Analysis of Roundabout Intersections on Routes of Abnormal Loads

JAN PETRŮ, KAREL ZEMAN
Department of Transport Constructions, Faculty of Civil Engineering
VŠB – Technical University of Ostrava
Ludvíka Poděště 1875/17, 708 33 Ostrava - Poruba
CZECH REPUBLIC
jan.petru@vsb.cz, karel.zeman@vsb.cz http://www.fast.vsb.cz

Abstract: - This paper deals with problems of passage of abnormal loads on Czech and Slovak roundabout intersections frequently present at routes of such transports. The key routes used for transport of such loads do not meet the parameters necessary for their passage. Neither the Czech nor the Slovak Republic have a regulation, which would stipulate parameters for design of roads and intersections enabling passage of oversize and abnormal loads. The article describes incorrect geometry of roundabout intersections, unsuitable placement of vertical traffic signs and of other elements present at roundabout intersections. It further presents video analysis, transportation statistics, software verification of passage including modelling of new types of vehicles with abnormal loads in the AutoTURN programme and their subsequential verification using GPS coordinates. This paper describes in detail two roundabout intersections on frequent routes with modelled problematic passage of an abnormal load.

Key-Words: - Oversize load, abnormal load, roundabout intersection, video analysis, statistics, AutoTURN

1 Historical and Contemporary Transportation

Heavy machinery industry and engineering are based in the Czech and the Slovak Republic for a very long time. The concerned sectors frequently make products, which may be considered non-standard with regard to their size and weight. This brings demands for transport from the place of production to the place of destination. Railway transport, due to passing clearances and radius curves, is not suitable for this type of transport. Transport of loads via water can hardly be used in our countries. Therefore these types of transports are done by special vehicles via road routes.

The routes for transport of oversize and abnormal loads, so-called “backbone routes”, that used to be protected by the Ministry of Transportation, were on our territory up to 1992. After 1992, these routes were cancelled, as they used to be primarily used for transport of military technique [3].

Currently the road network of the Czech and the Slovak Republic is absolutely inadequate for transport of abnormal and oversize loads. This primarily concerns dimensional parameters of intersections and roads with frequent passages of such transportations. We also have to mention inadequate carrying capacity and bad state of bridges.

This does not only concern transportations of products, but also transportation of construction machinery and mobile cranes, the weight and dimensions of which exceed the maximum standard permitted limits.

2 Route and Its Selection

Selection of the route depends on the type of the load, its dimensions and weight. The weight of the load has an impact on selection of the route with regard to carrying capacity of bridges. We have to mention that the transportation route is selected by the transporter or its escort. Approval of the proposed route is given by the appropriate body according to the relevant regulations. One day prior to the transportation, the carrier is obliged to check the selected route and he shall be accountable for its selection. Selection of the route including statistical calculations may last even up to several months.

3 Legislation

The maximum permitted dimensions of vehicles and vehicle trains in the Czech Republic are regulated by Decree of the Ministry of Transportation No. 341/2002 Coll., on approval of technical qualification and technical specification of operation on roads, as subsequently amended. Under the section 16 of this Decree the maximum permitted dimensions of vehicles and vehicle trains including their load are the following:
• Maximum permissible width is 2.65 m;
• maximum permissible height is 4.20 m;
• maximum permissible length of semi-trailer tractor is 16.5 m; trailer of a motor vehicle with one truck trailer is 18.75 m; trailer of a motor vehicle with one car transport trailer is 20.75 m; trailer of a self-propelled machine with sub-truck for working unit of the machine is 20.00 m; a train with two truck trailers or a semi-trailer and a trailer is 22.00m;
• the maximum permitted weight of road vehicles shall not exceed 48.00 t

4 Roundabout Intersections on Routes of Oversize Loads

Roundabouts became frequent on our roads. This type of intersection is highly used in towns, cities, and on significant roads. Roundabouts bring pacification of traffic and they remarkably contribute to safety of traffic [3]. Abroad [6] [7], they deal with geometric design of intersections and designs for truck transportation too. However designing of this type of intersections usually does not take into consideration transport of oversize and abnormal loads on their frequent routes.

4.1 Geometry

It primarily concerns geometric layout, suitable dimensions of the intersection, and parameters of semi-diameters at entry/exit [2]. Last but not least, major obstacles are elevated parts of intersections. Such as an elevated central island, intersection corners and elevated splitter islands. A vehicle train going across these elevated elements of intersection may cause their destruction or deformation. It may also cause defect to tyres and lodgement of the vehicle train at the intersection (eventually in its proximity on the road) during their replacement. The design and reconstruction at frequent routes of oversize and abnormal transportations should take into consideration their passage, in order to enable the vehicle train to go in the opposite direction. Another precaution is introduction of inside islands and lowering of curb of the central island. Roundabout intersections are frequently passed straight through. In such cases there may be utilised introduction of passage over the central island. Unfortunately all these things are not taken into consideration at frequent routes of such transportations. Frequently the current intersections and the newly designed roundabout intersections do not even comply with the principles of design of intersection geometry for safe passage of passenger and freight transport, much less of the abnormal transportation.

4.2 Roundabout Intersection Elements

Within this category there belong lamp posts, railing, immobile elements (preventing passages and disabling fast dismantling), decorative elements and lawn and planting. The lamp posts are placed close to the road and they frequently prevent passage of abnormal vehicle trains. Dismantling of lamp posts is very complicated and it requires participation of relevant experts. In most cases with unsuitably placed lamp posts the passage is impossible and there has to be selected another route. Rigid railing or crash barriers preventing passage of the load and other immobile elements on the route make transport difficult. This is not just time consuming during the passage itself but also during planning of the route itself. Fig. 1 presents a roundabout in Sokolov, which required cutting away a part of the railing at the roundabout intersection and dismantling of part of the traffic signs in order to clear passage of an abnormal load. The load blocked the intersection for the period of 3 hours.

![Fig. 1 Necessary cutting of rigid railing round the roundabout in order to clear passage of an abnormal load](image)

4.3 Traffic Signs

Traffic signs often disable passage of abnormal vehicles and they are placed close to the road. In case of passage of an abnormal vehicle train, such signs have to be dismantled. Unfortunately, the signs cannot always be dismantled, which causes complications during its removal or during the passage. During such transportation, the signs at many places are cut off and then welded back. Even the detachable signs may cause complications. This primarily concerns foundation bolts on the footing
anchored to the concrete base. On this base is then placed the post with traffic signs. These foundation bolts are protruding and the vehicle cannot get over such a place. Such places on the route have to be rebased. However such a solution is not always possible. Other examples are signs on a beam above the road. This primarily concerns the newly built or reconstructed pedestrian crossings. The beams are welded and it disables any turning during passage of a vehicle train. If there is not available any alternate road, the beam has to be dismantled. Such cases cause losses – regarding time and finance.

![Fig. 2 Problematic passage of a trailer under a beam with traffic signs](image)

Traffic signs at frequent routes should have different attachment of the traffic sign post. An example could be a post which can be pulled up together with the sign and put back after passage of the trailer. A beam with a traffic sign should enable turning out of the road. Unfortunately such solutions are not found on our roads.

### 5 Video Analysis

In order to subsequently model tractrix curves of abnormal vehicles in the AutoTURN software and to stipulate geometric parameters of intersections it is necessary to know exact passage of the vehicle trains through the intersection. Various types of abnormal transports on their routes were for the period of two years monitored by a research group of the Traffic Engineering, within which they register details of their passages. It utilises video recording (2 and more video recorders at entrance and exit branches of intersections), there is also made photo-documentation measuring speed of the passage itself. The recordings and photos are analysed with regard to size of passages via corners by the vehicle trains, also with regard to tasks performed prior to the passage of the vehicle train, during the passage and after the passage. There is also recorded eventual damage of the curbs or other elements on the intersections [8].

### 6 Quadrocopter

In order to facilitate detailed analysis of passage of oversize and abnormal loads, creation of new vehicle models in the AutoTURN 3D programme, and consequential verification of the created model using GPS, it is very important to monitor the area of interest (intersection) from above. Such essential data are very difficult to obtain viewed from the ground. In order to obtain the necessary data, several technologies enabling recording from adequate height, for sufficient period of time, and with the required picture quality, can be selected. An essential part of the entire system is ensuring its mobility on the route of the monitored oversize or abnormal load with minimum demand for number of service staff. For these purposes we may consider the following options: Telescope tube, Elevating platform or Radio-controlled helicopter model. Advantage of a telescope tube is its stability due to its fixation to the ground and ability of continual video-recording. However its disadvantage is relatively low above ground level (about 10 – 15 m) and necessity of fixation to a solid construction. In case of mapping of a load route and transport, such a method of video-recording is very demanding and disadvantageous. Partial advantage of the elevating platform is its mobility and lift height. Its disadvantage is the amount of space required for the elevating platform and the price of rental of an elevating platform for every monitored transport. The last option combines advantages of mobility, making of recording from required height, picture stability and monitoring of movement of the vehicle on the intersection. A multi-copter may be easily transported in a car. Just a single trained person is sufficient to operate the entire apparatus. The length of the video-recording depends on the multi-copter price. Considering all the mentioned options, we opted for the multi-copter option, for which we submitted the project called Mobile Recorder for Transport and Construction Research (SP2013/82). Further utilisation of this model in line construction is very wide. It primarily concerns passages of urban public transport vehicles, parking, conflict situation on...
roads, checking of inaccessible objects (bridges – primary control of construction condition, bridge bearings in inaccessible places – replacing a primary check by workers on secure roping).

6.1 Quadrocopter DJI-F450
For the monitoring we purchased quadrocopter DJI-F450. The model is driven by four alternating-current brushless motors with rotating case. Li-po four-cell battery supplies power to the model. DJI NAZA-M was used as an autopilot device. It enables comfort controlling of all main functions (rolling, pitching, yaw, and engine speed), remote adjustment of parameters of control electronics, as well as controlling of additional functions of the actual load. The model is further equipped with GPS automatic stabilisation of accurate position hold and of geographical position/altitude of the model. In order to stabilize the video-recording, the model is equipped with gimbal stabilisation module, which automatically, by mean of two engines, stabilizes the recorder during rolling of the model. The autopilot device is further equipped with a FPV set enabling transfer of pictures from the recorder attached to the model to 7” colour LCD display. The display further enables detailed guidance of the model during passage of oversize or abnormal load through intersection.

Fig. 3 Quadrocopter model with attached recorder and GPS module

6.2 Measuring at Roundabout Intersection
Problems of roundabout intersections were monitored during transport of an oversize load of the length of 66.0 m and weight of 463 t from Ostrava to Chvaletice harbour. The monitored section is in M. Třebová town and it is a highly frequented roundabout intersection. This roundabout intersection is used for routes of oversize loads. The AutoTURN programme stipulates tractrix curves of the vehicle on the basis of the video-recording. The recording further enables us to stipulate placement of traffic signs and lamp posts.

Fig. 4 Monitored passage of transport of an oversize load through a roundabout intersection

7 Transportation Statistics
In order to stipulate basic documents for design of roads (direct intersections and roundabouts, etc.) for eventual passage of oversize and abnormal loads, it is further necessary to know parameters of the vehicle trains transporting these loads. It is also necessary to know parameters and type of the transported load. On the basis of these parameters, we may model vehicles to verify intersections in the AutoTURN programme. There was made statistics of transports on the territory of the Czech and the Slovak Republic. As an example we may present some processed data of 2011 from the database of the Slovenská správa ciest (Slovak Roads Management).

Fig. 5 Graph with statistics of length of transportation for 2011

Fig. 6 Graph with statistics of width of transportation for 2011
8 Software Verification of Passage
Based on the video analysis, analyses of data of transportation statistics, materials from companies in the Czech and the Slovak Republic transporting oversize and abnormal loads and from companies producing multi-wheel trailers for such special transportation (i.e. information on parameters, types of vehicles and loads), there were modelled designs of vehicles to verify the tractrix curves of passage of oversize and abnormal loads using the AutoTURN software. These are newly modelled vehicle models, not already present in the programme. In these models, it was necessary to set behaviour (turning of axles) of the multi-wheel trailers. In order to do that, measuring was done using the GPS technology, which was installed on a vehicle train transporting oversize loads. The vehicle models were subsequently verified on the basis of monitoring and analysis of transports on roads.

![Fig. 7 Modelling a new vehicle in the AutoTURN programme](image)

Fig. 7 shows an AutoTURN programme window enabling modelling of a new type of vehicle (vehicle train transporting oversize loads) using data from technical papers of Goldhofer company. Such an elaborated vehicle database should be used to verify the existing, reconstructed and newly designed direct and roundabout intersections on the routes of oversize and abnormal loads.

9 Roundabout Intersection in Lukavec
As an example of a problematic passage at frequent routes of oversize and abnormal loads, the vehicle train has to use the unpaved part of the shoulder and slope of the width of 2.20 m. This is due to necessity to rebasing of metal sheets holding bases of vertical traffic signs. The carriers have to pass the central island just with a part of the multi-wheel trailer due to an eventual defect caused by shifting of the rebased wooden boards and passing over the metal sheets. Passing of the unpaved shoulder and slope may cause sliding of the tractor or the multi-wheel trailer.

![Fig. 8 AutoTURN programme modelled passage of the Lukavec roundabout intersection](image)

Even though the roundabout intersection is adjusted to passage of non-standard loads, the vehicle train has to use the unpaved part of the shoulder and slope of the width of 2.20 m. This is due to necessity to rebasing of metal sheets holding bases of vertical traffic signs. The carriers have to pass the central island just with a part of the multi-wheel trailer due to an eventual defect caused by shifting of the rebased wooden boards and passing over the metal sheets. Passing of the unpaved shoulder and slope may cause sliding of the tractor or the multi-wheel trailer.

![Fig. 9 Rebase of the vehicle train wheels during passage of the roundabout intersection toward the Lovosice harbour.](image)
We should also mention that the unpaved shoulder is not only passed over by oversize loads but also by the ordinary truck transports. This situation is obvious from the significantly deformed parts of the road, broken marker posts and knocked-off parts of the NEW JERSEY concrete crash barrier. Due to the above-mentioned reasons the roundabout intersection is not suitable for this type and other types of transport and it should undergo reconstruction.

Fig. 10 Passage of a trailer through a roundabout intersection using the unpaved shoulder

10 Roundabout Intersection in Litomyšl

The roundabout intersection in Litomyšl is on road I/35. Diameter of this four-way intersection is 39.00 m. The intersection has a paved ring of variable width. The corners in the point of direction have elevated curbs, behind which there is gravel surface. The splitter islands can be overtaken at entry/exit branches.

Fig. 11 Problematic passage of Litomyšl roundabout intersection marking overtaking of the corners

Fig. 11 shows passage of a non-standard vehicle train through this roundabout intersection. The AutoTURN programme modelled this passage. The modelled vehicle was specified on the basis of parameters of this vehicle train and included in the prepared vehicle database. The passage and demonstration of tractrix curves of the vehicle was done on basis of a video analysis and photos made during transport of the monitored oversize load.

Fig. 12 Overtaking of a corner by a vehicle train at Litomyšl roundabout intersection

Fig. 12 shows the problematic passage, where a vehicle while exiting (1) the roundabout it has to overtake a concrete curb-stone and an unpaved corner. The width of this overtaking is 2.45 m. It is demonstrated at the described figure, as the oversize load left tracking there. The vehicle train then overtakes the pedestrian island and it closely misses traffic signs in the front of the island. The second vehicle (pusher) entering (2) this roundabout has to overtake corner in the width of 1.15 m. Again, this vehicle left tracking on the gravel corner of the roundabout. This roundabout intersection suffered damage to concrete curbs caused by transports of oversize and abnormal loads. Passage of vehicles through the roundabout intersection causing destruction of curbs is analysed in the paper Analysis of traffic accident rate and conflicting situations at selected roundabout intersections in the Czech Republic [6]. As this intersection is on the route of oversize and non-standard loads, the road management should undertake construction works in order to enhance passage of such trailers.
11 Conclusion
The paper deals with analysis of roundabout intersections on routes of non-standard loads in the Czech and the Slovak Republic. The performed long-term research proves that at the frequent routes of these loads there are designed unsuitable roundabout intersections. Therefore transport of such loads is very complicated during the passage of the roundabouts itself, but it also causes problems during planning of the route. Such cases cause losses – regarding time and finance.

Czech products have competitive strength in quality and price compared to EU and worldwide products. Complications during transport of such loads, whether problems with roads or necessity to support bridges, have a negative impact on the price of the transport, and therefore it reduces competitiveness of the companies producing such products.

Neither the Czech Republic nor the Slovak Republic have a regulation which would stipulate parameters for design of roads and intersections enabling passage of oversize and non-standard loads. The project engineers dealing with projects on these routes are usually not acquainted with this type of transport and they only follow instructions of the submitter regarding safety and minimum building costs, regardless of oversize transports. This situation could be changed thanks to start-up and establishment of backbone routes and regulations stipulating spatial parameters of roads as well as parameters of bridges. The above-mentioned routes would be adjusted to this type of transport. This should help to avoid situations, such as building of new intersections or reconstruction of existing intersections, which in some cases did comply with this type of transport prior to the rebuilding. We have to take into consideration that this routes will not be only established for the transporters, but also for the investors and the production companies. Currently the union of transporters of oversize loads and production companies initiate establishment of a regulation, which would stipulate parameters of passage of oversize and non-standard loads on roads.

The problems of passage of transports via intersections are researched by Ing. Jan Petrů of VŠB – Technical University of Ostrava. These problems are solved within his thesis as well as within the research activities of the group of Transport Constructions as part of the project Development and Internationalisation of Top Scientific Teams and Enhancement of their Excellence at the Faculty of Civil Engineering of VŠB-TUO; in the Student Grant Competition for 2012 called Tractrix Curves of a Modelled Vehicle of Oversize Transport; and in the Student Grant Competition of 2013 called Mobile Recorder for Transport and Construction Research. These papers could be used as one of the basis for solution of this problem. The problems with transportation are also mentioned by the European Best Practice Guidelines for Abnormal Road Transports of May 17, 2006 [1], which recommends the member countries to build a whole-European network of corridors for transportation of oversize loads.

12 Acknowledgement
This paper was written with the aid from the Student Grant Competition called Mobile Recorder for Transport and Construction Research. (SP2013/82)

References: