Transportation system in the central parts of urban areas
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Abstract

The central parts of urban areas (the city cores) are susceptible to intensive traffic flows, public transportation vehicles and private cars. The traffic flows are intensive due to the attractive contents in the cores and historical monuments. The current use of certain areas and their uneven distribution result from the great number of trips in the city core and on the adjacent streets and squares.

The city of Split boasts many attractive historical monuments as well as Diocletian's Palace, recognized by the united Nations as a part of the World's cultural heritage. This city center is also the destination of a great number of trips from other parts of the town and suburbs.

The total number of trips to the city core was determined by applying a traditional model: trip generation analysis, trip distribution analysis, modal split analysis and traffic assignment analysis; the interaction between the number of trips and types of land use as obtained by applying multiple regression analysis.

The optimal land use in all parts of the city core will ensure comfortable pedestrian flows in the area under consideration and on the adjacent streets and squares within walking distances and to the planned parking places for private vehicles and public transportation means.

The investigations and the obtained results will be used for the development of the urban planning and physical-planning documentation.

1 Introduction

The central historical core and the port of the town Split developed during the period of 1700 years of the urban development represent the most attractive
point in the eastern coast of the Adriatic Sea regarding the transfer of passengers and the transport of goods. These investigations refer to the central part of the continental area of the town port where the Diocletian's Palace and the Medieval part of the town are located.
In addition, in the eastern part of the continental area of the Split port the facilities for the transportation of passengers and goods are located, but the hotels, tourist and public services are located in the western part. These three mentioned parts make the aquatorium of the town port with an intensive maritime transport.
The road network that links the area of the town port with the road network of the wider area of the Republic of Croatia and Europe makes a fast and intensive traffic flow.

Figure 1: Location Plan

This region is linked with the wider area by other transportation subsystems i.e. by railroad, maritime, air and telecommunications transport which make unique transportation system.
The Transportation Study of Split covered the integral transportation system in
which all subsystems contribute evenly to the transport of passengers and goods.

This paper especially deals with the road transportation subsystem that apart from its important role in the trip distribution has got an important role in connecting all other subsystems into unique transportation system.

Thus, we determine here the relationship between the number of trips to the central town area due to the attractive contents and available traffic areas in the present and planned period. This relationship results in the quality of traffic flows on the public town transport, private cars and pedestrian traffic.

There are two main aims in solving this problem: i.e. optimal traffic flow in the traffic areas in the centre of the town and the linking of this area with the traffic network of the wider area.

2 The Analysis of the Present State And the Function of the Transportation System

The following program and the methodology of the Transportation Study of Split have given an entire data basis of the traffic supply and demand as well as the subjects defining the traffic demand.

The data referring to the transportation system gave the information about the input data of the size and the level of the service of some elements of supply and the entire network as well as the work of the system.

The investigations of the traffic demand in the field covered household interview on the randomly chosen sample of approximately 4000 households. Polling of drivers, counting of vehicles at the crossroads as well as the counting pedestrians at the enterances and exits of the historical core, monitoring the stationary traffic, measuring speeds and other characteristics of the existing state of the traffic flow were carried out.

By this analysis of the existing state in the traffic flow of all kinds based on the above mentioned data and the economic data and the spatial limitations of the studied area formed the models of the transportation system by means of the program package QRS II.

The defined model of the relationship between traffic supply and demand the calibration procedure was made for the outer origin-destination and transit trips and local trips of all modalities which ensured the trip assignment.

2.1 The Studied Area

In order to analyze the transportation system in the central part of the urban area of Split we have divided the centre on the basis of:
- the town functions of the central area and the historical core;
- contact elements of the supply of the transportation system: roads and streets, public town traffic, car-parkings and pedestrian zones;
- defined intensity of the final forms of the transportation demand: parking and
pedestrian traffic;
- traffic regulations.

Figure 2: Distribution of Enterances to the Central Historical Core

The division was done into:
- the center containing the historical core of the town with the Diocletian's Palace and the Medieval Split, figure No 2.
- the centre with the historical core and the port can be divided into three characteristic parts:
  1. the western part with hotels, sports and recreation buildings and contents,
  2. the historical core with business, cultural and attractive historical buildings and contents,
  3. the eastern part with business and transportation facilities and contents.
- wider town center within the Ring road.

Apart from traffic flows of all kinds of traffic in the centre, a special attention in this analysis was paid to the kind, capacity and the way of regulation of access corridors which ensure direct and optimal communication of the central town area and the port with the road network of the wider investigation area and through its region with the road network of Croatia and Europe.
2.2 Road Traffic

Within the area of investigation the process of grouping, division and systematization of road and street network was carried out using physical and traffic criteria (the purpose and the importance of traffic, position, the kind of traffic, intensity and density of traffic, spatial landscaping etc.)

By using calculation methodology of the capacity recording to HCM-85, the results obtained by counting vehicles and the data from the road network, with HCS software as a tool, the capacities of all links in the existing road and street network of the wider investigation area have been calculated.

The results of the comparison between the peak traffic hours and the offered capacity of all sections and intersections give the estimate of the quality of traffic flows. The analysis showed that some links of the traffic network do not satisfied the traffic demand.

We can conclude that due to the attraction of the investigated area owing to spatial, cultural and historical values as well as business interests, complex functions and purposes take place here (especially in the town port) various kinds of traffic, especially road traffic can be met. This problem is very emphasized in the coastal area of the town port and at some access points especially during summer season.

2.3. Public Town Traffic

Public town traffic, that means the bus traffic, covers the whole town centre with its bus stations.

The lines run through the streets of the ring road around the town centre.

The routes are two-way streets that are very convenient for the traffic users.
The bus stations are both sides of the streets.

The vehicles of the public town traffic use the same streets with other vehicles which makes a lot of problems in some places in the centre and during peak hours.

Walking time is about 5 minutes.

2.4. Parking

The centre of the town with historical core and other attractive contents of a great historical value represents a very attractive place. A great concentration of traffic flows gives way to a very low level of service.

It greatly affects on relationship between parking supply and demand. Owing to the lack of parking areas all available space is used affecting badly the environment and pedestrian movements.

The monitoring of parking supply in the town center and in all legal and illegal parking areas was carried out.

In order to meet parking demands and other characteristics of the parking it is necessary to compare the number of the parked vehicles with the number of the
available parking places. There is a greater number of parked vehicles than the parking areas and it is not in conformance with the traffic rules.

2.5. Pedestrian Traffic

This investigation deals with the historical core which represents the most attractive part of the town with its contents and an intensive pedestrian traffic in the streets and squares.

The analysis of the existing state ensured the insight into the relationship between the use of the area and the traffic flows. It determined the quality of the flow and imposed the need for the following data:

- the land use, i.e. the purpose of the contents in some buildings,
- the size of the traffic areas, i.e. the size of the streets and squares,
- the pedestrian traffic flows in the traffic areas.

The places of counting the enterances and exits in the central historical core are showed in the figure No 2. In a half hour of time interval from 10^00-10^30 on an average day of a week 5197 pedestrians enter the historical core, and 4748 pedestrians go out, while 8616 pedestrians enter the wider zone of the town centre and 7302 go out.

If we compare the relationship between the size of the area per a pedestrian and the flow from the viewpoint of movement and comfort the boundary values which show the level of services are determined.

The analysis of the existing state shows that a more intensive use of the available attractive areas and buildings in the centre of the town attracts all traffic flows (public town traffic, private cars and pedestrians). It takes place in the limited traffic areas resulting in bad traffic conditions and a low level of service.

3 The Variants of the Planned Traffic Supply and the Prospective Traffic Demand

The concepts and the variants of the traffic supply answer the open questions:

- the solution of the traffic supply in the central town area and in the contact zones
- the development of all kinds of traffic supply in the studied area:
  - road networks
  - parking areas and garages
  - networks of the public passenger traffic
  - terminal areas of the passenger and goods transport of all kinds and their links with the transportation system
  - networks of pedestrian areas

Using the data of the planned land use, the state of the traffic demand, the modelled variants of the traffic demand development, it was necessary to foresee
the traffic demand for the outer origin-destination and transit trips and local
trips of all modalities. The spatial traffic planning used the traditional four-parts
model: trip generation, trip distribution, modal split and assignment.
The basic goal of the transportation system is to realize an integral
transportation system that will satisfy the demands for the transport of
passengers and goods on the basis of the spatial, demographic and economic
development of the studied area in the planned period to the year 2015. The
existing disproportion between the intensity of the all kinds of traffic flows, i.e.
the number of trips to the centre of the town and the available traffic areas can
be solved only by an optimal distribution of the number of trips to all kinds of
transportation system by an extensive use of the public town traffic.
The optimal distribution of the number of trips to the centre of the town to all
kinds of transportation system the prerogatives for a "comfortable" flow will be
realized.
The attractive monuments of historical value will be available to all present and
future traffic users.

4 The Suggested Solutions

The traffic areas in the centre of the town should be organized in a way that the
traffic flows and the subsystems of the transportation system (like passenger
traffic, public town traffic, delivery traffic, traffic of other vehicles, parking and
garaging of vehicles) can function in conformance with the defined aims and
priorities.
The suggested solutions can be used as input data of the traffic regulations for
each street and traffic area when a detailed planned and design documentation is
being carried out.
The goals of the suggested solutions according to their priorities and ranking
are: comfortable pedestrian traffic flows, preservation of historical heritage, the
requirements of the citizens, very attractive public town traffic, spreading of the
pedestrian areas, good delivery traffic, construction of large parking garages,
road traffic management and a desirable solution from the economic viewpoint.
The suggested solutions and the organization of traffic, all imposed demands
have been satisfied. The space for the better pedestrian traffic, the public town
traffic in the centre and the wider area of the town will be obtained.

4.1 Road Traffic

The enlargement of the existing streets to the full profile and the construction of
new sections and intersections in accordance with the planned traffic loading
and the required capacities and by taking into consideration the accepted
suggestion of the functional categories of the street and road network, as
showed in the figure No 4, the road and street network will be completed.
The planned traffic flows impose the demand for the satisfying function of all
elements of transportation subsystems, as it shows the figure No 3.

Figure 3: Planned Relationship Between Traffic Flow and Capacity

4.2 Public Town Passenger Traffic

The planned system of the public town traffic will be organized by buses and by a city railway. The coastal maritime traffic of passengers has been planned. Bus traffic is characterized by the routes as the ring and radial lines. The stations will be located in a way that their locations can cover the most important town destinations. Walking time will be 5 minutes.

The city railway completes the public traffic. The distances between the city railway stations will be from 600 to 1000 meters. The terminal where the mean of transportation can be changed (bus, railway, ship, ...) will be located in the eastern part of the town port.

The local maritime passenger traffic will be organized in the wider area of the bay.

4.3 Parking

The centre of the town Split is becoming more and more attractive to the visitors due to the everyday increased intensity of the use of its space and
buildings, but its traffic areas has not been enlarged. Therefore, the suggested areas, where big garages will be built, give the possibility of improving the existing state.

The obtained analyses in the Parking Study show the lack of the parking places at the end of the planned period, in spite of the new 14 planned parking garages (figure No 4).

This lack of parking places should be compensated by proper management and improvement of the public town traffic by defining the location of the traffic terminal where the transportation mean can be changed.

These measures should cover the total area of the town and should be represented as: urban-planning measures, traffic management measures and the management measures of parking facilities.

4.4 Pedestrian Traffic

The planned system of pedestrian areas is divided into: pedestrian streets and squares, pedestrian-vehicle streets and the roads with pedestrian corridor. This
part of the suggested traffic solutions in the centre of the town has been paid a great attention. Pedestrian flows start in the narrower centre. These plans suggest the enlargement of the pedestrian zone in the centre of the town by new organization of the traffic routes and the stations of the public town traffic. The most valuable historical space of the town, has been freed for the pedestrian traffic by the mentioned organization of the entire traffic in the centre of the town.

4.5 Delivery Traffic in the Centre of the Town

The planning documentation that has been made by now a greater part of the narrower centre of the town considers as a pedestrian zone. Today there is a need for a pedestrian zone which would cover the whole centre of the town. Thus, the road traffic would be eliminated in the area where the road traffic collides with the pedestrian traffic, except in the existing pedestrian zone.

Apart from giving the firm schemes of the road and pedestrian traffic in the centre of the town, it is necessary to define an adequate delivery system, especially in the centre by imposing the limitations of time and the use of delivery vehicles.

5 Conclusion

All suggestions referring to the urban-spatial, traffic, study and design documentation give the solutions for the optimal distribution of all kinds of traffic flows in the available traffic areas, whether they are inherited or new. This especially refers to the traffic areas and flows within the domain of investigation where the attractive contents and valuable historical monuments attract a great number of transit trips by private cars, by town buses and by pedestrian traffic.

These investigations try to solve the problem of a great dissonance of spatial and traffic possibilities and the increased demands due to the attraction of this area. The endeavours are complemented by economic demands and possible development.

6 Literature

3. Parking Study of the Town Split; Faculty of Civil Engineering, University of Split, Split, 1994.