Planning of parking structures in city centre (on the example of the city of Split)
I. Ložić, D. Cvitanić

Faculty of Civil Engineering, University of Split, Matice hrvatske 15, 21000 Split, Croatia
EMail: lozic@cigla.gradst.hr; cvitanic@cigla.gradst.hr

Abstract

Very intense use of the high value attractive space and structures in the city centre attracts all kinds of traffic flows (public transport, private cars and passengers). These traffic flows take place on limited traffic surfaces in the conditions of traffic congestion and low level of service. The existing disproportions in the mentioned traffic demand and supply could be solved by optimal distribution of traffic flows to all modes enforcing the use of public transportation.

The optimal distribution of different modes in the city centre will give better comfort and allow future users to reach the attractive areas and historical monuments. The research and planning of the parking structures design and construction in the city centre should be a permanent process and task.

1 Introduction

The central urban area with its historical core and other attractive contents, spatial and historical monuments represents a zone of great attractiveness. Concentration of all modes of traffic flow causes an intense traffic with a low level of service. That affects negatively the stationary traffic - due to the lack of number of parking places, all available areas are used, which influences the environment and prevents the movement of pedestrians.

The reasons are:
- incompatibility of the supply and demand of optimal number of parking places,
- incompatibility of the existing and planned use of this area and available traffic areas,
- insufficient and not on time investments which would solve this problem.
The required research and studies have been made as a basis of long term and continued settlement of the areas for the stationary traffic. The research and the process of making this study represent a continuation of the survey by which a larger urban area has been studied with the special emphasis on the city core.

2 Analysis of the existing state

The data on the existing state are the basis for the planning of traffic demand as well as the basic presumption for the planning of traffic demand.

It is necessary to make a statistical and documentary basis for all modes of traffic flows, traffic areas, and for all other traffic elements by making a survey of the existing state which is an important prerequisite for each planning.

It is required to define limit volume and methodology of researches in order to make the analysis of the existing state of the stationary traffic as an important part of traffic system.

The analysis of the existing state has been carried out in four phases:

1. Definition of research limits,
2. Research on parking supply,
3. Research on parking demand and
4. Relation between parking demand and supply.

2.1 Definition of study area

The city centre is the area which has the highest concentration of important public city buildings and the highest concentration of all traffic modes. Parking problems are very acute here but it is difficult to solve them due to the inherited urban structure.

To satisfy the demands of this research the city centre has been spatially defined. Apart from the city centre the area of investigation covers the boundary traffic ring with the highest parking demand and for all other contact areas which affect traffic movements within the research area.
2.2 Research on parking supply

The research on parking supply gives the evidence of the available traffic parking areas and:

- capacity,
- type of parking and its organization,
- type of parking on street for cars, bus stops, taxi stops ..., 
- type of parking off street - surface parking facilities and parking structures,
- property - private or public land,
- mode of payment and parking fee,
- time limitations etc.

The investigations were made in situ and gave the proper information about all available parking places in the entire road network and the off street parking. The types of parking were differentiated in the supply investigations:

- type 1 - parking on areas with off street parking facilities,
- type 2 - parking on areas beside the streets
- type 3 - parking on areas with on street parking facilities.
Table 1: Survey of monitored parking traffic demand (at one period of time) in the centre of the city and defined traffic supply.

<table>
<thead>
<tr>
<th>Monitored parking demand (parked vehicles)</th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of monitored area: city centre</td>
<td>Supply</td>
</tr>
<tr>
<td>Parking: monitored demand and defined supply</td>
<td>Determined</td>
</tr>
<tr>
<td>Type</td>
<td>Legal</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>3</td>
<td>PC 569</td>
</tr>
<tr>
<td></td>
<td>OTH 6</td>
</tr>
<tr>
<td>2</td>
<td>PC 546</td>
</tr>
<tr>
<td></td>
<td>OTH 3</td>
</tr>
<tr>
<td>1</td>
<td>PC 2304</td>
</tr>
<tr>
<td></td>
<td>OTH 94</td>
</tr>
<tr>
<td>∑</td>
<td>PC 3419</td>
</tr>
<tr>
<td></td>
<td>OTH 103</td>
</tr>
</tbody>
</table>

PC - Private cars
OTH - Other

Apart from the parts of the street network where parking was allowed (regulated or it was in conformity with the rules) it was registered that a ban was placed on parking in the remaining streets. It enabled the analysis of parking correctness of the, monitored vehicles during the research on parking demand.

2.3 Research on traffic demand

Monitoring of stationary traffic was carried out in the centre within certain limits and in all other legal and illegal parking areas. Due to the effectiveness and low cost, besides the in situ methodology, we used aerophotogrametric photos and statistical monthly reports of the firm “Promet”, which deals with the commercial public parking facilities.

Parking regulations were determined in conformity with general traffic rules referring to parking vehicles, i.e. according to the existing horizontal and vertical traffic signalization which legally determines the place and the way of parking which is one of the elements defined by the research of traffic supply. The data were obtained for traffic - urban areas and for the entire area in the centre of the city.

2.3.1 Theoretical parking demand in 1990.
We used several models from literature to determine the present parking requirements.

The first applied model which defines the number of needed parking places in the city centre implies the information of the number of inhabitants in the city, the number of inhabitants per car (in the questionnaire on households of the Traffic Study of Split, Sm was found out and it was 4.46 inhabitants per car)
and the city factor (approximately one parking place in the city centre was necessary for 5 to 8 registered vehicles).

The second method of determining the required number of parking places in the city centre implies the information on the number of private cars which commute to the centre. In 1991 the average number of trips to the city centre was 51,460 vehicles/day.

Finally, on the basis of the determined norms, frequency of trips and the land use in the city centre parking traffic demand was obtained.

If we compare these three ways of determining the theoretical parking demand in the centre of the city we found out that the needed number of parking places in the centre was about 9,800 places.

2.4 Estimate of the use of supply and determining the lack of parking places

In order to define the level of satisfying parking demands and other characteristics of stationary traffic, the data obtained by monitoring the parked vehicles were compared to available number of parking places. It was evident that the number of parked private cars (5907) was higher than the number of offered places (4287) and we can conclude that a great number of private cars was illegally parked, contrary to traffic regulations and traffic rules (2385 vehicles). The situation is very bad in the areas near the city centre, where most drivers are attracted by various contents. Due to the lack of parking places the situation is much worse here than in the areas relatively distant from the city centre where available parking places are not always occupied, where there is a considerable number of parking places outside the roads.

High number of illegally parked vehicles (2385) is evident in relation to the total number of parked vehicles (5907).

Regarding the obvious theoretical parking demands and the monitored supply, the research in situ proves the fact that considerable traffic movements are provoked by looking for a free parking place.

It leads to the conclusion that there is a lack of 5,000 parking places.

3 Future parking demands

These demands are based on the prognosis of population growth, social and economic development, land use and needs for private cars, etc. All this was presented in the Study “Traffic Study of Split” whose results were used here.

Various factors influence parking demand in the particular area:

- population characteristics,
- land and building use,
- alternative possibility of using traffic modes (public city transport),
- traffic availability,
- supply of available parking places,
3.1 Definition of needed number of parking places based on theoretical demand in 2005 and 2015.

Several methods were used to determine the needed number of planned parking places in the city centre. The comparison of the obtained data showed that 10,800 parking places should be ensured in 2005.

In 2015 (the end of the planned period) 14,910 parking places should be made.

4 Proposal of the planned parking areas and parking structures in city centre

4.1 Proposal of location for parking structures and their capacity

In small cities, on streets and off streets parking facilities can meet demands, while in bigger cities there is no place for on parking facilities. This problem can be solved by the construction of parking structures or underground garages. This solution should be applied in Split.

Planning and designing garage structures requires the decision on choosing the necessary area and location. It was necessary to carry out some research in order to choose the best locations for parking structures. It refers to the investigation of present parking supply in that area and present and future needs. The obtained results served as input data in further definition of location.

While planning future parking areas the following was taken into account:
- increased number of inhabitants and traffic growth depending on urban, civil engineering, technical, social and economic development,
- expected traffic growth resulting from the process of transportation planning,
- future parking areas should be precise and put into spatial documentation.

The needed space of traffic areas for parking directly or indirectly depends upon various factors, for example:
- method and intensity of present and future land use,
- number of vehicles,
- level of living standards and employment,
- development, frequency, comfort and fee of public transport,
- road capacity in the city,
- size of the city (area and number of inhabitants).
The choice of parking structure location is influenced by other factors. The following are very important criteria for the choice of parking structure (most criteria are valid for other parking facilities too):

- location in the vicinity of access roads,
- location related to the distance from the most important destinations,
- possible combinations,
- location related to the public transport stations,
- location of parking structure and environment,
- civil engineering aspects,
- economic criteria,
- price of land.

4.2 The estimate of location from traffic point of view

Several criteria influenced the choice of location type and size of parking area; the most important are the intensity and quality of traffic flow movements of all modes in the nearest environment.

The planned traffic flows require a satisfying and acceptable level of service of all elements of transportation system. Moreover, properly dimensioned elements of transportation system will enable its satisfactory function.

Therefore, we tried to satisfy the following elementary goals by giving proposal for parking structures locations:

- function of structures should be in accordance with the capacity of traffic network (streets and crossings),
- parking structure should be accessible from the city network, i.e. it should be located on the places with a stressed need for parking,
- capacity of built parking structures should partly compensate lost parking places,
- microlocation of parking structure should satisfy the requirements of the surrounding contents on parking places,
- pedestrian entrances to and exits from the parking structures should be adjusted to existing main pedestrian flows and stations of public transport.

4.3 Estimate of location from urban city planning point of view

The proposed location for parking structures resulted from the analysis of present documentation, spatial conditions, traffic flows etc. The spatial conditions cover a great number of topics which can be defined by criteria used to choose the possible locations of parking structures:

- all available spaces in the city to be used for this purpose were analyzed and registered on the basis of present documentation;
- available city spaces should be rationally used. Therefore, the parking areas should be planned on underground floors, the attractive and representative city contents should be located above them;
- influence of private cars, being an aggressive medium whether in movement or stationary, should be diminished as much as possible in order to protect the environment of the city and the quality of living;
- as these structures will be placed under the level of terrain (one or more underground floors), their influence on the physical structure of the environment will not be considerable, it will result in the elements above the ground level;
- multiple function is one of significant characteristics of city spaces.

Then, the structures, especially those which have close contact with pedestrians, should be rich in contents and offer to make these places attractive and of a high quality. Parking structures and parking surface facilities should be in combination with other contents, here in vertical zoning:
- construction of planned parking structures represents an important intervention in urban areas; therefore they should contribute to new quality of areas, new city identity and its new landmarks;
- environmental conditions should be analyzed in detail when planning documentation.

Figure 2: Distribution of planned parking structures with numbers of parking places
4.4 Proposed measures to compensate the lack of needed number of parking places

The city of Split has a problem of a great clash between the increase of the number of cars and the financial investment in to traffic infrastructure.

The other problem represents the stationary traffic having urban - planning characteristics. The city centre of Split has an increased intensity of building and space use so that it becomes more and more attractive for arrivals with the traffic areas defined earlier. Therefore, the proposed areas for parking give the last possibilities for solving the existing problems. They are not a complete solution of the future needs.

As it was mentioned earlier, in 2005 there should be 10,800 parking places and in 2015 there should be 14,910. Today there are about 4290 parking places. The construction of planned parking structures would be maximum 8,440 parking places more. This construction will cancel 2,260 existing parking places which are used today whether as access to the locations or at locations of planned structures. It can be concluded that there will be a lack of number of required parking places at the end of the planned period.

It is necessary to compensate the lack of needed number of parking places by improving public transport and by introducing a terminal where transportation means can be changed.

Special attention should be paid to economical management of parking structures of the stationary traffic upon whose efficiency the entire transportation system of the city depends. It should be applied to the whole city area and they should be represented as:

- urban - planning measures,
- traffic management measures,
- economical management measures for parking structures.

The plans should give solution for the location, number and size of parking structures and parking surface facilities according the present and future demands.

The needed number of parking places is determined by investigations and applying particular norms and rules.

Reasonable use of parking places in the city centre of Split implies the regulation of the use of parking places. Short - term parking should be better than long - term parking.

Parking places with paid parking fees according to the duration of parking represent a good means of preserving the attractive parking places for short - term parking. Owners of private cars cannot take for guaranteed that they will find a free parking place in the city centre.

The effective way of reducing the intensity of traffic in the central and business areas of the city is an optimum distribution of trips to the centre into all transportation modes by using city public transport at its maximum.
5 Conclusion

The solution for optimum traffic flows (mobile and stationary) in the city center was proposed according to the research.

The obtained data by Traffic Study of Split, complemented by special research for solution of parking needs were used in this transportation planning.

Free spaces convenient due to urban - spatial, traffic and other reasons were used for the location of parking structures in the city centre and its nearest surroundings.

From urban - spatial point of view some areas were analyzed and solutions were proposed taking into account mutual relationship between structures and space. The proposed solutions were analyzed from the traffic point of view, especially with regard to structures and their impact to traffic flows of the nearest surroundings i.e. on the streets and crossings of the street network.

The developed and accepted study will be used in further solution of this problem, as a basis for carrying out technical documentation and for the construction of some parking structures as well as an optimum organization of all modes of traffic flows.

References:

[1] Study on determining the need for the Construction of parking structures in the city centre of Split
   The Faculty of Civil Engineering, University of Split, May, 1994.
[2] Traffic study on Split, Solin and Kastela,
   The Faculty of Civil Engineering, University of Split, June, 1994.
[3] Parking and Mobility,
   Rotterdam, Netherlands, od No 1 (January 1991) do No 6 (January 1993).
[4] Parkhaus Aktuell,
   Chapter 15: Parking Loading and Terminal Facilities, James M. Hunnicutt.
   Paul C. Box, Institute of Transportation Engineers, Virginia, 1976.