Bence Hajós[1]

MOVEMENT OF OVERLOAD MILITARY AND CIVIL VEHICLES ON ROAD BRIDGES

KATONAI ÉS POLGÁRI TÚLSÚLYOS JÁRMŰVEK KÖZLEKEDÉSE KÖZÚTI HIDAKON

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Abstract

A special category of road transport is the transport of overload, oversize vehicles. Such vehicles are found in both civil and military transport. Oversized vehicles for civilian use typically transport transformers or manufacturing machinery, etc. Military overload vehicles transport heavy military equipment. There are many similarities and differences between the two groups of overload vehicles. In the case of military overload transports, quick decisions are required when checking the load capacity of the bridges is involved. This is the purpose of the STANAG 2021 standard. This paper describes the military and civilian procedures for bridge inspections related to overload transport and presents the objectives of the research that has been initiated.

Keywords: overload transport, AEP-3.12.1.5, road bridges, military transport, load capacity

Absztrakt

A közúti közlekedésnek speciális csoportja a túlsúlyos, túlméretes járművek közlekedése. Ilyen járműveket találunk polgári és katonai területen is. Polgári célú túlsúlyos járművek tipikusan transzformátorokat, gyártógépeket szállítanak. A katonai célú túlsúlyos járművek nehéz katonai eszközöket szállítanak. A túlsúlyos járművek két csoportja között sok hasonlóság és különbség figyelhető meg. Katonai túlsúlyos szállítások esetén gyors döntéshozatal szükséges az érintett hidak teherbírásának ellenőrzésekor. Ezt a célt szolgálja a STANAG 2021 szabvány. A

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tanulmány bemutatja a katonai és polgári eljárásrendet a túlsúlyos szállításokhoz kapcsolódó hídellenőrzések vonatkozásában és bemutatja a megkezdett kutatás céljait.

Kulcsszavak: túlsúlyos szállítás, AEP-3.12.1.5, közúti híd, katonai szállítás, híd teherbírás

Introduction

Military and civilian road transport (Figure 1 and 2) often share common infrastructure. The basic network of road transport in Hungary is made up of national roads, supplemented by local roads managed by municipalities.

The total length of the Hungarian national road network is 32 522 km, managed by Magyar Közút NZrt. and the concession companies operating the express roads. The supervision of national roads is the responsibility of the Ministry of Construction and Transport. The management of local roads is the responsibility of the local government, so there are 185 757 km local roads in Hungary. Funding for local roads is super visioned by the Interior Ministry. [2]

Figure 1: New Hungarian military vehicles for heavy transport[3]

2 https://www.ksh.hu/stadat_files/sza/hu/sza0030.html (downloaded: 03-03-2024)X

3 Farkas, Zoltán (2020): Új típusú nehézgépszállító szerelvények. Haditechnika, 54(5) p. 69.

Bridges are the key elements of the operation of the road transport network. Damage, destruction or deterioration of any bridge can cause significant disruption to the network. It is also true of bridges that we often only realise their importance when their absence causes disruption.

A special case of road transport is that of overload vehicles. This is necessary for both military and civilian purposes. A key consideration when planning the route of an overload vehicle is the load capacity of the bridges involved.

There are a total of 8284 bridges on the national road network in Hungary and an estimated 6000 bridges on local roads. In total, the load capacity of 14 000 bridges may therefore need to be checked to ensure that they are suitable for civil overload vehicles and military heavy equipment transporter's (HET). [4]

When organising road transport, preference is given to higher-order road network elements (e.g. motorways). However, due to the diversity of departure and arrival locations, it is essential to use lower-order road networks and the bridges on them. Furthermore, in the event of a bridge being unable to carry the load for whatever reason, the easiest way is to find a bypass, which typically results in the use of a lower-grade road network.

Some words about the overload road transport

In both military and civil road transport, when mass of the vehicles is over than 40 tonnes are considered as overload. The vast majority of vehicles on the road do not exceed this limit. Heavy civilian vehicles require a special permit, which is assessed and granted by the road manager, subject to ad hoc conditions. On the national road network, permits for oversized vehicles are issued by Magyar Közút NZrt., and on municipal roads by the competent local authority. The Hungarian Defence Forces authorises the transport of military vehicles under its own authority, which is carried out by the Hungarian Defence Forces Logistics Support Command in close cooperation with Magyar Közút NZrt.

Oversized vehicles are also often oversized, i.e. the width, height or length of the vehicle exceeds the prescribed limit. The assessment of the traffic of overload and, where appropriate, oversized vehicles is a

4 https://hidadatok.hu/ (downloaded: 03-03-2024)

complex process, which involves consideration of the road's load capacity, possible height obstacles, geometry for turning, possible signalling devices to be demolished, barriers, road edges, railway crossings, restrictions on other traffic, current road works, etc. [5] This present study is concerned with the load capacity of bridges, which is a key issue in the preparation of heavy vehicle traffic in both civil and military cases. The essence of the question is the same in both traffic areas: can the vehicle pass or not? I will present the military and civilian procedures, highlighting the similarities and differences and the development tasks ahead. Between 2000 and 2009, András Gulyás and Zoltán Havasi dealt with the topic in more detail. Their results were published in the Technical Military Journal[6] (Műszaki Katonai Közlöny) and in their PhD thesis.[7] The present study is a continuation of the work they started.

Bridge inspection for civilian overload traffic

Our main piece of legislation governing road transport is Act I of 1988 on Road Traffic[8]. Decree 36/2017 of the Ministry of National Development[9], which is linked to the Act, regulates the conditions for the circulation of vehicles exceeding a certain total weight.

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5 https://www.kozut.hu/ugyfelszolgalat/utvonalengedely-uvr-e-office/altalanos-tajekoztato/ (downloaded: 03-03-2024)

6 Gulyás, András (2002): Az érvényben lévő hídtervezési előírások és a hidak terhelési osztályba sorolása a STANAG 2021 szerint. Műszaki Katonai Közlöny, 12(1–2), 53–68. Online: https://folyoirat.ludovika.hu/index.php/mkk/article/view/3181/2428
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7 Gulyás, András (2009): Új építési technológiák alkalmazása a Magyar Honvédség béketámogató műveletei katonai építési gyakorlatában. PhD-disszertáció. Zrínyi Miklós Nemzetvédelmi Egyetem, Katonai Műszaki Doktori Iskola.
Havasi Zoltán (2007): A Magyar Honvédség ideiglenes hídhelyreállítási képességeinek, lehetőségeinek vizsgálata. PhD-disszertáció. Zrínyi Miklós Nemzetvédelmi Egyetem, Hadtudományi Doktori Iskola.

8 1988. évi I. törvény a közúti közlekedésről, Online: https://njt.hu/jogszabaly/1988-1-00-00 (downloaded: 03-03-2024)

9 36/2017. (IX. 18.) NFM rendelet a meghatározott össztömeget, tengelyterhelést, tengelycsoport-terhelést és méretet meghaladó járművek közlekedéséről, Online: https://njt.hu/jogszabaly/2017-36-20-2W (downloaded: 03-03-2024)

A vehicle is considered to be overload if its total weight exceeds the limit given in Table 1. In addition to the maximum laden mass, a limit applies to the maximum load on each axle and to the combined load of the axle groups. If a vehicle exceeds the limit values for either the total mass, the axle load or the axle group load, it is considered to be overload.[9]

A route licence must be obtained for the transport of an overload vehicle. The procedure is subject to a fee and, if the authorisation is granted, an excess weight charge proportional to the excess load and the distance travelled must be paid.

On the road network, there are bridges and road sections with weight restrictions, which must always be indicated to road users by prohibitory signs. There are three types of ban provided for in road traffic rules: a total weight limit, a maximum permissible weight limit and an axle load limit. Although the maximum permissible laden weight limit is rare in Hungarian practice, the advantage of this strict prohibition is that no discretion is required to determine whether an infringement has been committed, so that any penalties are much simpler. Driving onto such a road section with a vehicle with a load greater than the ban is possible with a special permit, in which case the case-by-case inspection of bridges should be considered in the same way as for general overload traffic.

In all cases, road bridges have a design load capacity. In the bridge design codes of each era, there has always been an ideal vehicle that embodied the payload of the load class. This value must be recorded and archived by the bridge operator.

In the current civil bridge design code, the ideal vehicle in load class A is 800 kN (quasi 80 tonnes) and in load class B 400 kN (quasi 40 tonnes). In addition to the ideal vehicle representing the maximum load, there are other effects (distributed loads, horizontal forces, etc.) in bridge design which are not discussed here. The ideal vehicles are generally designed to be more compact and less favourable in terms of load capacity of the same weight in practice. Thus, if a bridge capacity is marked A, i.e. 80 tonnes, it can certainly carry an overload vehicle of 80 tonnes, if other loads are excluded.

If the vehicle mass is significantly higher than the design basis value of the bridge (e.g. 120 tonnes, 150 tonnes) or there are other concurrent loads on the bridge (other vehicles in parallel lanes), a case-by-case assessment is required to take this into account.

PERMISSIBLE LOADS ON VEHICLES[10]

Table 1

Type of vehicles	Max weight
Vehicle with two axels	20 tonnes
Vehicle with three axels or hinged	26 tonnes
Vehicle with four or more axels or hinged	32 tonnes
Vehicle combination with three axels	28 tonnes
Vehicle combination with four axels	38 tonnes
Vehicle combination with five or more axels	40 tonnes
Type of vehicles	**Max axel load**
All vehicles	11.5 tonnes
Type of axel group	**Max group load**
Group with two axles, if axle distance < 1 m	11.5 tonnes
Group with two axles, if 1 m ≤ axle distance < 1.3 m	16 tonnes
Group with two axles, if 1.3 m ≤ axle distance < 1.8 m	19 tonnes
Group with three axles, if axle distance < 1.3 m	22 tonnes
Group with three axles, if 1.3 m ≤ axle distance < 1.8 m	24 tonnes
Group with more than three axles, with other rules	28.5 tonnes

The case-by-case assessment has two levels. In the simplest case, the bridge operator decides at his own discretion or requires the involvement of an external, independent bridge expert. More than 30 bridge engineers (bridge operators) are employed by Magyar Közút NZrt., partly in the central bridge department in Budapest and partly in the county directorates. Public Roads bridge engineers are not typically involved in design and expertise, but they do inspect the bridges under their management on an annual basis, and therefore have a wealth of experience in assessing overload vehicles.

A simple way of verifying the load capacity is to compare the measured loads (bending moments, shear, reaction forces). The procedure

[10] 36/2017. (IX. 18.) NFM rendelet a meghatározott össztömeget, tengelyterhelést, tengelycsoport-terhelést és méretet meghaladó járművek közlekedéséről, Online: https://njt.hu/jogszabaly/2017-36-20-2W (downloaded: 03-03-2024)

consists of comparing the bending moments from design loads applied to the bridge structure with the bending moments from loads applied to the individual vehicle under test. If the latter does not exceed the design impact, the vehicle can pass. The detailed rules of this method (concurrences, allowable tolerances) were developed by Dr. Träger Herbert. A simple computer program using this load comparison method has also been developed, which is a great help in the load capacity analysis of bridges for oversized vehicles.

If the bridge operator does not authorise the passage of a bridge on his own authority, he can require an independent bridge expert to carry out a load capacity test. The finding of an external expert opinion does not legally bind the bridge operator to do anything. The expert's opinion must be of a level of detail that is sufficient to verify the calculation carried out in the case of a verifiable crossing and at the same time to demonstrate to the operator that the expert has exercised due care and diligence.

The level of detail of the independent expert's bridge inspection may vary according to the difficulty of the task. The possible method of investigation can range from a bending moments comparison method to one of increasing complexity and sophistication. A detailed strength calculation can be performed like design plan. In the absence of reliable plans, a calculation based on non-destructive and destructive bridge testing (e.g. geometric survey on site, reinforcing steel exploration, strength determination) can be performed. In special cases, a preliminary bridge test, load test and a force calculation validated by on-site bridge deflection measurement can be performed.

The outcome of the expert investigation may be to allow the passage, to impose conditions on the passage (e.g. on-site management by a bridge expert, temporary reinforcement, shoring). The outcome of the investigation may also be to prohibit the passage.

A good example of quality assurance of bridge calculations related to the passage of overload civil vehicles is the monitoring of the deformation of the bridge during the passage of the load under consideration. The measurement results can be used to numerically verify the correctness of the preliminary calculation, and a large number of such measurements can be used to refine subsequent calculations. Such measurements provide a wealth of experience on the behaviour of old and damaged bridges (Figure 2).

Figure 2: Civil overload transport on the bridge
(photographed by the author)

In particular, a great deal of bridge testing experience is needed to assess the load capacity of older bridge structures. All possible factors (history of bridge construction and renovation, additional dead loads on the bridge, possible damages, etc.) should be taken into account when carrying out the load capacity check. The independent expert is responsible for the safety of the bridge passage.

As we have seen, the verification of the adequacy of bridges for civil overload traffic can be divided into two levels, a bridge operator analysis and, where appropriate, an independent expert examination. The analysis of a specific vehicle can range from the simplest and quickest check to a detailed expert examination, which can take several months.

The load on bridges increases exponentially as the total weight increases. The transport of overload vehicles is often made more difficult by the fact that the size of the vehicle is also large (oversize), which physically limits the number of possible routes (e.g. it cannot fit under a bridge which find over the road).

In the case of large transports in particular, the preparatory work may start several years earlier. This is very important in cases where the feasibility of transport is uncertain. In most cases, the manufacturer is interested in making the transported object as large and heavy as possible in order to minimise the work on site. However, transporting large objects can be disproportionately expensive, or disproportionately costly, or even impossible. Therefore, the item must be broken down into several transport pieces, which allows for transport but causes on-site assembly work. This is a complex iterative process that is only efficient if there is good cooperation between all parties.

Bridge inspection for military overload traffic

I presented the section of bridge control for civil overload transport in more detail to show the similarities and differences between military and civil overload transport.

Military overload transport is licensed by the Hungarian Defence Forces Logistics Support Command (in Hungarian: Magyar Honvédség Logisztikai Támogató Parancsnokság – hereinafter referred to as the MHLTP) under its own authority. This is possible in close professional cooperation with the road operators, in particular Magyar Közút NZrt and the municipalities managing the major bridge stock (e.g. Budapest, with the famous Danube bridges). [11]

The road managers provide regular data to the MHLTP, including the main data of the bridges. Subsequently, an analysis similar to the civil procedure can be carried out. This is made difficult by the fact that the MHLTP does not have a bridge engineer on staff and information on the up-to-date condition of the bridge stock is limited. Authorisation of vehicles with a load not exceeding or close to the nominal load of the design load class of the bridge is a simple task, in the case of significantly overload (e.g. 120 tonnes) the MHLTP can be assisted by the bridge engineer of the road manager on a cooperative basis (Figure 3).

Military transport tasks are different from civil tasks. Civilian transports are typically of equipment (e.g. transformer, generator, press, chemical reactor). Their transport is typically linked to a project and can be planned and scheduled well in advance. Military deliveries, on the other hand, involve the movement of systemised military equipment, so the transport tasks can be typified (e.g. heavy equipment transport with a tank). Military deliveries are less predictable in time, and the preparation and authorisation of the transport requires a quick decision.

[11] Sárkány, István Róbert (2019): A polgári és katonai együttműködés aspektusai a katonai közlekedés műszak vonatkozásában. Conference presentation

Figure 3: New Hungarian military trailers for 120 tonnes[12]

Another difficulty in planning military transport is the need to ensure mobility at NATO level in addition to national control, which also includes heavy military vehicles. It is desirable that bridge inspections for non-Hungarian NATO overload transiting through the country can be carried out by the allied army. The AEP-3.12.1.5 standardisation agreement[13], which regulates the load classification of military vehicles and bridges, was drawn up to regulate this uniformly.

STANAG 2021 - Standardised procedures

The Allied Engineering Publication[14], used under the NATO's Standardisation Agreement[15], aims to have determine a Military Load Classification (MLC) for all military vehicles[16] and bridges. If the vehicle's classification is less than that of the bridge, the vehicle can pass safely.

12 https://www.vezess.hu/haszongepjarmu/2022/08/27/magyar-honvedseg-scania/ (downloaded: 03-03-2024)
13 AEP-3.12.1.5 (2017): p. 3-1
14 AEP-3.12.1.5 (2017)
15 STANAG 2021 (2017)
16 Hajós, Bence (2024): A STANAG 2021 szerinti katonai jármű-teherosztályok a polgári hídszabályzatok tükrében, Hadmérnök, under publication

A total of 16 tracked and 16 wheeled ideal vehicles are included in the AEP-3.12.1.5 Appendix A, which provides the basis for the MLC classification. The method for determining the load capacity of bridges, including partial factors and dynamic factors (dynamic effect, impact), is left to national competence, as it is closely related to the existing bridge design standard, which may vary from country to country.

In all cases, road bridges must be double load rated, giving a classification for both tracked and wheeled vehicles. The usable load capacity of bridges is fundamentally influenced by the concurrency of traffic passing through. AEP-3.12.1.5 defines four types of concurrencies (Figure 4).

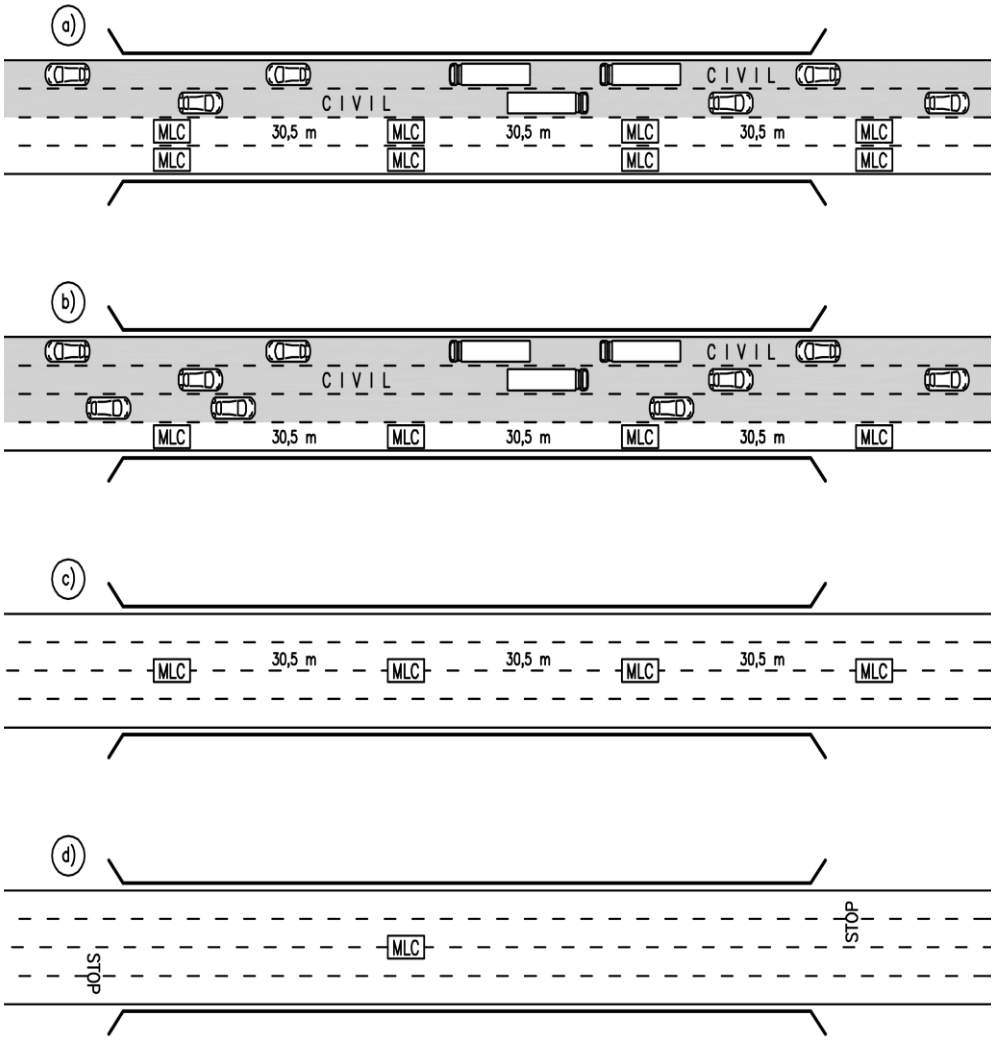

Figure 4: Vehicle coincidence cases for military load classes (drawing by the author)

The concurrency cases in Figure 4 can be adapted to narrower and wider bridges. In case a), there are two lanes for military traffic with simultaneous civilian traffic. In case b), there is only one lane for military traffic with simultaneous civilian traffic. In cases (c) and (d), there is no simultaneous civilian traffic, and the military vehicle is on the axis of the bridge. In case c) a convoy of military vehicles is considered and in case d) a single vehicle is considered. With the four types of concurrency cases, we can allow increasing military loads on the same bridge.

Of course, military vehicles that meet the general civilian traffic standards (vehicles with tyres and not overload, not oversized) can be allowed to travel as part of civilian traffic without any special military authorisation or analysis. In other cases (overload vehicles, tracked vehicles) a case-by-case decision is required.

Cases a) and b) are considered as normal cases when there is simultaneous civilian traffic. The corresponding military MLC bridge classification can be signposted in front of the bridge, facilitating military mobility (Figure 5). Bridge classifications for cases c) and d) should be treated as service data.

Figure 5: Traffic sign for military vehicles[17]

[17] https://wiki.openstreetmap.org/wiki/MLC (downloaded: 03-03-2024)

The ideal situation would be to have MLC for all bridges in Hungary, even for all four concurrency cases. AEP-3.12.1.5 provides possible procedures and a framework for bridge classification but does not specify many important details. Therefore, for the classification, the reliability factors, partial factors, dynamic factors and the load model representing the concurrent civil traffic for each case, based on the Hungarian civil bridge design codes, should be fixed. In the history of Hungarian bridge construction, 10 bridge design codes have been used from the first one in 1910 to the present. The necessary parameters should therefore be fixed taking into account the reference (initial) civil bridge design code.

For this work, the first step is to record the research needed to establish the procedure, and then the MLC of bridges can be carried out in a practical prioritisation. This work should be done in close cooperation between civil and military bridge engineers.

STANAG 2021-order of bridge load classes

The military MLC of the load capacity of road bridges is a function of four parameters in addition to the load level. A bridge can therefore have many different MLC. If a bridge can have more than one MLC, it is particularly important to indicate clearly under which conditions each classification is valid. This is the purpose of my proposal for the MLC marking of bridges. [18]

In addition to the MLC number of the ideal military vehicle (e.g. 100), which represents the load level, a further essential property should be treated as inseparable! For the marking system I have chosen the standard marking system for concrete as a model. For concrete, it is not sufficient to indicate the strength (e.g. C20), but the rest of the marking should include the environmental classes, the max grain size, the consistency of the fresh concrete, the type of cement to be used, etc. (e.g. C35/45-XC3-24-F3-CEM I 52,5 - 100 years - ISO 4798:2016)

For the load capacity of bridges, the following shall be indicated. The ideal vehicle type for sizing is tracked or wheeled. Recommended markings are T and W.

[18] Hajós, Bence (2024): Közúti hidak katonai és polgári terhelési osztályairól. Hadmérnök, under publication

Cases of concurrency of vehicles should be distinguished. Military traffic on two lanes (two ways = Two) or only one lane (one way = One). Simultaneous civilian traffic is excluded by caution (Cau) and risk (Risk) crossings.

The classification reliability symbol system is taken from the relevant tables in AEP-3.12.1.5 Appendix K. Thus, the assessor's expertise can be LA (Level A), LB, LC, LD and HN, and the procedure used can be A0 (Assessment level 0), A1, A2, A3, A4, A5 and A6.

The first element of the proposed standard notation is the classification code MLC (Figure 6), followed by the vehicle type, vehicle concurrency, assessor competence and procedure reliability, separated by long dashes. In the absence of information after the slash, only the MLC number of the bridge is not meaningful.

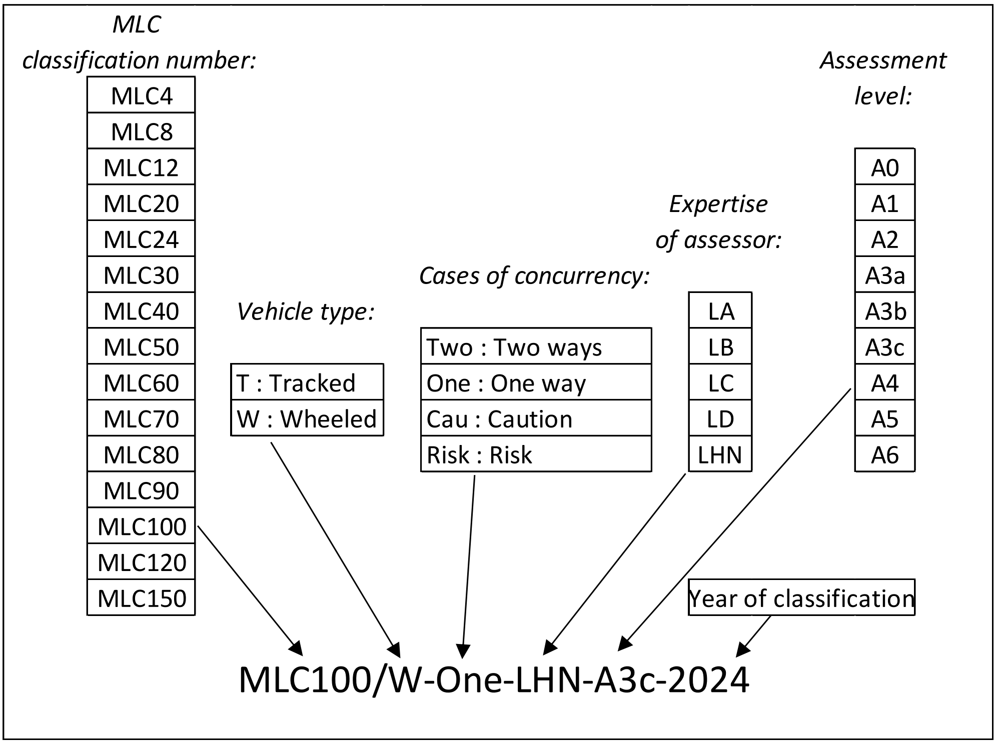

Figure 6: Proposal for a standardised marking of the MLC for road bridges
(edited by the author)

Thus, a bridge can have eight load classifications according to the publication (two types of vehicles and four concurrency, 2 x 4 = 8), which in theory can have a total of 35 reliability indices (five levels of expertise, seven procedures, 5 x 7 = 35). There are mutually exclusive parameters. The person with the lowest level of expertise certainly cannot perform the most reliable procedure.

If a bridge has a bridge load rating with the same meaning (vehicle type and concurrency) with two different assessment skills, the higher skill path should be used. Or if there are two different ratings from different reliability procedures, the higher reliability rating should be used.

The year of classification should be added to the end of the marking in Figure 6, as the load capacity of a bridge is not constant over time, and the deterioration of a bridge must be treated as well as the improvement resulting from a renovation or strengthening. The year of classification is therefore at least as important data as the designations for the reliability levels.

There are intrinsic relationships between the different vehicle and concurrency classifications of a bridge. A "force order" of the different classifications can be established.

Typically, a bridge classification for a wheeled will have a higher number of load capacity than a tracked classification. Similarly, a sequence can be set up for the concurrency cases Two < One < Cau < Risk.

The parameters and rules associated with each procedure are well defined if the condition that the higher confidence level is associated with a higher load rating is satisfied.

Research design

The aim of my PhD research is to investigate the MLC classification of existing civil road bridges and to propose the parameters for the calculations. A preparatory task for this is the analysis of the AEP-3.12.1.5 specifications and the study of foreign literature.

The research work started in January 2024 and some detailed studies are in progress. The classification of bridges is also closely related to the history of road bridges, road bridge design codes and the MLC of military vehicles. The outcome of the work is complicated by the fact that a complete renewal of the civil bridge design standard is currently underway. [19]

The aim of my one-year research is to formulate a technical proposal for the classification of bridges, covering the details and parameters of the procedure. The proposal will be suitable for detailed technical discussion and examination in order to finalise the classification of the load capacity of bridges.

In the event of military and civilian consensus, the exact procedure can be fixed and the classification of bridges can begin, which is the final objective of this work.

Summary

In the long term, the MLC of bridges is necessary for the management and organisation of military overload road traffic. This work requires preliminary research and analysis. The parameters of the procedure should be fixed, taking into account foreign examples.

This work is country specific, because the classification is based on civil bridge design standards. The aim of my PhD research is to develop these parameters and procedures.

There are many similarities between military and civilian overload vehicle traffic, which can be used to develop procedures. Military overload transport is characterised by typeability. For the organisation of military transport, a procedure is needed that allows a quick decision to be made, and this is the purpose of the STANAG 2021 standard. The purpose of the domestic use is to classify road bridges MLC for different vehicle types and concurrency.

The expected outcome of my PhD research is the development of a methodology and procedures to support the assessment of the load capacity of road bridges. For the practical application of the results, the professional cooperation of the two most important organisations, the Hungarian Defence Forces and the Hungarian Public Roads is necessary. I propose that, on the basis of the procedure to be developed in

[19] Hajós, Bence (2024): Paradigmaváltás a közúti hídtervezésben a hasznos járműterhek vonatkozásában Katonai alapterhek helyett polgári járműterhek bevezetéséről. Műszaki Katonai Közlöny, under publication

the doctoral research, Hungarian Public Roads should be responsible for the evaluation of the military load capacity of the bridges under its management and the transfer of the data to the Hungarian Defence Forces.

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