CONSIDERATIONS ON THE BEARING CAPACITY OF EXISTING PRESTRESSED CONCRETE BRIDGES

Andrei-Mihai POGÁNY

“Politehnica” University, Timișoara, Romania
pogany00@gmail.com

Abstract: Military actions generally unfold rapidly in different operational environments for which the commanding officer has to assess the bearing capacity of the prestressed concrete bridges existing in the country's road network. The bearing capacity is the maximum weight of the predetermined constitution convoy, which may safely circulate on the bridge, in stable conditions, considering the physical condition of the bridge. The paper shows that the bearing capacity will be assessed only through a technical analysis performed by an authorized expert together with a military engineer specialized in genius. This experts report will compare the initial condition of the bridge to the present one. The initial condition is based on the research of the execution design; the year of elaboration; the standard loadings at the moment; properties of the used building materials; execution modality, possible alterations occurring during execution as to the initial project. These data, together with the road traffic census, can be obtained from the company administrating the road network where the bridge is located. The current state to be assessed through analysis, calculation and static loading tests, showing if the capacity of the bridge can support the increase of traffic military vehicle loading and reduction of the bearing capacity due to fatigue phenomena in the reinforcement. The paper proposes that authorities draw up and approve a standard concerning the verification periodicity of the bearing capacity in the existing prestressed concrete bridges.

Key words: load bearing, prestressed concrete bridges, special military vehicles, fatigue resistance, technical condition of a bridge

Introduction

There are situations when military troops must move urgently within the country, by means of special vehicles for troops and special military equipment. On their way, the military units shall cross bridges and viaducts within the road network under the administration of the National Company of Highways and National Roads, as well as under the regional authorities. These works of art were designed and made several decades ago, when increased

loading of special NATO military vehicles were not known. In order to accomplish the movement the commander shall rapidly appreciate the load bearing of the existing wood, metal, reinforced and prestressed concrete bridges.

Prestressing is a distinct procedure meant to introduce an artificial state of compression to the reinforced concrete bridges (usually in beams), preserved during the all exploitation period of the structure. This is achieved by means of

metal tension straps (post tensioned, more rarely pre tensioned), placed inner structural elements. The joint of the straps to the structural element is controlled by anchorages. The artificial compression state, thus introduced, plays the role of cancelling the unitary stretching efforts in concrete produced by loads that action upon the bridge. The prestressed bridges are largely used both in Europe and on other continents, as well.

In our country, the way of establishing bridges bearing capacity on which military units shall pass have already been shown in [1], [2]. In this paper completes and comes with other considerations on the bearing capacity of existing prestressed concrete bridges. The other types – wood, metal and reinforced bridges would involve a huge special work that wouldn't meet the requirements of KBO 2020 International Conference.

Bearing capacity

The bearing capacity is defined as the maximum weight of the convoy with a defined scheme, that can be brought and cross the bridge under safety and stability circumstances, taking into consideration the physical condition of the bridge.

The strength structures of bridges, up to 2010, were calculated using the method of limit states, in which concepts of safety were not explained. After 2010 Eurocodes entered into force, conceptually using the same designing methods (limit state method), but, which are established according to the importance of the structure:

- failure probability of;
- durability of construction;
- updating certain partial safety coefficients;
- development of the content of limit states in case of regular use (especially of fatigue).

Durability of a bridge

The durability of a bridge refers to the period of time of exploitation, with normal

costs of maintenance, without major repairation works. For permanent bridges the duration is usually of 100 years [5]. There are bridges where certain structural elements may be replaced and which are not designed for the entire duration of the bridge. For temporary bridges the duration is established by the beneficiary.

Since 1990 the new designing standards (Eurocodes) have appeared, being implemented in Romania starting with 2010.

The Eurocodes state the sizing principles and requirements of structures to reach a certain level of security, by limiting the failure probability at an acceptable value.

For the existent structures one can easily find out that, because of aging, corrosion and alteration phenomena of structural materials properties (sometimes together with improper maintenance, which increases the involution of materials quality), their resistance is significantly decreasing in time. So, in order to evaluate security according to Eurocodes, it is necessary that separate studies be made. Moreover, in time, the increase of bearing capacity of military vehicles, diminish the security levels of the structures approached. The evaluation of the bearing capacity security of prestressed concrete bridges should immediately be available for the military unit commander. That's why in the following years, it is necessary that, the results of such evaluations be periodically made and be available for those crossing such bridges.

For the reasons above, the author of this paper appreciates that from now on, in the future, the established duration of a permanent bridge cannot be set for a period of 100 years. Thus, it is necessary to estimate the load bearing for less than 100 years, in order to avoid unexpected failure.

Estimation of bearing capacity

In order to estimate the load bearing of bridges it is necessary to take into consideration their technical condition if the construction material exhausted its

reserves through physical – mechanical degradation, through modifications aroused because of long term static loads effects and repeated loads (fatigue) [3]. So, we must take into consideration:

- the real geometrical characteristics of the elements, which are determined by measurements;
- the physical – mechanical characteristics of structural materials (concrete, reinforcement) determined by non destructive methods;
- increased loads of special NATO military vehicles;
- the history of the construction loads, from the road traffic evidence archived with the authority that manages the road network where the bridge is located;
- changes of the initial design during the works and after reception, due to visible degradation (cracks, crevices), to earthquakes, flood and car crashes.

The estimation of the bearing capacity shall be made only after the technical evaluation by authorized specialists in evaluating bridges technical condition [4], together with a specialist genius military engineer. In making the evaluation, the initial condition and the actual one shall be compared.

Work stages

The estimation of load bearing of a pre-stressed concrete bridge is a long term work, which can be accomplished in several work stages:

First stage – the team of specialists in technical evaluation of the bridge shall gather the data specified in the previous paragraph. The data shall be collected from the beneficiary of the bridge and by on-site inspection. With this data then a static and resistance calculation will be performed with will result if the bridge still has the capacity to support new loads, increased compared to the design date and if the structural materials have preserved their initial strength.

Second stage - the team of specialists shall decide if the bridge can be functional or not. If the answer is negative, there is a third stage, with three subvariants.

First subvariant: an analysis regarding the consolidation of the bridge, according to a design made by a certified specialist. The execution of the consolidation shall be performed by a certified company.

Second subvariant: provision will made to reduce the speed movement of vehicles on the bridge, marked with indicator boards. This will reduce the dynamic loads produced by vehicles crossing the bridge.

Third subvariant: gradual replacement of superstructure beams starting from the edge of the bridge for a traffic lane. The removal process can be carried out with cranes that are located on the existing bridge. The new beams, with a higher bearing capacity and corresponding to the new requirements will be executed on an existing field before or after the bridge. If this is not possible these beams will be ordered to be executed by a specialized company that will guarantee their quality. The mounting of the new beams will also carried out with cranes located on the bridge, which demounted the old beams. Then the cranes will pass on the traffic lane that is supported by the new beams and will proceed to the demounting of the old beams respectively to the mounting of new beams for the other traffic lane of the bridge. This subvariant is more difficult to achieve, requires directing the circulation on the bridge, the use of cranes for mounting the new beams, but it is the safest for to take over the increased loads from the circulation of special vehicles.

Conclusions

It is expected that in the future appear situations when it is necessary to verify the bearing capacity of existing prestressed concrete bridges. This paper presents the causes of such evaluations, as it follows:

- the increase in time, from initial design and execution of bridge, of the loads from

the movement of military vehicles, but probably also of the civil ones;

– the decrease of the resistance of the structure of the prestressed concrete bridges

because to the fatigues phenomena, the corrosion, the possible earthquakes and the improper maintenance.

In the paragraphs, Estimation of bearing capacity and in the Work stages, we show how this capacity can be verified and how it can be realized at an existing bridge increasing the capacity to the required one. For military actions, the knowledge of the bearing capacity is always available immediately. We can't risk a future crossing a bridge when that collapsing.

Likewise, the commander of a military unit cannot wait for long until the specialized commission for the technical evaluation of the bridge, can decide on its status.

It is necessary to develop a new Norm for the technical evaluation of bridges (of all types), in order to be able to know immediately their bearing capacity. The elaboration will be done by specialized engineers in construction together with military engineers specialized in genius. The Norm will be approved by the Romanian Government and will also specify with what periodicity, from time to time these evaluations will be realized and where they will kept for consultation and who will have access to them.

References

- [1] Ovidiu Damian, *Stabilirea unei metode unice NATO de determinarea a capacității portante a podurilor*, Revista Armei de Geniu, Nr. 1/2019, pag.48-52, Râmnicu Vâlcea, Romania.
- [2] Liviu Boscagini, *Implementarea la nivel național a modalităților de calcul a clasei militare de încărcare pentru poduri și autovehicule*, Revista Armei de Geniu, Nr.1/2019, pag.53-54, Râmnicu Vâlcea, Romania.
- [3] CD 138/2010, *Normativ privind criteriile de determinare a stării de viabilitate a podurilor de șosea din beton, beton armat, beton precomprimat, metal și compozite*, Buletinul tehnic rutier, Anul VII, Nr. 5/2011, pag.42-43, Compania Națională de Autostrăzi și Drumuri Naționale, București, Romania.
- [4] AND 552/2002, *Instrucțiuni tehnice pentru stabilirea stării tehnice a unui pod*, Buletinul tehnic rutier, Anul II, Nr.16/2002, pag.101, București, Romania.
- [5] NP 104-04, *Normativ pentru proiectarea podurilor din beton și metal. Suprastructuri pentru poduri de șosea, cale ferată și pietonale, precomprimate exterior*, Monitorul Oficial al României, Partea I, Nr. 554 bis/29.VI.2005, pag.8-10, București, Romania.