ENGINEERING ACTIVITIES REGARDING THE STARTUP OF A METALLIC BRIDGE OVER THE CRIŞUL REPEDE RIVER

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***Abstract**: This paper will present engineering works carried out in order to startup a metallic bridge over the Crisul Repede river in Oradea, Romania. The challenge behind this operation was that the above mentioned bridge's metallic superstructure was launched on the abutments and the piers, but after that, no interventions were made for one and a half year. Upon restarting the construction works, specific interventions had to be made in order to meet the imposed technical and safety regulations. The paper will present specific stages of the engineering works, both from the constructor's and the surveyor's point of view.*

***Keywords:** precision levelling, bridge deck corrections, bridge rise*

1. Introduction, technical data

The ”Mareşal Constantin Prezan” bridge is situated in Oradea, Romania, and was projected to establish a link between Dragoş Vodă and Făcliei streets, over the Crişul Repede river. The main reasons behind building this bridge were the possibility to relief the heavy traffic in the fast-expanding north-western area of the city, to decrease the travelling time between various areas of the city, and to increase the safety of traffic in Oradea. Although the bridge is meant to serve only light traffic, both the bridge and the access ramps can assure the use of heavy traffic, the bridge's loading capacity being classified as E category (for exceptional vehicles).

Regarding the intensity of the predicted traffic and the functions it should have, the bridge is classified as a category III bridge, as well as a category B construction (construction with a high importance).

2. Description of the current situation and the challenges

The project started with the Authorization of construction no. 1668/25.10.2010. As the bridge itself hasn't been finished in a timely manner, nor the access ramps or the neighbouring intersections could be finished as well.

The shut-down process took place on the 21.03.2015, based on a decree of the local council, and the bridge was taken into administration (at the current construction state) by the municipality. Unfortunately, after interrupting the construction process, no conservation measures have been taken on the already built sections, in order to protect them until the construction can be resumed. When a through-out technical expertise has been finally made in order to continue the construction process, it has a revealed a series of defections and degradations, which called for additional tasks, partially because the bridge hasn't been worked on for almost two years. The technical expertise stated (among other decisions) that the already built parts should be further used (mainly the already launched bridge deck) and they should be completed in order to finish the construction process. Parts of the original project were modified to assure the necessary technical and safety parameters, but the biggest problem was posed by the already launched, over 300 tons heavy metallic bridge deck.

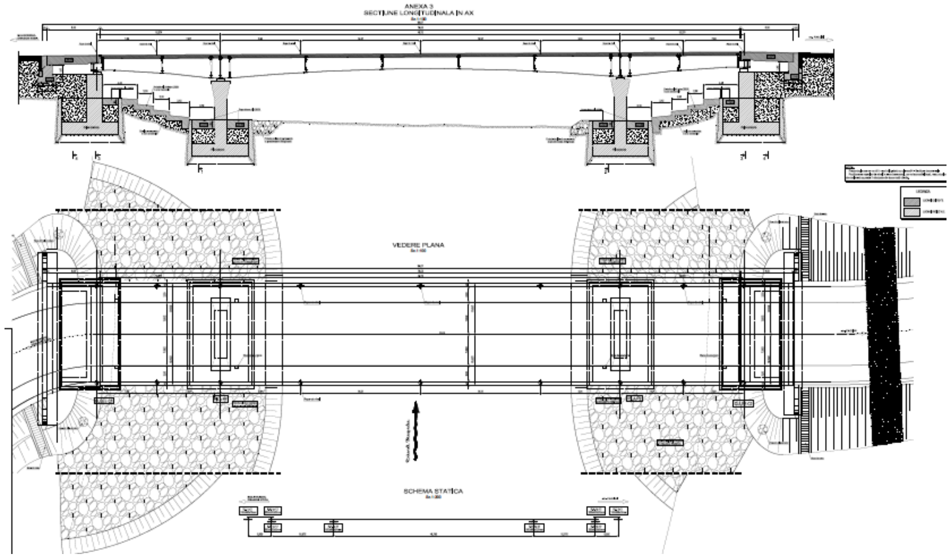

Fig. 1. Longitudinal section of the bridge

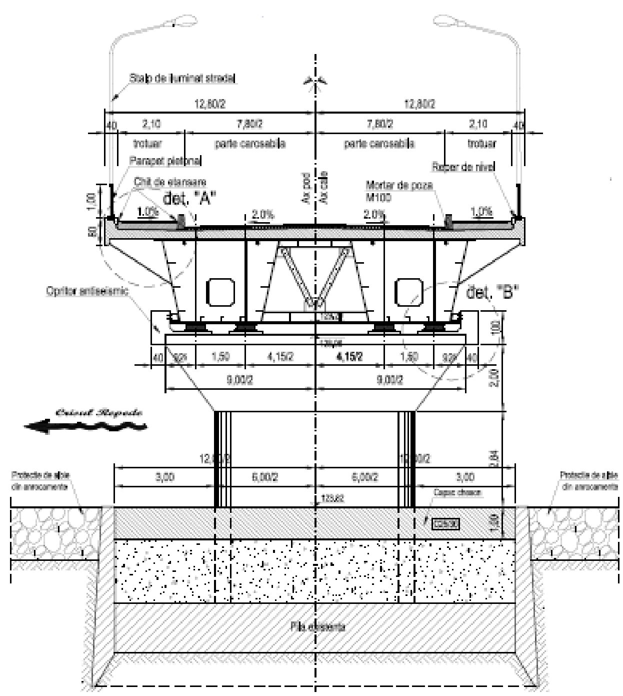

Fig. 2. Cross section of the bridge

As we mentioned before, the biggest problem was represented by the fact that the bridge's deck has already been launched. Various topographical surveys have been made, and based upon them, the expertise stated that the bridge rise is currently far from being in the needed tolerances (apart from other problems). The bridge rise correction process was realized in two different sessions, each session and sub-session needing its specific precision surveying process. The two proposed sessions were:

- partially ballasting the metallic structure
- external prestressing

3. The work process

The first phase of the bridge rise correction process (partially ballasting the metallic structure) will basically mean that the superstructure will be transformed from console support into a continuous girder with 3 openings, and thus assuring that the superstructure is suspended on the bridge abutments. The ballasting process is made with reinforced concrete, and is achieved by flooding concrete in the encasements number 0 to 7 from each marginal console (on a total distance of 14,92 meters, from each end). The filling proportion of each cassette is 100%, and each flooding phase is followed by high precision topographic measurements (high precision levelling), in order to measure the reaction of the metallic superstructure to the stress. Unlike other geodetic works, where sampling methods can be used [Suba, 2015], this type of works requires specific measurements at all times. These measurements were carried out on each of the four longitudinal girders, at specific distances (based on the project and the key points of the structure), comparing the results both with the previous measurements and the envisioned data values.

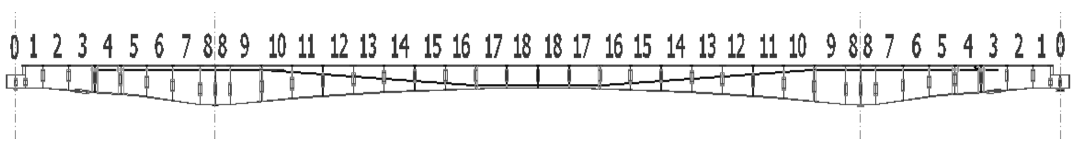

Fig. 3. Distribution of the metallic structure in 19 cassettes/encasements

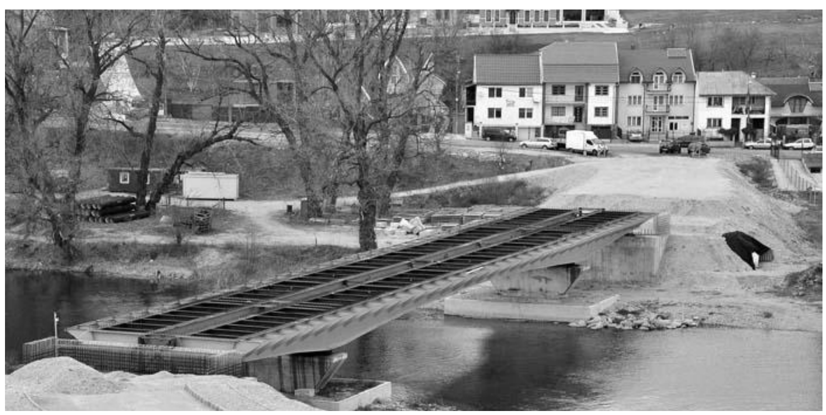

Fig. 4. Initial state of the metallic superstructure

Fig. 5. Encasements filled with reinforced concrete

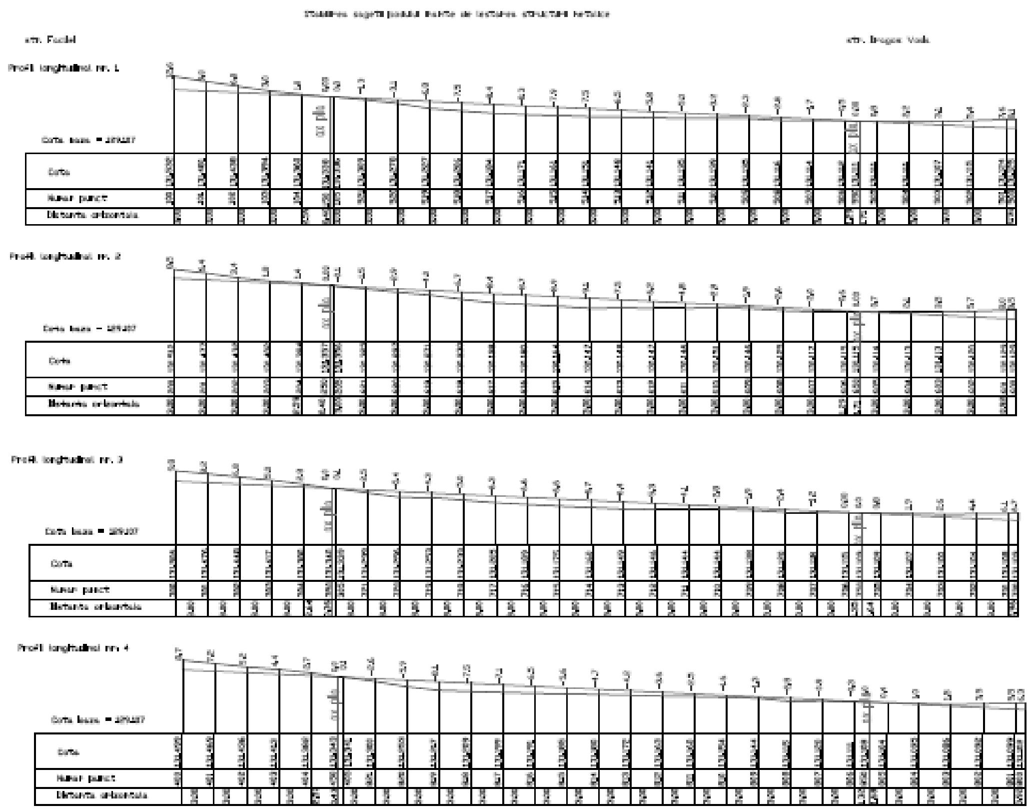

Fig. 6. Graphical and numerical representation of the measured values (one phase/all girders)

When the first phase was completed, measurements have revealed that the bridge rise was partially corrected, thus preparations began to engage the next phase. This phase is called external prestressing, and it’s used to apply compression efforts on the reinforced concrete before the load of the structure begins to apply the real efforts. These operations were carried out by a team of specialists, the prestressing cables being extended to specific values. The parameters of the prestressing used were the following:

Table 1. Prestressing parameters

Parameter	Value
Cable type	12T15.2
Elasticity module	E=200000 MPa
Characteristic compressive yield point	$f_{p(1)k}$=1670 MPa
Characteristic tensile strength	f_{pk}=1860 MPa
Cable pull force	N_p = 2697823.20 N

The prestressing procedure was carried out in 3 different phases, consisting of using 25%, 62,5% and 80% respectively, of the maximum cable pull force.

At the end of each of the prestressing phases, topographic measurements were carried out to verify the superstructure’s reaction to the stressing process. After reaching the third phase, measurements have concluded that enough stressing force has been induced in the structure in order to halt further prestressing operations and continue with the construction process. All measured values have been represented as shown in Fig. 6.

Fig. 7. The prestressing process

The last necessary activity was fitting the post-tensioned road slabs, which also affected the metallic superstructure (this stress action was taken into account when dealing with the anterior bridge rise correction phases). The laying of these slabs occurred on both ends of the bridge, which was followed by filling the central opening with concrete. The forces affecting the bridge were already minimised, to protect the slabs, which can break easily under specific forces [Bindea, 2015]

As the slabs and the concrete covered the exposed upper part of the longitudinal girders (which were used so far to measure the bridge rise modifications), we had to come up with another solution regarding the topographical measurements, in order to monitor this last major phase of the construction works. The solution was the terrestrial laser scanning method; by making precision scanning operations before and after laying the slabs and the concrete, we could measure the exact values and could add those values to the existing ones from the previous measurements.

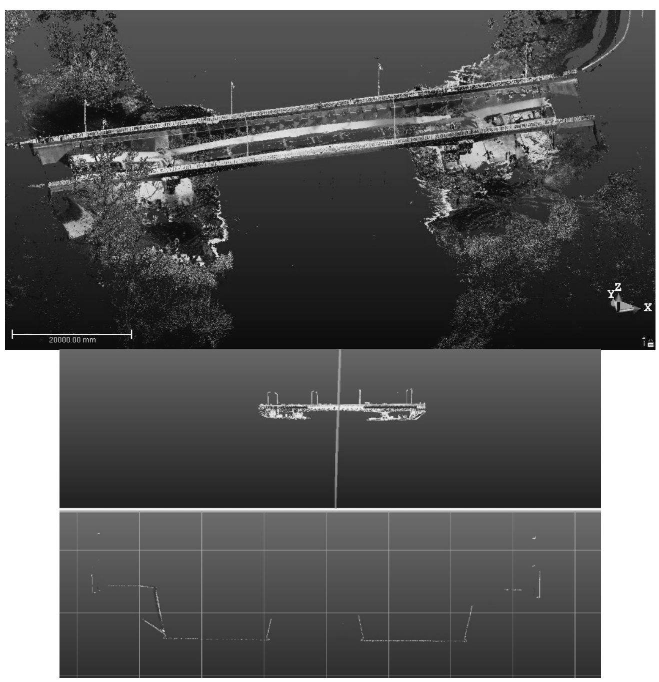

Fig. 8. Point cloud and cross-section obtained from the scanned structure

The following table will present the values obtained in each characteristic point, in each bridge rise correcting phase, for the girder 1 (downstream on the river). Represented values are in centimetres.

Table 2. Bridge rise correction values – girder 1, all points, all phases

Before ballasting	Ballasting casettes 0-1 100%	Ballasting casettes 0-7 100%	Prestressing with F=25%	Prestressing with F=62,5%	Prestressing with F=80%	Slab fitting
12.6	4.7	2.8	2.9	2.9	2.9	2.1
9	2.8	1.2	1.4	1.4	1.4	2.3
6	1.2	0.1	0.3	0.2	0.2	1.2
3	-0.5	-1	-1	-1	-1.1	1.7
1	-0.1	-0.3	-0.3	-0.3	-0.3	1.5
0	0	0	0	0	0	0
0	0	0.1	0.1	0.2	0.2	0.2
-1.3	0.4	0.8	0.8	0.9	0.9	0.3
-3.1	0	1	0.8	0.9	1	0.5
-6.8	-1.7	-0.6	-0.5	-0.3	-0.1	-0.6
-7.5	-1.5	-0.2	-0.1	0.4	0.6	0.3
-8.4	-1.3	0.1	0.4	1.1	1.4	0.9
-8.3	-0.4	1	1.3	2.3	2.6	2.1
-7.9	0.5	2.1	2.3	3.3	3.7	3.2
-7.5	1.2	2.6	2.8	3.8	4.2	3.7
-6.5	1.9	3.4	3.5	4.4	4.8	4.5
-5.8	2.3	3.6	3.7	4.5	4.9	4.9
-5	2.4	3.6	3.7	4.4	4.7	4.7
-3.2	3.2	4.2	4.2	4.8	5.1	5.2
-2.3	2.9	3.9	3.9	4.3	4.4	4.6
-2.8	1.1	1.9	1.8	2	2.1	2.3
-1.7	0.7	1.2	1.1	1.2	1.3	1.5
-0.5	0.3	0.5	0.4	0.5	0.4	0.9
0	0	0	0	0	0	0
0.8	-0.2	-0.5	-0.4	-0.4	-0.5	0
2.2	-0.3	-1	-0.9	-0.9	-1	-0.5
3.1	-1	-2.1	-1.9	-2	-2	-1.5
5.4	-0.4	-1.8	-1.7	-1.8	-1.8	-1.1
7.6	0.5	-1.5	-1.3	-1.3	-1.4	-0.7
8.1	0.4	-1.7	-1.6	-1.6	-1.7	-1

4. Conclusions

The initial value of the bridge rise was a maximum of -8,4 centimetres. By applying a series of construction methods, along with high precision topographic measurements, the same value was finally corrected to a positive 0,9 centimeters. This value is well within the tolerances given for such a structure. Construction works have continued with the laying of the pavements, the mounting of the parapets and the illumination systems, and all these works finally led to the startup of the “Mareşal Constantin Prezan” bridge in safe operating conditions.

5. References

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