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## 2. Enlargement of the Communal Stadium of Bologna (Italy)

<b>Owner:</b>	<i>Comune di Bologna</i>
<b>Designers:</b>	<i>Piero Pozzati, Enzo Zacchirolì, Franco Zarri</i>
<b>Contractors:</b>	<i>Consorzio Cooperative Costruzioni di Bologna</i>
<b>Works duration:</b>	<i>30 months</i>
<b>Service date:</b>	<i>1990</i>

### General

The Dall'Ara stadium of Bologna, built in 1926 from the design of the engineer Costanzini, provided a seating capacity of approximately 29 000, distributed on 21 tiers, supported by reinforced concrete frames (fig. 3) arranged in radial planes with a median distance between centres of 5.50 m; a high continuous brick wall encircled all the structures.

In the centre of one of the two longer sides of the oval there was a tall construction, also in brick (fig. 1), where the main entrance was situated. The football ground was also equipped with gymnasiums and six lanes for running competitions.

The seating capacity has been increased to 43 000 and stairways and spaces have been provided according to current security regulations. For a section of the terraces about 200 m long opposite the tower, a cantilever roof has been constructed with an overhang of 25 m, with no obstruction to visibility.

The enlargement has been achieved by extending the terraces both upwards, by 12 tiers, and downwards by another 3 tiers; the new upper level has been gradually lowered in the proximity of the tower, which has therefore retained its original prominence.

The existing construction has been left intact apart from the necessary restoration work. The structures bearing the new tiers in the upper part repeat the existing scheme: that is, they consist of metal frames coplanar with the existing ones of reinforced concrete (fig. 3). The tiers, instead, have been prefabricated and, with a special technique, strengthened in situ both in the longitudinal and the transverse directions.

Clearly the use of the load-bearing steel structures, indispensable for the new cantilever roof, also correspond with the intention of leaving in view as much as possible of the original stadium which has been declared a national monument.

### Description

The space available around the old stadium was limited by the presence of the swimming-pool building; therefore it has been necessary to extend the upper girders of the framework so that they project outward above all in the structural relation to the cantilever roof (fig. 2).

The load-bearing girders of the overhanging roof are of the cantilever type; that is, being hinged on the external pillars of the frames, on one side they display the aforementioned overhang of 25 m and on the other they extend for 5 m, with the ends restrained by connecting-rods consisting of pairs of bars of circular section. The dimensioning has been done so as to restrict the maximum vertical displacement to not more than 1/100 of the overhang length.

The core of the girders of the projecting roof, made of double T section, greatly increases in height in proximity to the hinge on the pillars (fig. 4), in such a way as to present a configuration able to receive and to spread the high vertical reaction of the restraint; meanwhile the danger of buckling is overcome by a lattice of slender stiffening ribs.

Every pair of connecting rods at the external extremity of every girder is fixed to the overhang of the two underlying planes by an inclined, stretched rod, confluent, in correspondence to the first plane, with the external pillar which has a hollow rectangular section.

The metal frames are connected to the top of the existing reinforced concrete frames to counteract the horizontal movement of point «A» (fig. 3) which, if it was left free, would create greatly increased deformation, and in particular a notable increase in the maximum movement for the cantilever roof's girders.

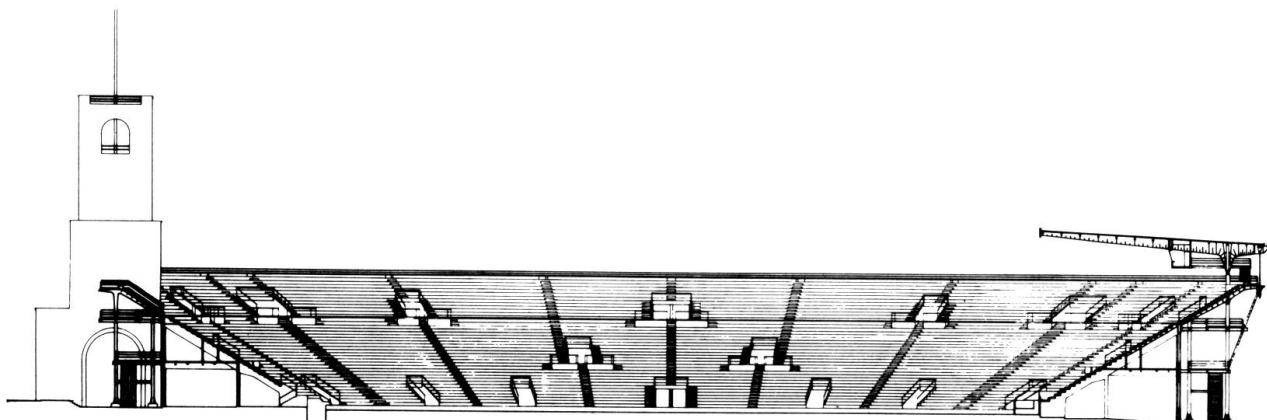


Fig. 2: Transverse section of the completed stadium



Fig. 1: Aerial view of the completed stadium

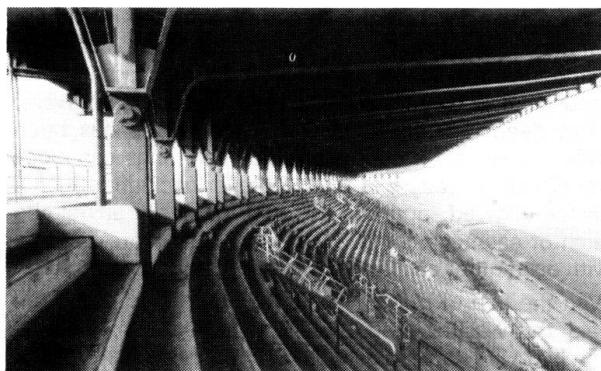


Fig. 4: View of the covered stand

Obviously, it has also been necessary to check the existing structures subject to supplementary horizontal action; the horizontal movements of the nodes of the reinforced concrete frames have been made negligible by reinforcing the short pillars that surround the pitch with a vertical wall.

The foundation of every new frame of the cantilever roof is composed of two plinths securely connected to and supported by four foundation piles, intended to limit as much as possible the relative movements between the old and new parts of the construction.

(P. Pozzati, E. Zucchinioli, F. Zarri)

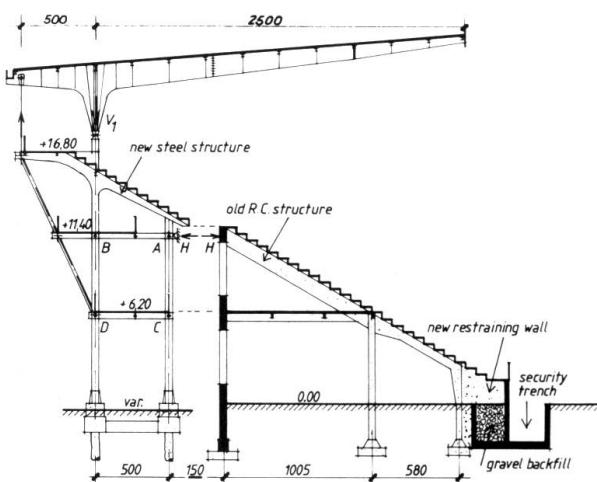


Fig. 3: Static scheme