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LJUBLJANSKA AND SLAVONSKA AVENUE - TRAFFIC KEY OF THE CITY OF ZAGREB

SUMMARY

The paper analyses the urban motorway, the Ljubljanska and Slavonska Avenue in Zagreb. As the key road, it is important for the city of Zagreb both regarding internal and external traffic links. The almost ideal location of the Ljubljanska and Slavonska Avenue has not been properly evaluated and used by the Zagreb urban and traffic designers. The traffic count, measuring the vehicles speed and the analysis of the existing interchanges have indicated the disadvantages, drawbacks and irregularities related to the design of the motorway. The measures for improving the traffic flows and change of signalling devices have been proposed and the design of interchanges has been recommended. The traffic forecast for the next ten years, according to the growth predicted by BDP, imposes urgency in realising the phases in improving the throughput capacity and safety of the traffic along this motorway.

1. INTRODUCTION

The Ljubljanska and Slavonska Avenue, in the East-West direction, passes almost through the geographical city centre itself. The historical centre of the Zagreb city (Gornji grad, Kaptol and Donji grad) is situated along its middle part, between the interchange with the Zagreb ring road west of Jankomir, and the interchange with the ring road near Ivanja Reka one to two kilometres to the north, in the extension of the Hrvatska bratska zajednica Street. The Street of Hrvatska bratska zajednica has been marked out so that, leading from the north to the south, from the Ban Josip Jelačić Square, over Zrinjevac, Glavni kolodvor (the main railway station), and between the buildings of the Zagreb municipal board and the Concert Hall "Vatroslav Lisinski", and bridging the Sava river, it leads to the central part of the Novi Zagreb (the new part of the city). Therefore, the Novi Zagreb centre is only about 2 km from the Slavonska Avenue. Since the overall length of the Ljubljanska and Slavonska Avenue amounts to about 22,400 m, the Street

Hrvatska bratska zajednica is about 10,550 m away from the interchange with the ring road. Thus, in a certain way, the Street Hrvatska bratska zajednica together with Ljubljanska and Slavonska Avenue forms a kind of a Zagreb urban and traffic cross. The centre of this cross is the geotrafic centre of the city.

This cross is positioned approximately in the middle of the Dubrovnik Avenue, which is the central street of Novi Zagreb. Allowing for a certain asymmetry, the Dubrovnik Avenue is connected towards the south-west, from the western side by the Jadranska Avenue leading towards Karlovac, Split, Rijeka, i.e. through the "Lučko" interchange to the Zagreb ring road. To the east, the Dubrovnik Avenue is extended by the Avenue of Savezna Republika Njemačka and the Velikogorička Road, which connect Zagreb with Velika Gorica and the airport, as well as further with Sisak, Petrinja, Pounje and a part of Posavlje (the Sava region), and also Zagreb with the ring road over the "Buzin" interchange.

The city of Zagreb spreads along the whole length of the Ljubljanska and Slavonska Avenue, to both sides - the north and the south. The length of the city from the east to the west almost equals that of the Ljubljanska and Slavonska Avenue. Unfortunately, such almost ideal position of the Ljubljanska and Slavonska Avenue has not been properly evaluated and used for the internal traffic connecting of the city of Zagreb by the Zagreb urban and traffic planners and designers. This is partly the result of the impossibility for consistent development of the overall urban space of a country such as Croatia, whose development was for 45 years subjected to unnatural laws and regulations. During that time the urban traffic development concept of Croatia was realised in even unintentionally promoting the development of big cities at the expense of the traffic and urban development of the whole. This is also partly the reason why the today's Ljubljanska and Slavonska Avenue accommodate

more vehicles (over 4,000 vehicles per day) than the "feasible" traffic capacity, causing thus frequent and long standstills, whereas at the same time there is the Zagreb ring road with 8,000 vehicles passing daily and the capacity of about 60,000 vehicles.

Apart from the fact that more than 20% of the overall population of Croatia lives in Zagreb, and that more than 30% of the vehicles and social production are in Zagreb, the knowledge that traffic jams make Zagreb less comfortable for living and less competitive on the world market of economic and cultural development, is a reason enough for serious worries.

The similar situation can also be found in other major Croatian cities (Split, Osijek, Rijeka). Such policy of urban disintegration, i.e. growth of the cities has damaged in particular the smaller towns, villages and even whole urban regions (Lika, Dalmatinska Zagora, Croatian islands, part of Slavonija). For the sake of comparison only, let us note that during the last inter-war period the urban disintegration has left the Republic of Slovenia almost untouched.

With the knowledge of these failures, and the unlimited possibilities provided by the new Croatian society in the Republic of Croatia, there is a chance, even over a ten-year period, for an economic turn, i.e. integration into the company of highly developed European countries. Among all the other tasks, one of the most important is the reconstruction, i.e. construction of a modern traffic system.

The disharmony in the previous development of the traffic system of Zagreb as a whole, as well as its subsystems, especially the road and railway traffic, requires a more versatile study and proposals regarding its future development in order to make the realisation as efficient as possible. The paper analyses a principled approach to this problem with the basic characteristics of the previous development and the concept of the traffic solution for the Ljubljanska and Slavonska Avenue as the urban motorway.

2. SIGNIFICANCE AND ROLE OF THE LJUBLJANSKA AND SLAVONSKA AVENUE

The significance and the role of this road in the saturation of the future traffic flows is reflected in:

- internal traffic flows circulating within the city from the eastern towards the central i.e. western parts of the city and vice versa,
- connecting Zagreb with the western and north-western parts of the counties of Zagreb and Krapina-Zagorje over the Jankomir interchange, and connecting it with the eastern and north-eastern parts of the county of Zagreb over the Ivanja Reka interchange

- connecting the main roads and motorways of Zagreb with the eastern Croatia (Slavonija and Hrvatsko Podunavlje - the Croatian Danube Region), Varaždin, Čakovec, i.e. Krapina, and over these roads also with the neighbouring countries of Slovenia and Austria, Hungary, SR Yugoslavia and Bosnia and Herzegovina.

Without internally connecting Zagreb there may be no efficient traffic and economic linking of Zagreb with its surroundings, nor with the rest of Croatia and the world. Therefore, the tendency has to be towards faster inter-linking of the single parts of the city, i.e. towards reducing the travelling time, increasing the safety of vehicles and pedestrians, reducing the adverse effects of traffic on the environment (noise, air pollution), towards optimal usage of the urban space and reduction of transportation costs in transporting goods, and especially towards reducing the travelling time of citizens in carrying out their daily activities.

3. ANALYSIS OF THE CURRENT CONDITION

3.1. The analysis of the current traffic and urban solutions regarding the Slavonska and Ljubljanska Avenue

The Slavonska and Ljubljanska Avenue represents the basic backbone of the urban traffic network. It attracts directly the population of about 40 km² of city area, including the city centre and the most important industrial and commercial zones, which means that the most important traffic flows in the city use this road (source and target traffic, inner urban traffic)

Apart from being the main internal traffic connection, The Ljubljanska and Slavonska Avenue also integrate the city of Zagreb over the six key European roads not only into the Croatian road network but also into the road network of the Central Europe, as well as the Danube region and the Adriatic.

The basic characteristic in the development of the road traffic system, i.e. the road traffic infrastructure, which most affects the traffic development, is present in the development through three main phases.

- 1) the first development phase after the World War II includes the construction of the urban motorway (Slavonska and Ljubljanska Avenue), road towards Krapina and Maribor, and the construction of the basic street network in Zagreb with the bridge over the river Sava in the Street of Hrvatska bratska zajednica,
- 2) the second, post-war phase, includes the construction and additional construction of the road network with the bridges (Most mladosti and Jadranski most), as well as the construction of the

motorway towards Karlovac. The second part of the phase includes the construction of the Zagreb ring road with the motorway towards Slavonski Brod, and the reconstruction, i.e. additional construction of the Ljubljanska and Slavonska Avenue

3) the third phase - (1980-1990) is marked by the construction and reconstruction of the road towards the Airport Zagreb and Velika Gorica, construction of the semi-motorway Ivanja Reka - Popovac, reconstruction of the Slavonska Avenue and the construction of the grade-separated (segregated) road-railway line crossings in the western part of the city (Selska, Vrapčanska). The third phase is marked also by a substantial extension and additional construction of the tram traffic.

The basic disadvantage in the road traffic infrastructure development is the insufficient throughput capacity of the road network in the east - west direction. This disadvantage could and had to be corrected by the construction of the Ljubljanska and Slavonska Avenue as a real city motorway, first as a four-lane and later in the future as a six-lane one. However, although it exists as the four-lane road with two separated carriageways, the at-grade crossings and complicated signal-controlled regulation, make this road a traffic barrier in the east-west flows, and in the north-south flows as well.

Thus, apart from having one natural barrier (the river Sava), Zagreb has got, apart from the railway line, one more traffic barrier.

This approach (the construction of the ring road as a complete motorway), has provided the maximum possible comfort for through vehicles, while the origin-destination, especially inner urban traffic flows have been completely neglected.

The basic drawbacks of inappropriate regulation and traffic flows organisation are reflected in:

- the failure of the previous investments, due to inadequate use of infrastructure,
- high transport costs
- lower level of traffic safety
- low average travelling speed
- long waiting times at intersections
- longer travelling distances and difficult orientation
- increased fuel consumption.

The regulation and organisation of traffic flows and their adequate control in the network and on the intersections can significantly contribute to the greater efficiency of the traffic system.

The signal-controlled regulation, especially at the beginning of the second phase (beginning of the 1970s), has started with a very complex regulation of multiple phase systems (such as e.g. the intersection of the Savska Street and the Vukovar Avenue). The same regulation models were gradually copied all over the Zagreb network, and partly in the Republic of Croatia as well.

This traffic regulation was aimed at achieving the maximum traffic safety. However, the result was the

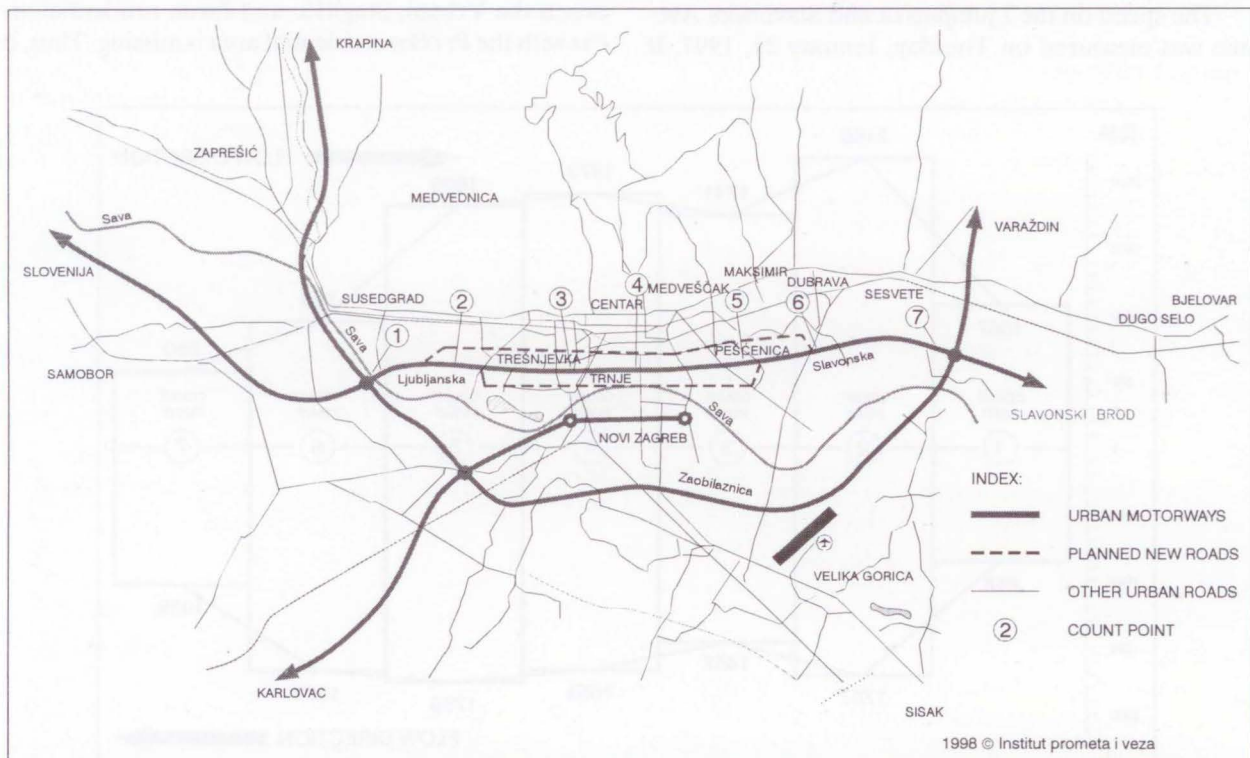


Figure 1 - The position of the Ljubljanska and Slavonska Avenue within the network of the City of Zagreb

complete opposite, and the Zagreb intersections are extremely dangerous and probably present the basic cause for unsafety in traffic.

The regulation and organisation of the traffic in the Zagreb centre, as well as the traffic regulation at the intersections in the wider central area of Zagreb, significantly reduce the efficiency of the urban public traffic.

3.2. The analysis of traffic along the Slavonska and Ljubljanska Avenue

Since Zagreb lies primarily in the East - West direction, just like the Ljubljanska and Slavonska Avenue, it is possible to obtain a complete picture of the traffic load by selecting seven section points (Figure 1). The picture of the traffic load would have been much more accurate if the traffic flows related to this avenue had been recorded. However, such a study would require a lot more means and time and it would need to be carried out as part of developing the entire traffic planning of the city of Zagreb.

In order to obtain the data on the traffic load of the Slavonska and Ljubljanska Avenue, the through traffic at the seven selected sections has been counted. Similarly, the vehicles speed on the Slavonska and Ljubljanska Avenue has been recorded in order to obtain the data on average speed between the intersections

Measuring the speed

The speed on the Ljubljanska and Slavonska Avenue was measured on Tuesday, January 21, 1997. It

was done in order to obtain data on the average vehicle speeds on the Ljubljanska and Slavonska Avenue.

The recording of traffic was carried out by a passenger car of standard dynamic properties. The task of the driver was to travel at the legal speed limit, and to follow a selected vehicle considered as representative compared to other cars in the flow and regarding its method of driving in the flow, and primarily regarding the speed.

The driving was done along the right traffic lane, overtaking only in specific traffic conditions (a car standing due to a breakdown, roadwork, or vehicles driving at very low speeds, such as vehicles for special operating purposes). The run itself started somewhat prior to the starting measuring point. Abiding by the mentioned rules, the run in the opposite direction followed immediately afterwards.

The average (mean) speed on the section between the Interchange Zagreb East and the Interchange Zagreb West was 44.1 km/h, and the average speed on return was 43.2 km/h.

The results analysis of the traffic count and vehicle speed recording

It is immediately obvious that there is an extreme load of vehicles on the section of Ljubljanska Avenue between the intersection with Zagrabačka (and Petrovaradinska), Slavenskog and G.Krklec (Figure 2). This result stands apart from the natural law of traffic flows only at the first glance. The results immediately indicate that a necessary local urban road link between the Vrbani, Staglišće and Jarun residential areas with the Prečko residential area is missing. Thus, it

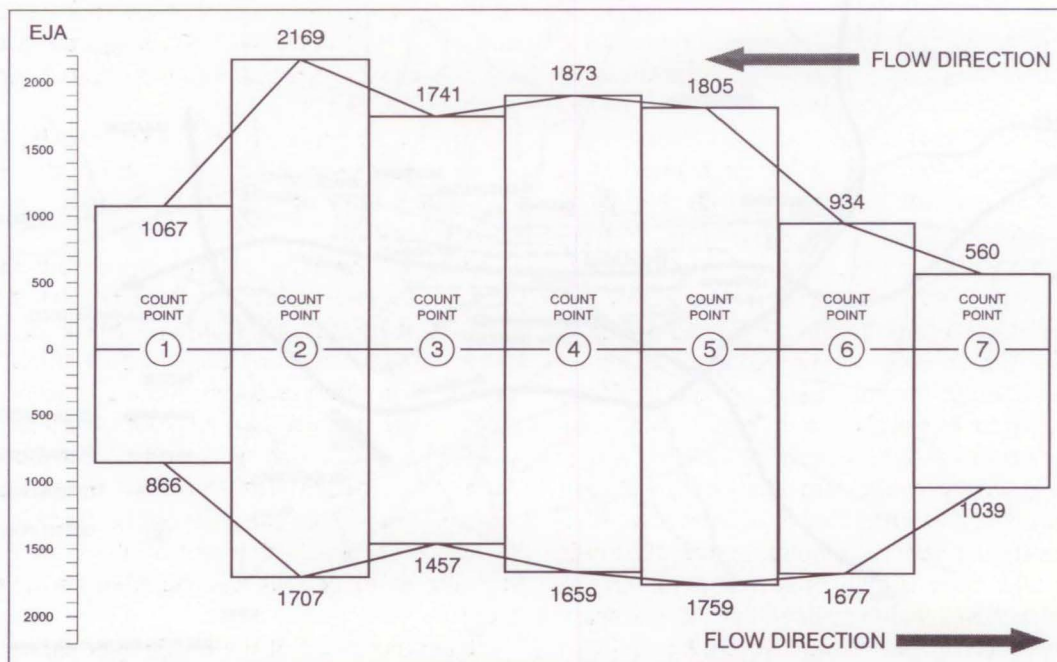


Figure 2 - The results of the traffic load between 3 and 4 p.m.

borders with absurdity that all the traffic flows connecting Prečko and Savska Opatovina with other parts of the city south from the Ljubljanska Avenue, have to pass along Ljubljanska Avenue. To make it even worse, this section of Ljubljanska Avenue receives also partly the flows from Špansko towards Rudeš and Voltino residential areas.

The middle part of this road has a similar situation. Thus Srednjaci and Knežija have a very bad connection more to the south of the Ljubljanska Avenue. The situation is extremely unfavourable because the Cvjetno naselje area is not connected to Savica, nor Savica with Radnička cesta south of Slavonska Avenue. Moreover, because of the bad interconnection of housing estates located between the Slavonska Avenue and the Railway Line, Čulinec, Sesevete, Vukomerec, Trnava and Peščenica, and the unsolved problems in the north-south communications due to the insufficient number of grade-separated crossings below the Railway Line, it is easy to find reasons for the overload to which this road is subjected.

By multiplying the peak load of a one-hour count by the number 11 (peak hour coefficient) will yield the peak daily load sufficiently reliable for determining the intensity of the daily traffic flows.

Thus the total daily load at the count point number 2, from 4 to 5 p.m., amounted to $3,750 \times 11 = 41,250$ (vehicles per day).

Taking into consideration the nature of traffic development, the biggest number of vehicles is to be expected at the cross section under the overpass on the Hrvatska bratska zajednica Street. There, the peak traffic load is from 7 to 8 a.m. - $38,26 \times 11 = 42,086$ vehicles/day.

Since the intersections on this avenue are of mixed type (grade-separated and at-grade), it is obvious that the number of vehicles exceeds the throughput capacity of the road. Thus, during peak daily loads, the level-of-service of this road is F, which means that there are frequent and longer standstills during the whole working day, from 6 a.m. to 9 p.m.

The achieved average speeds are extremely low. Thus the lowest speed measured on the section between the Falerovo šetalište and the Puljska Street on the Ljubljanska Avenue in the east-west direction amounts to 20 km/h, and on the section between Heinzelova Street to M.Čavića Street is 20.5 km/h also along the Slavonska Avenue westwards. The average measured speed westwards was 44.1 km/h, and eastwards 43.2 km/h. The measured maximum speeds between the two interchanges amount to over 100 km/h, indicating that there is a lot of speeding, high maximum speeds, long waiting times and low average speeds, especially in peak hours. It can be said that these conditions are simply "perfect" for reducing traffic safety.

3.3. The analysis of traffic flows crossing the Ljubljanska and Slavonska Avenue

Since the peak daily load on the mostly loaded section of the Slavonska Avenue (the Hrvatska bratska zajednica underpass) amounts to about 42,000 (EJA) conditional passenger cars, it was estimated that the traffic crossing the Ljubljanska and Slavonska Avenue ranges between 80,000 and 100,000 vehicles.

The certainly most intensive north-south traffic flows are those using the following streets: Hrvatske bratske zajednice, Savska, Držićeva, Heinzelova, Selška and Grada Gospića, Hrgovići - Drvinje, Petrovaradinska - Zagrebačka, Gustava Krkleca - Slavenska and Čulinečka. The flows are often zigzagged (turns) due to the lacking connections between the city districts north and south of the Ljubljanska and Slavonska Avenue.

The pedestrian flows crossing the Slavonska and Ljubljanska Avenue are also of high intensity, especially near the tram or bus stops. The detailed urban plans have not paid enough attention to the vehicle and pedestrian flows crossing the Slavonska and Ljubljanska Avenue.

3.4. The traffic analysis of the current interchanges on the Slavonska and Ljubljanska Avenue

The interchanges on the Ljubljanska and Slavonska Avenue have been constructed as interchanges (intersections) with one, two and three levels. Unfortunately, these interchanges have not been designed properly, neither from the traffic nor from the urban and aesthetic point of view. Although not considered here in detail, the traffic safety problem is present at almost all the interchanges.

Apart from the interchanges with the ring road and six more grade-separated intersections, all the others, i.e. intersections have been constructed as at-grade crossings.

With the exception of a signal-controlled intersection, where the traffic has been regulated by two-phase traffic lights (Slavonska - M.Čavića), all the other intersections are regulated in three or four phases. With long cycles of about 120 seconds, such traffic regulation causes long vehicle waiting times i.e. reduced average driving speed, lower intersection throughput capacity (missed green time in a certain phase), higher transportation costs (travelling time, number of stoppings, fuel consumption), reduced traffic safety and increased adverse effect on the environment.

The visible part of the traffic light equipment has been designed inconsistently. Thus, some intersections are fitted with lanterns over each traffic lane, and

at some intersections there is only one (with repeaters) on the approach.

Except for the grade-separated intersection of the Slavonska Avenue and the Hrvatska bratska zajednica Street and the interchanges of the Ljubljanska - Slavonska Avenue with the Zagreb ring road, there is no other interchange that might claim to have been well designed regarding traffic.

All these interchanges, except the interchange for Jankomir and the one with Držićeva Street, have traffic signal intersections at the urban level, with traffic flowing in three or four phases. Regarded from this aspect, such solutions are seldom found in the world traffic and urban practice. Thus, the four-phase traffic regulation system remained even after the Ljubljanska and Slavonska Avenue with Savska have been transformed into a two-level intersection. Although dependent on traffic, it causes traffic jams and therefore, is not co-ordinated neither along the Savska Street nor the Ljubljanska and Slavonska Avenue.

The interchange of the Ljubljanska Avenue with the access road to the cargo terminal Jankomir has been constructed as an extra-urban interchange. The drawback lies in the fact that the urban development plans will necessarily seek connection to the space south of Ljubljanska Avenue precisely through this interchange.

The interchange of the Ljubljanska Avenue with the Selska cesta has been designed by partly lowering the grade (concave curve) and rising of the grade (convex curve) of the Selska. The basic drawback of this intersection is its urban level at Selska. There is no possibility for the traffic coming down the exit arms along the Ljubljanska Avenue to continue straight (city bus), entrance to objects on the entry arm or exit from the objects along the exit arm. Moreover, due to the badly designed intersection at the Selska cesta, the signal-controlled traffic is regulated in three phases.

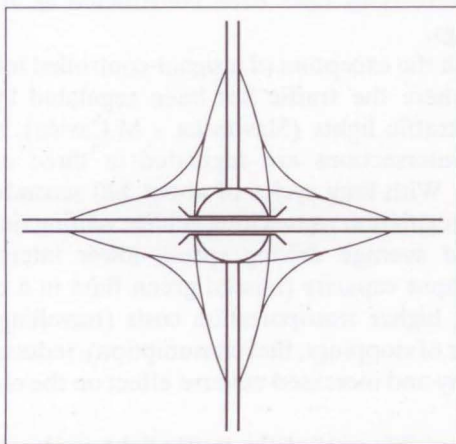


Figure 3 - An example of a conceptually well designed quasi-roundabout

The interchange of Ljubljanska and Slavonska Avenue and the Savska cesta, apart from having too narrow lanes compared to the volume of the traffic, with a narrow dividing median, it is a great pity that the "tunnel" underneath the Savska cesta has not been constructed as two tunnels with three lanes each, intended for the calculated speed of 80-100 km/h and the traffic lane width of 3.5 m.

The upper urban level with the Savska cesta has been intolerably badly designed. Thus, the traffic at that level flows in four phases causing nervousness both in motorists and pedestrians due to long waiting times and many other disadvantages. Moreover, it has not been planned, and now it would prove difficult, to add at the upper level the lanes for half-turns that would simplify the connections of the neighbouring infrastructure connected to the traffic network, along the connecting lanes to the Slavonska, i.e. to the Ljubljanska Avenue.

The interchange of the Slavonska Avenue with the Hrvatska bratska zajednica Street has been conceptually well designed (Figure 3). The quasi-roundabout at the urban level should have been of greater dimensions. It is also a pity that the design of the interchange had not foreseen the adding of two lanes along the Slavonska Avenue for the through traffic stream.

It is also difficult to understand why there are lanterns above every traffic lane on the intersection approach at the urban level, and only one on exit. Moreover, the exit-entry arms of this intersection have to be opened towards the residential area Trnje, i.e. a part of the residential area between the HTV (Croatian Television) Building and the Sloboda Bridge. This would simplify the traffic flows.

The interchange of M. Držića and the Slavonska Avenue is the only three-level intersection. It is no secret that it can be regarded as a complete traffic, urban and architectural failure.

Is there anywhere in the world a three-level intersection, with the traffic approaching and departing through signal-controlled intersections at a distance of 500-1,000 m?

This project is a true example of the ecological violence against the human environment (gases, noise, ambient devastation), and without any advantages for the traffic. On the contrary, this solution has damaged both the traffic flows and the traffic safety a lot.

As part of long-term urban traffic development planning, this interchange would have to be completely redesigned and reconstructed both from the traffic and urban point of view, and the so-called "left turn lanes" (the third level) must be removed.

The interchange of the Slavonska Avenue and the Grad Gospić Street; the lower urban level of this interchange has not been designed properly. At that level there is a tram line on the west side of the Grada

Gospić Street. At both signal-controlled intersections the traffic flows in three phases, additionally prolonging the waiting times and increasing the transportation costs.

Finally, after having analysed the single- or two- i.e. three-level interchanges one can only conclude that there is an inconsistency present together with various traffic and urban philosophies in the realisation of the traffic and urban characteristics of the given interchanges.

3.5. The analysis of traffic costs at the Slavonska and Ljubljanska Avenue

Such traffic load and the applied solutions cause a lot of stopping and long waiting times of vehicles. It would be very difficult to estimate all the costs involved in such traffic solutions, therefore, by using a simple but consistent approach we shall try to provide a sufficiently reliable estimate about

1. the number of vehicle stopping related to traffic flows along Slavonska and Ljubljanska Avenue and crossing Slavonska and Ljubljanska Avenue,
2. the fuel consumption caused by these stoppings
3. longer travelling times, i.e. lower average speed expressed through higher fuel consumption and the price of average driver's and passengers' hour of waiting,

Thus, 30,000 vehicles due to an average of 8 stoppings / vehicle daily, have to come to a stop 240,000 times. These vehicles consume therefore additionally 13,680 litres of petrol daily. The vehicles (100,000) crossing the Ljubljanska and Slavonska Avenue have to come to a stop 100,000 times and therefore consume 3,200 litres of fuel per day.

At the average fuel price of about 4 Kn/lit the stoppings consume daily 16,880 litres of fuel or 67,520 Kunas. For a total of 340,000 stoppings, 340,000 minutes are wasted, i.e. 5,667 hours or 396,690 Kunas daily. Thus the daily costs due to fuel and wasted time amount to 464,210 Kunas or 170 millions Kunas a year.

If other costs related to traffic safety, environmental protection, and additional damage and destruction of the road and vehicles are added to the before mentioned costs, the cost of such a traffic solution for the citizens of Zagreb and Croatia, its economy and state, cost more than 200 million Kunas a year or about 37 million US\$. The five-year losses caused in this way are much higher than the investments necessary for the reconstruction of the Ljubljanska and Slavonska Avenue as the fast urban road i.e. urban motorway which is estimated to an amount of about 760 million Kunas, i.e. 130 to 140 million US\$.

It should certainly be mentioned and pointed out that the actual costs due to the lack of high-quality

traffic connection along the Ljubljanska and Slavonska Avenue are probably double the amount of the stated ones, due to the daily long traffic standstills whose key lies precisely and mostly in eliminating the traffic standstills in the Slavonska and Ljubljanska Avenue.

It should be noted that the parallel connections which do not exist between the residential areas north and south of the Ljubljanska Avenue, are of extreme importance. Their construction would require additional 200 million Kunas.

4. THE FUTURE TRAFFIC REQUIREMENTS ON THE SLAVONSKA AND LJUBLJANSKA AVENUE

It is extremely difficult to forecast the traffic requirements on the Slavonska and Ljubljanska Avenue without the assumed input data such as elements of the traffic network and its quality, north and south of this road. The traffic demand would probably increase instantaneously by more than 20% if this road - street were quickly reconstructed into an urban motorway.

The forecast of the traffic demand for the current traffic solution over a period of the next 5 years, has been made under the assumption of no major changes in the traffic network. For the period of 5 to 10 years, it is to be assumed that the residential area Prečko will be connected across Jarun to the Prisavlje Street and further across Savice to Kozari put, i.e. that the residential areas Špansko and Voltino naselje will be connected. Over the ten-year period, at the most, all vehicle - pedestrian intersections at the Ljubljanska and Slavonska Avenue from the Čulinečka Street to the Gustava Krkleca Street (Špansko), should be transformed into grade-separated ones.

During this period the Vukovarska Avenue should be extended across Krapinska to Selska, i.e. Borongajska Road.

Over the following 5 years, the average daily traffic will increase at a rate of 5% (in accordance with the increase of the gross national product), i.e. within 5 years it will increase by about 28%. This means that the traffic between Savska and Držičeva Street will increase from about 42,000 to 54,000 vehicles. On other sections it will be reduced and at the end sections near the interchanges in Ivanja Reka and Jankomir, it will amount to 30,000 vehicles/day.

It will be very difficult to accommodate this kind of traffic flow along the existing road. In order to make it at least partly possible, the three- and four-phase traffic regulation system should be changed into a two-phase one (with, if necessary, post-phase flow of left-turning vehicles).

If traffic increase is assumed over the following 5 years as well, at a rate of 5%, i.e. 28% over the period between 2003 and 2008, then in the year 2008 about 69,000 vehicles/day would be passing this road along its central section from Savska to Držićeve Street. In order to make this possible, the section of the road from Čulinečka Street to the residential area Špansko would have to be grade-separated and a new parallel connection south from Žitnjak to Prečko constructed.

Assuming the traffic increase of only 3% annually, between 2008 and 2018, the traffic on Slavonska and Ljubljanska Avenue would increase by 34% following the year 2008, and it would amount to over 90,000 vehicles/day.

Since this road cannot accommodate such traffic intensity, a so-called North tangent will have to be constructed, which will through tunnels and over viaducts pass along the south slopes of the Medvednica mountain, from the New hospital area to Podsused.

The interconnection of Ljubljanska and Slavonska Avenue and their connection to the other parts of the main urban network will provide the possibility of accommodating such increased traffic flows. In order to make it possible, the advantages offered by the railway service to the urban and suburban transportation should be exploited. If this were not the case, then the alternative would be to expand the Slavonska and Ljubljanska Avenue in its central section, from the residential area of Špansko to the Čulinečka Street as a six-lane urban motorway.

5. CONCLUSION

It may be said that the ideal location of the Ljubljanska and Slavonska Avenue within the urban space of the City of Zagreb offers excellent possibilities for meeting the traffic requirements, i.e. traffic demands of source-target traffic flows, and for the inner urban traffic flows in the West - East direction as well. This is an East - West road which passes the central urban area and provides the best connection of the urban area over the Ivanja Reka and Jankomir interchanges on the motorways leading to Slavonski Brod and Varaždin, and towards Ljubljana and Maribor respectively. By the additional connections, the Ljubljanska and Slavonska Avenue connect the city through the Buzin interchange with Sisak, Petrinja and Pounje, and through the Lučko interchange by motorway with Karlovac, Rijeka and Split.

The Ljubljanska and Slavonska Avenue has been already constructed as a four-lane urban road with dual carriageway separated by a median. Just a short section of this road with the Jankomir bridge across the river Sava has two lanes.

Unfortunately, due to the maximum number of at-grade intersections (excluding 6) and the high in-

tensity flows connecting through these intersections the pedestrian and vehicle streams of the north and south part of the city, this road is already today completely overloaded in the traffic sense and it may be said that it is at the level-of-service F, where the traffic demand is greater than supply.

The lack of good parallel links between the residential areas from the southern and the northern side, present an additional traffic load, especially for the section of Ljubljanska Avenue passing through the city districts of Prečko, Rudeš, Špansko and Vrbani.

There is not one reason that could serve as an argument against constructing the Ljubljanska and Slavonska Avenue in its full length as an urban motorway, i.e. fast urban road with the following elements:

1. the calculated speed over the whole length should amount to 100 km/h, excluding only its central section from Selska to Heinzlova Street where it could be 80 km/h,
2. The road should have four lanes, i.e. a dual carriageway with two lanes each. At the central part of this road, the construction of grade-separated intersections with only four lanes (Savska, Hrvatske bratske zajednice, Selska and Držićeve Street), make the construction of this road as a six-lane one extremely difficult. All the estimates of the traffic demand indicate that the central section of the Ljubljanska and Slavonska Avenue should have six lanes (dual carriageway with three lanes each). This problem may be in the future mostly compensated by the road that would connect Jarun and Prečko (Horvaćanska Street) over Prisavlje, with Žitnjak, as well as with the change in traffic regulation and extension of the Vukovarska Avenue westwards and eastwards (Krapinska and Borongaj).
3. in its whole length this road should be grade-separated for the traffic flows between Ivanja Reka and Jankomir, both for vehicles and for the pedestrians. This means that the levels of all the existing north-south traffic links (vehicles and pedestrians) should be separated.
4. it is possible and desirable to lead all the pedestrian flows along this road separate from the carriageway (traffic lanes). When difficult to achieve, then it would be necessary to separate the pedestrian flows from the vehicle flows by a minimum 2 m wide protective strip.
5. all the intersections should be designed in two levels, and the current so-called "left turn lanes" (the third level at the Slavonska Avenue intersection) should be eliminated as part of a whole traffic redesign of this interchange in the future
6. since (as a necessity) the urban public bus transport will start using the Ljubljanska and Slavonska Avenue, the planning for grade-separated

intersections or near grade-separated pedestrian crossings should include the planning of bus stops,

7. all the intersections at the so-called "urban level" should be signal-controlled so that the traffic could flow in two phases with a possible post-phase turning left (within intersections it would be necessary, wherever possible, to plan for the possibility of U-turning after and before the intersection, provided there is physical space to realise this, and there should be no restrictions on traffic flows, as in the case of the grade-separated intersection of Ljubljanska Avenue and the Selska Street).
8. regarding the fact that this is an urban road, the lighting should be of high quality.

Based on this concept it is necessary (within the revised general urban planning of the city of Zagreb and its general traffic plan), to develop a complete traffic project design of the Ljubljanska and Slavonska Avenue with precise phase construction

If this road is not reconstructed systematically into a fast urban road (urban motorway), without shoulders, within the next five years at the latest, Zagreb will daily live through even several hours of traffic standstills, and another fast urban road will be "eaten up" by the transport costs and the time wasted in travelling.

SAŽETAK

LJUBLJANSKA I SLAVONSKA AVENIJA - PROMETNI KLJUČ GRADA ZAGREBA

U radu je analizirana gradska autocesta Ljubljanska i Slavonska Avenija u Zagrebu. Kao ključna cesta, važna je za grad Zagreb u smislu unutarnjeg i vanjskog prometnog povezivanja. Gotovo idealan položaj Ljubljanske i Slavonske avenije zagrebački urbanistički i prometni projektanti nisu na pravi način do sada valorizirali i iskoristili. Brojanjem prometa, snimanjem brzina kretanja vozila i analizom postojećih čvorova autoceste ukazano je na nedostatke, propuste i nepravilnosti pri oblikovanju autoceste. Također su preporučene mjere za poboljšanje vođenja tokova, izmjene signalizacije i date preporuke za oblikovanje čvorova. Prognoza prometa u idućih deset godina, a prema predviđanjima porast BDP-a, navodi na hitnost pristupanja realizacije etapa poboljšanja propusnosti i sigurnosti prometa ove prometnice.

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