Logistics of urban car parks

Introduction

Cities affect the natural environment and that causes the formation of an artificial environment. The system of delivery traffic (potentially transit traffic as well), bus service, and foremost the individual motorisation, the main source of fume emission, generate the so called city climate. The main characteristics of it are: increased cloud cover, higher rain level, more frequent fogs, and the formation of city heat islands with the local air temperature increase of as much as 12°C [1].

Given all that, the parking spaces for people travelling into city centres become a crucial problem.

Paper is meant to be a summary of the issue, as opposed to original research, the presented results are to be taken as preliminary, defining the development direction for the future research.

Providing the city transportation system assumes that the journey consists of sections, some of it done on foot, mainly the first and the last sections, and the intermediate sections, done with the use of private transportation and the municipal transport service (Fig. 1).

![Fig. 1. The city journey diagram [1].](image)

The relation between the collective and individual transportation, as described by the International Association of Public Transportation (based on the survey done in 100 world metropolises in 2000) is presented in Table 1.

Table 1 shows increasing interest into individual motorisation, which is typical of wealthy societies, the so called ‘car phenomenon’ effect. It can be defined by the increasing number of (registered) motor-cars [2].

The Polish Statistical Yearbook 2012 shows that the number of motor-cars registered in 2011 (on 31.12) was 18,125,000 units while the number of inhabitants is 38,5 ml [4]. The ratio of the both numbers gives 471 motor-cars used by 1000 people.

The individual motorisation in Poland in 2010 is presented in Table 2 [4].

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Table 1: The contribution of the public transportation and individual motorisation in the city travel operation in the world metropolises [1].

<table>
<thead>
<tr>
<th>Specification</th>
<th>Public transportation, %</th>
<th>Individual motorisation, %</th>
<th>Average distance, km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern America - Oceania</td>
<td>5</td>
<td>93</td>
<td>11.8</td>
</tr>
<tr>
<td>Middle East</td>
<td>14</td>
<td>82</td>
<td>7.3</td>
</tr>
<tr>
<td>Western Europe</td>
<td>25</td>
<td>68</td>
<td>7.9</td>
</tr>
<tr>
<td>Asia</td>
<td>39</td>
<td>42</td>
<td>7.0</td>
</tr>
<tr>
<td>Asian metropolises</td>
<td>42</td>
<td>48</td>
<td>11.0</td>
</tr>
<tr>
<td>Africa</td>
<td>42</td>
<td>56</td>
<td>7.5</td>
</tr>
<tr>
<td>South America</td>
<td>50</td>
<td>48</td>
<td>10.3</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>60</td>
<td>37</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Table 2: The number of motor-cars used /1000 inhabitants in 2010 [4].

<table>
<thead>
<tr>
<th>No.</th>
<th>Country</th>
<th>The number of motor-cars used /1000 inhabitants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Luxembourg</td>
<td>670</td>
</tr>
<tr>
<td>2</td>
<td>Italy</td>
<td>610</td>
</tr>
<tr>
<td>3</td>
<td>Austria</td>
<td>530</td>
</tr>
<tr>
<td>4</td>
<td>Germany</td>
<td>520</td>
</tr>
<tr>
<td>5</td>
<td>Spain</td>
<td>480</td>
</tr>
<tr>
<td>6</td>
<td>Great Britain</td>
<td>460</td>
</tr>
<tr>
<td>7</td>
<td>Poland</td>
<td>450</td>
</tr>
</tbody>
</table>

Given that a statistical polish family consists of 3 members, it is safe to assume that every Polish family uses a motor-car.

Consequently, the contribution of the collective transportation in the individual city transportation decreases. The number of the municipal transport service passengers in Poland in 1986–2001 is presented in Table 3 and Fig. 2. [personal elaboration based on 1]

Table 3: The number of the municipal transport service passengers in Poland in 1986-2004 [1].

<table>
<thead>
<tr>
<th>Year</th>
<th>The number of passengers, bilion/year</th>
<th>Participation in the 1986</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>9,1</td>
<td>100</td>
</tr>
<tr>
<td>1992</td>
<td>6,03</td>
<td>66,3</td>
</tr>
<tr>
<td>1994</td>
<td>6,0</td>
<td>65,9</td>
</tr>
<tr>
<td>2004</td>
<td>4,2</td>
<td>46,2</td>
</tr>
</tbody>
</table>

Fig. 2. The number of the municipal transport service passengers in Poland in 1986–2004 [1].
Parking in cities

It becomes more and more common nowadays, that travelling into a city involves individual motorisation and it starts in a garage and end in a parking space (work place, shopping centre, public parking space). The process involves not only the city inhabitants but also people commuting to schools, work places, shopping centres, administrative/culture/health institutions.

Regardless of the journey purpose, the motor-car users (at the end of the journey) look for an option of leaving their vehicle in a car park for a certain amount of time. Modern shopping centres, located on the outskirts, have got high capacity car parks at their disposal. Given the demand and the possibility, big car-parks are built in city centres as well.

The number of cars in city agglomerations poses aesthetic and functional issues for city planning. In the housing areas cars are typically parked for most of any twenty-four hour period. Therefore the attractiveness of housing areas comes from not just the option for fast public transportation but the car park spaces availability. Suburban housing estates offer more than one car space per apartment/house. In the city centres with a high population living in apartment blocks, the option of a minimum single car space is simply impossible from a town planning point of view. Also in the areas of old town buildings parking becomes more difficult. Challenges with finding room for parking space is one thing, but putting extra parking spaces may also ruin aesthetic and functional values of an estate.

Attractiveness of a parking space within city agglomerations depends on numerous factors divided into the following groups:
- town planning solutions: location / purpose / institutions and culture facilities proximity
- architectural: surface / configuration / number of levels / number of lots
- organisational-functional: availability (with the emphasis on the opening hours), price, payment options, as-you-go/bill / first hour rate / over-night parking / security.

Legal status

The legal nomenclature regarding building parking areas uses a division into:
- parking space, defined as disorganized, a single parking space meant for long or short-term parking
- open parking, multi-space parking area, located in an open space
- open multi-level parking with full open vertical dividers
- closed parking, described as a single or multi-level building, with closed vertical dividers, designed for parking.

Some of the organizational issues are regulated by the regulation[3], that says:

„§ 21. 1. parking spaces for motor-cars should be at least 2.3 m wide and 5 m long, while the disabled parking spaces should be at least 3.6 m wide and 5 m long, in case of street parking spaces – at least 6 m long and 3.6 m wide, with the option of restricting the space to 2.3 in width in case of an adjoining walk or bike path.”

In case of open (not permanently divided) multi-space parking areas, the manoeuvre space should be adapted to the vehicles that use those parking spaces. Depending on the positioning of the parking spaces in relation to the road axis it should not be less than [3]:
- at 90° – 5.7 m
- at 60° – 4.0 m
- at 45° – 3.5 m
- when parallel – 3.0 m.

Due to high parking space value in the city centres, the width of access roads is reduced to 5.0 m, unless (when the parking space is positioned at 90°) the width of the parking space gets increased up to 2.5 m.

Description of the study case

The analysed parking area is located in the city centre, outside a shopping centre with 120 retail units and restaurants. The parking area offers (on the levels) 630 car spaces at 90°. The car park entrance is off a quiet enough street.

Opening hours: Monday – Friday: 6.00 – 23.00; Saturday: 7.30 – 21.30; Sunday: 7.30 – 20.30;

Price list: first hour – free; second hour – 3 PLN; third hour – 3 PLN; fourth hour and more – 4 PLN.

Time for leaving the car park after paying is 10 minutes.

The car park management offers monthly subscriptions of 250 zł gross as well as loyalty cards:
- card for 20 PLN with 20% extra gives the value of 24 PLN
- card for 50 PLN with 20% extra gives the value of 60 PLN
- card for 100 PLN with 20% extra gives the value of 120 PLN.
Methodology and process results

The study focused on the users’ choice of car spaces in the car park in question every day of the week (Monday – Sunday) over the randomly chosen 7 weeks in one year. The selected weeks did not fall on any holiday times (Christmas, Easter, summer break, etc.).

The result of the study, which is the number of cars entering the car park on single days of the week, including Friday as the busiest day of any chosen week, is presented in Fig. 3 and 4.

![Figure 3](image.png)

Fig. 3. The number of cars entering the car park on the consecutive days of the randomly chosen week (own research).

![Figure 4](image.png)

Fig. 4. The number of cars entering the car park on Fridays of the randomly chosen weeks (own research).
Summary

Entering a car park increases all the local negative environmental side effects relating to the fumes emission. It happens due to low speed at which cars drive in, as well as the increased load resulting from the ramp incline (at the first and last stage of the incline it equals 8% and in between it is 15%).

The number of cars using the car park in question varies depending on the day of the week and fall between 1100 and 1700. At the car park capacity of 630 cars at a time, it means a fluent car rotation, keeping relatively short parking time.

The lowest number of cars using the car park was observed on Sundays, while the highest fell on Fridays and Saturdays. The reason for it is the increased pre-weekend shopping activity.

The difference between the Sunday and Saturday numbers could be linked to the lower interest in the non-retail offers.

There is also a difference in the number of cars using the car park on Fridays on different weeks – the difference ranges from 1400 till 2200 cars per day.

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Further analysis of the traffic load and functionality of the car park includes:

- the number of car using the car park only over the first hour, which is free of charge, the car park exit schedule
- the number and the parking time of the cars using the car park
- the type and age of the cars using the car park
- fumes emission prognosis and its individual (especially toxic) components.

Abstract

For many years the number of motor vehicles has increased, as they have become the most common means of transportation. Development of an efficient personal transportation system and creating enough car parking capacity in town centres has become a challenge for town planning. Given the rapidly growing populations in city agglomerations and the high land value, it is very likely that in the near future the interest in multi-level parking areas is going to increase. This article talks about the necessity of solving the pressing problems with the process of traffic infrastructure planning, and draws attention to the legal aspects of building parking areas. Paper is meant to be a summary of the issue, as opposed to original research, the presented results are to be taken as preliminary, defining the development direction for the future research. In order to analyse the character and capacity of car park traffic, a multi-level parking building was selected. It is located near a shopping centre in a busy city centre. The developmental nature of this project requires that certain problems are analysed more closely.

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4. Rozporządzenie Ministra Infrastruktury z dnia 12 kwietnia 2002 r. w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie (Dz.U. Nr 75, poz. 690).