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Autor: Satoh, I.
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10. Yokohama Stadium, Yokohama City (Japan)

Owner: Yokohama Stadium Co., Inc.

Design & supervision: Sowa Sekkei Co., Inc.

Construction: Shimizu Construction Co., Ltd., and affiliated contractors

Construction period: 12 months

Completion: 1978

Materials used:

Structural steel: 2,200 t
Reinforcing bars: 2,720 t
Concrete: 29,000 m^3
Formwork: 12,000 m^2

General description of the plan

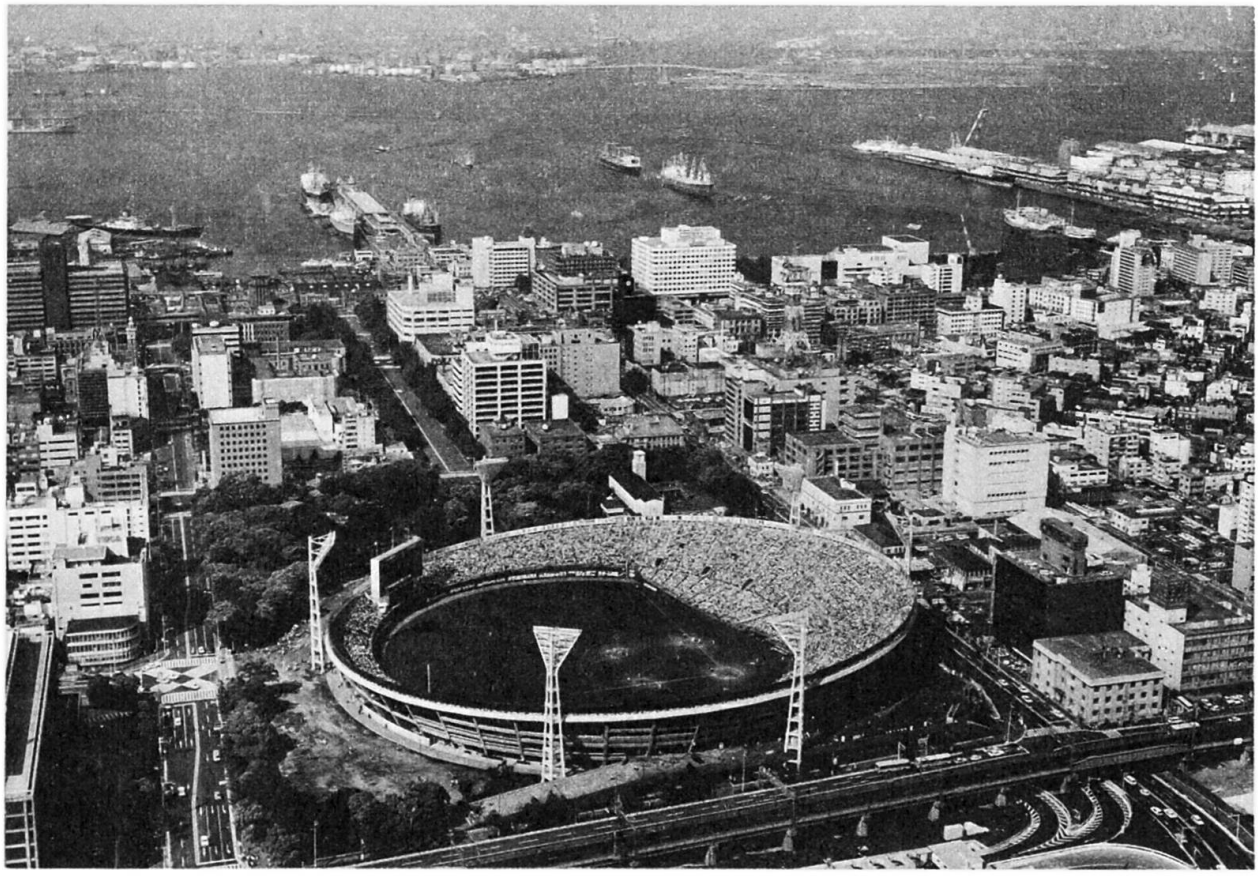
The site is within Yokohama Park, and has been designated for use as an emergency evacuation/shelter point in time of disaster. The stadium, located on a 64,000 m^2 site, has a total construction area of 16,000 m^2 and the playing field, which has a radius of about 69 m, has an area of 15,000 m^2. The field, besides being suitable for professional and amateur baseball, can also be adapted for soccer, American football and other sports and outdoor events because a portion of the stands are movable. Including the 5,800 seats in the movable section, the stadium has a seating capacity of 30,000.

The steel-frame movable stands are a prominent feature of the stadium. There are also six floodlight towers, an animated scoreboard including a large TV screen, a hydraulically-operated pitcher's mound, and other features. Synthetic turf is used for the playing surface.

General description of the structure

The stadium, as shown in Fig. 1 in plan view, is composed of three circles offset on the same centerline. That is, there is a 69 m radius circle describing the outer wall of the stands, an 85 m radius circle having its center 8 m closer to home plate which describes the outer wall of the stadium, and a 92 m radius circle with its center 4 m yet closer to home plate, which describes the top of the stands.

The structure is divided into 48 radial segments measured from the center of the stands, for which there are 24 pairs of truss-type Rahmen structures. As shown in Fig. 2, the stands are inclined 30°, and the outer wall is inclined 60°, both from the surface. However, by means of the combination of circles having different radii, the uppermost part of the truss structure and the location of the footings on the



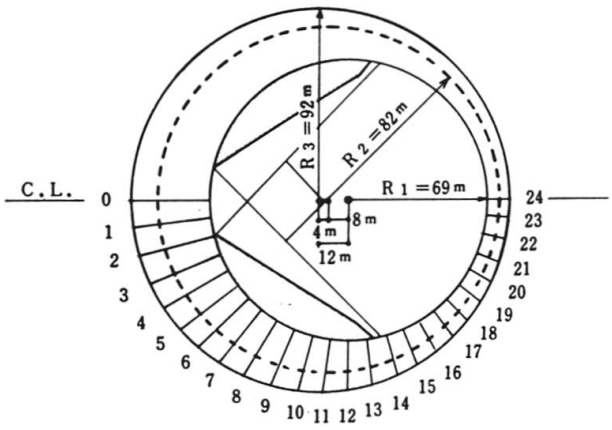


Fig. 1. Form Analysis of Structure

ground are offset vertically. The congruent triangular structures, in 24 pairs of combinations of different sizes and configurations progressively show a diminution toward the outfield bleachers.

Toward the circumference of the structure is a rectangular Rahmen structure.

General description of the design

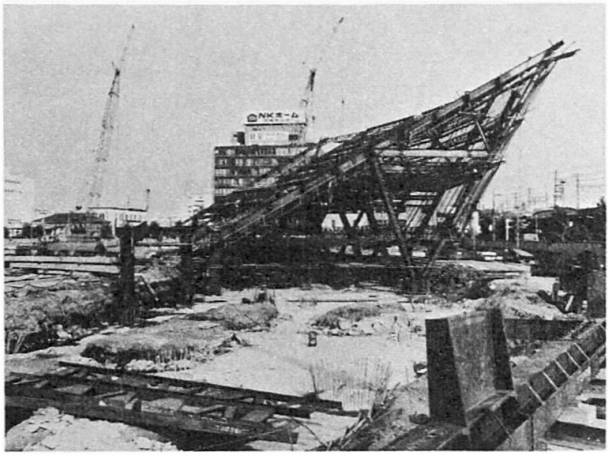
Steel-frame, reinforced concrete was selected from the viewpoint of its aseismic, fire-resistant, and relative ease of construction characteristics. Reinforced concrete was used for the concourse. In plan, in order to prevent cracking of the concrete due to expansion and contraction caused by change in temperature, the circumference was divided into eight parts by provision of masonry joints.

Regarding stress analysis of the structure, vertical load was analyzed by the fixed moment method, and the seismic horizontal load was analyzed by the D-value method based on the relative stiffness ratio. Because the structure has been designated for emergency use in time of a disaster, the design shock was taken at K=0.3.

With special reference to stress analysis in the direction of the diagonal structure, a temperature of 30° C was assumed at the stands' surface, and the stress caused by it was studied. Further, the periphery of the structure was analyzed as an infinitely continuous Rahmen structure. Beams at the uppermost part of the structure were analyzed three-dimensionally as they functioned as a tension ring.

Borings indicated that the upper 30-40 m of the soil was composed of accumulated alluvial plain silt, and the bearing layer was below that. Therefore the piles for the stands are reverse circulation piles made at the site, 3,000-1,000 mm in diameter and 26-62 m in length, and piles for the concourse area are SPIP (Super Pact in Place) piles (made at the site, mortar piles); they are 700 mm diameter and 26-30 m long.

Outer walls are exposed concrete, and the field and concourse are paved with tiles in some areas. The surface of the stands is treated with urethane resin for waterproofing.



General description of the construction

Although the site is in a park, the stadium is immediately adjacent to a train station, City Hall, a hospital, offices and a commercial district thus necessitating special attention to the prevention of noise and vibration during construction. Moreover, the construction period was limited to 12 months including one month for demolition of the existing stadium.

Noiseless and vibrationless methods were employed for foundation work; for the stands area, 156 piles were used and in the field and concourse areas 106 piles were used. After completion of the adjacent shell for the stands, 34 steel tube piles were driven as the foundation for the movable stands.

Construction of the steel-frame was a complicated undertaking because the inclinations and lengths of all of the structures (24 paired truss structures and 48 structures outside their circumference) were different. Special care was required to attain accuracy in positioning the outer structures, and optical range-finders were used.

The frame was erected by means of bolting to the heads of the piles; this enabled the frame to be erected before work with anchor beams, and greatly contributed to minimizing construction time.

Regarding the reinforced concrete work, similar to the fabrication of the steel-frame, the formwork was exceedingly difficult because there were almost no surfaces perpendicular to the ground. For concrete, successful results were attained by the use of super plasticizer.

(SCC: I. Satoh)

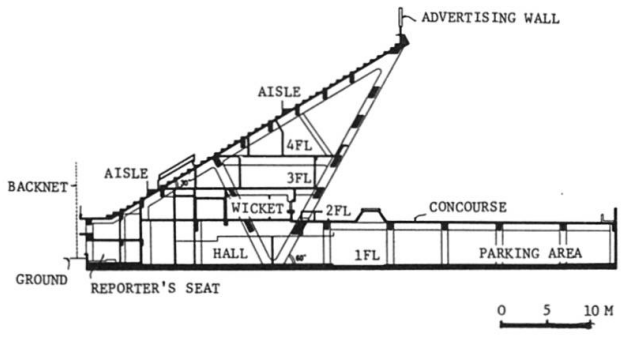


Fig. 2. Section