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Principles of Formation of Underground Transport Systems of Megacities

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Summary

The principles of formation of the underground transport systems of megalopolises are explained. Problems of development of the modern megalopolises, the bound to increase and concentration transport and passenger traffics between business and residential areas are considered. The conditions defining need of creation of underground infrastructure of the city are defined.

The expediency of construction of city automobile tunnels as bases of developed underground infrastructure is shown.

Landmark development of underground transport infrastructure by formation of uniform system, creation of the multilevel transport systems and their interaction is proved.

Keywords: transport systems; underground space

1. Introduction

The underground transport systems are distinctive feature of the modern city. The need for them arises in process of development of the city production, economic and social and economic infrastructure, body height of the population, merge of certain settlements in huge inhabited conglomerates. In process of their formation of communication of different types, they are gradually transferred under the earth that considerably improves a view of the cities and accommodation conditions. One of the major factors defining comfort of residence in the megalopolis is the effectiveness of its transport system, in many respects determined by the considerable number of natural and cultural factors.

As a rule, formation and development of the transport systems of most cities, especially megalopolises are delayed behind the rates of development changes in city infrastructure. Transport communications of a historical part of the cities often exist in an invariable look during the long–lived periods of time. The modern areas which do not have a historical part of value can rather often and with high rates to be reconstructed while the existing transport system cannot undergo any changes. The number of floors in buildings and constructions grows, increases at the expense of house adjoining territories of their area. It leads to sharp increase in number of the living or working citizens, and respectively, to decrease in comfort of accommodation, increase in social tension in the city residential district. At the kept invariable channel capacity of transport communications of the area it leads to an overload of the transport system, emergence of hours–long transport traffic jams, and in some cases, the especially bound to climatic cataclysms, to a collapse of the transport system. Especially it is characteristic of the cities with the composite land relief having in the infrastructure island territories, communication with which is carried out on bridge constructions with a restricted channel capacity (on weather conditions, number of strips for driving in both directions, to navigation conditions in passages – movable bridges etc).

Improvement of conditions of residence in the modern city at the available level of developed high–speed individual and public transport changed priorities of availability of these or those objects. If earlier the distance between objects was considered as one of key indicators of quality of the transport system (for example, distance between the residence and the place of work or administrative structures), then now ensuring high availability of an object – i.e., time spent for the road is priority. Adoption of this principle led to development of system in the cities of multi–level interchanges which in particular conditions significantly unload traffic flows. In too time this way of development of the transport systems in many respects sputtered out as creation of traffic intersections has to be strictly coordinated to the existing infrastructure. Traffic intersections occupy the significant areas, have the restrictions to height.

According to many experts, the complex system of underground transport has to be created in all cities with population more than 1 million people [1]. Therefore, the prospects of development of the transport systems of the city require a complex development of the uniform transport system created step by step and developed sequentially on various elevation marks of the underground horizons.

2. Types of the underground transport systems of megalopolises

At justification and study of options of creation of the transport system of the megalopolis it is necessary to consider the staging of its development, availability to its separate elements and system in general caused by growth of urban areas and accession to this system of the similar transport systems of the satellite cities, also inclusion in the system of the external railroads.

At assessment of the made technical solutions of placement of objects of city infrastructure accounting of effectiveness of the solution of the main problems of the megalopolis, such as ecological and socio–economic factors, health and safety, comfort of accommodation and infrastructure appeal is necessary.

For the megalopolises located on the sea coast and having island territories, creation of underground terminals for seaports and construction of tunnels of a deep underlay for creation of the uniform transport system of the large city is also expedient.

Urban development in the considerable range of elevation marks causes existence of highways with the biases close to the limiting. Frequent changes of biases on sections of routes, rather slight on extent, steep turns, and existence in traffic flows of heavy–load transport affect on traveling speed, accident rate, and life of paving. Padding complications during the winter period create even an atmospheric precipitation,

especially ice phenomena, slight on intensity. On certain sections of routes with the limiting biases driving in the composite weather conditions can be forbidden that follow–up worsens the common situation.

For the megalopolises located in the composite conditions of the cross–country terrain, development of underground space has especially relevance that is defined by features of their building, division into districts under the terms of a relief, development of transport networks. Strong breeds, rather high carrying capacity of soils, the considerable excesses of a land relief, from several tens to hundreds of meters, assume construction of underground objects in a mountain part of the containing massif.

It should be noted the following advantages of the underground transport systems:

–provide a basis for further development of underground infrastructure of the large city both on the area and in depth of the containing massif;

–do not depend on external natural and climatic conditions;

–provide formation of the padding transport communications of the considerable channel capacity allowing to unload significantly city streets, to optimize routes of public transport

–improve conditions of comfort of movement of the population and availability to objects of the welfare sphere, places of work and accommodation owing to what the possibility of decrease in social tension in megalopolises appears;

– promote considerably restriction of entry into the city of heavy–load transport that allows to simplify significantly a situation on city streets and to reduce number of the road accidents.

It is expedient to form the uniform transport system of the megalopolis at several levels:

1. Pedestrian zones and tunnels. Level is formed on the basis of a combination of underground parking, the industrial, economic, and welfare facilities located in chamber developments under buildings and constructions, the structurally bound to transport communications on a surface.

2. The automobile tunnels included in the transport system of the cities or intended as access roads to objects of underground city infrastructure, car terminals – and railway stations.

3. Lines of the subways – the system of passenger transport.

4. Tunnels of railway transport of a normal track of – the system of railway passenger and cargo transport presented by set of underground excavations (the main and auxiliary tunnels, sloping, and chamber developments) connected by means of portals to railway lines on a surface.

It should be noted that the system of underground railway transport unlike the subway is open system and, in fact, is a life support system of urban areas.

In this regard a circumstance ensuring unity of the created systems is necessary. At the same time the used types of vehicles, elevation marks allowing to unite separate same elements in uniform network when keeping admissible biases and preservation of normal airing have to be considered.

Example of the fissile underground construction is Toronto (Canada) which till 1998 consisted of six administrative educations. After their merge the population of the city made 2.7 million people, together with the cities satellites – 5.9 million. Under the city the underground PATH complex which represents the pedestrian zone with a total length of 28 km and with a total area of 371.6 thousand m^3 is created. The modern complex was brought into operation in 1987. Now it unites more than 50 residential and office buildings are bound among themselves by means of "PATH". 20 parking, 6 metro stations, two huge department stores, 8 large hotels and railway terminal. Development plans for the city provided expansion of the pedestrian transport system to 60km [2].

Extent of the underground pedestrian RESO complex Montreal (Canada) is estimated at 32km, its area – 12.0 sq.km at population of 1, 6 million people. The underground network connects 10 metro stations, two bus terminals, 1 200 offices, more than 2 000 shops, about 1 600 units of housing, 200 restaurants, 40 banks, 40 movie theaters and also the cultural and exhibition centers. The complex is the largest in the world [3].

Under the area of the Central station of Tokyo (Japan) the largest underground complex which is visited every month by 8–10 million people is located [4].

Pedestrian zones are organically bound to the systems of city transport by means of approach tunnels, underground parking, and landing terminals. It is apparent, that development of the pedestrian transport systems will constantly develop that is bound not only to improvement of access to destinations, but also is determined in many respects by climatic and geomechanical conditions of territories of the modern cities.

Automobile tunnels provide availability of objects of city infrastructure and in the constrained conditions of historical building, the composite land relief, the composite climatic conditions allow to unload the surface transport automobile network significantly.

Features of motor transport, an opportunity to overcome rather larger biases allows to create the multi–level underground interchanges which are not crossed among themselves that significantly reduces accident rate on roads, increases average traveling speed on the city, and respectively availability of objects of city infrastructure. Accommodation conditions in the territory owing to decrease in level of noise and ecological impurity improve.

The number and extent of automobile tunnels, taking into account technological approaches is defined with loading of roads, narrowness of the carriageway, admissible biases. In this regard their length (without technological approaches) changes from several tens meters to several kilometers.

For example, within Moscow 21 tunnels are constructed now. Their extent changes from 77 to 3 200m and at their projection various engineering architectural concepts are made. The Vinchesterny tunnel has two tiers, the movement on which is carried out in opposite directions. The design of a tunnel is caused by narrowness passable a part of the highway under which it is constructed. Kutuzovskoy a tunnel represents a two–level design: the lower – level the carriageway for motor transport, the top – developed underground space for pedestrians and premises of services of operation of tunnels. A Severo–Zapadny tunnel – two–multistage. The lower tier is intended for train service of Moscow Metro, the top – for motor transport. The Gagarinsky tunnel of – a three–storied automobile and railway tunnel the Extent of an automobile tunnel is about 1 100m, railway – about 900m. A tunnel the railway section – two main has on four strips for motor transport in both parties, paths [5].

Similar solutions of a transport problem is available also in other cities. Especially modern tunnel construction in the cities with the composite relief and having island territories.

Distinctiveness of megalopolises is creation of the subways. Construction of the subway can be conducted and develop according to ring, radial or linear schemes. Extent of separate lines of the modern subways is measured by tens of kilometers.

Need of formation of the transport system of the fourth group is a necessary condition of creation of a life support system of the megalopolis.

The cities with the composite mountainous relief rather often have elements of such system. In particular, in Vladivostok the tunnel of Stalin–single–line railway development 1 382 long is reconstructed now [6].

The underground systems of railway transport of a normal track can be presented by two–traveling or two one–traveling developments. Experience of mine and underground construction shows that building of dual developments of small section is always represented more technological and economically expedient in comparison with carrying out heave–gage individual developments. Cooperative section of two one–traveling developments is always more, than one two–traveling. At the same time more technological and safe conditions of conducting driving works, high performance of airing and safety of operation of an underground complex are provided. Dual developments provide independent driving of rail transport in opposite directions. Taking into account a configuration of urban areas formation of the transport system can be executed according to the ring or bilateral scheme.

The choice of the direction of development of such scheme will be defined not only by a land relief, but also features of formation of the surface infrastructure of the megalopolis.

3. Philosophy of formation of the transport systems of megalopolises

The concept of underground construction has to be based on unity and a rational combination of buildings and constructions on the land surface and the created underground objects.

At the first stage formation of the transport systems is carried out at the same time with construction of urban areas. Eventually and in process of body height of the population, development of city infrastructure these systems cease to conform to requirements of the population. Need of increase in a channel capacity of highways into the account of their expansion, construction of road outcomes becomes the following stage. This resource is significantly limited at impossibility of change of the existing building, the high cost of city lands. There is a need for the following stage – construction of the underground transport systems under the existing objects of the surface infrastructure.

Projection and construction has to be carried out on the basis of preliminary mapping of the surface infrastructure and the existing utilities. Depending on estimated volumes of construction the complete mapping can take the long–lived period of time. At the same time economic justification of expediency of construction of the underground transport system taking into account its influence on development of infrastructure of the city in general has to be executed.

Formation of the transport system can be carried out due to construction of underground tunnels in most gorges of city traffic.

The load of city traffic, admissible biases of routes for different types of transport assume that underground pedestrian zones and motor transportation systems in city conditions have the discrete character in many respects determined by density and altitude of building, a land relief. Depth of an underlay of such systems is rather small. On average the maximal height of city underground constructions is estimated at five–six floors today. Depth of an underlay of city automobile tunnels in their lowermost part is 25–30m [5, 8].

Lines of the subways and the railroads are put at much larger depth. Depth of their arrangement for the subways is defined by the common scheme of the transport system and number of the operated lines.

For railway transport depth of an underlay is defined in many respects by the elevation marks of points of an entrance and an exit in underground systems leading biases of developments and also existence on the route of decreases in a relief up to an exit on certain sites to the land surface. In such places construction of passenger and cargo terminals is expedient.

Therefore the following stage should be considered creation of the uniform underground transport system.

Binding element of the transport systems are cargo and passenger terminals. The main terminal can be created underground or on a surface outside urban areas and is equipped for transfer of the freights entering as by rail, and the motor transport. The underground terminal is more preferable as it actually does not depend on external weather and climatic conditions. Underground placement of an object will provide microclimatic conditions, necessary for comfortable work of personnel. At the same time minimum impact on the environment during construction and operation of the terminal is provided.

Creation of transshipment passenger–and–freight terminals is expedient from calculation for one on the city residential district. The actual placement of underground complexes has to be carried out on the basis of geological and geomechanical researches with an obligatory binding to the existing city infrastructure. Such their arrangement will allow to optimize city bus transportations, to reduce the extent of their routes, to increase availability of people to places of work, objects of the welfare sphere.

Terminals in combination with the combined transport system provide [9]:

– cargo delivery by floor accumulator loaders from cars in warehouse cameras and further heavy–load elevators on vertical trunks in the large shopping centers located on a surface;

– cargo delivery by floor accumulator loaders from cars in warehouse cameras, then the low–tonnage motor transport on sloping developments to a surface and further to consumers on a surface.

– movement of people by escalators in sloping tunnels from passenger platforms to a surface, trading floors, underground parking.

For the megalopolises located on the sea coast and having island territories creation of underground terminals for seaports and construction of tunnels of a deep underlay is also expedient.

4. Discussion

Need of creation and formation of underground infrastructure of megalopolises is caused by continuous increase in sizes transport and the passenger traffics caused by increase in activity and population density in administrative, socially oriented and residential areas.

Changes in sizes of transport and passenger traffics of streams are periodic. Their peak is reached in the working days in morning and evening clocks. Resources on increase in a channel capacity of city highways and number of parking spaces in areas with the dense building are almost exhausted.

Formation of the transport system has to promote preservation and increase resource (human, the material, economic, etc. types) of the capacity of megalopolises.

The choice of places of joining of the surface and underground infrastructures has to be based on rational application of a method of division into districts of urban areas.

The solution of transport problems of megalopolises is possible only by creation and development of the multilevel transport system representing a rational combination of land and underground transport infrastructures.

Underground infrastructure of the megalopolis is the flexible, open, constantly developing system of road tunnels, transfer clusters and the accompanying underground subjects to auxiliary appointment.

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– do not depend on external natural and climatic conditions;

– the padding transport communications of the considerable channel capacity allowing to unload significantly city streets, to optimize routes of public transport are formed

– the comfort of movement of the population and availability to objects of the welfare sphere, places of work and accommodation increases owing to what the possibility of decrease in social tension in megalopolises appears;

– entry into the city of heavy–load transport is considerably limited that allows to simplify significantly a situation on city streets and to reduce number of the road accidents.

5. Conclusion

Creation of the uniform multilevel transport system of the cities in combination with formation of city infrastructure promotes implementation of the concept recognized around the world "The city for people", promotes improvement of conditions of accommodation in mekhapolisa and is the interesting engineering and scientific task demanding carrying out researches in underground construction, geomechanics, architecture and other branches of knowledge.

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