PERSPECTIVES OF URBAN ELEVATED METRO

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ABSTRACT

The article presents an analysis of the most effective technical solutions for creation of overhead metro in the largest cities of the Russian Federation. It is proposed in construction of metro lines of this type to use pre-fabricated elevated above-ground tunnels in closed cylindrical shells of precast concrete and steel composite concrete. The importance of the problem of removal of the infrastructure of high-speed rail transport from the zone of contact with roads due to the growth of motorization in the cities of modern Russia is emphasized.

Keywords: *overhead metro, precast concrete, haul running tunnel, closed cylindrical shell, anthropogenic factor, megacities.*

Background. *The implementation of the most effective technical solutions for creation of the overhead metro in the largest cities of the Russian Federation, primarily in the megacities of Moscow and St. Petersburg, is one of the promising areas for development of urban passenger transport. A fundamental transition from the underground laying of new lines and of new sections of extended existing lines of metro to their above-ground construction can provide a positive social, technical and economic effect. In addition, the global situation develops precisely under the influence of anthropogenic factors.*

Objective. *The objective of the authors is to consider perspectives of construction of urban overhead metro in major cities of Russia.*

Methods. *The authors use general engineering and particular transport construction methods, comparative analysis, evaluation approach, scientific description.*

Results.

The world community is concerned about the growth rate of motorization and related transport and environmental problems, especially for large metropolitan areas. In these circumstances, priorities focus on more environmentally friendly modes of rail transport [1–4] as railways and metro.

It is not a secret that for the most efficient development of the territory of large cities, including development of nearby suburbs, and in order to improve transport accessibility and increase population mobility, special preference is given to construction of metro lines. The choice of an option of laying metro lines either underground (sub-surface or deep stations), above ground, or on the surface depends on many factors. Each of the possible options has its own advantages and disadvantages (limitations). For example, for St. Petersburg, where, as it is known, the geological structure of near-surface geo-massifs with extremely low bearing capacity, does not allow construction of running tunnels and construction of sub-surface stations. Therefore, metro passengers in the «northern capital» are now spending more time on the escalator descent and ascent (due to the deep stations) than directly on the travel between stations.

At the same time, the existing ground metro lines are open lines that operate in adverse meteorological conditions – under the influence of precipitation, solar radiation, and high heating of the upper track structure in the summer, at very low outdoor temperatures in winter (up to -40˚C and below) and the presence of ice. Ground open lines also create noise when trains move, painfully perceived by residents in the zone of urban development closest to the metro.

Against this background, it is of interest to use technical solutions, which are based on construction of pre-fabricated elevated above-ground metro tunnels in closed cylindrical shells of precast concrete and reinforced concrete. For sections of lines which are curved in plan or in longitufinal profile, with slopes of up to 0,01%, similar structures, prefabricated with toroidal design, can also be used.

Metro stations shall be designed only in the elevated version with the access of structures to the elevations of the urban road network, which will provide optimal conditions for public transport and create maximum comfort for movement of passengers. Architectural planning and design solutions of the stations, as well as the architecture of the external appearance (design) of the running tunnels, including emergency evacuation exit systems, remain open for creative thought.

Overpasses of running tunnels and premises of metro stations, whose supports are located on foundations made with drilled piers, should be elevated above the natural surface of the earth at the height which is not less than the height marks of the bottom of their structures, preventing contact with the aquatic environment during emergency flooding of urban areas. For example, such an approach is highly expedient in St. Petersburg in case of emergency destruction of protective dams separating a city from rising waters in the Gulf of Finland of the Baltic Sea.

The maximum elevations of the bottom structures of above-ground running tunnels, as well as of the stations themselves, if they are located at the places where transport hubs are formed, are determined by the need to construct interchanges at different levels in accordance with the general development plans of Moscow, St. Petersburg and, possibly, a number of other major cities. Deciduous trees are not excluded on both sides of the overpasses of overhead closed metro. Under overpasses, it is convenient to have parking lots and all sorts of one-story buildings. Running tunnels of overground metro lines can be either double or single track respectively for each direction of train movement.

The required number of specially controlled emergency exits to the outside for passengers and metro personnel – within the stations and throughout all the hauls between the stations, as well as to provide access to the tunnels for rescue services and fire teams, should be provided in the running tunnels.

In general, in our opinion, the use of above-ground metro facilities does not require significant and costly work on redevelopment (transfer) of existing engineering communications, and that will *undoubtedly reduce the cost of construction of such facilities.*

Innovative technical solutions for construction of elevated above-ground tunnels and metro stations are becoming possible for implementation in transport construction as a result of many years of creative work by scientists of Russian University of Transport (MIIT), which resulted in the receipt of the RF patent for invention «Composite carrier block and mounting connection of bearing blocks of the prefabricated building structure» [5].

The invention, according to this patent, relates to construction of engineering structures with a supporting frame in the form of prefabricated composite structures with shell, slab or shell-slab large-size structure, single and multiply, including cellular, with mounting blocks of reinforced concrete with steel or non-metallic rod fittings, with possible inclusion in the shells and plates of plate or thin-walled shell elements of steel sheet metal and embedded metal tubular parts, forming compounds of mounting blocks interconnected with other building structures.

New steel concrete precast shell structures are appropriate:

• for use in construction areas such as bridge construction, bottom subsea tunneling, foundation engineering, reservoir construction;

• for creation of roadbeds of embankments of railways and highways (with the height of special structures of such embankments ranging from 2 to 6 m) [6, pp. 15–18];

• for construction of retaining walls and special bank protection structures;

• for construction of sea and river port berths, structures of transport galleries, columns, walls and ceilings of industrial buildings, high-rise structures, toroidal, dome, cylindrical and conical vaulted structures;

• for construction of the bases of fixed offshore above-water platforms and mobile underwater platforms (bottom ones – at sea depths up to 400 m) for hydrocarbon production on sea shelves;

• for construction of high-rise structures of ventpipes and chimneys, cooling towers, sea and river terminals.

Besides, prefabricated shell structures of the «tower» type can be used for shafts [7].

Conclusion. *A. Toffler noted that communication becomes increasingly important in the process of wealth creation [8, p. 28].*

The solution of the transport problem of megacities, related to their accelerated motorization, the lack of a developed and unloaded network of roads, the emergence of new mass housing on the outskirts of cities, in the near future will acquire a more pressing political and socio-economic character. This, of course, will require adequate measures aimed at eliminating imbalances and «bottlenecks» in development of urban transport infrastructure and, as a result, a need to reduce the harmful effects of road traffic on the environment.

According to preliminary estimates by experts, annually due to traffic jams on the roads, Moscow and St. Petersburg lose in total about a trillion rubles, and every year this figure grows. On average, Muscovites spend 2,5 hours a day in traffic jams. Residents of St. Petersburg spend in traffic jams about two hours a day. The generalized trillion includes both budgetary losses (wear and tear of the roadway, expenses for traffic management, environmental damage) and losses incurred by drivers (excessive consumption of fuel and personal time, car depreciation). According to the calculations of «Smilink» information-analytical agency, for each hour of idle time of one vehicle, the state and the driver pay about 500 rubles «on the principles of co-financing» [9].

In our opinion, only construction of new (above all – overhead) metro lines and sections of railways (as structures of «green» modes of transport) in the «city–suburb» chain can significantly help to meet challenges imposed by the transport and environmental situation in megacities.

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