SCHEME OF CROSSING WITH INTENSIVE VEHICLE TRAFFIC

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ABSTRACT

Severity and urgency of road safety problem at intersections of highways with railways require not only a sound and long-term control strategy for reducing a number of accidents and a risk of an accident at regulated crossings, but also continuous improvement of technical equipment of control plots by devices intended to prevent possible collision of cars with rail rolling stock. The proposed model of a gateway scheme of a crossing concerns conditions of passage through railway tracks of a motor transport moving with a high intensity (more than 7 thous. vehicles per day). Gateways with barriers and laser sensors-informants are added to standard devices, order of movement is adjusted, causing significant loss of crossing capacity, while safety increases fivefold.

Keywords: railway crossing, safety, gateway scheme, road vehicle, transit capacity.

Background. *Railway crossings are a place combining two traffic flows. Safety of moving units is provided here due to safe operation of control system, compliance with the principle of absolute priority of railway vehicles over road cars as well as fulfillment of all other rules and regulations prescribed by the law «On Road Traffic Safety» of the Russian Federation of 10.12.1995, № 196-FZ. This document clearly defines tasks of protecting the interests of society and the state when using public transport on roads, of prevention of traffic accidents and reduction of severity of their consequences [1]. And with regard to accident prevention crossings just play a special role, because any disturbances in the zone of intersection of traffic flows are fraught with the most serious losses.*

Objective. *The objective of the authors is to consider operation of regulated and unregulated railway crossings in terms of intensive car traffic and to propose a modernization scheme.*

Methods. *The authors use statistics and engineering methods, evaluation approach.*

Results.

Facts and factors

On the railway network more than 11,5 thousand crossings are operated, of which 2,4 thousand are serviced by men on duty, 49,7% are equipped with an automatic signaling system and crossing gates, 37,2% have a concrete floor, and 37,4% have rubber-cord coating [2].

Since 2000, additional safety feature has been introduced, that is railway crossing barrier, excluding entering of vehicles on the roadway when trains are passing. 71,5% of places served by duty staff are equipped with them.

However, the situation at the railway crossings in terms of safety continues to be a major challenge.

Every year more than 200 accidents involving railway rolling stock are recorded, in which more than 150 people are killed and injured. The vast majority of accidents occur at unprotected crossings. Especially grave consequences are caused by collisions involving passenger transport.

Despite the fact that the annual number of accidents at crossings is by about a thousand times less than the number of road accidents, because of severity of consequences they receive a great public resonance.

Accidents at intersections of roads and railway lines are usually associated with gross violations of traffic rules by drivers of vehicles, and there is an obvious trend towards the conscious non-fulfillment of established requirements, disregard of all known laws.

Traffic safety drops often because of shortcomings relating to the technical condition of crossings, their maintenance and operation, including low-quality of flooring and driveway of roads on the approaches to railway tracks.

The greatest number of violations was detected at Moscow railway. However, since the beginning of 2015 the number of traffic accidents at crossings (collisions of road transport with rail transport) of MR has decreased by more than 2 times, for ten months – from 35 to 17 over the same period of the previous year [3].

To ensure safety and reduce a number of traffic accidents at crossings of metropolitan main line railway staff carries out comprehensive work. It includes maintenance and modernization of infrastructure facilities, explanatory and information campaigns. Since the beginning of 2015 at 33 crossings rubber-cord coating was replaced, at 369 – pothole filling was conducted, at 15 crossings overhaul was performed [3]. But only with these measures it is not possible to achieve a desired result. A subjective factor interferes.

With the increase in traffic, many experts see the risk of increased probability of errors committed by drivers of vehicles in the evaluation of road conditions; they often show carelessness, haste, neglect and other negative qualities, which lead to tragic consequences in some cases.

In addition, trying to upgrade infrastructure facilities should be followed by considering subjective factor covering psychological aspects, e.g. variability of driver's behavior (chauffeur, train driver) in situations at crossings when he has to choose between prohibition and risk, danger and safety.

To increase safety level at the most demanding crossings the authors have set a task to offer a prospective design of regulated railway crossing.

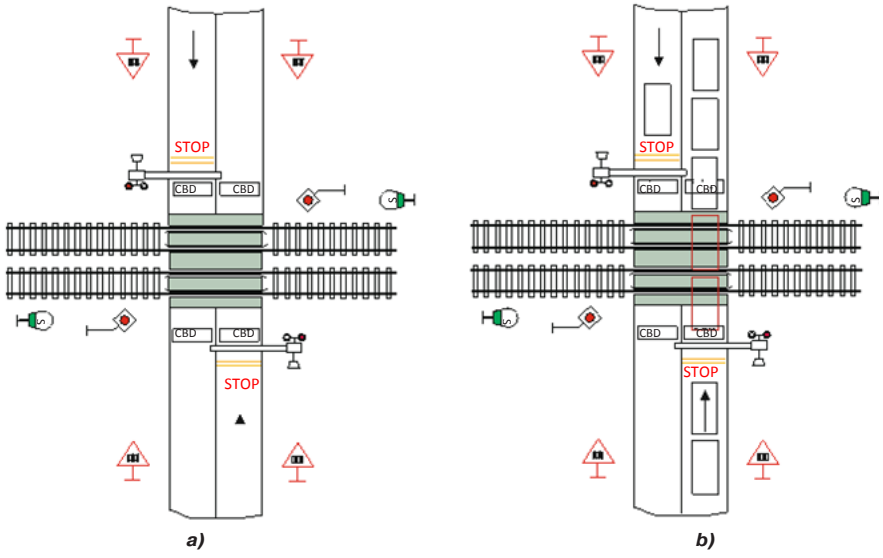
Features of regulated crossing

As it is known, braking distance of a train is many times greater than breaking distance of any trackless vehicle.

It is enough to say that for a moving train emergency braking distance to a full stop is 1000–1700 m [4]. Taking this into account, the vehicle driver must cross railway tracks only at designated locations, showing increased attention, care and caution.

Signs respectively 1.1 «Railway crossing with a barrier» and 1.2 «Railway crossing without a barrier», as well as signs 1.4.1–1.4.6 «Approach to railway crossings» inform a car driver on approaching to any railway crossing, regulated or unregulated [1].

Approaching railway crossing it is necessary to reduce speed. To what extent? It depends on the state of road surface at the intersection. Often the space between rails has a noticeable unevenness, joints (cavities) emerge between rail and road surface that impede movement.



Pic. 1. Scheme of unregulated railway crossing: a) construction with installation of additional barrier devices; b) a typical situation peculiar to a crossing with a similar infrastructure.

Motion above the rail road at high speed due to impacts of unevenness can cause loss of control, damage and stoppage of a vehicle.

Driving a vehicle through the crossing should be done at small constant speed, having a certain margin of traction on the drive wheels. For this purpose it is necessary to go in advance to a lower gear.

Overtaking at railway crossings and closer than 100 meters in front of them is prohibited. Parking of vehicles, within 100 m on either side of the crossing is also banned. And within a crossing both stopping and parking are not allowed [1].

At the entrance to the unregulated crossing the driver's attention should be drawn primarily to barrier's position, light and (or) sound signaling. It should be noted that at railway crossing with a barrier there is always a duty man, who, if necessary, for example, in case of failure of automation, light or sound signaling, has a right to regulate vehicle movement himself.

Starting movement through a crossing is possible only when the gates are open and light and sound signaling is turned off. If at least one of signaling systems is activated (light or sound), even if the barrier is open cars are prohibited to move.

It is necessary to keep firmly in mind that in all cases, approaching the intersection place, a driver, regardless of the state of the barrier and signaling should also make sure that there is no train approaching, and only then enter a crossing.

To let pass the approaching train when movement through the crossing is prohibited, it is necessary to stop a vehicle no closer than 5 m to the barrier or traffic lights, and at unregulated crossings – not closer than 10 m to the first rail.

If in front of crossing there is marking «stop-line» and (or) signs 2.5 «Movement without stop is prohibited» and 5.33 «Stop-line» with the prohibitory traffic light it is necessary to stop respectively in front of marking or signs.

Forced stoppage directly at a railway crossing, even short-term, poses a real threat of collision with a train. Therefore, a driver of a vehicle must take all measures to make a crossing free. What are these measures? In many ways, they depend on the nature of failure or malfunction of a vehicle, as well as on options for «salvation» available for a driver. The safest way is to drag or to push a trapped vehicle from a crossing.

With increased intensity of car traffic at crossings it is carried out as a continuous stream, so the likelihood of violations of the established order will inevitably grow.

So, at the example of Karacharovsky crossing in Moscow such a situation arose every day and created a threat of an accident, until it was closed.

On road sections after passing through such a crossing on sections with a length of 200–250 m traffic jam often arises that entails a risk of a backward car stoppage on railway tracks.

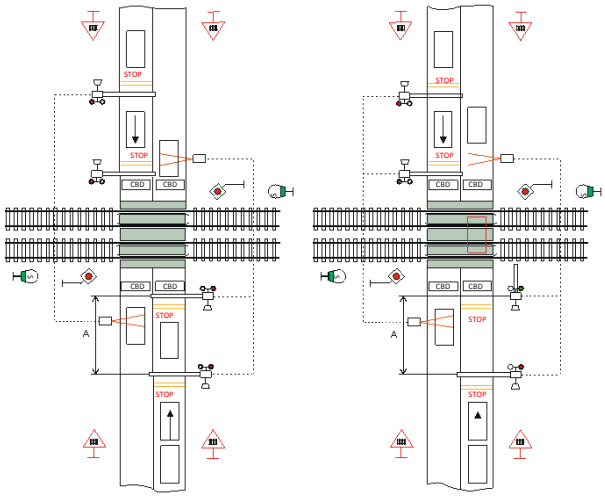
The movement of vehicles must be carried out in succession with an interval, so that in case of an emergency a car trapped on rails could be shifted from tracks. However, with existing traffic intensity almost no one observes the safe distance and a vehicle stopped at the site of potential collision is of common occurrence.

During movement vehicles move close to each other. The distance between them is an average of 1–2 m. With such overcrowding in the case of filling of the area with cars at the exit from railway tracks for the car, that entered the road, there is no way out, forward cars do not move, and the rear cars press.

Such a situation occurs daily at crossings with similar infrastructure, which, in particular, is shown in the chart of Pic. 1.

Modernization of construction

The current crossing has additional barriers device (BD) designed to prevent the unauthorized entry of vehicles on the track. The device consists of four-automatic barriers mounted in the roadway of the road at the same level as its covering. Simultaneously with prohibiting signals protective covers of barriers are raised in the direction of the approaching vehicle to a height of 50 cm, blocking the whole roadway. If the vehicle is within the



a) b)

Pic. 2. Scheme of a proposed railway crossing: a) a situation where one car is in the gateway area, and the other in the area at the exit from the crossing; b) a situation where the car is located on a railway track.

boundaries of the crossing after its opening for the train, front barrier's cover under the influence of the vehicle wheels takes a horizontal position and allows free passage. BD is equipped with sensors for detecting obstacles in a controlled area, which send a prohibiting signal to traffic lights and locomotive traffic light in the driver's cabin.

The situation shown in Pic. 1b describes cases at a conventional regulated crossing with high intensity of vehicle movement (more than 7 thous. units per day).

Possible options for this situation:

• the car is on railway track and cannot move forward, since exit is occupied with other cars, and it cannot go back because of the place in front of the barrier being occupied by other cars;

• car broke down and stood on the tracks; it is necessary to pull or push it from the railway tracks, but there is no enough place to do so, all space is occupied by vehicles.

These circumstances initiate the development of the design of a regulated railway crossing with a higher traffic safety – see Pic. 2.

The difference of the proposed design of the already existing is the presence of the gateway zone on each side of a crossing with barriers and laser sensors that determine the position of the vehicle at the crossing. This modernization ensures location in the danger zone of only one vehicle and in case of emergency its transportation to a safe place.

Pic. 2a shows a car located in the gateway zone in anticipation of movement. Barriers behind and in front of it are closed. The waiting car stays in the gateway area until the vehicle traveling in front of it frees the zone after leaving the crossing.

The position of transport in each zone is fixed by laser sensors that control the barriers.

In Pic. 2b the car is in the area of the crossing exit and fixed with laser sensors that control all barriers, which are opened or closed depending on the location of a car moving at a crossing. In the illustrated case, the gateway barrier is closed.

Modernization of a structure of a regulated crossing is a set of standard devices of a conventional crossing with addition of a gateway zone and control system for car movement barrier devices.

The carrying capacity of such crossings is reduced by 1,5 times, however, their application can increase safety of a crossing five-fold.

Conclusions.

1. The proposed design is suitable for railway crossings with intensive car traffic.

2. Estimated reduction in carrying capacity is entirely offset by a significant increase in safety at the intersection area of roads and railway tracks – and therefore the question is in choosing priorities.

3. The proposed construction in 80% of cases can be used at existing crossings.

REFERENCES

1. Road Traffic Rules 2015 (RTR2015/2016) [*Pravila dorozhnogo dvizhenija 2015 (PDD2015/2016 g.)].*

2. Crossings of Russian Railways: analytical materials / Department of track and structures of JSC Russian Railways [*Pereezdy Rossijskih zheleznyh dorog: analiticheskie materialy / Departament puti i sooruzhenij OAO «RZhD»*]. Moscow, Akademkniga publ., 2004, 152 p.

3. Number of accidents at crossings of Moscow Railway have diminished by more than twice [Press release of Moscow Railway – a subsidiary to JSC Russian Railways: in Russian]. [Electronic resource] http://mzd.rzd.ru/news/public/ru?STRUCTURE_ID=12&layer_id=4069&refererPageId=704&refererLayerId=3941&id=113298. Last accessed 15.12.2015.

4. CRB-757. Instructions for signaling on railways of the Russian Federation, 2015 [*CRB-757. Instrukcija po signalizacii na zheleznyh dorogah Rossijskoj Federacii, 2015 g.*].

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