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# ASSESSMENT OF THE CURRENT STATE OF THE CONCRETE STRUCTURE OF THE TRIBUNE

# OCENA BIEŻĄCEGO STANU KONSTRUKCJI BETONOWEJ TRYBUNY

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**Abstract**

*The paper is focused on diagnostics of reinforced concrete structure of the tribune of Závodisko Bratislava. The structure was realized by a combination of monolithic and prefabricated concrete elements as well as steel load-bearing elements. The complex state of the rough construction was evaluated, including the verification survey of the foundation of the construction. Non-destructive and destructive methods were used. Based on the results of the diagnostics and recalculation, it was decided to further progress the finish of the tribune.*

**Keywords:** reinforced concrete, tribune, diagnostics, non-destructive testing, destructive testing

**Streszczenie**

*Artykuł koncentruje się na diagnostyce konstrukcji żelbetowej trybuny zlokalizowanej na „Závodisko Bratysława". Konstrukcja została zrealizowana przez połączenie monolitycznych i prefabrykowanych elementów betonowych oraz stalowych elementów nośnych. Oceniono złożony stan konstrukcji, w tym badanie weryfikacyjne fundamentu konstrukcji. Zastosowano metody nieniszczące i niszczące. Na podstawie wyników diagnostyki i ponownych obliczeń zdecydowano o dalszych działaniach, aby ukończyć trybunę.*

**Słowa kluczowe:** żelbet, trybuna, diagnostyka, badania nieniszczące, badania niszczące

## 1. INTRODUCTION

Závodisko Bratislava (state-owned enterprise) in 2010 announced a public tender for the construction of the tribune of Závodisko located in the cadastral area Petržalka in the estimated value of 2.8 mil. Euro without VAT. The multifunctional tribune (SO-01 Tribune B), with dimensions 73.6 m by 22.5 m, should have four floors and covered by a trapezoidal sheeting (Fig. 1). Part of the tender was also to build a paddock, paved areas and related landscaping.

After the evaluation of the tender and the start of realization, the construction of the tribune stopped in 2012. In 2017, the University of Žilina was asked with a request to assess the current state of the unfinished tribune. After realization of diagnostics in 2018 and after recalculation of the structure, steps were proposed in terms of possible completion of the tribune (detailed results with a design of actual solutions will be published in the near future).

The paper presents the results of the realized survey and the description of the diagnostics. A detailed evaluation is given in the Inspection and Diagnostics Report [1].

## 2. DESCRIPTION OF THE TRIBUNE

The tribune was designed as a reinforced concrete skeleton with a combined steel-reinforced concrete roofing. The skeleton is reinforced concrete, partly monolithic and partly prefabricated. The object should have four floors and was designed as a

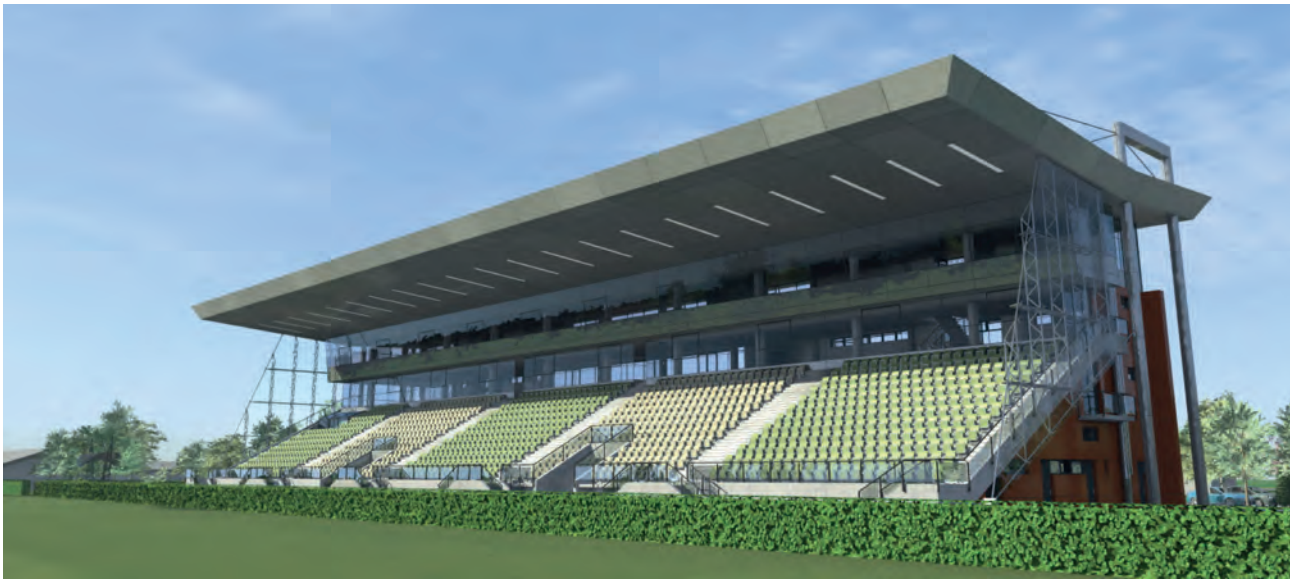

*Fig. 1. Original visualization of the planned tribune*

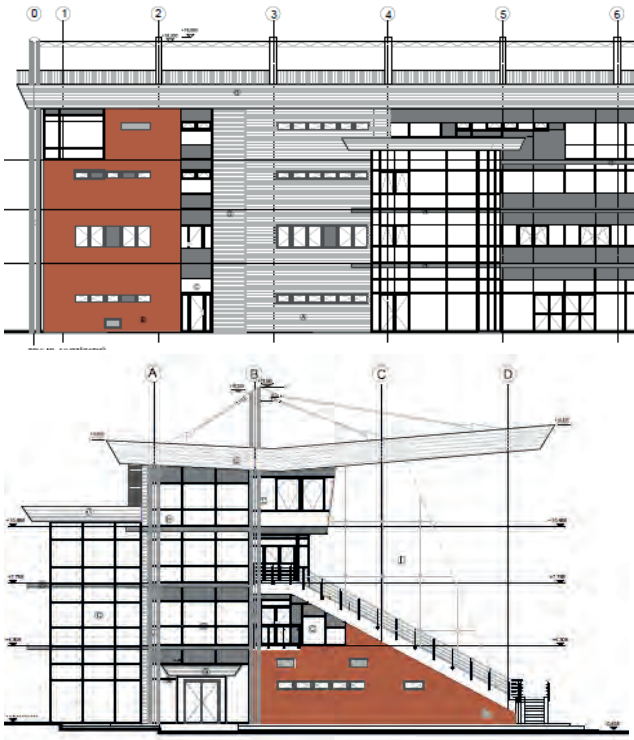


*Fig. 2. Division of tribunes into sections*

multifunctional building. The object is divided in the longitudinal direction by the axes "0" – "12" and in the transverse direction "A" - "D" (Fig. 2).

The object of tribune is based on deep foundations. The deep foundations consist of piles of diameter 600 mm, 800 mm and 1 200 mm, at depths of 4 m – 16 m. They are reinforced with reinforcement B 500B and used concrete class is C 25/30 XA2. The piles are around the perimeter in the points of columns, load-bearing perimeter walls, stiffening walls within the elevator shafts and at the points of stairs connected foundation strips. The foundation strip concrete is designed from class C 25/30 XC2. The foundation strips have the thickness of: 300 mm, 400 mm, 450 mm, 500 mm, 750 mm, 800 mm and 875 mm. The height of the foundation strips is 700 mm. The strips are connected by a base slab. The base slab of 100 mm thickness is made of C 25/30 concrete and leveling screed of concrete class C 12/15 with thickness 50 mm – 100 mm.

The prefabricated and monolithic reinforced concrete columns, tribune prefabricates, rungs and prefabricated L-shaped benches are designed within the skeleton. The axial distance of the transverse bonds between axes '2' to '10' is 7.2 m, and a span of 6.0 m is proposed at the edges between the axes '0' – '1' and '11' – '12'. The transverse bond on the storey of the first and second floors consists of monolithic and prefabricated columns, reinforced concrete slabs with a thickness of 200 mm, and inclined prefabricated tribune beams. On the axes "0" to "12" leeward steel walls are designed.

## 3. DIAGNOSTICS OF THE TRIBUNE

The subject of diagnostics was the object under construction of the Závodisko tribune. At the time of assessment, only two overground floors of the load-bearing structure of the tribune were built (Fig. 3).

*Fig. 3. View of part of the tribune under construction (January 2018)*

After the building was preserved in February 2012, the object partially under construction dilapidated and until today the building is not completed.

As a part of the comprehensive diagnostics [2-8] the following was carried out:

- visual inspection of the whole object,
- checking the dimensions of some load-bearing elements,
- checking the construction of reinforced concrete monolithic and prefabricated structures, steel structures, column anchors and some details,
- indicative measurement of deflections of ceiling slabs,
- measurement of the inclination of some columns,
- passport of defects and deficiencies in terms of construction realization,
- determination of concrete strength in a non-destructive and destructive way,
- scanning of reinforcement in reinforced concrete elements - slabs, walls, columns (prefabricated and monolithic), floor beams,
- uncovering of reinforcement in some load-bearing reinforced concrete elements,
- evaluation of status of uncovered reinforcement and check of cross-sectional characteristics of reinforcement,
- carbonation of concrete (using phenolphthalein),
- checking the bulk density of lightweight concrete,
- verification survey of the foundation of the building.

Construction diagnostics showed some differences between the actual realization and the original project documentation. As part of the diagnostics, several control core boreholes were carried out on the slabs and walls (Fig. 4).

*Fig. 4. Core borehole in the slab (2nd floor)*

One sample was also taken from the base slab, whose thickness was approximately 100 mm. One layer of reinforcement with 8 mm diameter, at distance 100 mm (in both directions) was directly at the bottom edge of the base slab. The second layer of reinforcement was just below the base slab, i.e. the reinforcement in the base slab was almost without cover. Cracks on the base slab were recorded in the range of 0.5 mm to 2.0 mm.

Scanning of the slab reinforcement was carried out linear and areal in several places. Each scan position showed the actual reinforcement placement and the cover that matched the original project. The originally

designed profile and the type of reinforcement were also confirmed by destructive probes. By the reinforced concrete walls were found to be denser reinforcement but a smaller reinforcement profile compared to the original project. The difference in cross-sectional area between these different reinforcement is approximately 4.0%. The reinforcement of the monolithic and prefabricated columns was checked in a non-destructive way – by scanning the reinforcement with a scanner and destructively by exposing the reinforcement directly. Both for the slabs and for the verified columns, in reinforcement the conformity was confirmed with the original project.

Detailed chemical analysis (e.g. profiles of the pH distribution of concrete pore liquid on the thickness of the cover) was not carried out.

## 4. THE CURRENT STATE OF THE TRIBUNE AND CONCEPT PROPOSALS FOR COMPLETION

During the inspection, a statically unsuitable solution of openings in the perimeter walls was found (Fig. 5). In this part of the wall there is a ceiling slab and the load-bearing wall is insufficiently supported at one end. It was recommended to statically strengthen this wall.

*Fig. 5. Incorrectly static distribution of holes in the load-bearing wall*

At the same time, it was recommended to concreting the doorway at the "C" axis, by adding the steel inter-window pillars to hold this wall at the place of window and between the existing doorways. Another possibility was to demolish the wall, whereby the existing ceiling slab has to be sufficiently temporarily supported and a new one have to be concreted with another statically suitable arrangement of the openings.

The realized load-bearing walls are in contradiction with the original project documentation. It was recommended to demolish the lintel (Fig. 6) and to concrete a new one, or to use another suitable method of repair.

*Fig. 6. Part of monolithic lintel with missing cover*

In Figure 6 is showed the removed side cover layer of monolithic lintel. Probably the layer was removed due to inaccurate realization and the original cover interfered with the prefabricated elements that were to be placed at this location.

Cracks in the width of 0.1 mm to 0.2 mm were present on the tribune beams (Fig. 7). Cracks occurred on the beams on both floors.

*Fig. 7. Cracks on the tribune beam on the 2nd floor*

The anchoring (Fig. 8) of reinforced concrete prefabricated columns with dimensions of 300 mm by 500 mm had to be checked on all columns. It was recommended to dismantle the steel frame along the perimeter and to properly inspect, clean and repair

the frame. During the diagnostics, an interruption of the anchorage reinforcement was detected in some places.

*Fig. 8. Detail of incorrect anchoring of columns*

## 5. CONCLUSIONS

The results of the diagnostics show that the unfinished load-bearing structure of the tribune is poorly realized in some parts. Insufficient quality of realization was visible on some of the load-bearings elements and it leads to the following conclusions: In several places of the load-bearings elements of the structure (walls, staircases, floor beams and columns) the concrete was not sufficiently compacted. In some places the reinforcement was uncovered or the reinforcement cover was not observed. At the joints of the load-bearing elements, whether prefabricated - monolith or monolith - monolith, the filling of the joints with PUR foam was seen. Poorly concreted inter-window pillars in several places had to be repaired. Since their dimension in terms of bearing capacity is insufficient, they cannot be considered as load-bearing elements. Poor arrangement of load-bearing elements due to window and door openings. The anchoring of the rectangular columns to the foundation structures was incorrectly realized. At the time of diagnostics, the steel anchor parts were affected by surface corrosion. In some places, the cavities were under the steel anchoring elements, which is unacceptable for column anchorage. The inner circular reinforced concrete columns were not concreted exactly in the vertical position. For this reason, it was recommended to repair them, respectively strengthen them [9, 10]. Repair of columns is necessary not only because of geometric inaccuracy due to faulty realization, but also because of static resistance of these columns.

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