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Urban Traffic
Review
U. D. C.: 656.2 :711.553
Accepted: Mar. 8, 2005
Approved: May 3, 2005

RAIL SYSTEMS FOR PUBLIC URBAN TRANSPORT

ABSTRACT

The experience of major cities in Europe and in the world has influenced the dimensioning of the required capacities of the transportation means. Based on this knowledge, the criteria for using individual modes and systems as well as types of transportation means were created. The increase in passenger flows beyond capacity margins has resulted in the introduction of transportation means of higher capacities. The decision on the very choice is made on the basis of an integral analysis of advantages and drawbacks of individual modes and systems, including in the decision-making process the current situation in the traffic in the city with the evaluation of passenger flow values in the future. The size of the traffic demands in the City of Zagreb requires higher capacity transportation means, on the standard rail system gauge, featuring much higher commercial speed, reliability, comfort, safety in relation to the previous transportation means. The decision about the mode and the system should be made as soon as possible.

KEY WORDS

rail systems, public urban transport, transport means, transport demand

1. INTRODUCTION

Rail traffic means all modes and systems of transportation with the main route consisting of rails. Apart from the conventional railway system operating the public scheduled railway transport, i. e. regional, county and suburban transport, this category includes also the transportation systems such as: urban trains, narrow-gauge, standard-gauge and broad gauge tracks, as well as monorail railway.

The rail systems have developed differently through history. The innovations at the beginning of the 19th century started the mass usage of rail vehicles both in public scheduled railway transport and in urban transport. This lasted until serial production of passenger cars was invented (1913 – Ford), when passenger cars started to be introduced on a big scale into the road traffic, and especially into urban transport. This caused significant reduction in passenger transportation and the use of rail systems, and even technical and technological lagging behind in development. This was particularly the case in the time period between 1930 and 1960.

Following 1960, especially in a number of European and US cities, and even other cities in the world, due to inefficiency, i. e. congestions that followed because of excessive use of personal cars, there came again to the expansion in the use of rail systems, especially regarding passenger transport in the cities. In that period new modern suburban railways or suburban-urban railways came into being as extensions of the urban railways – metro, followed by modernization and expansion of the tramway network. Over the last years, in many mid-size, larger and large cities the share of rail system in the passenger transportation is increasing and becoming every day a more significant feature in the public urban transportation of passengers. This is best seen in the data of the major cities of West and Central Europe where the share of rail systems in the passenger transportation is growing annually at a rate of even up to 3-4%.

2. SOME EXAMPLES IN THE WORLD

The rail system started to be rapidly developed with the invention of the steam engine, that is, the steam locomotive in 19th century, when the steam trains started to develop and started to be used in scheduled railway transport from 1830. Later, with technical improvements, it started to be used more and more in urban transport.

Along with the development of regulation and control, traffic organization and charging for carriage, all the technical improvements facilitated the expansion of the public urban and suburban traffic. Naturally, the transportation means developed as well in several transportation modes, i. e. systems as well as the respective infrastructure.

The infrastructure in rail urban traffic includes the following facilities:

- rails and rail structures with substructure and permanent way for rail transport systems;
- electric catenary with instruments and other devices for the movement of transportation means;
- commercial buildings that serve to organize and complete the transportation service production processes.

The investment costs for the rail transport systems depend on whether the transportation system operates on the ground or separated from other traffic, that is, grade-separated. These costs may include:

1. Costs of land including: purchase of land for the tracks and the stations, as well as other facilities necessary for the rail system operation. These costs vary a lot along the entire track since they depend on the area of the city which it passes through and the facilities constructed there.
2. The construction costs vary depending on the separation of the track and track construction costs include also the preparation works, construction works and track finishing costs. Therefore, the lowest costs are for the construction of the tramway route which passes over the surface, and the maximum costs are in case of metro whose greatest part of the route goes underground.

   The costs of other rail systems (lightrail, high-speed tramway, separated track tramway) vary depending on whether the route is grade-separated and on the type of the route, i. e. whether the route is separated on the surface or a track has been built in the tunnel.
3. The costs of constructing stations vary depending on the type of the station. The maximum costs are in case of underground stations affected by several factors: number of levels, position of platforms, station equipment, etc. Tramway stations feature the lowest costs since they are at-grade.

The costs of the permanent way consist of the costs of the rail and rail structure (turnouts, crossings and other facilities). The electric power supply costs include the costs of stations and costs of power supply network, third rail or catenary. The costs of control and communication include the communication means and signal-safety devices along the tracks, which are usually calculated per metre or kilometre of the line. The costs of other components of the control and communication system, such as construction of a control centre, remote control system for connection and communication with vehicles and other accompanying equipment on-board vehicles, are specially calculated since they do not directly depend on the line. The costs of control and communication vary depending on the type of track and they are substantially lower in case of tramways since they have no signalization along the track but rather only on at-grade crossings, whereas the most expensive are in case of metro which has complete signalization control requiring also central control for the entire system. The scope of investments into vehicles and infrastructure between various systems is of crucial significance in selecting the transportation system and it is necessary to include also the criterion which refers to the efficiency of exploitation which favours the rail transport system. For the sake of illustration, Table 1 [1] shows orientation values of equipping the rail systems in the USA, and as example for comparison also possible assessments, i. e. decision-making about the use of certain transport modes. These costs per 1 km should be corrected according to the relevant costs of labour on the domestic market. Besides, an analysis of every unit separately is necessary, and they should be separated regarding costs according to the type of system taking into consideration all the possibilities and specific characteristics of the local environment and market.

Table 1 – Range of infrastructure costs for rail systems in the USA

Systems	Costs of capital per 1 km Min. (in mill. dollars)	Costs of capital per 1 km Max. (in mill. dollars)
Light rail system		
- at grade	5	10
- overground	24	31
- underground	43	53
Metro		
- overground	24	34
- underground	43	55
Railways	3	10

The sizes of the cities have affected the dimensioning of the passenger flows that can be met by certain types of transportation means, so that during exploitation of certain transportation means their physical and economic limits have been determined, up to which the use of certain transport means is justifiable. The increase of the passenger requirements, including the increase of passenger flows above the limit capacities has resulted in the introduction of higher capacity transportation means. The very choice of introducing new transportation system is made after having completed a comprehensive study of the advantages and the possibilities of the included cities, naturally, at the given moment with the projection of how this is going to affect the future. Anyway, this has to be in the function of the development of the public urban transport

Table 2 – Characteristics of the existing transport systems

System characteristics	Values	Tramway	Light rail system	Underground tramway	Metro	Conventional railway
Path		trmwy. line	trmwy. line	trmwy. line	line	line
Vehicle guidance		steel wheels	steel wheels	steel wheels	steel wheels	steel wheels
Vehicle drive		el. engine	el. engine	el. engine	el. engine	el. engine
Vehicle dimensions (length / width)	m	14,31/2,2	Composition 80/2,7	31,0/2,5	30,0/2,5	30,0/3,0
Max. speed	km/h	60	60	60	80	120
Commerc. speed	km/h	8-18	20	2	35	50
Vehicle capacity	pax places	110-240	80-360	290	350-400	8000
Line capacity/h	places /h	13500	25000	20000	48000	75000
Land use per 1km of line	m^2	3500	3700	3500	3800	4000

and the improvement of the transport service that will have social and economic significance, since the organization and the quality of the transportation service in the cities affects the leisure time left to the working and other citizens.

According to some studies, by using the existing public transport the citizens of Zagreb lose annually 20 million hours a year or 833 days which must not be neglected, especially having in mind the world experiences. According to these world experiences the total journey time from the place of residence to the place of work should not take longer than 40 minutes for 80-90% of passengers in the biggest and very big cities, i. e. 30 minutes in other, smaller towns.

At the moment the capacities of the current urban transport are reached and when its speed results in the loss of time on the path from the periphery to the city centre greater than 30 minutes, then the construction of metro becomes an imperative [2]. Also, according to the valid rules for the basic level of comfort in the vehicles, they should not be occupied by more than 4-5 passengers per square metre of useful floor space.

With the increase in passenger flows, almost all the big cities, especially the capitals, both in Europe and in the world encounter almost identical problems. Precisely due to the knowledge that numerous and complex problems of public urban transport as well as the increasing requirements of the traffic complexes can be best solved by combining the integral system with high-speed traffic, including certain elements of the existing system and introducing high-speed traffic (metro). The transport power and the transportation capabilities are affected by a number of factors which are interdependent. These are the level of safety, load on the traffic route, vehicle characteristics, influence of other traffic systems and connections with them, passenger frequency, charging systems, etc. Practical values differ significantly from the theoretical ones, and the comparisons among the systems are presented in Table 2 [1], obtained from the catalogue of vehicles of individual transportation vehicle manufacturers.

Great advance in the technology of transport occurred in the last 100 years. This technological development had significant influence also on the development of modern civilization, and especially on the urbanization of the cities. Today, no city can be imagined without some mode or system of public urban transport. A great number of inventions has created a certain number of different technological systems so that today these modes and systems can satisfy the needs of any urban area. Therefore, the objective of urban transport technology is to ensure high-quality service in the transport of passengers and the transport to a desired destination. Parallel to the development of the cities, the technical and technological transport modes and systems of passenger transport in the cities developed as well, adapting during the process to the new requirements in the passenger transport in the cities. The harmonization regarding transport demand and ways of satisfying these needs resulted in the classification of the transportation systems (the general division of transportation systems is into conventional and non-conventional ones), with the rail system belonging to the conventional transport systems, divided into subsystems such as those presented in Table 3.

Table 3 – Numbers indicating construction level of single subsystems of the rail system per periods of time in the world

	Until 1900	Until 1925	Until 1950	Until 1975	Until 2004
Metro	5	9	4	28	50
Light metro	0	0	0	0	22
Light rail system	15	25	3	3	15
Tramway	157	57	50	32	70
Conv. railways	33	55	7	1	0

Table 4 – Number of kilometres per individual sub-systems in the world

Subsystem	until 1900	until 1925	until 1950	until 1975	until 2004	total
Metro	807.7	1,064.0	708.9	1,510.9	1,399.5	5,491.0
Light metro	0	0	0	0	510.2	510.2
Light rail system	645.8	603.0	37.5	153.1	393.1	1,832.8
Tramway	8,264.8	1,596.7	2,064.9	833.1	989.2	13,748.7
Conv. railways	833.4	1,539.2	159.7	5	0	2,537.3

Table 3 [3] clearly shows the method in which the subsystems developed over years which are characteristic for the development of certain subsystems in the rail system, as well as the method in which these were implemented at the time, i. e. what was their fate in further application in the passenger transport in the cities. Also, the comparison of the level of construction of certain subsystems is very interesting, as well as the total number of the constructed subsystems of the rail system, that were applied in the passenger transport prior to 1925 (when there was no widespread use of personal cars) and after 1925. Before 1925 there were 356 different subsystems in use or 55.54 percent of the total number of constructed subsystems, whereas after 1925, i. e. until 2004 (which means after 79 years) there were only 285 or 44.46 percent of the total of constructed subsystems in use.

Similar situation results when the constructed subsystems are presented in kilometres of installed rails which is presented in Table 4, with the ratio before 1925 being 15,354.9 km of rails or 63.66 percent and after 1925 until 2004 this was 8,765.1 or 36.34 percent. This comparison shows that the percentages of the total kilometres of constructed rails are somewhat greater than the percentage of the number of subsystems in use, and this is the consequence exclusively of the expansion of rail networks of the mentioned subsystems.

In the rail system there are also subsystems that defer regarding the distance between rails which has resulted from the very development of the rail system, i. e. the older the subsystem, the narrower the gauge, i. e. the newer the subsystems the broader the gauge. Thus, in Europe today and in the world there are gauges in the rail system from 750 mm, to 2150 mm, which is bad for the integration and development of the rail system into the public urban transport, but it is also understandable that in some countries, that is, cities, due to the lack of financial means the replacement of the narrow-gauge railway line by a standard one or possibly broad-gauge one is not possible. When this division is analyzed with the data from Table 4 [3] the data presented in Table 5 are obtained.

As seen in Table 5 [3] the most widely used in the world is the standard gauge which is equally widespread in the cities in the entire world.

Table 5 – Number of kilometres of tracks according to track spacing in the world

Gauge (distance between rails)	Kilometres	Percentage
Standard (1430-1450mm.)	12,111.5	50.21
Broad (1520-1600 mm.)	6,089.1	25.25
Metre (1000 mm.)	4,262.9	17.67
Other	1,656.5	6.87

The broad-gauge track is used in the regions of the former countries of the Soviet Union, Brazil and somewhat less in the USA.

The metre track gauge is mostly used in Europe, particularly in Germany, Switzerland, Italy, Spain, and France and these had all been installed before 1900. By the way, this gauge had been used most of all the track gauges until 1925, and 86 percent of railway lines of the total of lines constructed with this gauge had been constructed and operating until that year. After 1925 until 2004, only 14 percent of railway lines were built with this gauge.

Out of other rail systems, the most often used is 1067 mm, in Japan, and somewhat less in England (this gauge is used by 45 subsystems in these countries). These include also the gauges of 750-950 mm (this gauge is used by 20 subsystems), and 1100 mm (2 subsystems), 1200 mm (2 subsystems), 1220 mm (1 subsystem), 1372 mm (4 subsystems), 1495 mm (1 subsystem), 1676 mm (2 subsystems), 2060 mm (3 subsystems), 2150 mm (1 subsystem).

The characteristics and the scope of the transportation demands in the cities in the world are influenced by numerous factors. First of all, the social and demographic structure of the population, population growth, standard of living, inherited and acquired behaviour models, structure of residence, and then last but not least, important factors such as volume and quality of transport offer provided by the transport companies. Besides, the significance and the role of the rail system in the traffic system of a city are directly and constantly determined by the level of motorization of its population. In the last 50 years, in the cities of the more developed European countries, there has been a typical re-orientation from the public urban transport, i. e. rail system to individual transport. This

Table 6 – Km length and number of lines per continents

Continent	Metro		L. metro		Light rail system		Tramway		Conventional rail-way	
	km	line	km	line	km	line	km	line	km	line
Europe	2,512.7	144	57.9	10	1,451.1	74	11,616.0		2,060.3	94
N.America	1,276.2	58	327.4	26	117.1	8	582.3			
S.America	529.6	32	72.0	6	47	1	31.5	4	94.0	2
Asia	1,108.5	62	9.5	1	217.6	14	1,084.3		383.0	32
Australia							265.7			
Africa	64.0	2					168.9			
Total	5,491.0	298	510.2	43	1,832.8	97	13,748.7	4	2,537.3	128

Table 7 – Number of subsystems per continents

	Continent	Metro	Light metro	Light rail system	Tramway	Conventional railway	Total
1	Europe	46	5	42	277	73	442
2	N.America	13	12	6	34	1	66
3	S.America	13	4	2	8	2	28
4	Asia	24	1	12	33	20	90
5	Africa	1	0	0	6	0	7
6	Australia	0	0	0	8	0	8
7	Total	97	22	61	366	96	641

process began a little earlier in North America than in Europe, and later the process continued in Japan as well.

However, the level of motorization that is present in these countries and in other countries of the developed world, has seriously endangered the efficient functioning of the city centres. Therefore, the primary goal in big cities is rightly the need to balance the individual and the rail system of transportation. Here, the rail system has to achieve adequate quality and quantity, in order to become competitive to the individual transport and in order to provide the possibility of survival of the big cities in which there is an ever greater need of the population for mobility. This increased need for mobility leads to the need to greater requirements of using personal cars, as result of the increased standard of the population, and also the "discomfort" in using the public urban transport, clearly including the rail system, as consequence of insufficient investments and the lagging of the public urban transport behind the needs of increasing mobility of the urban population and their visitors.

On the contrary, in the developing countries, where the level of population mobility has remained low, because the entire groups of citizens walk every day kilometres due to the impossibility to afford public urban transport, so that the transport systems are insufficiently occupied and underdeveloped, as can be seen in Tables 6 and 7 [3]. This is particularly true for the African countries where there is quite a number of cities with even more than 250,000 citizens, without having any organized public urban transport. It is also very interesting that Africa has 40 cities of million and more citizens, out of which six have more than 5 million inhabitants. Nigeria and South African Republic have 6 cities of more than a million citizens while Congo has 4 such cities and none of them has rail system, i. e. public passenger transport system. The rail systems in Africa exist only in Egypt, in four cities (Cairo has also a metro), and the South African Republic, i. e. Kimberley where tramway is operating on 0.4 km long rails.

Similar situation is also in Asia where India has 36 cities with more than a million citizens, out of which 7 have more than 5 million citizens, and only Calcutta has a metro and a tramway. China has 44 cities of more than a million citizens (including Hong Kong) out of which 5 cities have more than 5 million citizens and only 5 metros in the length of 132.2 kilometres of rails with 9 lines and 5 tramways in the length of 94.9 km of rails. Asia has 161 cities with more than a million citizens out of which 24 have more than 5 million citizens.

In South America there are 63 cities with more than a million citizens, out of which 7 have more than 5 million citizens and as seen in Tables 6 and 7 an insufficiently widespread rail network, which is of poor capacities not able to meet the current requirements and even less the future requirements.

Naturally, with the increase in the standard of this group of population, which is not small as one can see from these data, the need to use public urban transport will significantly increase. Before that it should be modernized and expanded in order to be able to handle the increased transport demand.

In some more developed countries the share of public urban transport in the mobility of the urban population is extremely small and ranges between 11-18% which does not at the moment represent any greater difficulties in the functioning of these cities due to the well-branched road infrastructure, although recently reduced safety of the traffic participants has been noticed with longer peak loads as well as congestion in the busiest streets. Besides, in the cities that have metros and lightrail systems, the citizens are increasingly using these to travel to work and from work to the central parts of the city. This is understandable, since these systems operate on separate lanes with longer inter-stop distances, not being affected by the traffic congestion, with all these advantages facilitating much higher speeds compared to other modes and systems of transport. Besides, these systems act very favourably on the passenger car users who may park their cars as necessary at certain parking lots and continue their journey to their destinations using rail systems faster than by personal vehicles.

Indeed, the rail system is the most efficient system on the suburb – city centre relation and within the downtown area.

The rail transport is used more in the European countries and very little in Australia, New Zealand, USA and Canada regarding the number of citizens in the cities. Europe has 75 cities with more than a million citizens, out of which 6 have more than 5 million inhabitants, and the rail system has a fairly well developed network which is used more and more, although at one time, in the period between 1930 and 1960 it was completely neglected in Western Europe, the tramway lines even being completely closed down and the rails dismantled. At the same period in Eastern Europe the most of the rail systems were constructed and used, thus creating an illusion of a continuous development of the rail system in Europe, which could not substitute what had been lost.

On the other hand, Australia has 4 cities with more than a million citizens, and New Zealand only 1 such city, and only 8 cities in these countries have tramway lines.

The USA has 51 cities of more than a million citizens, out of which 11 cities have more than 5 million citizens. If the functioning of the public urban transport were analysed, then the USA would be a typical example. All the big cities, namely (naturally, also those with more than a million citizens) that had become such before the automobile boom, are the cities with very well organized public urban transport, particularly rail system. The cities that had become bigger during the automobile boom and after that, have very little or no public urban transport, but they do have a very big and widespread network of road infrastructure, which has more difficulties in handling the requirements of an increasing number of personal and other road vehicles. A similar case is in Canada which has 6 cities of more than a million citizens and one with more than 5 million inhabitants. A low level of using the rail system is a consequence of very big usage of personal vehicles and low density of suburbs that cannot be connected by this transportation system.

Besides, in these countries, as well as in the European countries of course, the costs of exploitation exceed the costs of revenues from the passenger transport which is additional burden on the city authorities which have to subsidize the means for normal operation. It should be noted that the revenues from the sold tickets do not cover even 51 percent of exploitation costs (this clearly includes also the costs of employees' incomes) thus resulting in very little investments or complete absence of investments into the development and modernization of the public urban transport, including rail system, continuing thus the lagging behind in the development with heavy material consequences.

The basic causes of the difficult material position of the public urban transport company include:

- large number of employees,
- tariff policy determined by the city authorities and characterized by low adaptability of the tariffs to the range of company costs,
- the need for public traffic functions also on the unprofitable lines (social requirement).

Public urban transport, particularly in big cities, is operated by several carriers, i. e. companies which operate independently, since the companies are organized according to their functions protecting their interests, resulting therefore in non-uniform offer i. e. service (division of zones, serving areas, several parallel lines, non-uniform tariffs, etc.), and this is clearly reflected on the efficiency of the public urban transport system.

This is precisely the reason for starting the process in Europe of integrating the system into the public urban traffic, and simultaneously the reduction of losses caused by lack of coordination in the operation of carriers, i. e. increase in the operation efficiency, as well as the improvement of the concept of public urban transport.

3. TRAFFIC FUNCTION

The traffic function in major and big modern cities is one of the most important, and in the conditions of dynamic economic and cultural life its significance is even more important. With the increase of social incomes and standards, by shortening the working hours and changes in the method of earning and others, it is justifiable to expect also a significant increase in mobility. Here, the growth in the number of citizens and various facilities of the population activities should be added, which significantly increases the total mass of trips in the city. With the very fact that the city area is growing, the distances are also growing between the place of residence related to different needs of the population from the place of work, recreation, education, etc. At the same time the average distance of travelling grows as well, and also the duration of travelling. Naturally, with these values grows also the need for transport, primarily depending on the material possibilities of using personal vehicles, and also of using public urban transport. Since all the consequences, especially the costs of the entire infrastructure of the public transport are covered by the city community, it needs to ensure efficient solutions both regarding serviceability, and regarding finances.

In such circumstances the role of adequate organized and structural public urban transport is becoming more important so that the citizens and the visitors from the wider region could reach their destinations as fast as possible and as comfortable as possible. The more so, since justified requirements are increasingly imposed to raise the standard of living in the city and the reduction of all forms of harmful impacts on the environment with the traffic function playing here an important role. From this aspect it should be determined whether the structure of the entire system of public urban traffic of Zagreb corresponds to the existing types and the possibilities of their development, or whether it is necessary to include some newer and more powerful systems in order to meet the traffic demand. Based on the research, the results have been obtained that have been carried out in the developed countries, known as the bottom threshold for the introduction of fast means of the public urban transport, and that is the approximate value of the average distance of travelling of about 5 km [4]. In order to make conclusions it is possible to use the data of research of an older date [5] and these are presented in Table 8.

Table 8 – Average trip distance (km)

Year	1974	1985	2000
in personal cars, including walking	6.0	6.9	7.3
only in automobiles	5.9	6.4	7.0
in public urban t., incl. walking	6.0	8.4	9.2
only in public urban transp. vehicles	5.7	7.6	8.6

The research data on 1974 condition show that the mentioned bottom threshold was exceeded in the City of Zagreb already a quarter of a century ago. The forecast also shows that in the future the increase of average trip distances should be expected, regarding the large share of trips from the surrounding close or wider areas that have their destinations in the city centre. For better illustration of the expected transport values, including the significance of the problem complexity, that need timely reaction by adequate measures, which have to include also the expected population growth and especially justifiably expected increase in the mobility of population as an expression of the development of mobility freedom and general freedom as well. These values have been calculated according to the data from the same source and presented in Table 9 [5].

These data clearly show the significantly more intensive growth of the total mass of journeys than the increase in the population growth and their mobility individually. Obviously, the basic problem appears and it needs to be solved, how to insure so many trips with no harmful consequences on the urban structure and environment or, on the other hand, how to prevent the harmful consequences of the possible mobility restrictions.

The size of the area covered by the City of Zagreb (ca. 29.6 x 16.9 km) and its surrounding, i. e. region, is certainly a big refuge of big increase of the future transport demand with the mentioned factors. This requires provision of high-speed and high-quality relations between the distant parts of the city, and especially of the wider area and the city suburb with the city centre. On the one hand there is an obvious conflict between the desired lines in connecting all the urban areas and conflict of these desires i. e. traffic routes in the very centre. On the other hand, this is opposed by the relief of the urban area, construction level of the city structures, i. e. restrictions and liabilities, already determined and embedded in this area. In the City of

Table 9 – Number of whole-day trips in the City of Zagreb

Year	number of citizens	Factor 1974	Mobility of citizens	Factor 1974	Mass of trips - total	Factor 1974
1974	688,000	1.00	1.09	1.00	749,900	1.00
1985	830,000	1.21	1.75	1.69	1,425,500	1.94
2000	1,065,000	1.55	2.25	2.06	2,396,250	3.20

Zagreb, the old core of the city is in the foreground, which means the Donji grad, Kaptol, Gradec that need to be protected against destruction, satisfying at the same time the traffic demand of higher quality connections and the living conditions in the city. This is obviously possible only with the orientation to public mass transport that will be able to provide fast and efficient resistance to the charge of personal cars into these areas, without harmful consequences.

Regarding the current situation in the number of trips in the City of Zagreb, the public urban transport allows for approximately 41.26% of trips, and 58.74% of trips using personal cars. The share of personal cars in the transport is growing daily, due to the increase in the level of motorization in the City of Zagreb, which is approaching at dizzy rate the critical point of 500 cars per 1000 inhabitants, and all this with slight increase in the capacities of road network and the parking areas.

4. CONCLUSION

The work analyzes the relevant modes and systems of rail traffic on the basis of their development in Europe and in the world.

Some examples in the world have been shown, and the traffic function in major and big urban agglomerations stressed, which results in a significant rise in mobility.

The basic results of the mentioned analysis are reflected in the need to rationalize the traffic system in major cities, including Zagreb, where first of all high-speed and rational public urban and suburban traffic should be insured.

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SAŽETAK

TRAČNIČKI SUSTAVI ZA JAVNI GRADSKI PRIJEVOZ

Iskustvo većih gradova Europe i Svijeta, utjecao je na dimenzioniranje potrebnih kapaciteta prijevoznih sredstava. Na temelju tih spoznaja su izgradili kriterije korištenja pojedinih vidova i sustava kao i vrstu prijevoznih sredstava. Povećanje putničkih tokova iznad granice kapaciteta ima za posljedicu uvođenje prijevoznih sustava većeg kapaciteta. Odluka o samom izboru donosi se na osnovu cjelovite analize prednosti i nedostataka pojedinih vidova i sustava, s tim da se u proces odlučivanja uvrsti postojeće stanje prometa u gradu s procjenom veličina putničkih tokova u budućnosti. Veličina prometnih zahtjeva u Gradu Zagrebu, traži prijevozna sredstva većih kapaciteta, na standardnom razmaku tračnica tračničkog sustava, koja će imati znatno veću komercijalnu brzinu, pouzdanost, udobnost, sigurnost u odnosu na dosadašnja prijevozna sredstva. O kom vidu ili sustavu je riječ treba se što prije odlučiti.

KLJUČNE RIJEČI

tračnički sustavi, javni gradski prijevoz, prijevozna sredstva, prijevozna potražnja

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