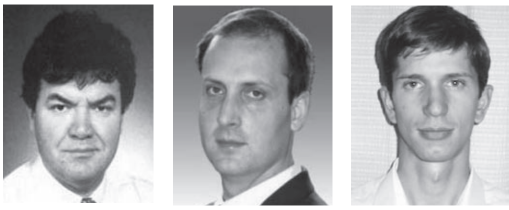
RENOVATION OF A NATIONAL MONUMENT IN HUNGARY: THE KEREPESI GRANDSTAND



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The racecourse "Kerepesi Ügető" in Budapest was closed in year 2000 and all of its buildings were demolished except the Class II Grandstand which was earlier declared as a National Monument. Our task was on the one hand to perform the comprehensive statical investigation of this Grandstand and on the other hand the development of the methodology for structural strengthening. Investigations included in-situ measurements, laboratory material tests and finite element analysis of the structure. According to the results of statical calculations, the method of strengthening was proposed, which included the injection of cracks, integration of new structural elements, application of concrete jacketing and bonded CFRP sheets. The applied strengthening and renovation method extended the life-span of the Grandstand with 50 years.

Keywords: renovation; strengthening; urban heritage; grandstand; reinforced concrete; CFRP sheet; concrete jacketing

1. INTRODUCTION

The building-complex of the racecourse "Kerepesi Ügető" in Budapest included several reinforced concrete grandstands of different classes to be used by the audience. The racecourse was closed in the year 2000 and the land was sold to investors who utilized the ground for the construction of the second largest shopping centre and amusing complex in Europe. All of the buildings of the racecourse were demolished except the Class II Grandstand (*Fig. 1*) which had to be protected since it was declared as a national monument. Our tasks were to perform a complete statical investigation for this Class II Grandstand and to develop the strengthening and renovation method of the structure. An important objective of the work was to ensure the seamless integration of the old Grandstand and the surrounding urban environment including the complex of the new shopping centre (Bódi, Koris, Erdődi; 2002). The life-span of the Grandstand was extended by 50 years and the function of the structure was renewed by the applied renovation method.

2. HISTORICAL AND STRUCTURAL BACKGROUND

The building-complex of the racecourse including the Class II Grandstand was built between 1935 and 1941 according to the original plans (*Fig. 2*) of the architect Ferenc Paulheim Jr.

Fig. 1: The Class II Grandstand before renovation

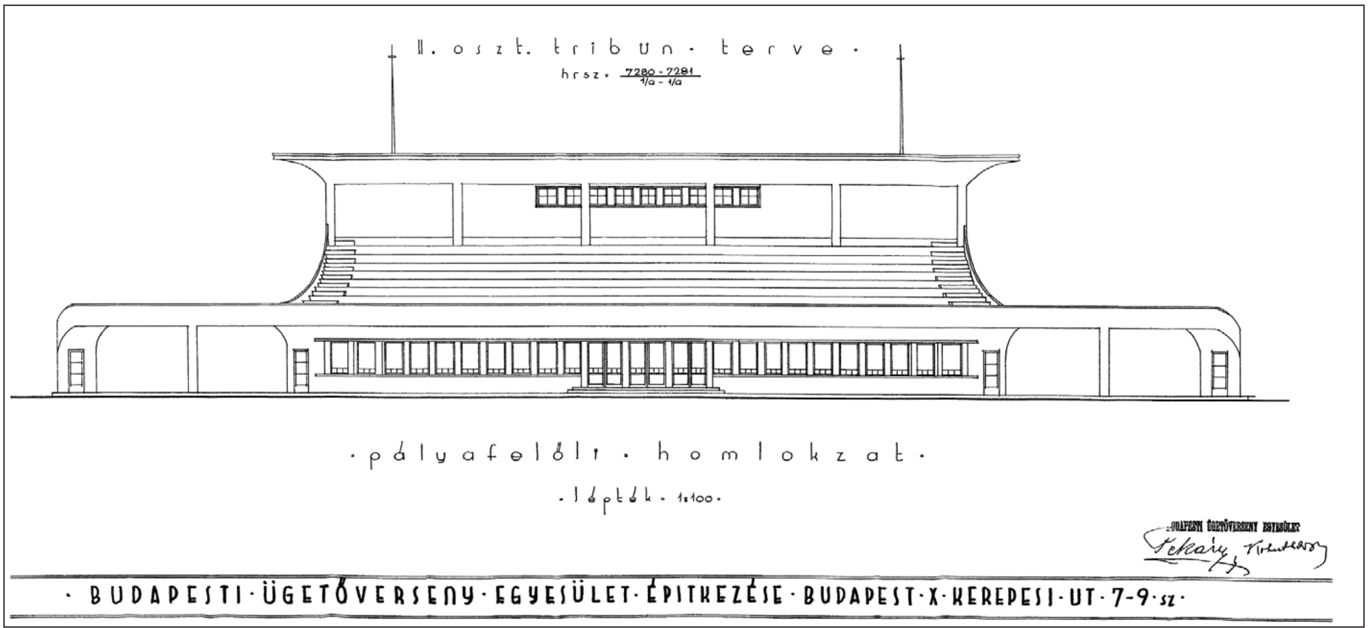

Fig. 2: Front elevation of the Class II. Grandstand on the original plan from 1935

(Paulheim, 1935). Statical calculations and structural drawings were produced by Vilmos Obrist civil engineer (Obrist, 1936) in 1936. The Class II Grandstand was built on the basis of the original plans with minor changes in the construction. The structure was not modified or strengthened during the next 66 years, it remained intact even during the World War II.

The superstructure of the Class II Grandstand consists of monolithic reinforced concrete frames connected with crossway beams supporting the concrete slabs (Obrist, 1936). The roof is a ribbed concrete slab structure supported by cantilever beams of the frame. Equilibrium of the cantilever roof beams are ensured by concrete columns under tension. The reinforced concrete columns have pillar foundations. The two-storey Grandstand has curved concrete stairs leading to the second floor.

3. PERFORMED INVESTIGATIONS

3.1 Investigations on site

The Grandstand was investigated altogether six times in 2002. Physical conditions of the building were recorded by visual inspection and the amount and types of structural damages were also registered. Concrete core samples were bored at seven different locations and these samples were tested later in the laboratory. Structural uncovering was performed at several locations to identify the reinforcement. A Proceq Scanlog profometer was also used for the same purpose at different locations of the building. The strength of reinforcing steel was examined by Poldi hardness tester. Some results of the investigations by Poldi hardness tester are presented in Table 1. Non-destructive concrete strength tests were also performed by N-type Schmidt hammer in 49 different points of the structure. Results of non-destructive concrete strength tests were corrected by the laboratory test results.

During the in-situ investigations, no visible sign of major damage or overloading of the load carrying structural members was detected (Bódi, Koris, Erdődi; 2002). However, cracks were spotted at the connections of the outside columns and cantilever beams. These cracks were mainly caused by tensile forces in the columns and the cantilever beams. Some cracks caused by shrinkage of the concrete were also detected in the secondary structures such as concrete barriers and banisters. Significant corrosion of reinforcing steel bars and the lack of concrete cover were observed on the outdoor structural members including columns, beams and slabs (*Fig. 3*). These problems were mainly caused by inappropriate waterproofing. No sign of surface corrosion or decrease of bond between steel

Table 1: Results of in-situ investigations by Poldi hardness tester

Number	Place of investigation	Impression [mm]		Strength [Mp/in^2]		Design value of strength [N/mm^2]	Remarks
		Rebar	Comparison metal	Measured values	Mean value		
1	*Column*	3.70	3.00	22.2	21.8	225	Ø = 24 mm (plain)
2		4.00	3.20	21.5			
3		4.05	3.25	21.6			
4	*Beam*	2.95	2.50	25.7	22.3	230	Ø = 16 mm (plain)
5		3.25	2.60	21.1			
6		3.25	2.55	20.05			

Fig. 3: Spalling of concrete cover and corrosion of steel bars at different structural elements

bars and concrete was detected during the uncovering in case of undamaged beams and columns.

3.2 Laboratory tests

Cylinder shaped concrete specimens were prepared from the core samples bored on site for the purposes of destructive testing. The diameter of the specimens was 63 or 73 mm (according to the inner diameter of the drill head used on site) and the height of the cylinders varied between 98 and 141 mm. Uniaxial compression tests were carried out on the concrete specimens in the Structural Laboratory of Budapest University of Technology and Economics (*Fig. 4*). Test results were evaluated according to the Hungarian Standard MSZ 4720 for different structural parts (beams, columns, slabs, balustrades) so we achieved the characteristic values of concrete strength for different structural members separately (Bódi – Koris – Erdődi, 2002). Deviation of the concrete strength in case of some columns was significantly higher than expected. It turned out that there were originally chimneys inside these columns. The impact of the high temperature gases streaming inside these chimneys resulted in significant decrease of the local concrete strength. Concrete strength was also evaluated by in-situ non-destructive tests based on the hardness of the concrete surface. Results of the compression tests were used for the calibration of the non-destructive in-situ test results. Strength of the smooth steel bars was determined by in-situ investigation using Poldi hardness tester (Bódi, Koris, Erdődi; 2002). The value of steel strength was around 210 N/mm^2. Tensile test was performed in the laboratory on some steel bars taken from the Grandstand during the investigation on site. Results of the tensile tests were used for the refinement of the in-situ test results.

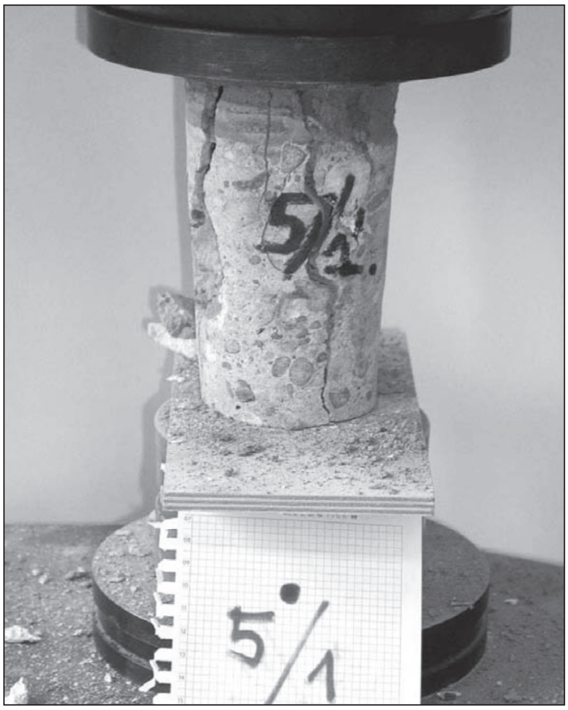

Fig. 4: Uniaxial compression test of a concrete cylinder specimen

3.3 Statical calculations

The design values of internal forces were derived by finite element analysis (Bódi, Koris, Erdődi; 2002). The Axis VM 6.0 software package was used to prepare the finite element model (*Fig. 5*) of the Grandstand's characteristic segment. Geometrical sizes measured on site and material properties derived from in-situ and laboratory tests were used during the calculations. The actions were calculated according to the European Standard "MSZ ENV 1991 Eurocode 1: Basis of design and Actions on Structures". The possible action groups as well as local effects – such as snow trap load or concentrated

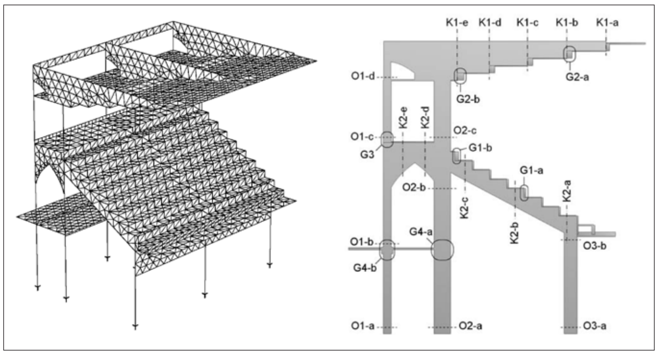

Fig. 5: Finite element model of the Grandstand and the locations of the controlled cross-sections

service load – were considered during the analysis. A simplified calculation method was also used to verify the results of the finite element simulation.

The typical cross sections were controlled by using the Standard MSZ ENV 1992-1-1 Eurocode 2: "Design of Concrete Structures. General rules and rules for buildings". Investigations were performed in 26 different cross sections. Beam sections were examined for bending and shear with or without simultaneous axial force (depending on the location of the beam). Column sections were examined for eccentric compression or tension. Deflection of the structure was also evaluated and controlled. Local values of concrete and reinforcing steel strengths derived from in-situ and laboratory tests were used for the calculation. The geometrical data (including the amount of reinforcing steel) of different cross sections were taken from structural investigations on site and original plans as well. Most of the controlled cross sections fulfilled the requirements of the Eurocode Standard; however, the load carrying capacity was insufficient in some places. The tensioned columns outside the roof that provide anchorage to the cantilever beams were practically in ultimate limit state. The load carrying capacity of the 6 cm thick stepped concrete slab was satisfactory in case of distributed loads but it was insufficient in case of concentrated live load (Q = 1.5 kN as demanded by Eurocode 1). Load carrying capacity of the

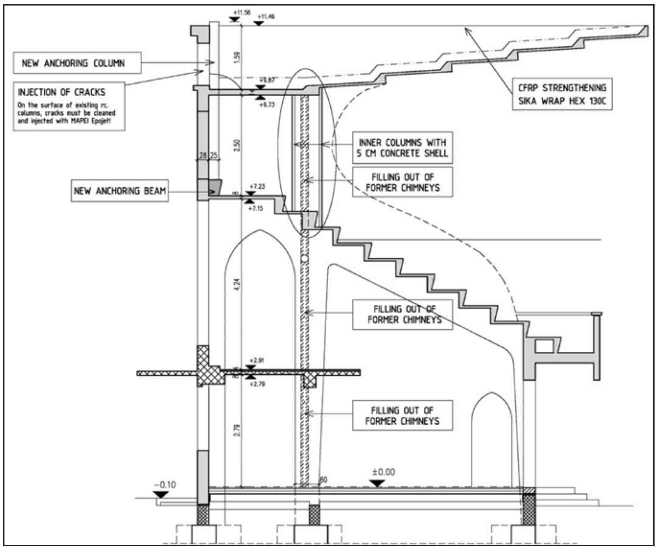

Fig. 6: Strengthening plan of cantilever structure (CAEC Kft, 2003)

longitudinal beams on the first floor, as well as the resistance of the front column under the first floor, was insufficient. Due to these problems the strengthening of the Grandstand had to be performed.

4. STRENGTHENING OF THE GRANDSTAND

Results of the complete statical investigation were used to plan the methodology for the necessary strengthening that could extend the life-span of the Grandstand with additional 50 years (Bódi, Koris, Almási; 2008). No major damage of the reinforced concrete structure was found; however, the resistance of some cross-sections did not fulfil the requirements of the Eurocode Standard; therefore, the following actions were implemented (Almási, Varvasovszky, Juhász; 2003).

To provide the necessary anchorage for the cantilever roof beams, new anchoring columns were manufactured (*Fig. 6*). A new anchorage beam was also applied above the second

Fig. 7: Strengthening of the cantilever structure: a) New suspension column; b) Injection of cracks; c) CFRP sheets

Fig. 8: The Class II Grandstand after complete renovation

level to withstand the additional tensile forces. Cantilever beams on the roof were strengthened by bonded CFRP sheets (*Fig. 7*) to provide the necessary load bearing capacity (Sika Hungária, 1999). Cracks in the concrete structure were cleaned and injected with MAPEI Epojet resin before strengthening (*Fig. 7*). The concrete strength in the upper section of middle columns was insufficient therefore these columns were also strengthened by 50 mm concrete jacketing (*Fig. 6*). Former chimneys were cleaned with water jet and the holes were filled with concrete of C20-8/K quality. The stepped concrete slab was originally built with a thickness of 60 mm and the applied reinforcing steel inside the slab was only Ø5/120 mm. Due to these reasons the resistance of the slab is insufficient against concentrated live load. A force distribution layer was applied on this slab to provide the necessary resistance against concentrated loads. Shrinkage cracks were observed in the secondary concrete structures, such as curved stairs, concrete barriers and banisters. These cracks were again cleaned and injected with MAPEI Epojet resin to avoid further corrosion problems.

Strengthening of the reinforced concrete structural parts was followed by complete restoration of the Grandstand including isolation of the roof, facing of walls and columns and tiling of floors and stairs, decorative lighting, etc. (*Fig. 8*).

5. CONCLUSIONS

Most of the buildings of the former racecourse in Budapest were demolished to enable the construction of a new shopping centre. The building of the Class II Grandstand was declared as a national monument so it was preserved and integrated into the new building complex. A complete statical investigation of the Grandstand was carried out including measurements on site, laboratory tests and computer analysis. The strengthening of the building was designed and performed in view of the results of the previous investigations. The complex strengthening and careful renovation (*Fig. 8*) restored the original structural conditions, extended the life-span of the building with 50 years and ensured the integration of the 70-year-old Grandstand and the surrounding urban environment.

6. REFERENCES

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