Traffic Organization Features in Transport Stream Congestion

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Abstract. The paper discusses traffic safety problems in large cities related to road networks where there is transport stream congestion. An analysis of traffic regularities is made, traffic congestion situations are presented according to their causes and contributing factors, classification of congestions is given with their comments. The author presents directions of engineering activities related to the study of transport congestions, traffic characteristics mentioning short-term and long-term measures.

Introduction

Traffic safety improvement issues in Yerevan city and generally in large cities of the world have become more urgent during the recent years. In the conditions of the existing discrepancy between road network development and the size of the vehicle fleet complicate the traffic conditions, main urban streets are often blocked by traffic congestions so that movement becomes difficult if not impossible (chaotic situation). The developed countries were the first to face these challenges for they experienced growth rate of motorization level earlier.

The main role of transport is to meet the needs of economy and population in quick and safe transportation fully and timely, movement of people and goods from one location to another on the basis of capacity development and quality improvement of the entire operation of the conveying system.

The car as a means of transportation compared with other vehicles has a number of obvious advantages. First of all it is its high mobility, relatively simple control, next, motor transport is the only available form of transport in many parts of the country, and finally, for people it is the most important means for everyday household activities.

The road capacity expansions were necessary conditions for the land-use sprawl, and consequently, contributing causes for the traffic growth. Ex-ante analyses seem not to have included the land-use effects, and this is understood as part of the explanation for the discrepancies between ex-ante expectations and actual development

Materials and methods

Currently traffic safety in the Republic of Armenia is ensured by a number of departments and organizations whose activities are related to the improvement of road network and traffic conditions, management process, regulation and control, as well as distribution of transport streams. With the fleet everyday unprecedented increase in the country and especially in Yerevan city will not only raise risks of road traffic accidents increase but also from time to time road network will be blocked by congestions.

Traffic congestion is a major problem, which bothers our urban traffic sustainable development at present. Congestion charging is an effective measure to alleviate urban traffic congestion. Based on the practice of Singapore and London, it can be concluded that congestion charging practice should take scientific plan [1, 2].

Congestions as well as any delay of traffic lead to economic losses (passengers' loss of time, decrease of cargo transport efficiency and increase of fuel consumption). Congestions also lead to the growth of accidents (primarily head-on collisions). In addition to the main negative consequences of

traffic congestions, especially in urban conditions, there is a sharp deterioration of the environment. The increase of fuel consumption, engines operation in unstable and idle modes are factors that can at 30 per cent and more increase the amount of harmful substances exhausted directly to the environment, which have fatal consequences for the health of people.

In analyzing road traffic regularities as well as solution of traffic regulation practical tasks a need arises to apply interdependency of transport stream characteristics. Interdependency of the stream intensity, speed and density for a lane can be represented graphically, so called in the form of the main diagram of the transport stream (Fig.) and expressed by the following dependency:

$$N = vq$$

where N is the traffic intensity of the given lane, car/hour; v is the velocity of the transport stream km/h; q is the steam density car/km [2].

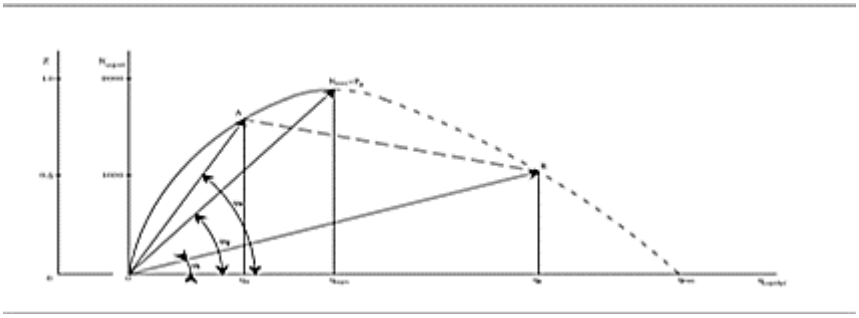

Fig. Transport stream main diagram

The Fig. shows the transport stream state change depending on the increase of its intensity and density. The left part of the curve (full line) shows the stable state of the stream, when in case of the continuous increase of density the transport stream passes to the following traffic stages: free, then partially bounded and finally bounded, reaching to its maximum intensity point – capacity ($N_{max} = P_c$). In case of such changes the speed of the stream drops and it is characterized by the tangent of φ angle of the inclined line. This line as a radial vector originating at the origin *0* of the coordinate system for any point of the curve characterizes the average speed ($V = N/q = tg\ \varphi$).

At $N_{max} = P_c$ point of the curve the values of the stream density and speed according to capacity are considered optimal (q_{opt}, v_{opt}). In further increase of density the stream becomes unstable (dotted lines beyond P_c point of the curve).

In the Fig. two characteristic points are plotted – point *A* corresponding to the steady traffic of the transport stream, and *B* corresponding to unsteady stream when the stream approaches to the congestion state. When the congestion is settled due to the maximum density of the transport stream, the stream can be slowed or dead because of the increase of transport stream intensity exceeding capacity of the given section of the road network. In such case the loading factor becomes more than one [2, 3].

Traffic congestion and road accidents are two external costs of transport and the reduction of their impacts is often one of the primary objectives for transport policy makers. The relationship between traffic congestion and road accidents however is not apparent and less studied. It is speculated that there may be an inverse relationship between traffic congestion and road accidents, and as such this poses a potential dilemma for transport policy makers [3, 4].

Several factors most notably: speed, congestion, and road horizontal curvature were found to have mixed effects on road safety and need further examination [5, 6, 7]. Traffic conflict is viewed as a major contributing factor to high accident rates observed in the high v/c range [8, 9].

At the same time it is necessary to note that congestion states are quite different in terms of their development causes and contributing factors as well as size and duration. There is no official classification of congestions, in spite of the fact that many authors regarding this point suggest various

viewpoints. On the basis of generalization of the expressed opinions it is possible to suggest a simple classification dividing congestions into accidental and regularly "pulsating".

Accidental traffic congestions can be developed at any quite unexpected points, for which traffic accidents and other obstacles may be the cause (faulty automobiles, damaged roads and communications etc.). In such cases the road traffic capacity may decrease to 50-100 per cent.

Regular traffic congestions do not occur by chance, the main source of their formation is sign controlled intersections which are unable to let so many vehicles pass through the intersection or pass "bottlenecks" of the given road (for example, construction of different objects near roads when a section from the road is cut with a fence, long-term planned repair-and-renewal operations are implemented).

Regular road congestions are predictable and therefore it is not difficult to develop corresponding measures designed for their alleviation or elimination although limited frameworks of possible measures depend on the degree of the road network development and many other factors which cannot lead to notable positive results without radical changes. Amongst basic measures is the construction of new main streets or undergrade intersections which will enable to increase the capacity of a road network.

Road congestions are characterized by their duration and amount of vehicles involved there. In its turn the latter index can be approximately determined by the length of waiting vehicles taking into account the average length of vehicles in the transport stream and the safety clearance between stopped ones. Many researchers and experts believe that the stream should be estimated as congestion when the lower speed level is 10 to 15 km/h (the pace of traffic is 4-6 min/km). Several times at rush hours, when road congestions are usually formed, the Chair of Construction Machinery and Traffic Management, NUACA and "Road Police" Service of the Republic of Armenia jointly carried out investigations in a number of main streets (Admiral Isakov, Kievyan, G. Lousavorich, Myasnikyan, Sebastia) of Yerevan city. During such investigations in case of 10-12 km/h speeds the following was fixed – the pace of traffic was 5-6 min/km, in case of 15-25 km/h – the pace of traffic was 2.4-5 min/km.

To study the problem on each main street at least two fixed observation points were installed and the results of observations measurers put on the specially designed below-mentioned form (Form 1).

Form 1

Protocol of automobiles license plates recording

_____ (day, months, year)	_____ (street under study)	_____ (point of study)
_____ (the beginning of the observation)	_____ (the end)	_____ (full name of the recorder)

Automobile License plate number	Type of automobile	Time

The importance of paying attention to this problem is explained by the fact that the first condition of congestion elimination solution is discovering the points where their formation is expected and where already road network unsatisfactory capacity elements are apparent (for example, their being overloaded). This task can be reliably solved by carrying out general monitoring of the main road network. To do this it is necessary to get the map of the entire road network of the city (with traffic characteristics) for which necessary measures should include continuous study of the street loaded level, measurements of communication rates, study of delays and causes of forming queues (in the first place the most loaded light-regulated intersections) [3, 10].

Engineering activity in investigation of transport congestions in the city road network can be illustrated by the below-mentioned block-diagram (Form 2).

Form 2. Block-diagram of engineering activity in road congestions study

Directions of engineering activity in the study of road congestions				
Study of road traffic and information gathering on its organization state	Discovered places of regular congestions and causes of their formation	Study and analysis of road accidents in accidental and regular congestions	Local and system measures for elimination of regular congestions to improve road traffic regulations	Design solutions and economic justification of road traffic regulations to improve and eliminate congestions

For next-generation smart cities, small UAVs (also known as drones) are vital to incorporate in airspace for advancing the transportation systems. The application of UAVs are important in three major domains of transportation, namely: road safety, traffic monitoring and highway infrastructure management [10, 11, 12].

The use of drones is a very effective way for collecting accurate data on locations and sizes of road traffic congestions. The elimination of accidental road traffic congestion or reduction of its duration can be achieved through operational actions of "Road Police" Service.

The main objective of the road traffic management service employees is the development of preventive and operational measures regarding the formation of regular congestions which will increase the capacity of road sections and intersections.

More effective are long-term measures which should be adopted by specialized design organizations. On the basis of these measures a performance specification is developed which can include main streets carriageways widening, construction of underground and ground paths, reconstruction of neighboring streets and finally, construction of overhead crossings [13].

Without waiting for the implementation of long-term activities it is reasonable to apply short-term measures. Such measures may include carriageway markings, organization of directed traffic within crossings limits, optimization of speed regime, prohibition of stopping and parking on carriageways, construction of "pockets" near route transport stops, adoption of one-way traffic, optimization of light regulation cycles, prohibition of left turns at some intersections etc. [14].

Conclusion

Road congestion and any traffic delay lead to economic losses, the increase of traffic accidents, sharp increase of negative impact on the environment etc. Taking into consideration the presented analytic comments, the study of traffic within a road network should be complex to decrease and prevent road congestions. The obtained results should serve as a basis for the development and implementation of both short-term and long-term measures, otherwise congestions will periodically lead to traffic blocks.

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