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crossings and can be executed in a restricted space with little impact on roadway traffc or the neighboring environment.[1,2)]

The QCIB Method centers on core technologies which include established fundamental design methods and construction methods, and aims at rationalizing the structure of the bridge system as a whole, including the foundation, substructure, and superstructure, with constant attention to weight reduction and prefabrication. The method was developed by reconstructing these techniques in combination with a quick-closing method. This paper describes the newly developed quick-closing integral bridge method.

## 2. Technical Tasks in Development of Quick-closing Method for Intersection Grade Separation Bridges

The goals of development of this construction method were to achieve a substantial reduction in the site work period, alleviate secondary congestion caused by the work, and control costs to the same as or less than those with conventional techniques. The technical tasks in development included the following:

(1) Maximum prefabrication of members, considering the limited work yards available on existing roadways.

(2) Development of optimum structure and construction method, assuming a system where the bridge piers and superstructure, which are assembled separately during foundation work, are delivered and connected to the foundation as a unit.

(3) Establishment of design and construction planning techniques which make it possible to perform work on the superstructure and substructure in parallel. Particular importance was attached to the development of compact construction machinery for foundation work and bridge erection on the soft ground typical to urban areas.

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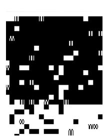

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## 3. Features of Construction Method

The features of the construction method, as illustrated in **Fig. 1**, are summarized below.

(1) Adoption of a rigid frame bridge design with an integrated superstructure and substructure in the bridge improves seismic performance and economy, while maintaining harmony with the urban landscape.

(2) Block precast steel structures are used for all main girders, piers, and footings, reducing assembly time at the site.

(3) JFE Steel’s screw-type ground-penetrating steel pipe piles, “Tsubasa Pile” and “Micro-pile with Plural Wings,” are used as foundation piles, enabling low-noise, low-vibration construction with no discharge of surplus soil. Since cementing is not used, the QCIB Method does not cause problems such as groundwater pollution or industrial waste.

(4) As the foundation connection method, steel footings are mounted directly on the foundation pile heads, reducing costs and shortening the work period.

(5) In parallel with the foundation work, the integral bridge is assembled as a unit in the smallest possible work occupancy area which avoids the intersection, minimizing the necessity of traf f c lane restrictions.

(6) The construction procedure is as follows:

Step 1: The bridge, which was assembled in an integrated unit at the two sides enclosing the intersection, is lifted as a unit by air casters or a deck lifter on a self-propelled vehicle, moved in the direction of the intersection, and connected.

Step 2: At the same time, the steel footings of the bridge piers are inserted on the completed foundation piles and then joined with concrete to form an integral structure. This closing and joining work ce e to ffof a ! r þ m gr Ÿ g

(2) After confirming perpendicularity, the pile is driven by turning.
(3) In case of continuous piles, the middle/upper piles are put in an erect position and welded to the preceding pile end.
(4), (5) The pile is driven to the specified depth using pincers, and driving is discontinued.
(6) The pincers are recovered, completing the driving procedure.

As a pile driver, the small-scale 3-point pile driving shown in **Fig. 7** is used. In addition to vertical piles, this machine is also capable of driving raked piles at angles of up to ±15°, and is suitable for projects where quick work is required at sites with limited yards.

blown onto the floor surface below the air caster torus bags, forming a thin air film between bags and floor. This reduces the coefficient of friction between bags and floor to approximately 0.003, enabling easy movement. The specifications of the air caster (Type K60UHD) are shown below.

(1) Capacity: 534 kN/bag
(2) Internal pressure under maximum load: 34.5 N/cm$^2$
(3) Air consumption: 2.38 m$^3$/min
(4) Diameter: 1 524 mm
(5) Thickness (not in use): 70 mm
(6) Thickness (in use): 159 mm
(7) Lift: 89 mm
(8) Dead weight: 1 421 N

The JFE Group uses air casters to move hybrid caissons in the yard, and became the first in Japan to apply an air caster construction method to bridge construction at the Komasegawa Bridge (ordered by the Japan Highway Public Corp.), where it was used to move the structure 260 m. Although self-propelled vehicles are used in the conventional bridge movement, rails and heavy-duty trucks are necessary, and in some cases, the truck height and economy are problems. In comparison, the air caster meth ] ] я ] я eÅ omp ¾ a φ e o t