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Artikel: Prestressed concrete shooting range building, Tokyo (Japan)
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9. Prestressed Concrete Shooting Range Building, Tokyo (Japan)

Owner:	*Tokyo Metropolitan Adm. Dep. of Metropolitan Police Agency*
Architect/Engineer:	*KUME Architects and Engineers*
PC structure:	*Fudo Building Research Co., Ltd.*
Contractor:	*JV of Fudo Constr. Co., Ltd./ Fukuda-guimi Constr. Co., Ltd./Aizawa Construction*
Prestressed Concrete:	*Fudo Building Research Co., Ltd.* *P. S. Concrete Corp., Ltd.*
Work duration:	*19 months*
Service date:	*1987*

Introduction

This firing range, completed in April 1987, has a building area of 5,650 m^2, a total floor area of 6,894 m^2 and is the largest building in the East. The site is located on reclaimed land facing onto Tokyo Bay, about 15 minutes by subway from central Tokyo.

The firing range comprises three galleries with spectator seats on the second floor. These galleries cover areas of 40 m × 27 m. 40 m × 63 m and 40 m × 27 m, with targets of 20, 50 and 20, respectively.

In designing this building, various studies were made to find a roof structure with bullet-proofing, sound-proofing, durability work and as large open spaces as possible. As a result, a prestressed concrete structure was adopted as the most suitable.

For the roofing, precast, prestressed concrete flaps were used. The No. 1 and No. 3 20-target practice range roofs are of one span construction while the No. 2, 50-target range roof is of three span construction with two cast-in-situ post-tensioned girders incorporated in it.

The PC folded plates are asymmetrical in cross-section and sky-lights are set between them over the whole length. Therefore, in order to make the amount of deformation in the folded plate coincide with the deformation in window frame torsion etc., it was checked by doing a full size loading test of the folded plate deformation and an F.E.M. analysis.

Prestressed Concrete Design

Because of the large (40 m × 63 m) open space design of the No. 2 practice range, two post-tensioned girders (concrete strength 35 N/mm^2) were put across the 40 m span. In order to reduce the weight of these girders and also to increase the torsional rigidity, the girders are hollow box beams. 24 VSL tendons type E/E 6-12 are used for PC cables and the effective prestress strength is 37,600 kN at the center of the beams.

Two types of PC folded plates have been used in the roofing material, both post-tensioned and pre-tensioned types. The former was used in the roof of the No. 1 and No. 3 practice ranges. This block has a span of 27.2 m, so the folded plates were made at the factory in three segments of 8.6 m, 10.0 m and 8.6 m and after being carried to the site were assembled into one unit with a single strand of ∅ 19.3 mm and put in place. These folded plates have a thickness of 200 mm and the strength of the concrete is 45 N/mm^2. The induced stress of the prestressed concrete is $P/A = 5.6\ N/mm^2$. The latter type was used for the roof of the No. 2 practice range. This block has large post-tensioned girders across it. One span is short at 18.78 m. The thickness of the flaps is 150 mm.

Analysis of the folded plates with the Finite Element Method

In order to calculate the stress and torsional deformation in the transversal direction of the plate, an analysis was conducted using Finite Element Method (F.E.M.). In order to place the axial force of the prestressed concrete on the folded plates, a model was made using pins and rollers for supports. The result of the analysis was that, since 24.5 mm could be expected from the long-term deformation, the corresponding deformation of the sky-light frames was made 25 mm. Also, based on the F.E.M. analysis, it was decided to reinforce the bars in the transversal direction plates.

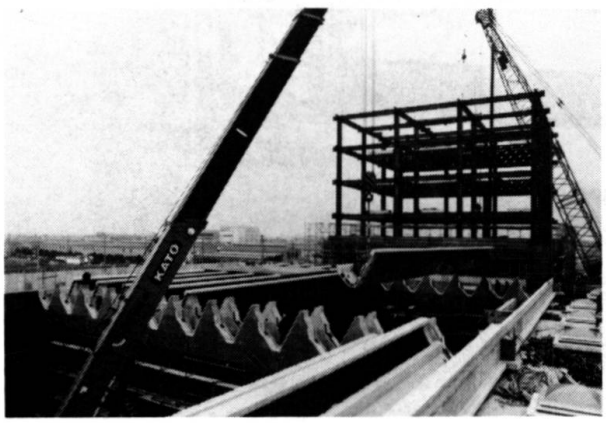

Fig. 1 Erection of folded roof panels

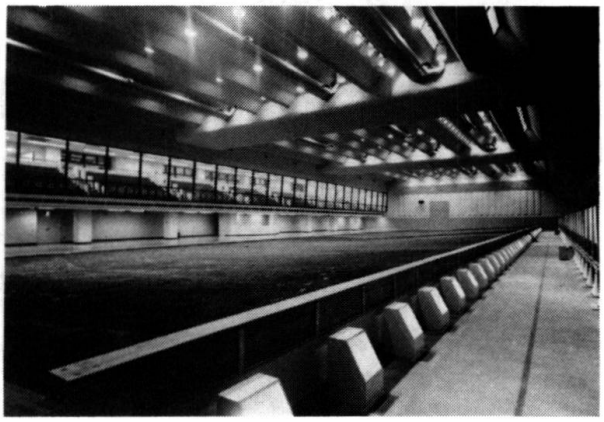

Fig. 2 Inside view of practice range No. 2

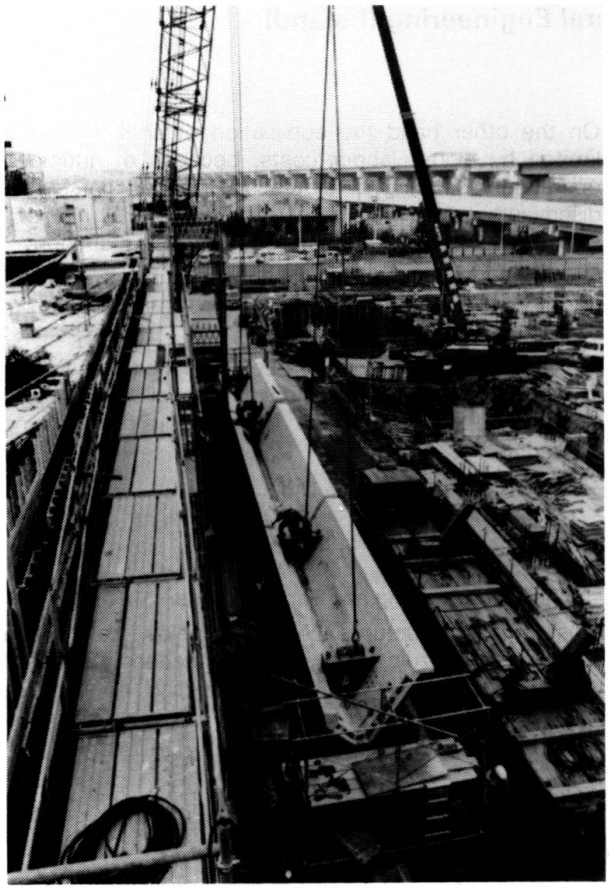

Fig. 3 Assembly of post-tensioned panel on site

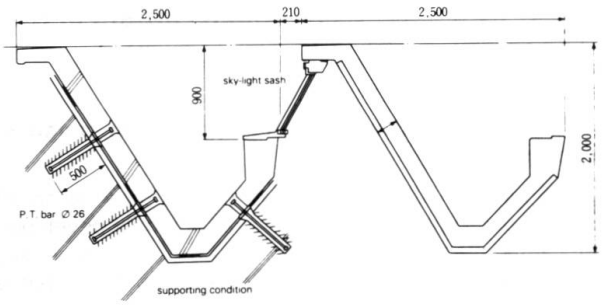

Fig. 4 Cross-section of the roof panel

Measurement of the Deflection Deformation

The amount of flexible deformation of the PC folded plates was estimated by means of a full-size test.

The folded plates used in the test consisted of three 27.2 m segments of post-tensioned material joined together. The test was loaded in a state of simple support, with the same weight (530 N/m^2) as the actual weight in the design (the weight of the skylight and waterproofing) and the deflection and bending moment at the center was measured. Vertical deflection averaged 15.9 mm which was 1.15 times the value of 13.8 mm which was obtained in the F.E.M. analysis. With the curvature of the short side, since some H steel for the linear load on the centroid of the short side was provided, the loading conditions differed from those in the F.E.M. analysis model and an accurate value could not be obtained. However, the nature of the deformation showed a trend similar to that of the F.E.M. analysis and confirmed that the F.E.M. analysis was of practically usefulness.

Therefore, in measuring the variation of the PC folded plates, the values obtained in the F.E.M. analysis were assumed to be valid and used in the design.

Manufacture of the Prestressed Concrete Folded Plates

There are a total of 55 folded plates with a total weight of 1,770 metric tons that took three and half months to make. The interior of the folded plates has been precoated with 50 mm of wood wool cement for bullet proofing and the bond section has had self-adhesive tape applied to prevent the concrete whitewash from seeping into the moulding box. The slabs have a height of 2 m, so the concrete slump was made 150 mm and compacted sufficiently with a vibrator.

Erection of the Prestressed Concrete Folded Plates

In order to assemble the post-tension type flaps into a single unit at the site using PC cables, an assembly for the connection was formed. After fixing the central block and coating the joints with adhesive, each was put in place usisng PC cables. The weight after assembly into units was about 54 tons for the ordinary type and 73 tons for the special type. Two hydraulic cranes (160 tons and 180 tons) were used to lift the folded plates into place.

The pre-tensioned folded plates were first lifted directly off the pole trailer using a 400 ton crawler crane and then put in place using the 180 ton hydraulic crane installed at the building site.

The PC folded plates were connected to the receiving beams using Ø 26 mm P.T. iron bar anchor bolts. The P.T. bars were passed from the PC folded plates through a sleeve into the steel tubing set into the receiving beams and were fixed by pouring in non-contracting mortar.

(H. Takeyama)