Underground pedestrian routes as an option for arranging the transfer from one type of public transport to another

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Abstract. The article highlights the issues of pedestrian movements within cities and focuses on the architectural and planning organization of transfer between two types of public transport. The amount of time citizens lose on the pedestrian sections of their way from home to work were analyzed. The article describes factors that influence the speed and the comfort of pedestrian movements as well as provides rationalization for connecting two types of transport in the underground space. The article also touches upon the issue of the negative cost impact caused by excessive time losses, including the ones that appear on the pedestrian sections of the route. Architectural methods that may ease a pedestrian's psychological adaptation to the underground space are listed in the article. The results of experimental designing that prove the reduction of the travel time by forming underground pedestrian ways in cities were described. The article features the model of a multi-functional underground space under Serpukhovskaya Zastava square in Moscow. It is noted that pedestrian routes in the cities which do not allow easy movement on the above-the-surface space provide comfortable movement for the citizens.

1. Introduction

Whether it is a private vehicle or public transportation a person uses to get to work, the route starts and ends with a pedestrian section. Citizens of the big cities use private vehicles for moving about in the city less often than those who live in the smaller cities. Moscow citizens use private transportation in 80% of the trips they make whereas only 20% of trips are made with the use of private vehicles. In big cities of Russia that have weakly developed underground railway system or do not have it at all about 70-75% of trips are made by public transportation and 25-30% of the trips are made with the use of private vehicles. Globally, in the cities that have highly developed public transportation system less than 15% of the trips are made with the use of private vehicles. This leads to the conclusion that the overwhelming majority of the citizens of big cities use public transportation.

It seems quite obvious that this trend is a long-term one since the means of public transportation are developing dynamically while the car ownership level is being curbed. Similar studies were conducted with the aim of evaluation in generating a model of pedestrian demand across London [1-5] For example, one of the largest underground cities in Toronto is a place where urban scientists study underground public places [6].

The bigger the city is, the more often people have to change one means of public transportation to another during their trip. These changes take up a significant part of the overall time a citizen spends on a trip. If a trip from home to the workplace takes 60 minutes, a person living in a big city may

spend about 15 minutes (waiting time included) for changing which amounts to a quarter of the overall time of the trip.

If using effective architectural methods will cut the changing time from 15 to 8 minutes, the citizens will get 14 free minutes a day which makes 1 hour and 10 minutes a business week which makes 4 hours and 40 minutes a month. This amounts to almost 5 hours that can be spent on communicating with family and friends or other important things. People who live in big cities are always in a rush, they feel short of time and long changing from one means of public transportation to another may be one of the reasons for that. This is why one of the most relevant city planning goals related to upgrading urban areas is developing design solutions that can reduce the changing time.

2. Architectural methods of reducing the transportation costs for the city and its citizens

The distance from one public transport stop to another has to be covered by foot. Speed and distance influences the time. An average passenger moves at a rate of 3 kilometers an hour. This speed hardly ever increases since a person will not start running unless he or she faces a threat, yet the speed can be decreased if there are obstacles on the way, such as stairs. This speed also may be decreased by the time spent waiting for the green traffic light on a crossing. In bigger cities the waiting time for the pedestrians' turn to cross the street may take up to 90 seconds. If there are 2 traffic lights on the way, a person does nothing but stands and waits for 3 minutes.

This way, in order to shorten the changing time, the distance has to be shortened without making new obstacles and such obstacles as traffic lights have to be taken away. The distance can be cut by arranging pedestrian ways that connect two public transport stops at the least distance. In historically developed cities where there is an old existing street and road network, building straight pedestrian ways can only be made possible if they are built underground. If the pedestrian ways are placed underground, the time spent on waiting for the green light of the traffic light will be saved.

An important factor that affects the speed and the comfort while changing the means of public transport is the weather conditions. As practice shows, if it rains or snows, people and cars are moving slower. If the temperature is very hot, people naturally slower their walking speed in order to protect their bodies from overheating. Only when the temperature is very low we try to move faster, yet waiting for the green traffic light becomes significantly unpleasant. A closed underground object allows to support constant temperature. Underground pedestrian ways are able to protect people hurrying to work from any harsh weather conditions.

As discussed by Limao Zhang: «Three factors, namely the length of evacuation route, time of evacuation process and density of pedestrian flow, are identified to have significant impacts on the efficiency of the evacuation process, especially at peak hours in a metro station» [7]

Recent years have seen the global city planning community giving a lot of consideration to the issues related to pedestrian movement. Jeff Speck, a city planner and an urban designer, the author of 'Walkable city' defines the term of 'walkability' and develops the 'theory of walkability' [8]. Speck believes that a pedestrian way is attractive when it is useful, safe, comfortable and interesting. The author has not looked into the issue of underground pedestrian ways but after analyzing the structure of an underground pedestrian way, we have reasons to state that it meets the requirements of the theory of walkability.

An underground pedestrian cross is:

- Useful since it allows to change one means of public transport to another or leads to a necessary object
- Safe since it is isolated from the street and road network
- Comfortable. There may be constructed more underground pedestrian ways than on-the-surface pedestrian ways since it is easy to support constant lighting and humidity levels as well as the air purity.
- Interesting. Design and additional services provided is the key. We may take one of the pedestrian underpasses in Singapore as an example. It is fitted with paintings and various exhibitions are held regularly. The passengers have a chance to enjoy art while walking by or using travolator.

Travolators are often built in large transport junctions such as airports in order to reduce the changing time. It is worth mentioning that a travolator does not increase a passenger's speed on a specific section of the way yet gives a passenger a chance to rest without decreasing the overall speed. Travolator is, in fact, an effective means of saving time for changing on a distance more than 600 meters or when a passenger is carrying luggage. This means that in smaller transport junctions where the distance between the stops does not exceed 600 meters, it seems reasonable to reduce the travelling time not by the use of mechanized means but by creating comfortable environment that may include underground space.

To summarize, we can say that constructing multi-functional underground spaces in the places of large transport conjunctions will significantly reduce the overall travelling time and increase the level of passengers' comfort.

3. Experimental design

In order to provide reasons for conclusions that were made, we conducted experimental design. The results of experimental design of the underground pedestrian space in the city of Moscow in the area of the Tulskaya underground station are shown below. Figures 1 and 2 show the way that a passenger has to make in order to get from the underground station to the bus stop.

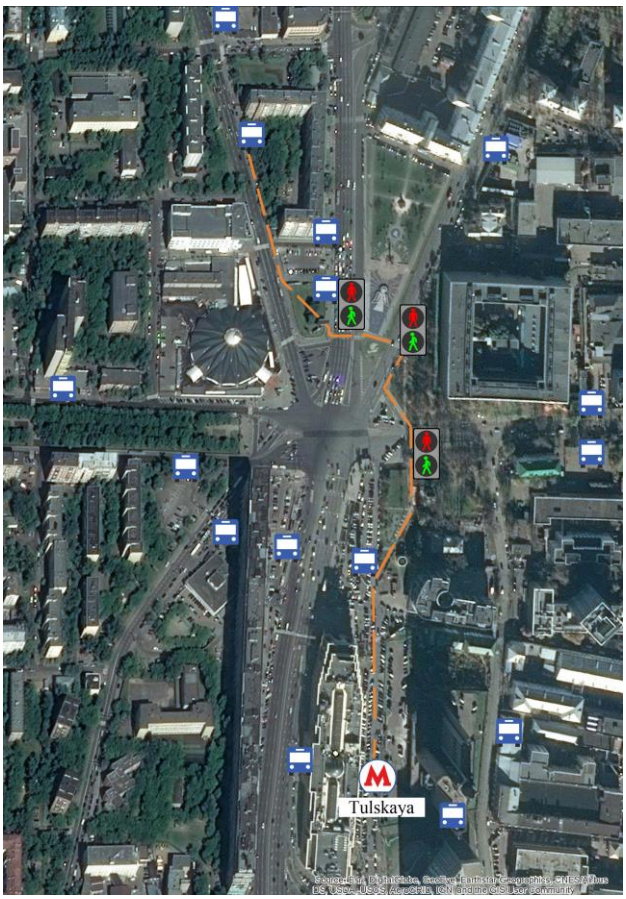

Figure 1. Way from the underground station to the bus stop. Variant 1

In the first case it amounts to 670 meters and 3 traffic lights whereas in the second case the distance amounts to 600 meters and includes 2 traffic lights and one pedestrian underpass. The third figure presents a model of an underground multi-functional space under the Serpukhovskaya zastava square. The underground space has exits to every road that is connected with the square. The exits to the streets should be constructed on both sides of each road that leads to the tram lines. Such design of the

underground space is able to replace all pedestrian cycles of the traffic light and provides access to all significant objects at a walking distance.

The distance between the underground station and the bus stop that is shown on the first figure may be reduced from 670 to 470 which saves 200 meters. The model of an underground space as shown on the figure three will help to avoid three traffic lights.

If 200 meters of distance and 3 traffic lights are excluded from the overall distance, the overall travelling time will be decreased by 6 or even 7 minutes that were mentioned above in the work.

In the second case that is shown on the figure 2 the distance that a pedestrian has to make in order to change the underground to the public land transport stop will be reduced from 600 to 450 meters. A pedestrian will not have to spend time on waiting for the green light of two traffic lights. In the second case the overall travelling time will be reduced by 4-5 minutes.

In the process of designing public urban sites we have to take into account passengers' psychological comfort as well as their physical comfort. Underground sites are still being associated with confined spaces, basements and something disturbing in general. This association may be related to the fact that many films show victims and prisoners being held in underground spaces.

Global experience of designing underground sites shows that a variety of methods can be used for reducing the negative psychological effect that may appear while spending time underground. Sophisticated architectural solutions used in highly developed countries can make the transfer from the land to the underground so smooth, wide, well-lit and beautiful that a passenger may often cross the underground way without realizing that this part of the way was, in fact, the underground space. Such methods have been introduced into practice in the city of Saint-Petersburg. Thus, pedestrian underpasses on Nevsky Prospekt have been reconstructed and the stairs were replaced with spacious ramps that have minimal slope.

The experimental design project presented in this work implies excluding the stairs which are considered as an obstacle and replacing them with smooth descents and ascents at the borderline of the on-the-surface and the underground spaces. If such solution is applied to the second variant which is shown on the figure 2, the travelling time will be reduced by 0.8 minutes due to increased speed of crossing the ramp compared to the existing stairs of the pedestrian cross.

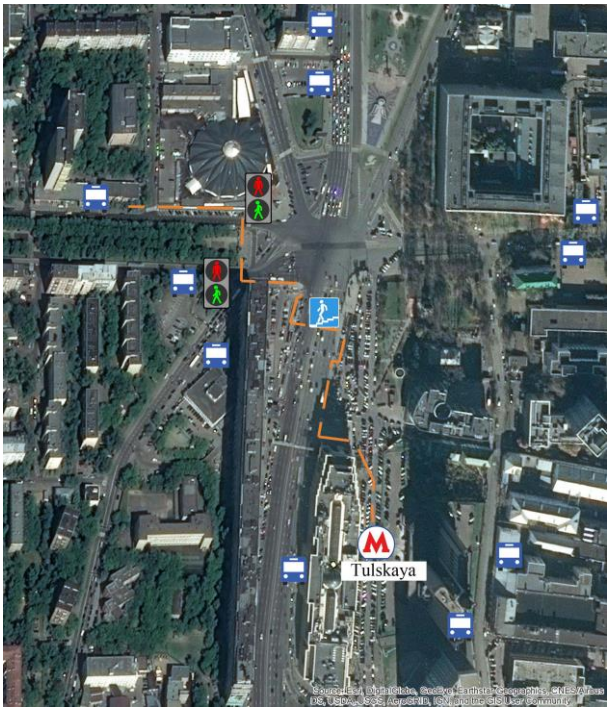

Figure 2. Way from the underground station to the bus stop. Variant 2

The proposed variant of arranging the underground space under the Serpukhovskaya zastava square allows to organize additional services as well as build the pedestrian ways at the least distance. The designed space is large enough to build in shops with basic goods, service businesses and public catering enterprises.

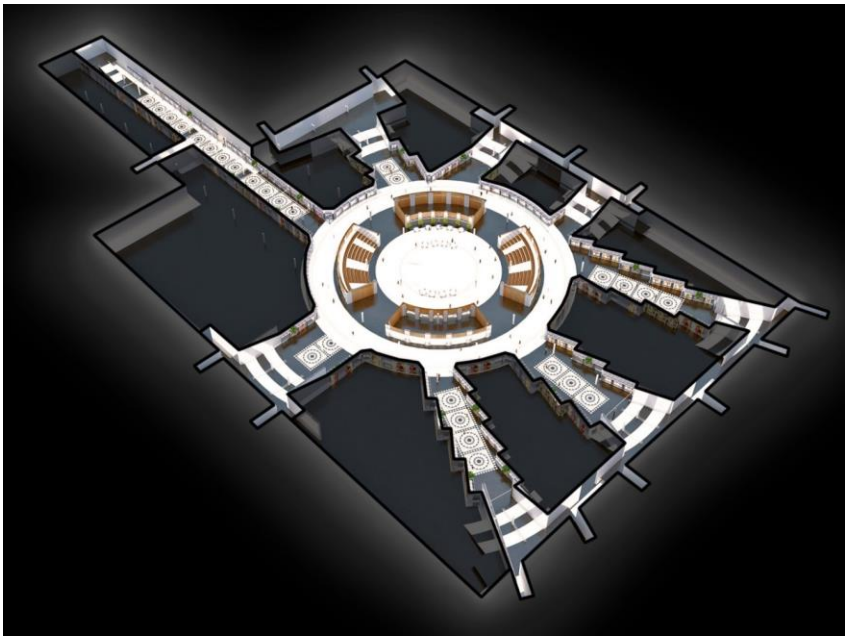

Figure 3. Model of the underground space under the square of Serpukhovskaya zastava in Moscow

Global urban transport system planning specialists have defined and successfully introduced various methods that allow to determine the economic value that is based upon reducing economic costs of the movements of the citizens. [9]. Thus, studies conducted in the city of Portland have shown that if the citizens save 11 minutes of their travelling time a day, the economy of the USA saves 1.5 billion dollars a year [10]. The population of Portland amounts to 600 thousand people. These methods have not been adapted to Russia and it seems impossible to count the exact economic benefit yet the overall advantage is obvious, especially for the big cities with the population of more than one million people.

The experimental design of the Serpukhovskaya zastava square was prepared as part of the work conducted under the guidance of the author of this article against order of the city authorities. The research work was devoted to the formulation and the approbation of the methodologies aimed at finding underground territories suitable for developing multi-functional underground spaces in Moscow [11].

4. Conclusions

The conducted analysis of on-the-surface and the underground variants of developing pedestrian sections of the daily way a person makes to get from home to work leads us to the conclusion that constructing pedestrian ways underground is the most comfortable and reasonable solution.

Experimental design has proven that constructing pedestrian underpasses can help every citizen save a significant amount of time which makes them economically beneficial for the whole city.

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