Special Feature

Construction of Ueno–Tokyo Line

JR East Construction Department

Introduction

East Japan Railway Company (JR East) has a wide-ranging operations area from Kanto and Koshin'etsu to Tohoku. When JR East was established in 1987, traffic conditions on most sections of conventional (narrow-gauge) lines in the Tokyo area, including major sections of lines radiating from central Tokyo (Tokaido, Chuo, Joban, Sobu lines), the Yamanote Line, etc., had morning rush-hour congestion rates in excess of 200%. As a result, enhancing transportation capacity to alleviate congestion was a major issue. Furthermore, with subsequent diversification of values accompanying social changes, users' railway needs went beyond merely alleviating congestion to shorter travel times and improved comfort while travelling, etc., so problems related to improving transportation in the Tokyo area also diversified. In this context, JR East has taken various initiatives to improve the quality of railway services. This article gives an overview of work on the Ueno–Tokyo Line, which is one such initiative.

Project Overview

The Ueno–Tokyo Line started as a plan to develop new double-track between Tokyo Station and Ueno Station to support through services between the Utsunomiya, Takasaki, Joban, and Tokaido lines (Fig. 1). The Council for Transport Policy Report No. 18 published in January 2000, targeted opening of the Ueno–Tokyo Line (A1) by 2015. In November 2007, the Minister of Transport gave permission to change the basic plan to a plan for laying new tracks between Tokyo Station and Ueno Station and then permission was given in March 2008 to change the railway facilities. Construction started in May 2008 and was completed in about 6 years. The line opened on 14 March 2015, following 5–month training run.

Table 1 Congestion Rate and Passenger Condition

Congestion rate	Passenger condition
100%	All passengers are able to sit, or hold on to a strap or column near doors.
150%	It is possible to hold open and read a newspaper easily.
180%	It is possible to read a newspaper if folded.
200%	Contact with adjacent passengers, but possible to read a magazine.
250%	Unable to maintain balance when train sways, or to move arms.

No. Passengers÷Passenger capacity=Average congestion rate
(http://www.mlit.go.jp/kokudokeikaku/monitoring/system/english/contents/11/11-1-1.pdf)

Expected Effects

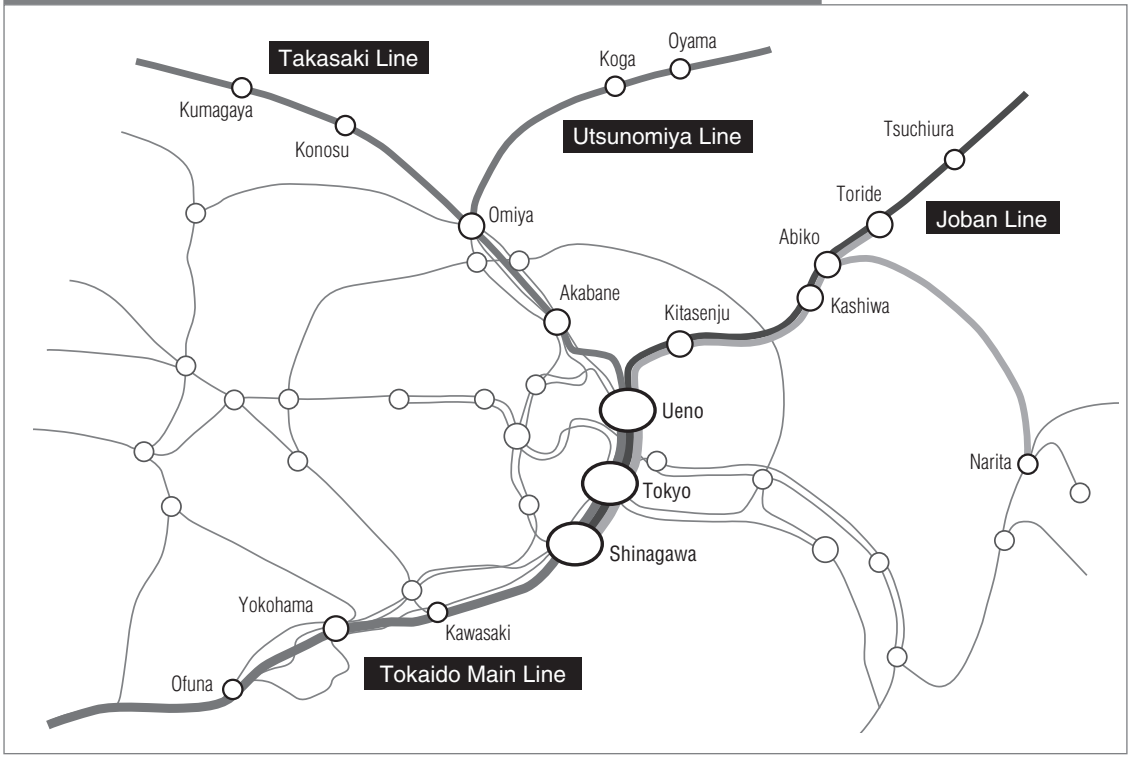
Alleviating congestion on Yamanote and Keihin-Tohoku lines

The sections between Ueno Station and Okachimachi Station on the Yamanote and Keihin-Tohoku lines have high densities of passengers travelling from northern Tokyo, northwest Chiba, and Ibaraki towards Tokyo Station and Shimbashi Station; these sections have some of the highest congestion rates during morning rush hours in the JR East operations area. Train occupancy between Ueno Station and Okachimachi Station in 2012 was 197% but this is expected to be alleviated to less than 180% following the opening of the Ueno–Tokyo Line.

Improved travel times using through trains

Journeys between the Utsunomiya, Takasaki, and Joban lines and the Tokaido main line used to require transfer to the Yamanote Line and Keihin-Tohoku Line at Ueno Station and Tokyo Station. During rush hours, trains on the Yamanote and Keihin-Tohoku lines stop at every station, most of which are only about 1-km apart, causing long travel times. The opening of the Ueno–Tokyo Line has shortened the travel time by about 7 to 10 minutes due to the start of through services between the Utsunomiya and Takasaki lines and the Tokaido main line as well as through trains to Shinagawa Station on the Joban Line.

Figure 1 Takasaki, Utsunomiya, Joban and Tokaido Main Line Route Map



Construction of Ueno–Tokyo Line near Kanda Station (JR East)

Regional revitalization by strengthening railway network in capital region

The Shonan Shinjuku Line started operations in December 2001 connecting the north and south regions of the Tokyo Metropolitan Area (TMA) with through services running between the Saikyo Line and Rinkai Line in conjunction with the opening of Osaki Station on the Rinkai Line in December 2002. These routes run on the west side of the Yamanote Line, passing through Ikebukuro Station, Shinjuku Station and Shibuya Station, and have generated new direct traffic between Yokohama and Omiya, helping revitalize areas along the routes. The present development of the Ueno–Tokyo Line adds a new through route east of the Yamanote Line running through Shimbashi Station and Shinagawa Station, strengthening TMA north–south connections and encouraging traffic between the Utsunomiya, Takasaki, and Joban lines and the Tokaido main line (Fig. 1) and contributing to further trackside revitalization.

Plan Overview

The conventional lines between Tokyo Station and Ueno Station use the quadruple tracks of the Yamanote Line and Keihin-Tohoku Line (sextuple tracks between Tokyo Station and Kanda Station with Chuo Line). In the Japanese National Railways era until 1975, the current section of the Tohoku Shinkansen between Tokyo and Kanda included conventional tracks but the extension of the Tohoku Shinkansen from Ueno Station to Tokyo Station used the roadbed for conventional lines as the shinkansen roadbed, stopping local passenger trains using these tracks from 1973; train services also stopped on the deadhead line between Tokyo Station and Ueno Station in November 1982. Construction work on the Tohoku Shinkansen in 1983

Figure 2 Overview of Construction Work

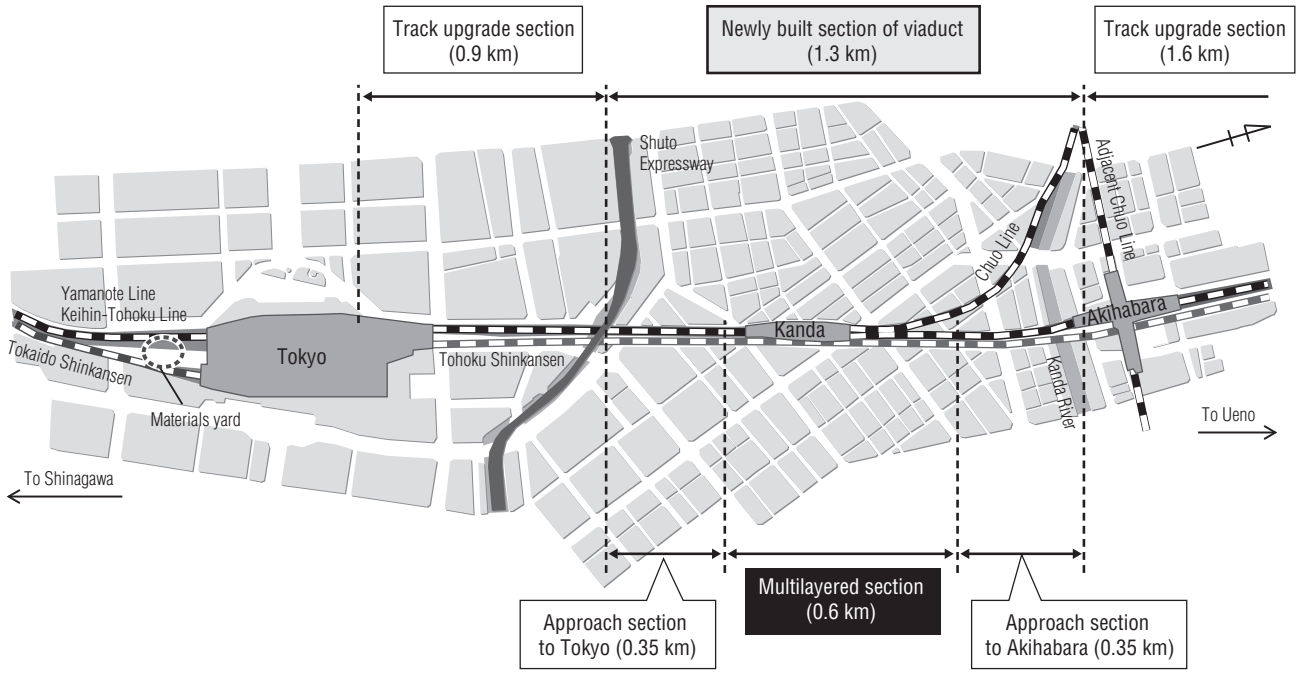
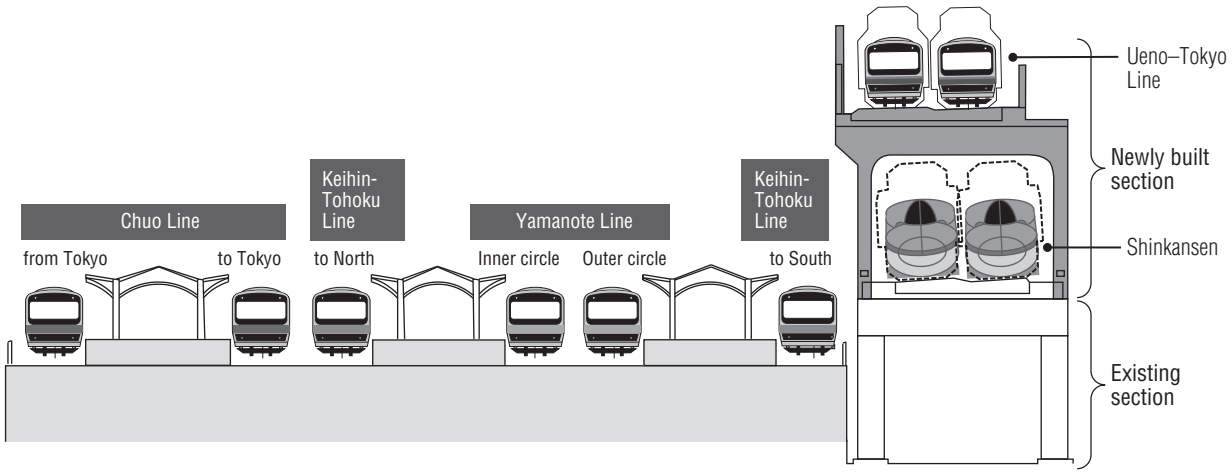


Figure 3 Cross Section image of Mutilayered Section in Kanda Station



removed some conventional-line viaducts obstructing the shinkansen track structures; the Ueno–Tokyo Line restores these tracks but Tohoku Shinkansen structures near Kanda Station required locating the Ueno–Tokyo Line as a layered structure above the shinkansen structures (Figs. 2 and 3).

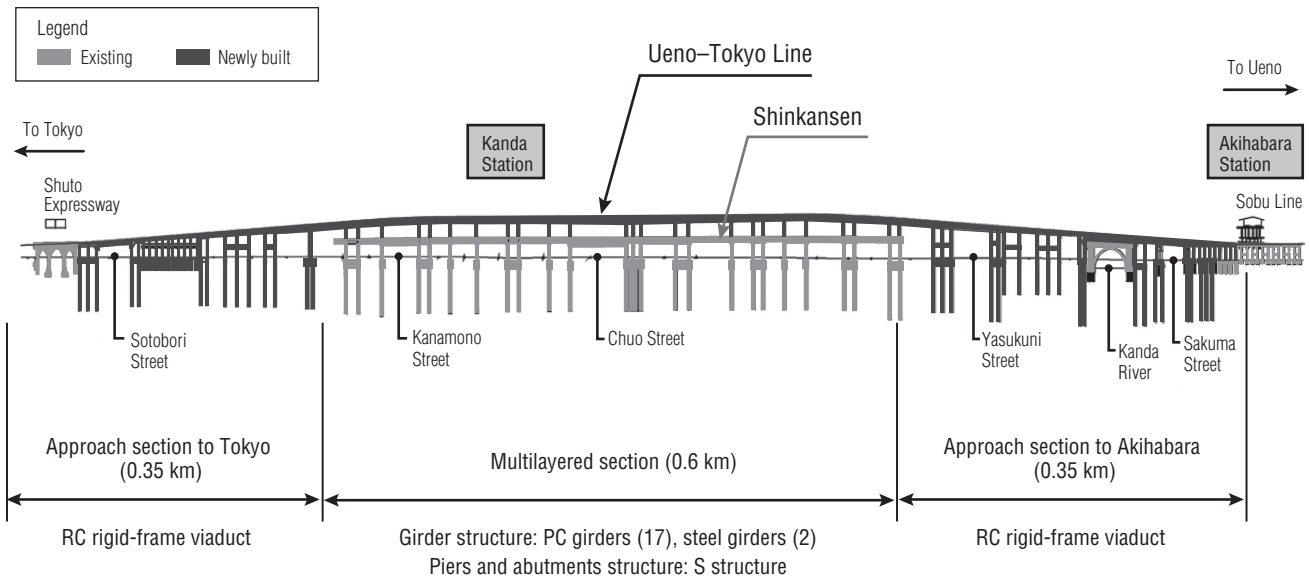
Tokyo Station yard

Tokyo Station serves the Tokaido main line using two island platforms for tracks seven to ten. Abolishing locomotive-waiting tracks on the north side of Tokyo Station when *Blue Train* services stopped allowed construction of structures for the Ueno–Tokyo Line. Furthermore, lead tracks in Tokyo Station yard were upgraded for Ueno–Tokyo Line structures and converted to main lines. The No. 8 turnout north of Tokyo Station was upgraded to a No. 12 turnout in conjunction with the Ueno–Tokyo Line conversion.

Multilayered section

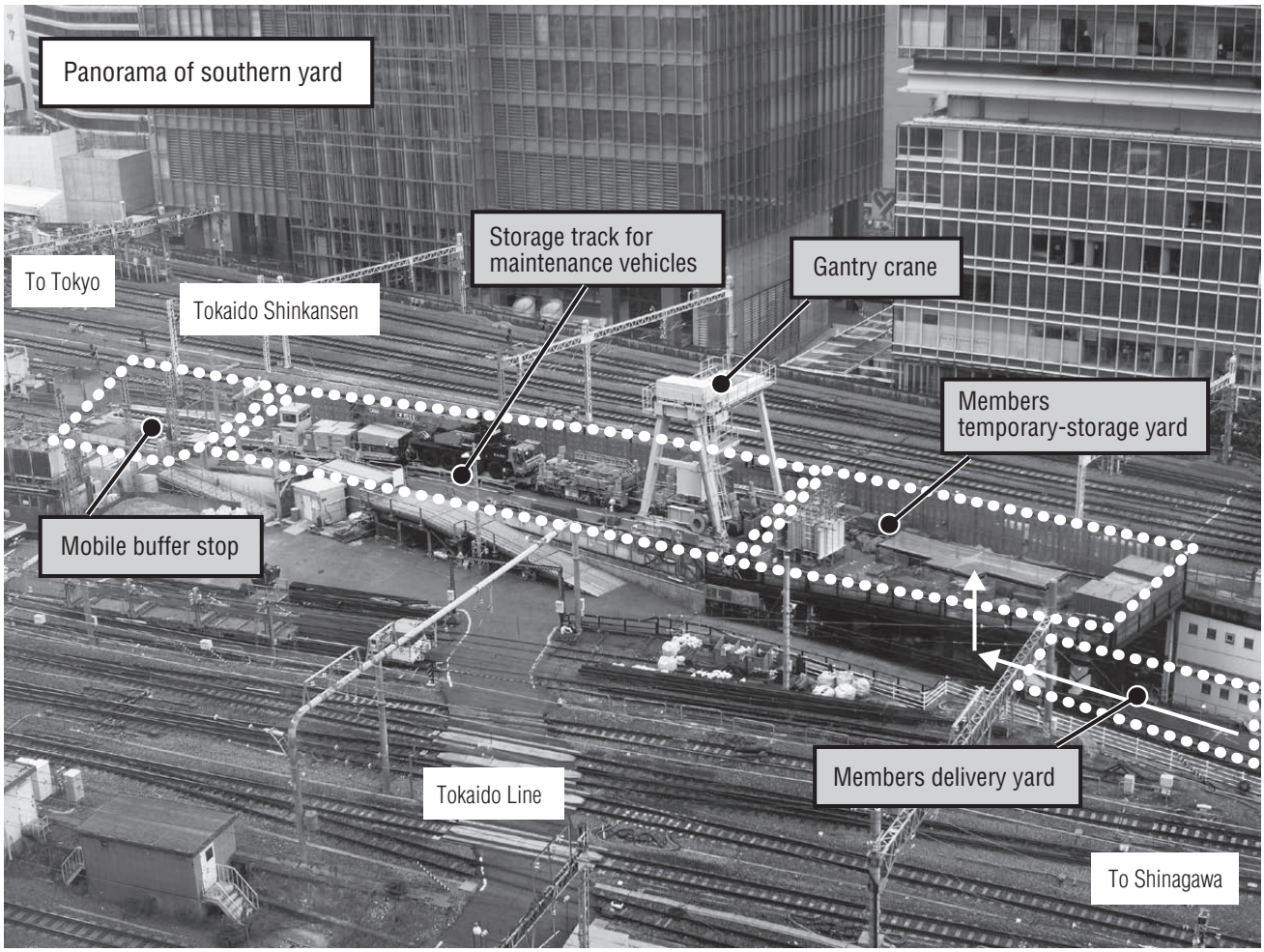
The Keihin-Tohoku Line and the Tohoku Shinkansen run parallel to each other about 600 m from Kanda Station, where the viaducts for the two lines become very close. Since there was no available free space, the structures for the Ueno–Tokyo Line have been built directly above the shinkansen structures (Fig. 4).

Figure 4 Existing Shinkansen Viaduct and New Viaduct for Ueno–Tokyo Line



Conventional lines and Shinkansen line located adjacently.

Aerial view of multilayered section before construction (JR East)



Construction Site in Southern Yard (JR East)

Starting from Tokyo Station, the Ueno–Tokyo Line intersects the Shuto Expressway near the 0k700m marker; at around 1k050m, it is directly above the shinkansen where the grade of the 350-m section is 35‰. At 1k650m, it is no longer directly above the shinkansen, but the 350-m section until 2k000m (where it intersects the Sobu Line at Akihabara Station) also has a grade of about 35‰. This is called the approach section (AP section).

Existing steel piers and abutments on the Tohoku Shinkansen were extended with new steel frame members for use as piers and abutments for the Ueno–Tokyo Line with a substructure of eight steel piers and eight steel abutments. Seventeen PC girders and two steel girders were erected by on-site assembly of pre-cast members on the piers and abutments.

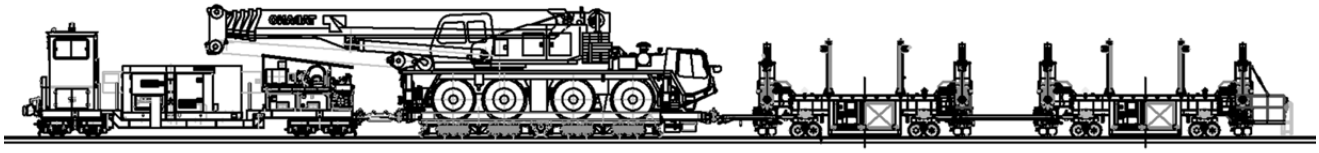
Ueno Station yard

The south side of Ueno Station yard had ten storage tracks connected to three platforms at Ueno Station by three deadhead lines.These tracks are the main lines for the Ueno–Tokyo Line so, in conjunction with work to convert the deadhead lines to main lines, four elevated storage tracks were retained above the shinkansen tunnel near Akihabara Station and the other storage tracks were abolished. To provide alternate functions, it was necessary to upgrade storage tracks in Oku Station yard on the Tohoku Line for compatibility with partial 15-trainset configurations. This work started in March 2007 before work on the Ueno–Tokyo Line.

Work Overview

Selecting the construction method for the Ueno–Tokyo Line structures imposed very severe conditions. Many factors needed careful consideration because the work was in a densely-inhabited area between Tokyo Station and Ueno Station. Moreover, it was above key track sections, especially the Tohoku Shinkansen, Yamanote Line, Keihin-Tohoku Line, etc., with many nearby residents. In the multilayered section near Kanda Station, the Yamanote and Keihin-Tohoku lines

Figure 5 Series of Vehicles for Erecting Steel Frames



Driving bogie | 100-tonne crane bogie | Steel-frame carrying bogie (i) | Steel-frame carrying bogie (ii)

(JR East)

100-tonne all-terrain crane erecting steel frame (JR East)

run very close to the Tohoku Shinkansen. The approach road to the shinkansen viaduct was just 8.0-m wide with a row of private buildings. Furthermore, ensuring safe and stable transport on the shinkansen and conventional lines required working only during a 6-hour track possession period each night after the end of commercial operations.

Steel frame erection

Steel frame erection required securing a delivery route for heavy machinery and steel frame members. However, since there was no space for a work yard near the shinkansen, a temporary gantry was erected at the south end of the platforms for the Tohoku Shinkansen at Tokyo Station (called the southern yard) about 1.5 km from the erection site; it was developed into a delivery and loading yard for the steel frame members. Furthermore, the crane for erecting the steel frame members was moved onsite during the track possession period each night using a series of vehicles comprised of a driving bogie, 100-tonne crane bogie, and steel-frame carrying bogies (Fig. 5). Every possible measure was taken to build-in redundant systems so they could still run even in the unlikely event of a breakdown.

Next, the various constraints on the sizes of the steel frame members and cranes had to be considered. These were related to the size of members that could be transported safely on a road trailer from the factory to the

southern yard; not obstructing the structure gauge when moving members from the southern yard to the erection site; keeping the maximum width for hoisting the steel frame within the 4.0-m width of the overhead contact wires, etc. As a result, 263 members were used in the 16 piers and abutments. The crane used to erect the steel frames was a 100-tonne all-terrain crane with a maximum lift mass per member of about 20 tonnes. It was self-propelled and moved between the shinkansen up and down lines to avoid the overhead catenary structures while erecting members above them.

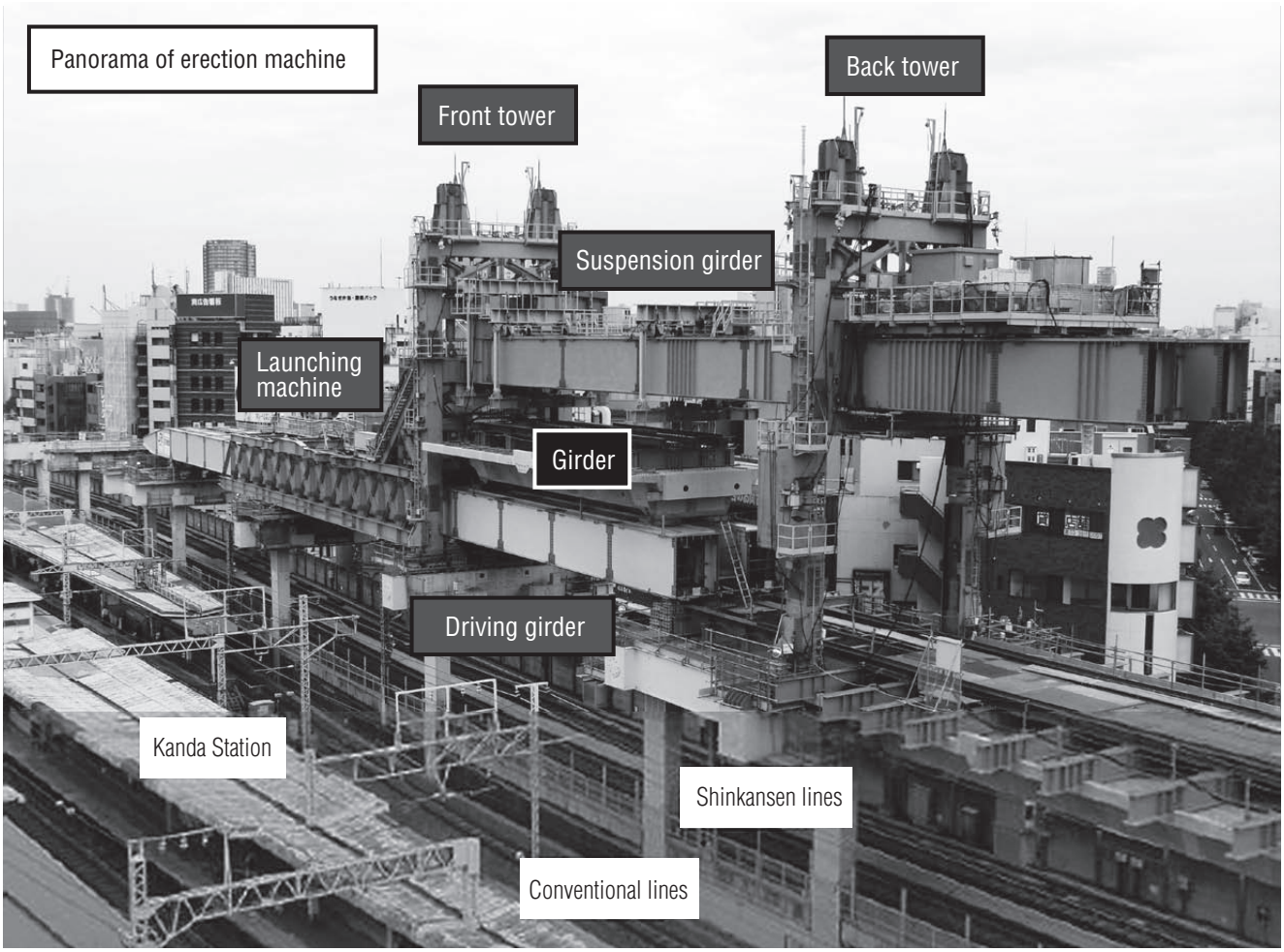
Movement of heavy machinery to and from the erection site took 60 minutes, leaving only 180 minutes for erection work from 01:00 to 04:00. Only one member could be erected in this limited time frame each day and sometimes other work prevented construction, so only about half the days in a month were used for erecting steel frames. As a result, the first of the 263 frames was erected in September 2009 and the last 26 months later in October 2011.

PC and steel-girder erection

Since no yard could be secured for delivery of PC and steel girders and the frontage was narrow, we created an access 'aperture' on the newly built viaduct between the conventional lines and shinkansen lines near the start direction for delivery and assembly of girders. Delivery of girders using large heavy machinery was impossible due to space constraints, so the plan was to produce the PC girders and steel girder members at a factory, disassemble them, carry them onsite, and hoist them using a gantry crane on a temporary gantry to reassemble them. Size constraints due to road-trailer restrictions from the factory to the yard kept the mass of each member to 30 tonnes or less and the aperture size to 12 m × 4 m or less. As a result, we divided the PC girders into 11 to 19 members/girder and the steel girders into 25 to 30 members/girder, resulting in a total of 304 members. The total weight of PC girders came to 590 tonnes, and 550 tonnes for the steel girders.

Since there was no space to install a large crane over the shinkansen, the launch construction method was used. A mobile erection machine with a maximum length of about 210 m and a mass of about 1700 tonnes was used to erect a girder with a maximum span of about 60 m. The machine was composed of a launching machine, driving girder, suspension girder, front tower, and back tower; a propulsion jack inside the launching machine moved the driving girder. All girders were erected during the night track possession periods. Preparatory work included moving the erection machine onsite and moving assembled girders onto the driving girder. When girders were erected, they were hoisted

Girder Erection (JR East)

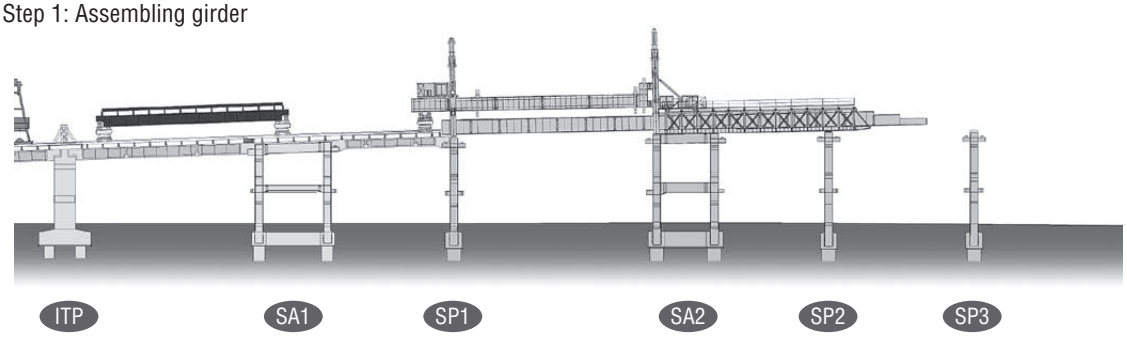


Overview of girder erection (JR East)

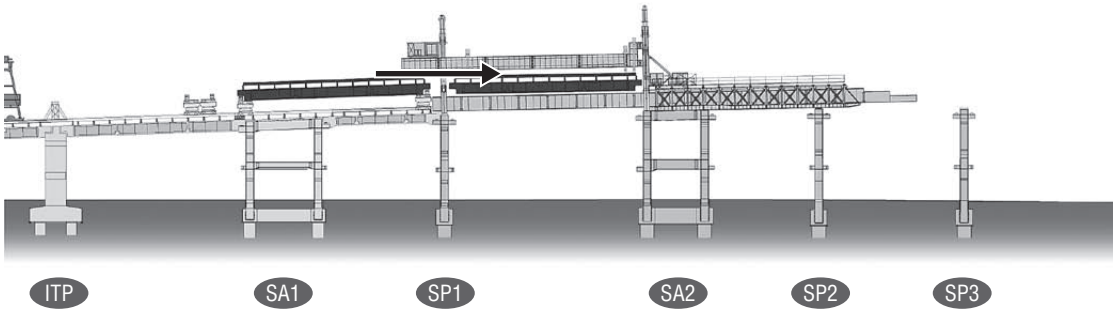
Gerder erection in progress (JR East)

Figure 6 Step-by-Step Girder Erection

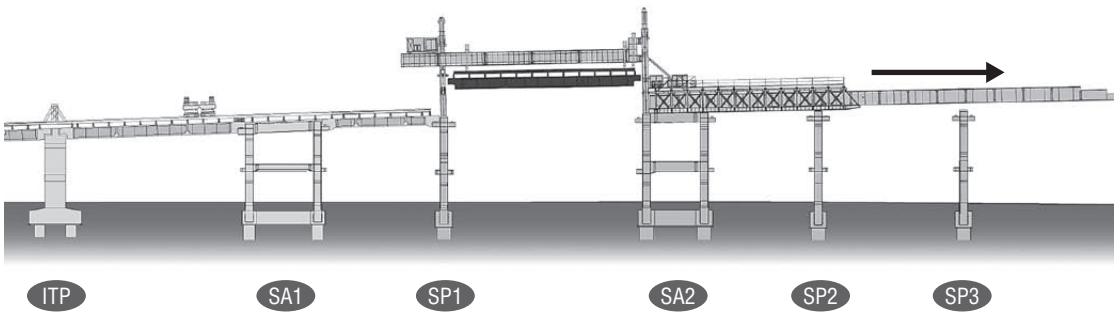
Step 1: Assembling girder



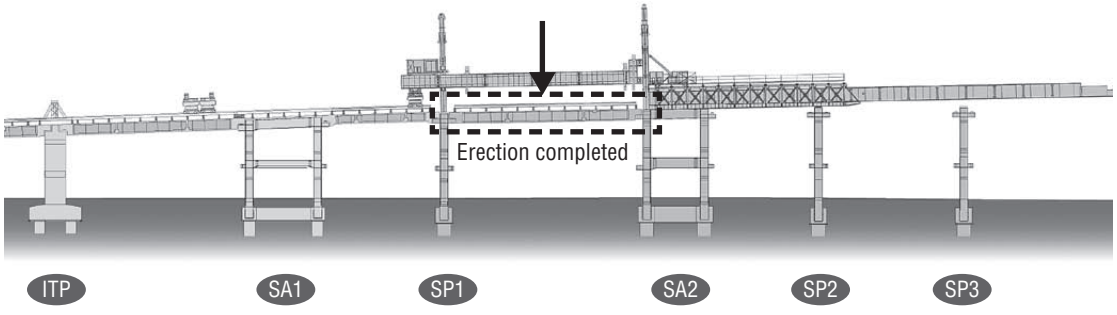
Step 2: Moving girder on to driving girder



Step 3: Pushing out driving girder



Step 4: Lowering girder



Night when girder erected

by the suspension girder, extended in the finishing direction by the driving girder, and lowered into position.

To reduce risk when moving the erection machine and ensure safety if an earthquake struck, the machine was secured at all times to the already-constructed Ueno–Tokyo Line structures.

A period of 1 to 2 months was usually required to erect each girder taking into consideration the time for carrying blocks to the assembly position and erection of the PC block girders; erection of all 19 girders started in December 2010 and was completed 28 months later in April 2013.

Safety management

The work directly above the Tohoku Shinkansen was difficult and had no precedent worldwide. If any trouble occurred, an enormous amount of time would be required to recover, resulting in stoppage of shinkansen services between Tokyo Station and Ueno Station and preventing operation of all trains on the Tohoku, Joetsu, Nagano, Yamagata, and Akita shinkansen. To minimize any impact, shuttle trains were prepared at Ueno Station. At the time, Tokyo Station and Ueno Station were on the same AT feeder section, so cutting the power at Tokyo Station during a problem would cut off Ueno Station too. To prevent this risk, a disconnection switch was installed to separate the feeder sections for Tokyo Station and Ueno Station. A special timetable for abnormal circumstances was prepared along with an emergency announcement system to provide passenger guidance if a problem occurred.

Completed Ueno–Tokyo Line running near Kanda Station (JR East)

Conclusion

The Ueno–Tokyo Line opened on 14 March 2015 after a 6 year construction and 5 months test drive period. It has enhanced the Tokyo railway network and enabled direct access from the Utsunomiya Line, Takasaki Line, and Joban Line to Tokyo Station and Shinagawa Station, and from the Tokaido main line to Ueno Station, dramatically improving convenience by shortening travel times due to elimination of transfers. Furthermore, transportation capacity between Tokyo Station and Ueno Station has been improved substantially, alleviating congestion, especially during the morning rush hour.

The work was large-scale and difficult, but thanks to the cooperation and guidance of many people, it was completed without mishap. ■

Acknowledgement

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