for facilities for persons with reduced mobility and orientation

System design of pedestrian routes

- ❖ To provide for comfortable foot connections of all city quarters to the city centre
- ❖ To provide for foot connections between the individual residential and other urban areas of the city
- ❖ To provide for foot connections to the city outskirts with facilities for rest and recreations of the citizens
- ❖ To provide for foot connections to the surrounding municipalities on demand

10.1. Safety Conditions for safe pedestrian movement

Safer traffic also needs appropriate infrastructure, particularly the application of measures which improve safety of vulnerable road users (e.g. separate lanes for cyclists, refuges in pedestrian crossings and staggered pavements, optical highlighting and lighting of pedestrian crossings, etc.). Higher road safety in urban areas may also be helped by equipping vehicles with modern technologies (night vision device, brake assistant, accident prevention system, sleep prevention device, etc.). The key elements in promoting safer behaviour are predominantly education and information campaigns, which aim to promote higher awareness for public in terms of their behaviour in traffic.

Transport safety support

- To assert application of modern elements of traffic calming down, such as raised pedestrian crossings, slow-down islands, elements for reduction of passage speed etc. Traffic professionals exercise long-term efforts at introduction of modern traffic calming down and traffic safety elements to practice
- To provide for location of pedestrian crossings to natural pedestrian routes.
- The most inconvenient way from the pedestrian safety point of view is the current practice of placement of pedestrian crossings in the crossroads off the adjacent pavement line. The pedestrians then continue along their natural routes, cross the street off the crossing situated behind the block corner and thus the inconveniently situated crossings do not add to pedestrian safety, rather making the situation even worse
- To provide for protected pedestrian crossings on access routes to schools and healthcare institutions
- To prefer separation of foot and cycling paths rather than to build joint pedestrian/cycling/skating paths

11. Restrictive measures for individual car transport

Many positive measures supporting desirable transport behaviour of population need to be supported by restrictions of individual car transport; otherwise the effect may not occur. The most common types

of restrictions are closures of parts of towns for car transport (designing pedestrian zones), parking fees and limited number of parking sites, and entry fees in some town areas.

12. Conclusion

In conclusion it should be stated, even in view of the above facts that the regulations regarding the position of pedestrians in the Czech Republic are at the level of the European standards both in the sphere of active and passive safety. Particularly recently it has become obvious in the whole society that each road user is starting to understand in a better way the importance of enhanced safety of pedestrians.

The Czech legal regulations still do not contain an unambiguous positive definition of the term "Pedestrian"; from the regulations in effect it is therefore necessary to derive that Pedestrian is a road user who directly takes place in the road traffic and at the same time is not a driver, coachman, or person accompanying led or driven animals; Pedestrian is also a person who pushes or pulls a toboggan, perambulator, wheelchair for the disabled, or hand cart the total width of which does not exceed 600 mm, a person moving on skis or roller skates, and/or by means of a manual or motor wheelchair for the disabled, a person leading a bicycle, a person leading a motorcycle of cubic capacity up to 50 cm^3, a person leading a dog, etc.

Rights and obligations of pedestrians in the Czech Republic are mainly governed by the following legal regulations:

Act No. 13/1997 Coll. on roads as amended;

Decree No. 104/1997 Coll., which administers Act on roads as amended;

Act No. 361/2000 Coll. on road traffic and on modifications of some Acts as amended;

Act No. 200/1990 Coll. on infractions as amended;

Decree No. 369/2001 Coll. on general technical requirements ensuring the use of constructions by persons with limited movement and orientation ability;

Act No. 114/1992 Coll. on nature and countryside protection as amended.

In conclusion it should be stated, even in view of the above facts that the legal regulations regarding the position of pedestrians in the Czech Republic are at the level of the European standards both in the sphere of active and passive safety. Particularly recently it has become obvious in the whole society that each road user is starting to understand in a better way the importance of enhanced safety of pedestrians. This was mainly helped to by relatively new legal regulations encompassing some essential elements of pedestrian protection, such as the introduction of an absolute right of way of pedestrians, decreased speed limits of vehicles in towns, and also reduced tolerance to drinking and driving. This work has introduced a certain legal framework, which defines a mutually relatively well-balanced system of rights and obligations of road users increasingly focused on the protection of pedestrians as relatively most vulnerable road users. Nevertheless, any legal arrangement only provides a certain degree of formal protection, and to achieve the highest possible safety of pedestrians a strong appeal to each individual is necessary.

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