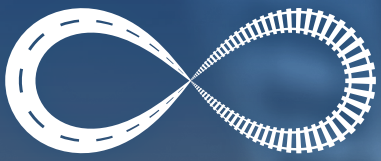

CETRA 2018

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

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CETRA 2018
5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

TITLE
Road and Rail Infrastructure V, Proceedings of the Conference CETRA 2018

EDITED BY
Stjepan Lakušić

ISSN
1848-9850

ISBN
978-953-8168-25-3

DOI
10.5592/CO/CETRA.2018

PUBLISHED BY
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Kačićeva 26, 10000 Zagreb, Croatia

DESIGN, LAYOUT & COVER PAGE
minimum d.o.o.
Marko Uremović · Matej Korlaet

PRINTED IN ZAGREB, CROATIA BY
"Tiskara Zelina", May 2018

COPIES
500

Zagreb, May 2018.

Proceedings of the
5th International Conference on Road and Rail Infrastructures – CETRA 2018
17–19 May 2018, Zadar, Croatia

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USING OF DIFFERENT ROAD VEHICLE COMBINATIONS FOR ABNORMAL TRANSPORTS BASED ON THE ASSESSMENT OF LOAD RATING OF BRIDGES IN SLOVAKIA FOR THE MOST CRITICAL VEHICLE COMBINATION

Juraj Jagelcak, Jan Vrabel, Monika Kiktova
University of Zilina, Slovak Republic

Abstract

This paper deals with the use of different road vehicle combinations for abnormal transports up to gross combination mass of 120 tonnes based on the definition of the most critical vehicle combination for the assessment of load rating of bridges in Slovakia. Possibilities of using different road vehicle combinations are examined by verifying the axle loads and axle distances. The paper analyses four different vehicle combinations to define the most critical vehicle combination which shall be used for the assessment of load rating of bridges in Slovakia for defined route. The aim is to develop the procedure which can be used to simplify issuing of abnormal transport permission in Slovakia. In this paper are not described load models of bridges in Slovakia because of its complexity. They are described in Technical regulations TP 104 – The load rating of road bridges and footbridges [16].

Keywords: abnormal transport

1 Maximum allowed vehicle dimensions and masses in road transport in Slovakia

Maximum allowed vehicle dimensions and masses in Slovakia are based on the European Council Directives (96/53/ES, revised by 2015/719/EU). A tandem axle means two axles in a row, the distance between the midpoints of which is not more than 1.8 m (partial wheelbase). A tridem axle means three axles in a row, the sum of partial wheelbases of which is not more than 2.8 m. A load on an individual axle of a tandem or tridem axle of semi-trailers and trailers must not exceed 10 t, [1, 2].
Abnormal transport is transport, where the one or more maximum permissible masses of the vehicle/ vehicle combination or the maximum permissible axle loads exceed masses or axle loads which are specified in Annex 1 of Government Regulation no. 349/2009. Abnormal transport is also when the vehicle/vehicle combination exceed maximum dimensions which are allowed according the same government regulation. This paper is focused on axle loads and axle distances which are considered for the assessment of load rating of bridges in Slovakia. Authorization procedure for the special using of roads is necessary to perform before realisation of abnormal transport. This procedure shall meet the conditions defined in technical regulations TP 103 [15] to get permission for special use of roads (abnormal transport) in the Slovak Republic.

DOI: https://doi.org/10.5592/CO/cetra.2018.961

2 Load rating of road bridges

Load rating of bridges on highways, expressways, roads I., II. and III. class and local roads is determined by the maximum immediate mass of one vehicle whose driving can be permitted on bridge under the conditions specified in technical regulations TP 104 [16] .These technical regulations specify the normal load rating, exclusive load rating and exceptional load rating of road bridges. Individual load ratings should be explained in terms of the importance of prohibited traffic signs for vehicles which exceed a total mass of vehicle combination. [1], [3]
Normal load rating allows the passing of vehicle with the most immediate mass of the vehicle passing through the bridge without additional traffic restrictions. These vehicles can pass through the bridge in the normal traffic – arbitrarily, at any number and at an unhindered speed, only their total mass is limited at the time of passing the bridge. If the immediate mass of the vehicle/vehicle combination does not exceed the normal load rating of the bridge, it is possible to pass through this bridge without special restrictions.
Exclusive load rating allows the passing of a vehicle with an immediate mass higher than the normal load rating of the bridge, but less or equal to exclusive load rating of the bridge, excluding other road vehicles – as a single vehicle, but arbitrarily, without limitation of the speed caused by the load rating of the bridge, and with arbitrarily trace of the area of the road space for the road vehicles. The driver is obliged to ensure that other vehicles do not entry on bridge from both directions.
Exceptional load rating allows passing of a vehicle with the most immediate mass of a special vehicle transporting exceptionally heavy loads. This may pass through the bridge only when all other traffic is excluded, and other restrictions fulfilled (e.g. a single vehicle in the middle of a bridge with a maximum speed of 5 km/h without the use of an auxiliary vehicle).
In the case of an abnormal transport, the carrier assesses the required route electronically, by the online service. It is only a simplified and preliminary modelling, but nowadays, the carrier has to assess all combinations of vehicles.
If this static report for an abnormal transport required, it may only be issued by an Authorized Civil Engineer. He assesses the most critical and problematic bridges for all vehicle combinations of the carrier's fleet.
An Authorized Civil Engineer shall determine the conditions and / or the means of passing over and over the bridge. If necessary, it may also order that measures be taken (eg, bridge relief, bridge support, temporal modifications, protection of selected bridge elements, bridge measurements during cross-abnormal transport, subsequent main or extraordinary checking, etc.).
Currently each vehicle which realizes abnormal transport shall have the permission for special use of roads, in Slovakia. Carrier performing abnormal transport on given route is required to ask the competent authorities and road administrators for permissions under which a decision to permit the realisation of abnormal transport will be given. The decision determines the transport conditions under which the transport may be carried out by the vehicle/vehicle combination, [4].
The aim of this paper is to find a way to simplify a procedure, in which the carrier would consider the most critical vehicle combination. Then, with all the vehicles in the carrier´s fleet, the carrier would be able to execute abnormal transport on the assessed route without further assessments of given route for other vehicles/vehicle combinations. The article explains and compare a few ways how to get the most critical vehicle/vehicle combination.

3 Vehicle combinations to select the most critical vehicle combination

Following section describes all considered vehicle combinations owned by a carrier from different manufacturers. Vehicle combinations are marked as indicated in the figures below. The first vehicle combination is a 4-axle tractor and lowloader semi-trailer with 5 axles, to which special 3-axle module is added so it creates 8-axle lowloader semi-trailer with detachable gooseneck. This combination is marked as A1. There is a possibility to extend the loading area by 8 250 mm so maximum extended state is marked as A2.

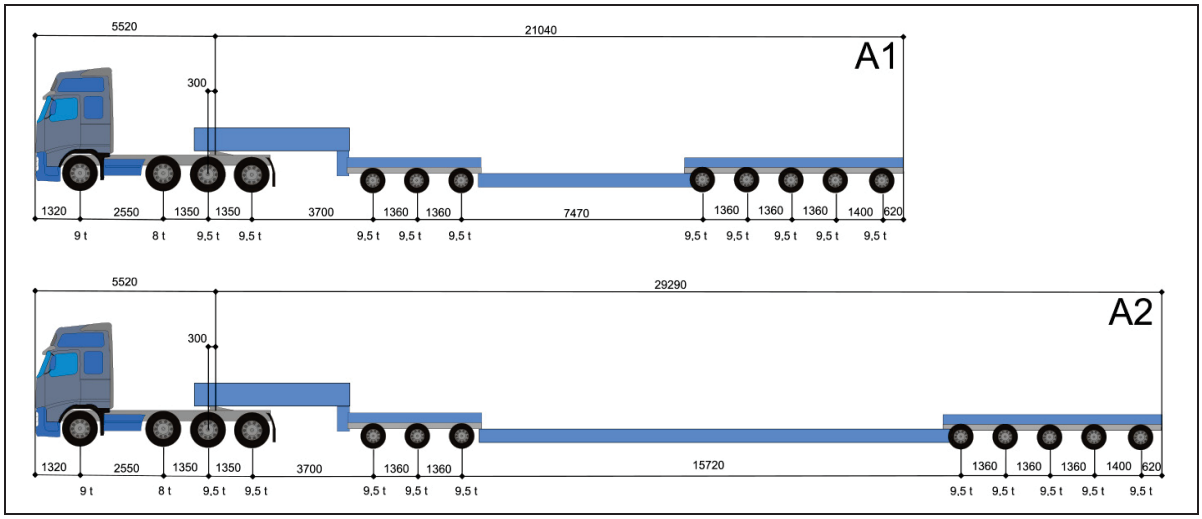

Figure 1 Vehicle combination A1 – minimum length and A2 – maximum extended state

Another vehicle combination consists from the same 4-axle tractor, with the same lowloader semi-trailer but without the special 3 axle module, so lowloader semi-trailer has only 5 axles and detachable gooseneck. This combination is marked as A3. Again, loading area of the trailer can extend by 8 250 mm so maximum extended state is marked as A4.

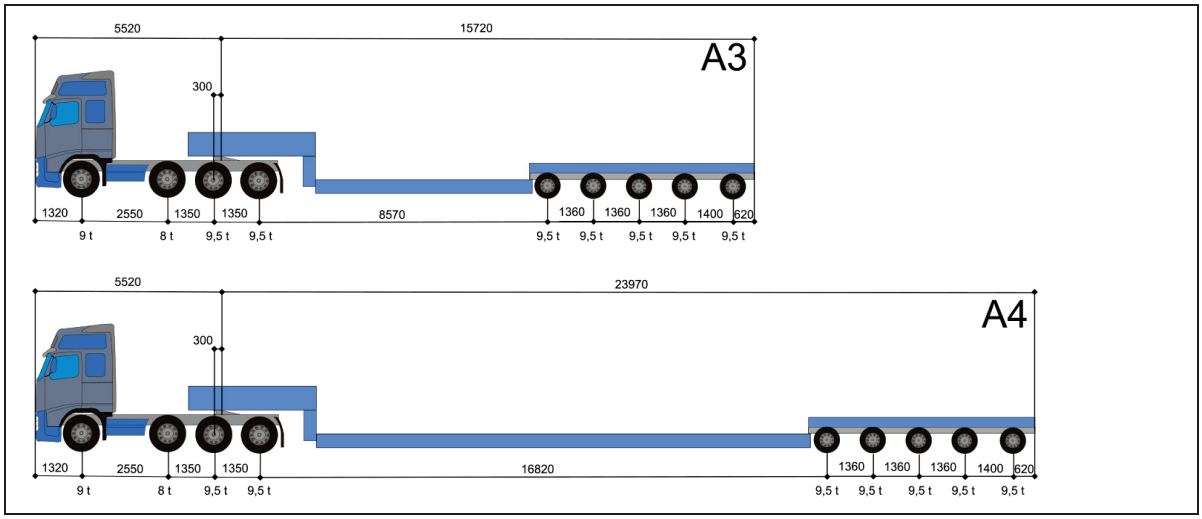

Figure 2 Vehicle combination A3 – minimum length, A4 – maximum extended state

Using the same 4-axle tractor, but another 5-axle low bed semi-trailer, we get another vehicle combination to assess. This low bed trailer differs from previous lowloader semi-trailer predominantly by construction and wheelbases. The combination with minimum length is marked as B1. There is also the possibility to extend the loading area by 14 150 mm. Thus, is created a new combination with maximum extended state marked as B2.

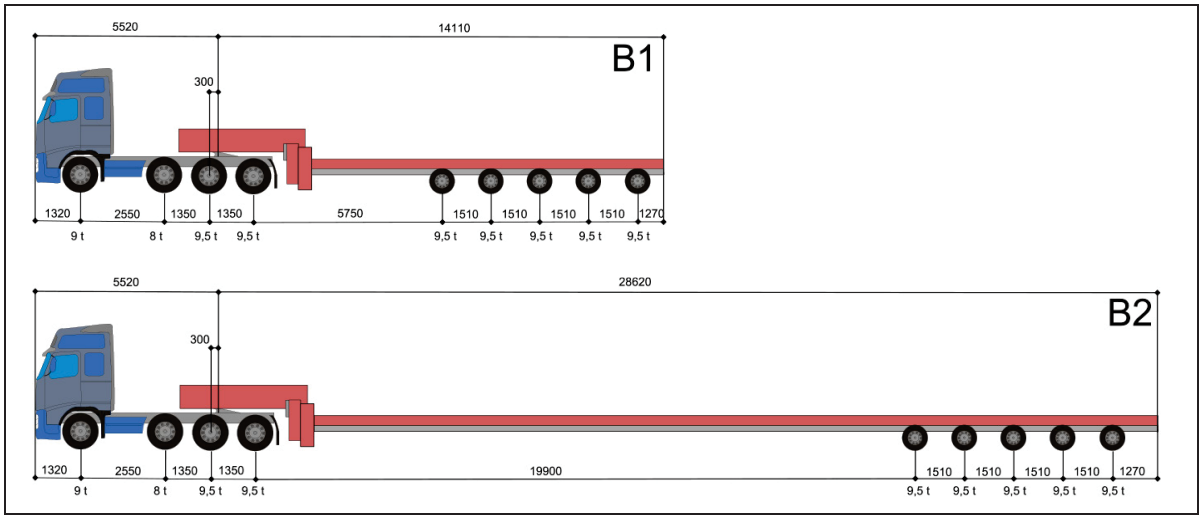

Figure 3 Vehicle combination B1 – minimum length, B2 – maximum extended state

The carrier also uses the 3-axle tractor and the 3-axle lowloader semi-trailer. The lowloader semi-trailer has also the option to extend the loading area by 5 300 mm, so minimum length is marked as C1 and maximum extended state as C2.

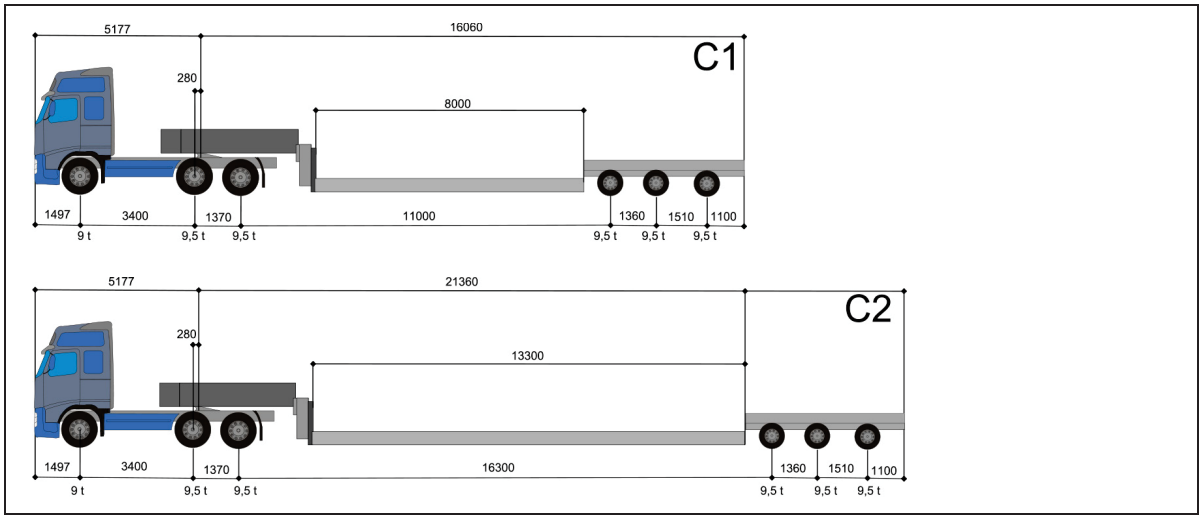

Figure 4 Vehicle combination C1– normal state, C2 – extended state

4 Ways of assessing vehicle combinations in term of load rating of road bridges and finding the most critical vehicle combination for abnormal transport

Figure 5 shows different ways of assessing the axle loads for the vehicle combination A1 to obtain a comparative indicator to determine the most critical vehicle combination of the carrier.

The yellow line marked as A1 simple shows a simple approach in which we have marked individual cumulative wheelbases (from 1 to 11) on x-axis and the cumulative axle loads (e.g. 1, 1+2, 1+2+3…) of individual axle combinations on the y-axis. From this curve, it is not possible to determine the most critical state of the vehicle combination, because it does not take into account other cumulative wheelbases as well as the cumulative axle loads (e.g. 2+3+4…) which can have higher loading in the vehicle combination.

The way to consider the most critical state of the vehicle combination is to define all axle groups for the bridges of any length as A1 all1, A1 all2, ..., A1 all12. This is made by individual cumulative combinations of wheelbases of individual axles, group of 2 axles, 3 axles, up to group of 12 axles and the cumulative axle loads appropriate to individual axles, group of 2 axles, 3 axles, up to group of 12 axles. For example, the marking A1 all5 depicted as brown dots show all 5-axle combinations immediately following each other. The x- axis is the cumulative value of the wheelbases of axles and on the y axis there is their cumulative axle loads. This approach shows all loading which vehicle combination can have on bridge of any length, but it is very difficult to compare several vehicle combinations with this way, [5, 6].
The green dashed line marked as A1 min (w) max (t) depicts the minimum cumulative value of the wheelbases (w) for each axle group on the x axis and the maximum value of the cumulative axle loads (t) for each axle group on the y axis. However, this curve also creates non-existent combinations of the wheelbases and axle loads so it can be used as a theoretical maximum but not as real maximum. To find real maximum, it is necessary to approach the most critical state of the vehicle combination in another way.

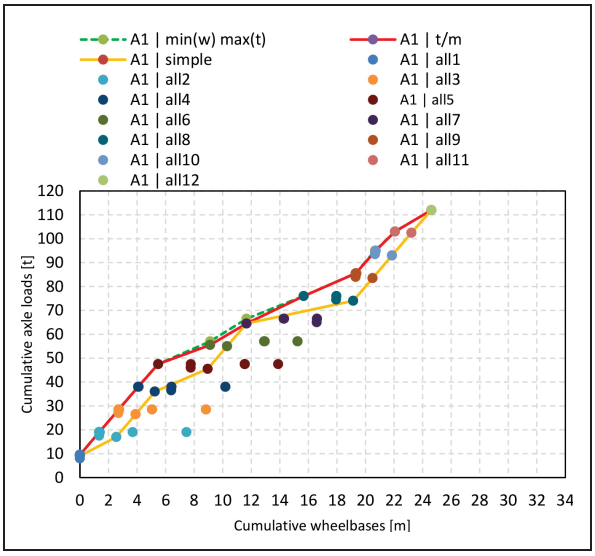

Figure 5 Different approaches to assessing the axle loads of the vehicle combination depending on the cumulative wheelbases

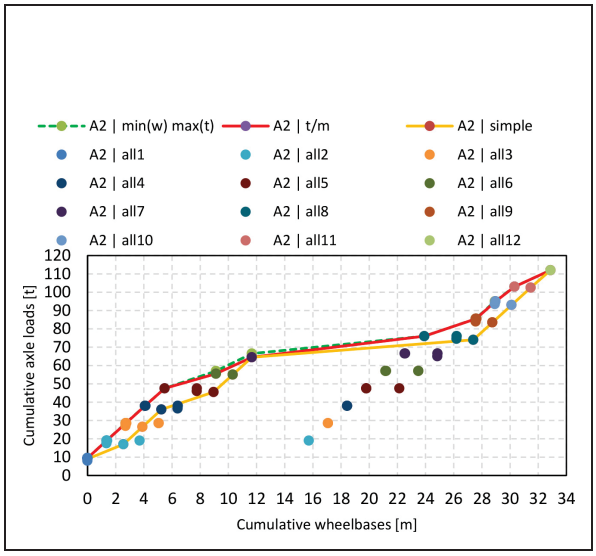

Figure 6 Loadings of vehicle combinations A2 – maximum extended state

The Figure 5 gives us two possible approaches to consider the most critical state of the vehicle combination. The first possibility as theoretical maximum is marked as A1 min (w) max (t) (green dashed line) and second possibility as real maximum is A1 t / m (red solid line). These lines are above all the points (A1 all1, A1 all2, ..., A1 all12) that are shown in the graph. This clearly indicates that this is the most critical state of the vehicle combination A1. However, if we compare these two possibilities to each other, more correct approach to determine the most critical state of the vehicle combination is A1 t / m as it evaluates the real maximum loading of the vehicle combination and does not create non-existent loadings as A1min (w) max (t). Therefore, only the t / m line is showed for each vehicle combination in the overall comparison of vehicle combinations. This procedure to obtain the most critical state of the vehicle combination can be applied to all vehicle combinations with which the carrier executes abnormal transport and ask for permission for special use of roads within the territory of the Slovakia.

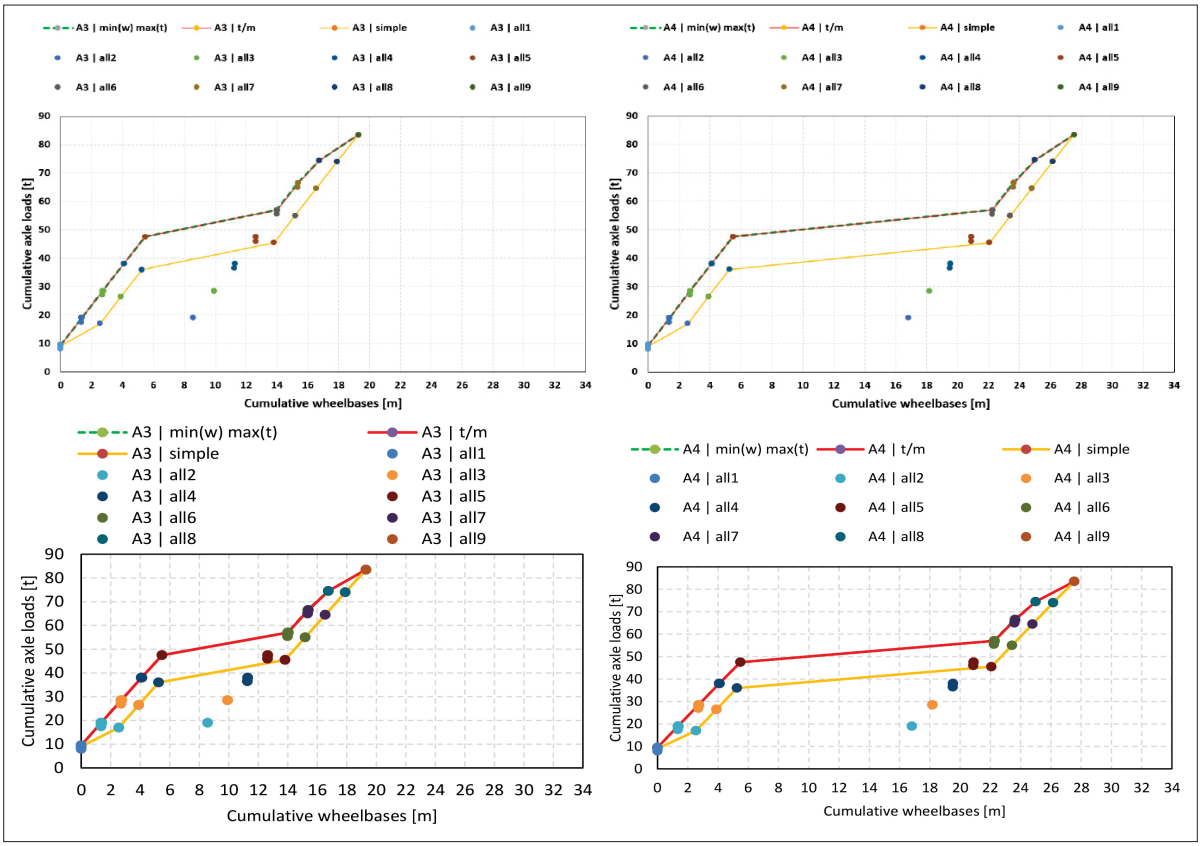

Figure 7 Assessment of the most critical state of axle loading for the vehicle combination with minimum length A3 and maximum extended state A4.

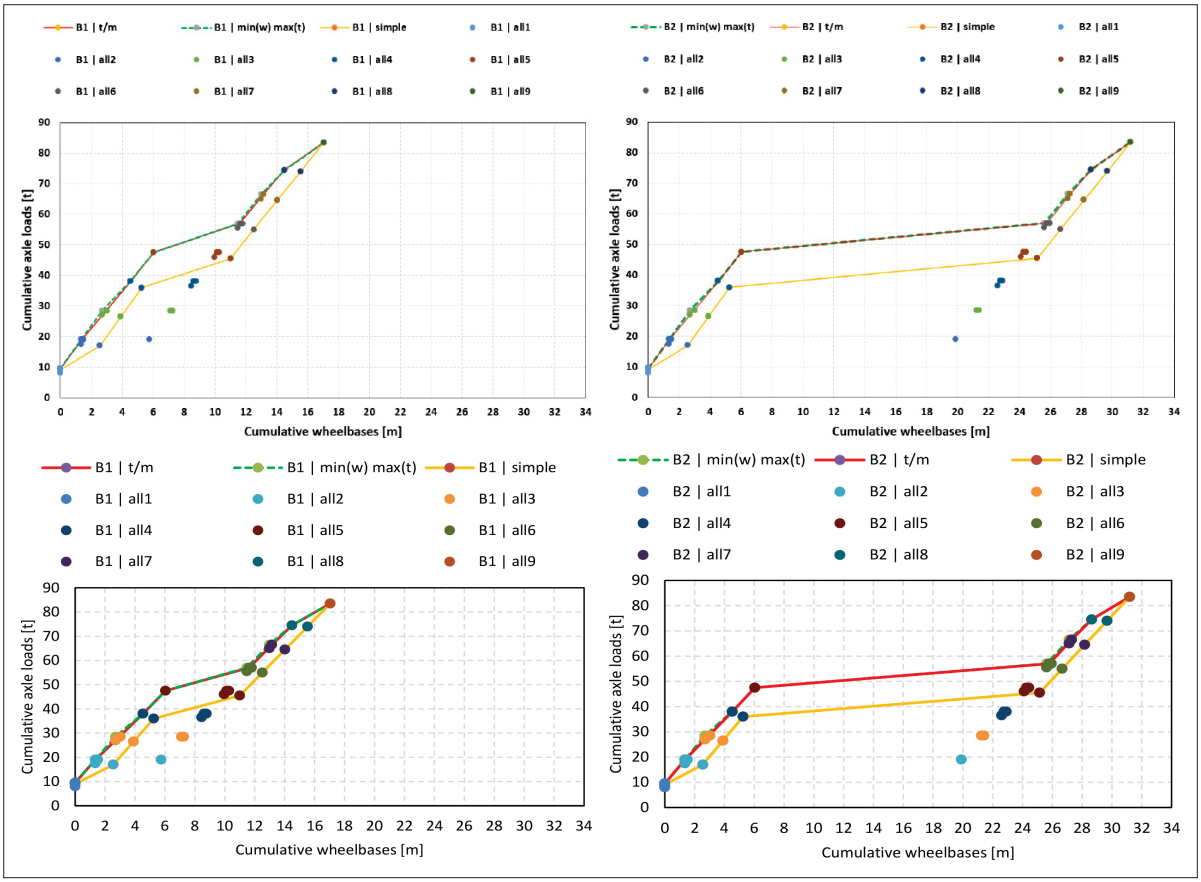

Figure 8 Assessment of the most critical state of axle loading for the vehicle combination with minimum length B1 and maximum extended state B2

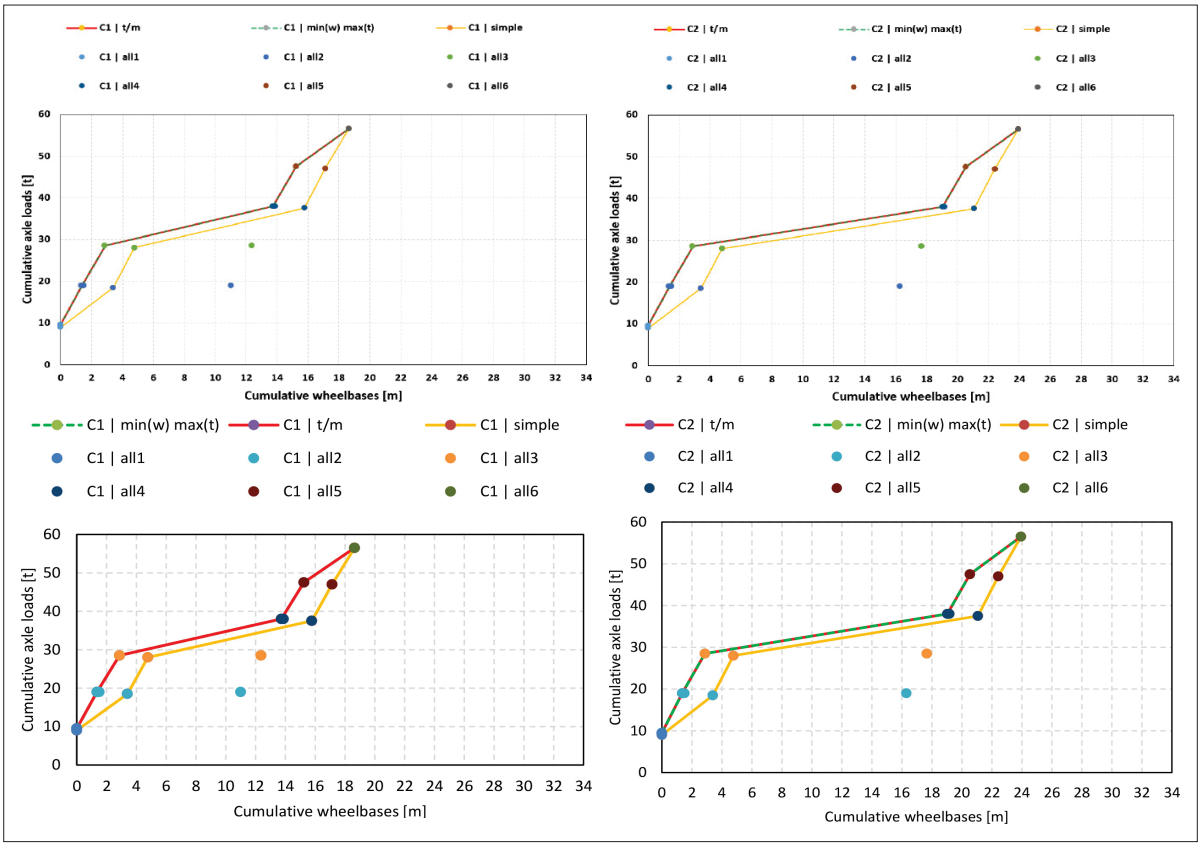

Figure 9 Assessment of the most critical state of axle loading for the vehicle combination with minimum length C1 and maximum extended state C2

Figure 10 shows t/m lines of all analysed vehicle combinations from figures 5 to 9. There are two most critical vehicle combinations A1, B1 for assessment of the transport routes required to obtain a permit for the special use of roads in Slovakia. The lines of A1 and B1 intersect each other at cumulative wheelbase of about 14 meters. To find the most critical combination we have to make theoretical vehicle combination, which takes into consideration loadings of vehicle combinations of A1 and B1.

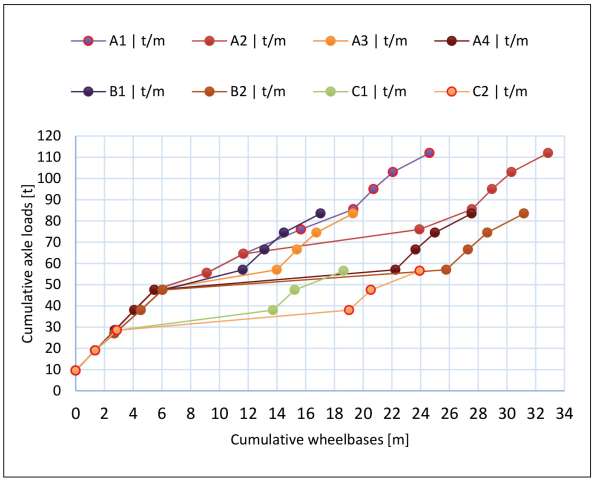

Figure 10 Different t/m loadings of analysed vehicle combinations for min. length and max. extended state

Figure 11 shows the most critical vehicle combination which is a combination of A1 and B1. This vehicle combination does not exist in a carrier´s fleet but meets the criteria of the most critical vehicle combination for the needs of assessment of the routes required to obtain a permit for the special use of roads in Slovakia, [4, 7].

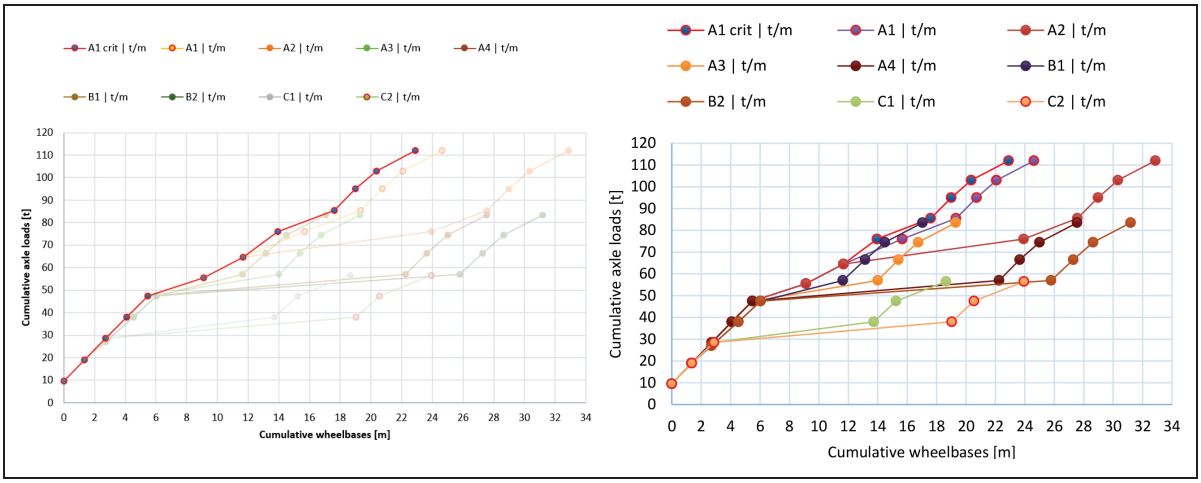

Figure 11 Designation the most critical vehicle combination

The A1 crit vehicle combination was created by replacing the wheelbase 7470 mm between the 7th and 8th axle of the A1 vehicle combination by wheelbase of 5 750 mm between the 4th and 5th axle of the B1 vehicle combination. The sketch of the most critical vehicle combination is in Figure 12.

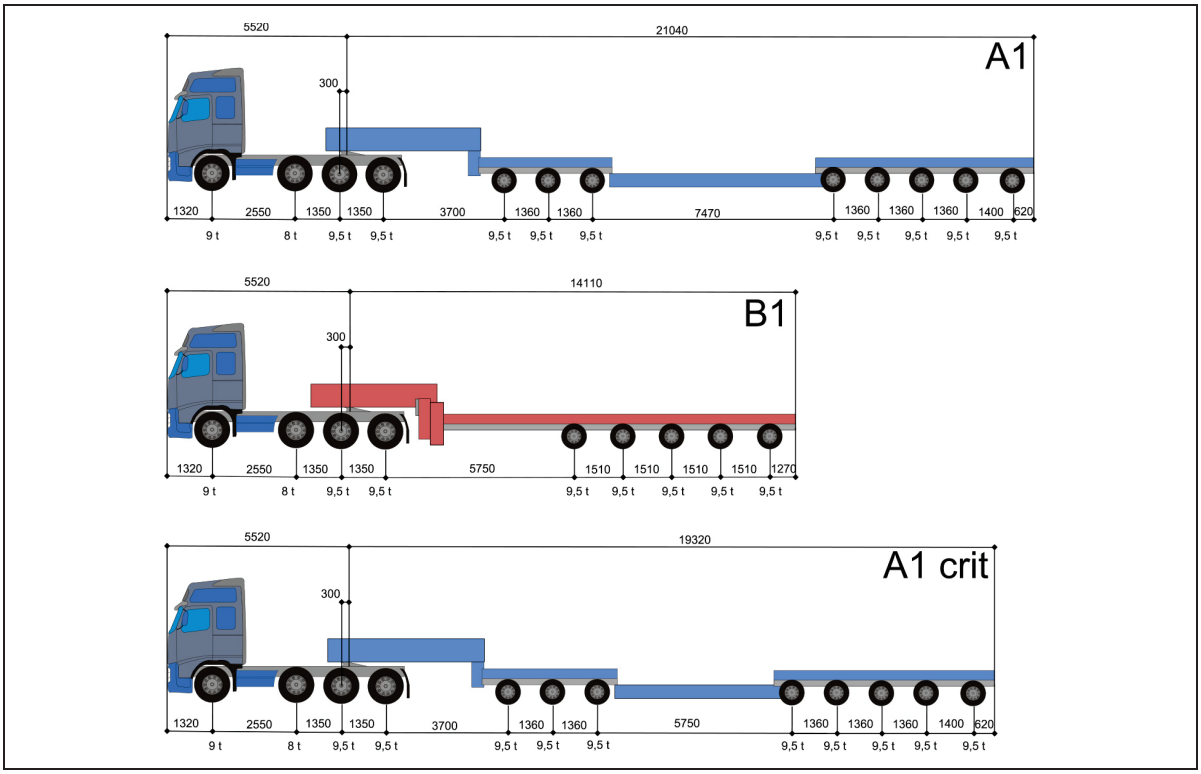

Figure 12 Sketch of the most critical vehicle combination A1 crit for the assessment of load rating of bridges

5 Conslusion

The article focuses on ways to obtain the most critical vehicle / vehicle combination and suggests that the current route assessment procedure for load rating of bridges is based on the length of the bridge and the maximum axle loads located on the bridge. Therefore, the aim was to find the most critical vehicle combination, which by any combination of axles, would cause the highest load rating of the bridge with any length.

We showed four above-described ways for considering the most critical vehicle combination. We choose the way of finding real loading maximum for bridge of any length. In this way, we have assessed all the carrier´s vehicle combinations and we have identified the most critical vehicle combination, which is in fact the combination of A1 and B1 vehicle combinations. This vehicle combination A1 crit is the most critical and should be used for the assessment of road bridges for given route. Other vehicle combinations do not create higher loading than A1 crit. This procedure is applicable only for electronically, online assessments for abnormal transport for the required route. If the static report from this electronical assessment contain requirement for issuing by an Authorized Civil Engineer, he assesses the most critical and problematic bridges for all vehicle combinations of the carrier's fleet, not only for the most critical vehicle combination.

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