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The grandstand at Doncaster racecourse

Shell roof of precast prestressd lightweight-aggregate concrete

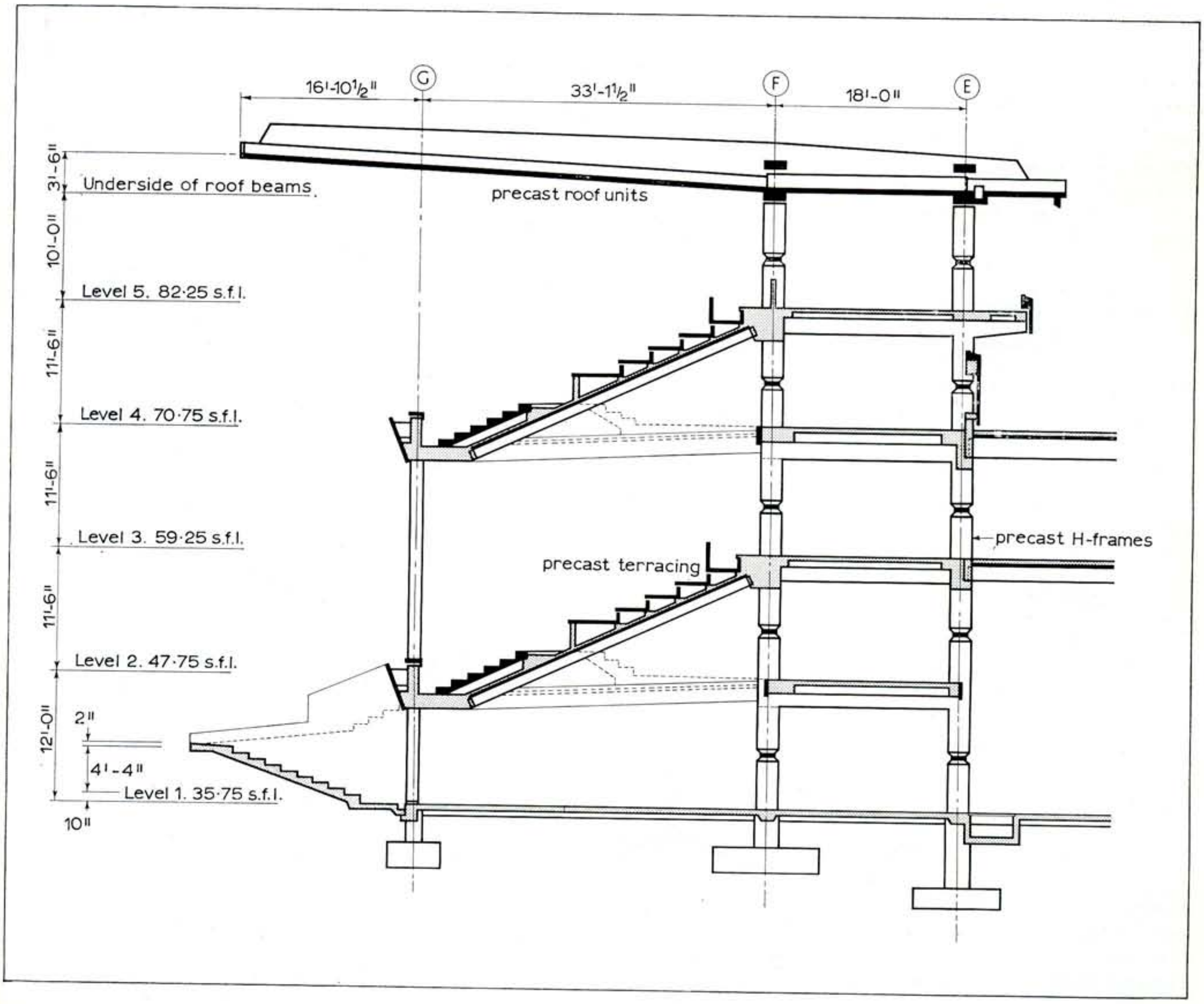
Firms and organizations
Client: Doncaster Corporation
Consulting engineer: Jan Bobrowski and Partners
Architect: Howard V. Lobb and Partners
General contractor: John Laing Construction Ltd
Precast concrete suppliers: Dow-Mac Concrete Ltd and Portcrete Ltd

Figure 1 (top right). Columns and roof units.
Figure 2 (below) The main structure.

IN 1966 a modernization plan for Doncaster racecourse was prepared. Racing is held at Doncaster on only 24 days per year, so the architects' brief envisaged maximum use of the buildings for other functions.

The new stand, which replaces all the stands previously situated in the grandstand and paddock enclosures, is angled at about 18° to the course, and has clear sightlines from two storeys of stepped terraces. It has a betting hall, with up to 90 bookmakers in attendance, some 40,000 ft^2 in area, separate members and Tattersalls enclosures, associated bars, restaurants, and tote facilities. An adjoining block houses administrative offices. The grandstand accommodates between 10,000 and 13,000 spectators in the two enclosures, of whom 30% are seated.

Precast concrete was selected for several reasons. Firstly, it was necessary for the stand to be completed between successive St. Leger meetings, thus leaving only ten months for demolishing and reconstructing the stand, and relaying the turfed areas. Construction had to be carried out without interfering with race meetings, and the main part of



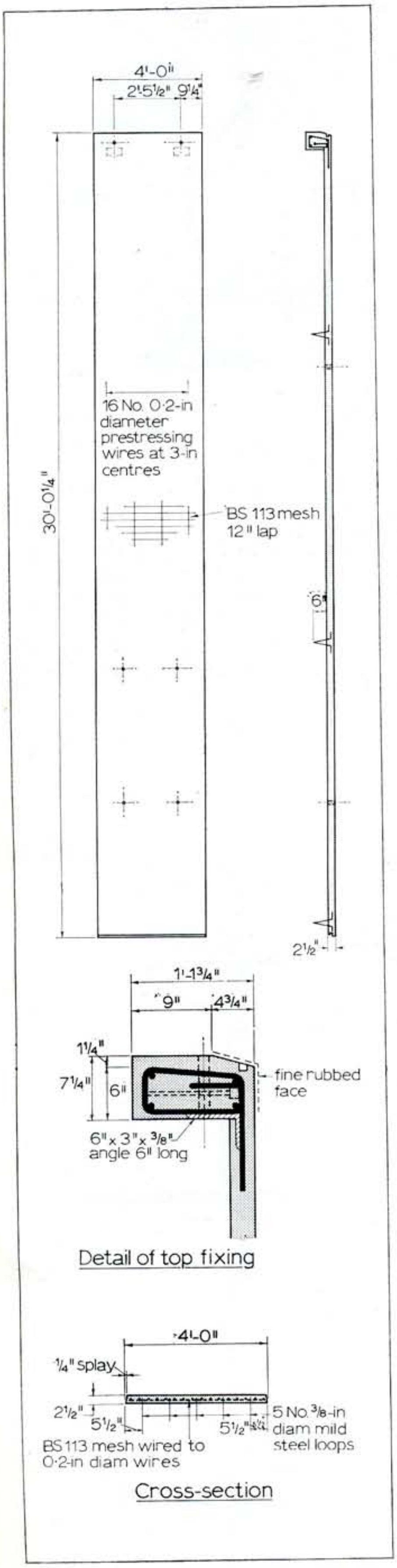


Table Data for Doncaster grandstand

Plan dimensions:	400 ft × 200 ft
Floor area:	150,000 ft²
Details of concrete—	
For precast H-frame components:	
specified 28-day cube strength	7,500 lb/in²
For prestressed precast flooring components:	
specified cube strength at release:	7,500 lb/in²
specified 28-day cube strength:	9,000 lb/in²
For prestressed precast lightweight concrete roof units:	
mix proportions:	1:0·6:1·3 of white cement; clean sharp sand; single-sized Lytag aggregate
water : cement ratio:	0·43
density:	117½ lb/ft³
average crushing strength at 7 days:	6,000 lb/in²
average crushing strength at 28 days:	7,600 lb/in²

the work had to be undertaken during the winter. In addition, concrete provides a high standard of finish, thus reducing maintenance and eliminating applied surface treatments or external painting. The adoption of precast construction also permitted competitive quotations for the structural components to be obtained and orders placed prior to the appointment of the main contractor, Work was thus able to start immediately following the 1968 St. Leger meeting; those tendering consulted the nominated suppliers and subcontractors when drawing up a programme of work. Each contractor was required to submit with his tender, a critical-path programme based on dates of delivery of precast components and escalators, which were also ordered in advance.

The structure consists of two sections of different construction; a front five-storey section forming the main stand, and a rear section of three storeys housing the betting halls at ground level, with snack bar and restaurant above. The main structure of the five-storey section supporting the roof (*Figure 2*) is formed of precast H-frames in white-cement concrete, each frame consisting of two 24-in by 15-in columns connected by an 18-in by 15-in cross member. Steel shoes with locating dowels are welded to the main reinforcement at the ends of each column. For each complete structural frame the components were cast in a single mould assembled flat on the floor to ensure exact alignment between the shoes of adjacent frames.

The floors between the H-frames are of standard precast twin-core planks 8 in in thickness and 30 in wide. Elsewhere in this section, the floors are of 8-ft-wide double-T components, having ribs at 4 ft centres. For the sloping structure forming the viewing terraces these components are 16 in deep, span 33 ft, and are prestressed with four ½-in Dyform strands. Two 1⅛-in-diameter high-tensile bars are also provided near the bottom of the ribs, projecting beyond

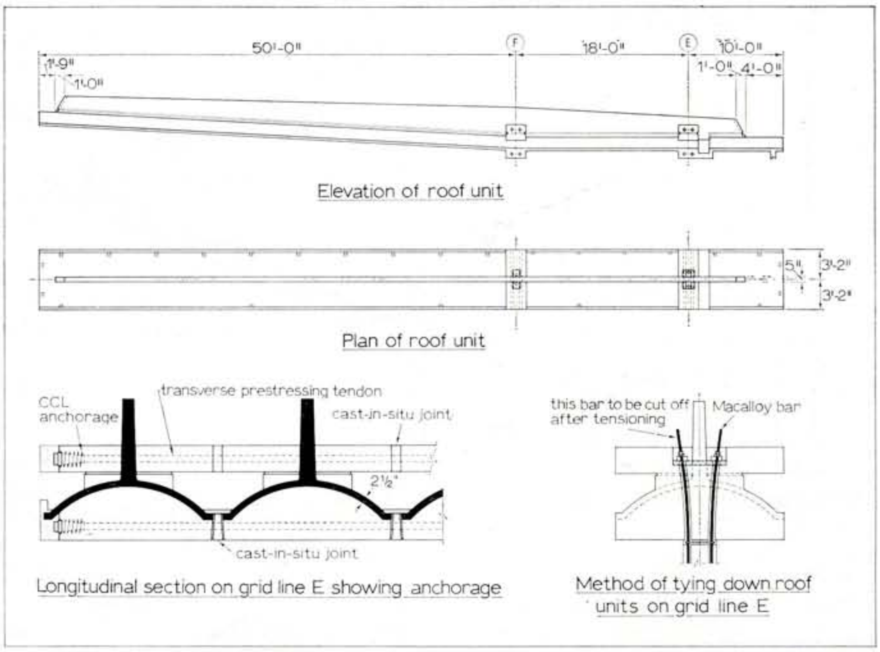


Figure 3 (above) Typical external cladding panel.

Figure 4 (right) Details of roof units.

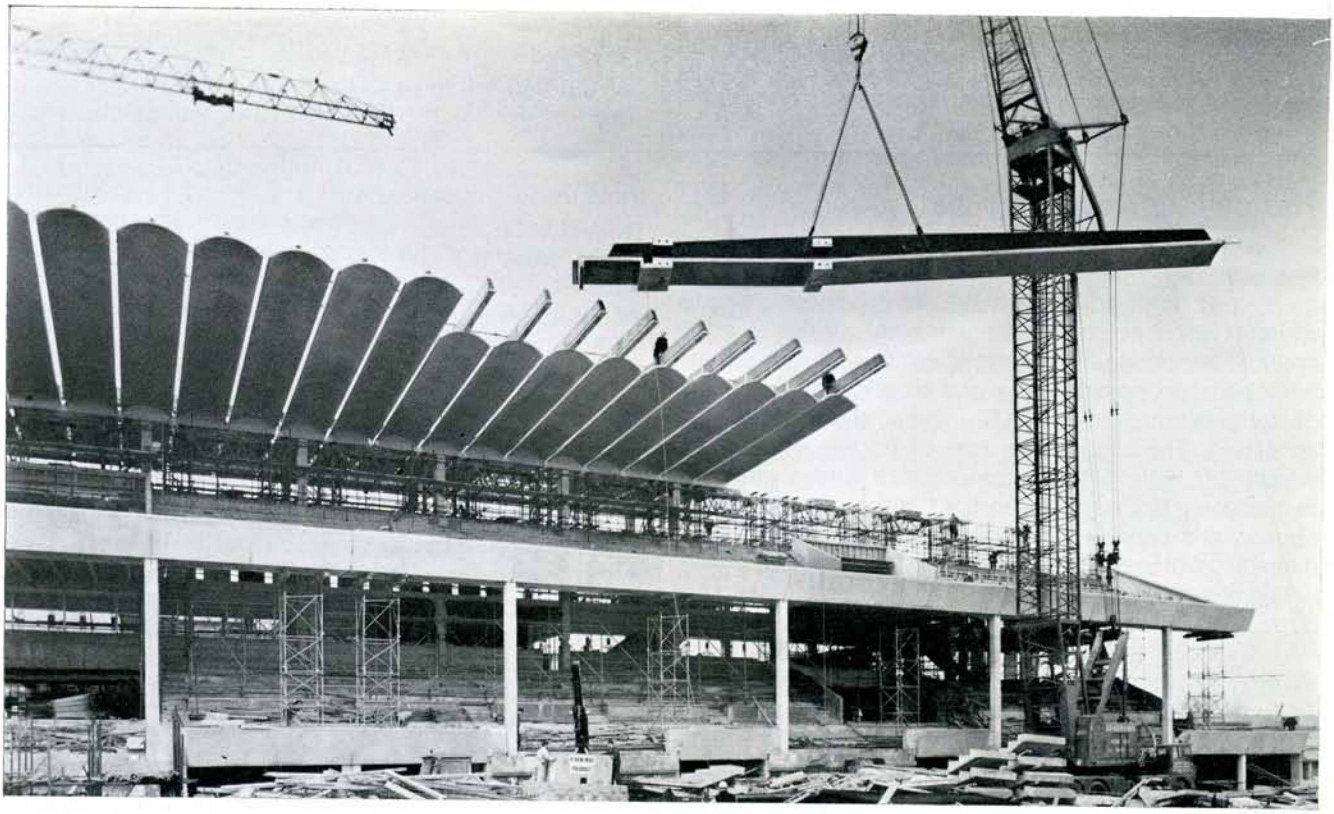


Figure 5 Erecting a roof unit.

the ends of the components to provide anchorage with the cast-in-situ beams. The ribs of the horizontal floor units are either 12 in or 22 in deep according to the span, and are prestressed with eight or six ½-in strands, respectively.

The components were cast in steel moulds, and during the finishing stages they were painted and in some areas, acoustic tiles were fixed between the ribs. Most of the cast-in-situ beams are lined with 2½-in precast planks which act as permanent formwork and provide an attractive surface finish; these planks are of Capstone-aggregate concrete, and have fine-rubbed exposed surfaces and roughened internal faces to provide a key with the cast-in-situ concrete. Since these planks are prestressed, they are flexible and no problems regarding adjustment and alignment were encountered.

The terracing and seating components are of normal precast reinforced concrete. Carborundum dust was sprinkled on the surfaces during casting to form a slip-resistant surface.

Perhaps the greatest design problem was presented by the roof. The 50-ft cantilever and the height above ground of 60 ft ruled out the use of cast-in-situ construction, and there were serious problems regarding the feasibility of erecting precast components. The components were to be 78 ft long and 6 ft 8 in wide, having a curved cross-section stiffened by a spine rib as shown in *Figure 4*, and would have weighed about 20 tons each if made of dense concrete, but using prestressed lightweight-aggregate concrete the weight of a typical component is 15¼ tons.

There are 49 components forming the structure of the roof, each having a modular width of 6 ft 8 in (less 4 in for a cast-in-situ joint), and a spine beam which varies in depth from 1 ft 9 in at the end of the cantilever to 3 ft ½ in at the first support. In general, each component was prestressed by 14 Dyform strands, but 22 strands were used where it was necessary to support the weight of the judges' box or the glass screens.

Considerable attention was paid to aerodynamic design of the roof. Investigation indicated that there was no danger of wind-induced resonant vibration and that structural damage would not be caused by wind loads. However, in those areas of roof supporting the judges' and commentators' boxes the additional loading reduced the natural frequency of the structure such that resonance could possibly occur. Experiments showed that the self-damping of the structure was negligible, so external damping in the form of spring mountings and friction pads was therefore necessary; this technique was also needed to prevent vibration being transmitted to television cameras in the press box.

The roof components were erected by a mobile crane, placed in front of the stand. They were landed and then anchored at the back with 1⅛-in-diameter Macalloy bars using anchor plates and connectors cast in each column at levels 3 and 5. When all the components on one side of an expansion joint were in place, the gaps between them were concreted, the post-tensioning cables threaded, stressed, and grouted, and the anchorage bars loaded and grouted in.

The external cladding (*Figure* 3) consists of prestressed precast fine-rubbed Capstone-aggregate panels, contrasting with Sandtex-finished brickwork. The panels are 2½ in thick, 4 ft wide, and up to 51 ft long, and are stressed with 0·2-in-diameter wires.

The three-storey building has precast storey-height white-cement-concrete columns. As in the main stand, most of the cast-in-situ beams are formed using permanent formwork of prestressed Capstone-aggregate planks. Eight-inch beam planks span between angle shelves attached to the columns. The long-span flooring consists of standard double-T components either 22 in or 12 in in depth. Cast-in-situ topping having a smooth trowelled finish was used to obviate screeding. Fascia and hanging cladding panels are similar to those used on the stand.

The buildings are carried on spread footings. Although the site is in a mining area, investigations showed that an unmined pier has been left under the racecourse, and it was therefore unnecessary to provide for mining subsidence.◇