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MEASURES FOR REDUCING TRAFFIC CONGESTION IN CITIES

SUMMARY

Traffic planners and designers are daily confronted by the problems of traffic flow. Finding a solution for the optimal organisation of the traffic system in the wider (at the state level) and the narrower sense (cities, towns), requires accurate planning and adequate financing. With Croatia being a developing country that has higher investments into the traffic system, the material means need to be rationalised and the human and land resources cautiously managed. With the development and implementation of the traffic studies, an improvement of the traffic in cities can be expected. The work describes the traffic measures which provide higher quality traffic flow, with low investments. They can be used as guidelines in planning the traffic and as the first implementations of solutions from the traffic studies.

KEY WORDS

urban transport, traffic rationalisation, urban infrastructure, national income

1. INTRODUCTION

How can the development of a city be adapted to the development of its traffic flows - that is the question which is not easy to answer. Since the real development (expansion) of traffic began in this century, so do the answers to traffic problems date from that time. One of the first solutions was the so-called all-traffic concept described by Le Corbusier in 1924 in his book *Urbanisme,* and translated as *The City of Tomorrow,* 1987. In this work, the author presents the concept of a city with multi-level traffic, as one of the possible city development concepts. The centre of the city has a great number of offices compressed around the central station. This central station has six levels.

(+2) first level .... taxi
(+1) mezzanine .... passenger car
(0) ground level .... pedestrians
(-1) first underground level .... metro
(-2) second underground level .... local railway
(-3) third underground level .... regional railway

Corbusier wanted to use this structure to reduce the number of streets in the city centre by two thirds. He applied a grid system to the streets (right angles), at intervals of 360 metres. Such city arrangement has never been realised anywhere, but it indicated the problem of traffic demand, where every form of transport has its own requirements so that the traffic systems are segregated.

Since the inherited traffic infrastructure is far from such an "ideal" structure, the only thing we can do is to repair the consequences of a long-term plan-less development of the city infrastructure. The described measures can only alleviate the traffic problems in the cities.

High quality organisation of traffic provides the basis for the development of any society, including the Croatian. In case of standstill, the whole society and the country economy suffer great losses. The traffic standstills with losses expressed in time, are especially big in major urban units (towns, cities). The traffic growth is closely connected to the increase of the gross national product. For the countries such as Croatia, this amounts to more than 6% annually. This is also the rate of traffic growth (motorisation, number of rides, the volume of transported goods). The traffic growth is greater in cities which are the administration and economic centres such as Zagreb, Rijeka, Split, Osijek. The traffic standstills that occur weekly over several hours, are becoming longer and more frequent, paralysing the traffic system as a whole even for several hours daily. Such problems can be solved by applying the traffic studies of cities and the studies with solutions regarding the given problems.

The results of such comprehensive activities have been obtained after long analyses, and certain implementation phases are sometimes even not realised.

Since Croatia is a country with increased investments in the traffic system, a rationalisation of material means is necessary, as well as careful management of human and land resources.

2. MEASURES FOR REDUCING TRAFFIC CONGESTION

The starting point is very often that only comprehensive studies and long-term solutions can solve the traffic problems in the cities. Although studies and projects are necessary, during their realisation it is extremely important to study and find those solutions which can be realised with small funds and within a short period, giving exceptional results. The measures are given in three basic groups:

1) group of short-term measures consisting of three sub-groups:
   - regulation and organisation of traffic flows in the street network of cities and towns, in order to reduce the unnecessary conflict points of traffic flows, i.e. in order to increase the throughput capacity of the street network (especially the intersections; by using this measure the intersection throughput capacity may be increased even up to 30%, thus including the street network as well). These measures mean the correctly directed traffic flows (one-way streets, information signals, etc.), not restricting the turning possibilities unless precise knowledge on the possible consequences of such restrictions are available.
   - the change of the traffic signal regulation system, where almost always the dual phase system of traffic flow can be implemented, with introducing the post-phase green period for turning left, when necessary. This method can increase the intersection throughput capacity even up to 20%, and reduce the average vehicle waiting time by as much as 30%.
   - the systems for automatic traffic control can improve the traffic flows by 5 to 10%, which means that they have to be implemented after applying the mentioned two measures. The system of automatic traffic control understands computer-controlled traffic signal intersections and exchangeable traffic signs, based on the actual data about the current traffic flows. This includes co-ordinated operation of the traffic signals to maximally reduce the vehicle waiting time, i.e. increase the average travelling speed and shorten the passenger travelling time, especially when using the urban public transport.
   - minor reconstructions at single intersections so as to increase the throughput capacity and integrate into the traffic flow organisation and regulation system
2) the medium-term measures lasting several years include major traffic and technical works that significantly improve the current condition.
3) the long-term measures include measures that significantly and permanently change the current condition (construction of new streets, fast city roads, urban and suburban railway systems, etc.). It is very important to set the phases and priorities, i.e. the sequence of the realisation. It is also important to realise all the measures within the shortest time possible, to disturb the traffic as little as possible (in our country the problems in traffic flows caused by the reconstruction and works carried out in the urban street network is not considered with due care that should be based on a better traffic and technical study of the problem and development of adequate project analyses).

Measures for reducing the traffic congestion in the cities are listed in the ascending order regarding the price and especially the time needed for their implementation according to the mentioned groups:

- organisation of traffic flows in the network, so as to eliminate the unnecessary conflict points of the main flows. The organisation of traffic flows includes the systematic organisation of traffic streams in traffic networks aimed at optimal use of the network with minimum costs, i.e. reducing the conflict points at intersections to a minimum. Many methods are used here, ranging from changing the directions of traffic in the streets, converting parallel two-way streets into one-way streets, even when this is not in the interest of the residential area citizens, to opening of "secondary - auxiliary" streets. It is very important to recognise the unnecessary conflict points in the network and diagnose and reconstruct the critical conflict point at an intersection. The knowledge about the methods of organising the traffic flows and the implementation during planning itself, saves a lot of material funds. The theory of traffic flow organisation was implemented in practice, among others, in Zagreb, in the area of Mihanovićeva Street. The congestion problem has been solved by the methodology of minimising the weaving sections between the flows, which means that the excessive conflicting paths (crossing, merging and diverging) have been reduced to a minimum. The excessive crossing of traffic flows is present in complex networks such as the road network in the urban centres where travelling from source to destination can be achieved by taking different routes. It should be noted that by minimising the superfluous conflict points in complex networks, the traffic efficiency would be increased without reconstruction, i.e. with small investments. Starting from the existing condition in traffic, the surveys or measurements can indicate the spots where standstills or difficulties occur in the traffic. Thus, the critical spots can be identified, that need to be improved, but the improvement of one or more such places, often results in new traffic bottlenecks. This is often the result of isolated study of traffic flows at one intersection.

- appropriate and systemic adjustment of traffic signals (cycles and phases) for the optimal efficiency at isolated intersections. There are numerous examples of isolated intersections operating with dozens-of-years-old programs, which do not take into account the newly developed traffic situations. By counting the traffic count on a characteristic day and by adjusting the length of the "green period" in proportion with the intensity of the approaching vehicle flow, give good results in reducing the traffic standstills.
- the standstills can be reduced during the design phase by geometrically designing the road (entries and exits) and traffic signals in such a way as to offer as little resistance to traffic as possible, using the principle of:
    - reducing the number of signal phases to two, taking into consideration the protected left and right turns. The dual phase traffic is almost a rule in the cities that have no traffic standstills. The collision diagrams should be studied, and by a better intersection design, with improved optical traffic control by changing the drivers' visual environment, the accidents should be reduced. The uncritical setting of three- and four-phase traffic causes traffic chaos, which is often justified by stating the fact about the increased traffic safety. The ratio between the number of phases and the number of necessary programs needs to be studied. The dual phase system at the signal-controlled intersections requires much fewer signal programs than the three- and multi-phase systems.
    - reducing the red signal of the main flow (arterial red), at the same time increasing the number of entry and exit traffic lanes. In a dual phase system, shorter cycles are needed (40 to 60 s). It should be stressed that in converting the three-phase system (whose cycles usually take more than 60 s) at intersections, to dual phase systems, the cycle duration itself needs to be shortened in order to provide faster "discharging" of the left turning lanes. It is necessary to consider the change from the traffic area being "unoccupied" to "occupied", and the time (e.g. in a dual-phase system the left-turning vehicles enter the intersection thus reducing the time of the starting of the first vehicle, and the queue can be increased by at least two vehicles, and they may pass in case there are no vehicles in the main stream, increasing significantly the passage of the left turning vehicles, for as many as 100 to 400 vehicles/h, i.e. 2 to 4 vehicles per cycle).
    - adding of a separate lane for the left-turning vehicles so as not to cause stops in the main stream, i.e. to provide continuous flow in the traffic lane. In case of a great number of left-turning vehicles, it would be useful to introduce the additional "green" arrow for post-phase discharging.
    - introduction of one or more through lanes for the main stream
    - possibility of synchronisation (co-ordination) between the intersections. It should be emphasised that the traffic control co-ordination design is not compatible with the vehicle detectors. It is also very difficult to combine traffic signal-controlled intersections fitted with devices of different manufacturers into an automatically controlled traffic network, without expensive electronic interfaces. This fact should be considered in designing new traffic signal-controlled intersections.
    - displaying of the signal "no left turns" or "no turns" on the screen. The message must be displayed on time, it must be unambiguous and if necessary repeated before the given intersection. This is the simplest example of a variable traffic regulation.
    - introduction of traffic lanes with reversible flow direction or any combination of the already mentioned measures. It is necessary to consider the implementation of this measure based on the approaching and departing traffic.

For changing the cycle duration of single phases the following can be applied:

- approaching vehicle detectors (in vehicle queues). These have to be properly installed and their proper functioning controlled.
- automatic traffic counting devices, activated by the given traffic volume, and "switching" the required change

- speed detectors which react to the given average speed and activate the mechanism
- detectors which measure whether the traffic lane is occupied or not
- conventional watches
- manual controls of traffic technicians or policemen (highly specialised and educated personnel) The presence of traffic wardens at the intersections is inversely proportionate to the quality of the traffic flow, and can be accepted for two reasons: if there has been an accident, or for insuring the passage of V.I.P. vehicles or special freight transport.
- remote manual control by the traffic engineers who monitor the traffic via screens in a closed TV circuit (CCTV) or a combination of two or more of the mentioned issues

Other signalling techniques include:

- signalling screen with programmable, variable speeding display
- programmable devices with screens displaying messages (e.g. *recommended speed X km/h*)
- measuring of input flows in order to optimise the period (usually for the approaching ramps at motorways, but can be applied also to left- and right-turning vehicles of the main streams at traffic signal-controlled intersections)
- monitoring of the approaching traffic in the main stream or of a series of signal-controlled intersections by creating a pool at the first signal, at locations where traffic "bottlenecks" occur
- avoiding construction of the new signal-controlled intersections or adding of new phases for the left-turning vehicles even when the traffic volume starts to increase

- ban on blocking the street or lane during the peak traffic hours at certain locations (e.g. road-works)
- ban on slow-moving vehicles in certain streets at certain times (e.g. stipulate the minimum driving speed, and mark the co-ordinated section by the recommended vehicle speed display)
- ban the left turns at certain locations at certain times (but not as a rule so that one has to drive several blocks around in order to arrive at the destination). Uncritical implementation of this measure is very frequent in Zagreb. Thus, it is impossible to take a direct left turn from the Vlaška into the Maksimirska Street all the way to the Bukovačka Street, and a similar situation is also in the Street of Kralj Zvonimir.
- ban on parking, stopping or supply in certain street and at certain times (the parking vehicle manoeuvres in the streets with co-ordinations simply wipe out the sense of "the phased traffic lights", i.e. the throughput capacity is reduced)
- ban on the usage of certain lanes in certain streets for all vehicles except high occupancy vehicles (HOV). This would provide more comfort and faster travelling by HOV along separate lanes (the existing bus and taxi lanes). Within this measure, the usage of separate "yellow lanes" may be allowed to passenger cars with three or more passengers. This or a similar scenario would be applied also to vans and motorcycles with two passengers
- classification of traffic regarding employees travelling to work, transport of schoolchildren or similar groups
- marking of the existing four- and six-lanes streets so as to obtain two lanes for left turns resulting in greater capacity. Frequent congestion of the left-turning vehicles causes the drivers to avoid such intersections and to proceed to the next one. This causes unnecessary conflicting of the traffic flows at other locations, and further decrease of the traffic throughput capacity of the whole network.
- re-marking of the one- and two-way roads in order to obtain the additional (even narrower) lanes for through traffic.
- introduction of the network co-ordination with the adequate information technology support
- construction of geometrically improved roads:
  - construction of dual traffic lanes for left and right turning vehicles (even three left-turning lanes may be considered)
  - construction or extension of the existing left-turn lane
  - application of roundabouts (it is necessary to consider the central island radius and the level of the whole intersection with access roads)
  - reconstruction of entries and exits to and from shopping centres, industrial zones, etc. in order to reduce the number of signal phases, decrease the red period to the main stream and eliminate the halting of the main stream (by setting at least one through lane for the main stream)
- construction improving the intersection design in order to change the priority of passage (e.g. islands, for right turns off the main stream)
- finding of the funding sources for the urban public transport of passengers; better supply and organisation of the public urban transport services to attract as many passengers as possible
- construction of grade-separated intersections

- expansion of the existing streets and main roads in order to increase the capacity
- construction of fast streets and urban motorways at new locations. This method is approached when all the possibilities of expanding and using of one or more local street that run parallel to the overloaded road and are only a block or two away from it, have already been used.

3. CONCLUSION

A systematic and gradual improvement of urban traffic should be started based on the development of adequate high-quality traffic solutions based on their systemic study. The solutions should be implemented which allow optimal usage of the existing infrastructure.

Research carried out in cities has indicated that at traffic signal-controlled intersections the traffic flows even up to 5% faster than in similar conditions in smaller towns. The reason lies in a more dynamic way of living of the inhabitants of the big cities.

This advantage needs to be used as much as possible by the proper regulation of the traffic signals. Also, the existing infrastructure in the cities needs to be studied in order to take the maximum advantage before designing new roads. The presented measures only alleviate the consequences of inconsistent implementation of the correct traffic policy.

Many open issues remain faced by the traffic engineers, planners and designers. One of the biggest is the lack of qualitative design manuals so as to provide a consistency in designing and controlling the road traffic.

At this moment, intensive work is done on the traffic linking of towns and regions in the Republic of Croatia. It should be remembered that by not investing in the city infrastructure, the process of creating the national income is hindered at the most important generating sources. The cities are, namely, places where not only the major part of the gross national product in traffic can be generated, but its irrational and wasteful expenditure can be significantly reduced, as well.

SAŽETAK

MJERE SMANJENJA ZAGUŠENJA PROMETA U GRADOVIMA

Prometni planeri i projektanti svakodnevno su suočeni s problemima u odvijanju prometa. Iznalaženje rješenja za optimalno usklađivanje prometnog sustava u širem (na razini države) i užem (gradovi, naselja) smislu zahtjeva precizno planiranje uz odgovarajuće financiranje. Budući je Hrvatska zemlja u razvitku s povećanim investicijama u prometni sustav, potrebna je racionalizacija materijalnih sredstava i pažljivo upravljanje ljudskim i zemljišnim resursima, izradom i implementacijom prometnih studija, može se očekivati poboljšanje odvijanja prometa u gradovima. U radu su opisane prometne mjere kojima se može postići kvalitetnije odvijanje prometa, uz mala sredstva investiranja. Mogu poslužiti kao smjernice za planiranje prometa i kao prve provedbe rješenja iz prometnih studija.

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