Durability assessment of prestressed concrete buildings in Bucharest

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Summary

During the period 1995 - 1997, the Building Research Institute - INCERC Bucharest worked out several studies having the object of the inspection and diagnosis of prestressed concrete structure durability for ten cinema buildings, radio concert hall and circus hall. The main aim of this studies consisted in the assessment of the prestressed concrete structural members built more than 30 years ago (1959 - 1969) and to identify the deterioration phenomena with the effect on durability.

1. Inspected Buildings

1.1 Cinemas

The inspection was applied on six cinemas of 800-900 seats capacity, designed and constructed in 1961-1963. The roof of these cinemas was conceived in composite cast in place vertical box grid (honey comb) with upper (partial precast) and lower slabs. The prestress was applied in two or three directions. Other group of four inspected cinemas of 500-900 seats capacity and built in 1963-1969 were conceived with the roof structure composed of prestressed concrete beams placed in one direction.

1.2 Radio Concert Hall

The roof of the Radio Concert Hall with a plan trapezium shape and transverse dimensions 17.4 to 38.0 m / 44.85 m long was built in 1957-1958. Roof structure was conceived in 7 reinforced concrete archs with prestressed ties. Upper side of the roof is composed by slabs and longitudinal beams supported by the archs through variable reinforced concrete bars.

1.3 Circus in Bucharest

The main circus hall built in 1959-1961 was covered by waved cupola of 60.6 m diameter and 13.5 m height, composed by 16 double curved waves, supported on 16 contour columns and prestressed polygonal ring.

2. Inspection Results

2.1 Cinemas

Inspection of the structural members of the ten cinemas roofs was restricted by the impossibility to observe all details subject of potential deterioration.

Results of the experimental tests on concrete
Experimental in situ tests shown a compact concrete cover, with carbonation depth of 2-4 mm. Other experimental tests performed on concrete cub samples provided from the same concrete during construction shown a porosity value of 4.6-5.5% and water absorbtion of 1.51-1.86% with a good bond matrix – aggregate, in each case failure taking place in aggregate. Also carbonation depth was of 3-7 mm on these samples, with a pH value of 12.
Results of the experimental tests on reinforcements
The width of concrete cover corresponds to the environmental conditions, except some isolated zones placed on lateral faces of beams where on limited areas the passive reinforcement bars appears visible at surface and having superficial corrosion. All other tests shown a good protection of reinforcement (no corrosion) by a compact and alkaline concrete cover.

2.2 Radio Concert Hall

Experimental tests on the ties, including inspection on the state of cracking, destructive tests on concrete cover and metal sheath until the post-tensioned wires, test on alkalinity, non-destructive tests on concrete strenght, shown: a depth of carbonated concrete cover not exceed 5 mm, existing cracks on the one tie only were caused either by shrinkage or more likely by technological procedures and have the width of max. 0.2 mm. The destructive tests on concrete cover until the post-tensioned wires shown clean wires covered by compact and alkaline cement grout placed in metal sheath with no traces of corrosion

2.3 Circus Hall

As well as in the case of cinema roofs presented above, the inspection of Circus roof structure and especially of the reinforced concrete cupola from bellow was hindered by false ceiling.
Results of the experimental tests on concrete
The depth of carbonated concrete cover not exceed 2-3 mm.
The concrete appears as compact and there are no segregations.
The existing cracks placed at the inner side of the main reinforced concrete cupola are old, inactive and have the width of max. 0.2-0.3 mm.
Results of the experimental tests on reinforcements
The examinations made at the inner side of the main cupola shown that there are no visible reinforcements and traces of corrosion.
The destructive tests on concrete cover shown clean reinforcements covered by compact and alkaline concrete.
The observations on the aspect of exterior surfaces of the joints (the zones for anchorages of post-tensioned tendons) of prestressed ring did not shown degradation phenomenons (cracks, traces of corrosion).

Conclusions

The investigations regarding durability of some cultural prestressed concrete buildings shown the necessary and the importance of extended (in-depth) inspections which are the same time more difficult due to the presence of false ceiling, finishes and exterior isolation.
Only when a complete access to all elements susceptible to corrosion is available, it is possible the correct diagnosis of damage causes and to allow the application of measures for reducing / elimination of these causes and repair / strenghtening. So it is important to plan an inspection during the repair period of ceiling, finishes or exterior isolation.
One of the main requirement for new buildings, regarding their durability, is to provide, in the design stage, the access to structural members and their joints if they are susceptible to suffer deterioration in time.
Also, it is necessary to provide periodical inspections to be perfomed by a specialist in the behaviour of the prestressed concrete structures.