

# Kyoto Subway Projects and Extension of Tozai Line

*Toshikazu Kubota*

## Introduction

Kyoto was established as Heian-kyo in 794 and its 1200-year history gives the city an eternal sense. Modern Kyoto is a major Japanese city but its famous Buddhist temples and Shinto shrines—17 of which are World Heritage sites—and its close proximity to nature, create an aesthetic cityscape where city residents and visitors enjoy culture and arts steeped in tradition.

In addition to preserving its traditions and culture, Kyoto is striving to create a new 'Shining Kyoto' by asking its citizens and experts for their opinions on how to ensure a safe and pleasant lifestyle, serving as the launch pad for a new era of local autonomy. To achieve these goals, the city established the 'Kyoto City Basic Promotion Plan Stage 2' in July 2004. The policy for urban transport has adopted the theme of 'Kyoto—a City for Walking' with the goal of making Kyoto a city where people enjoy walking. Furthermore, Kyoto demonstrated its responsibility to lower dependence on automobiles and reduce fuel consumption by being the first city in Japan to enact a Local Global Warming Countermeasure Ordinance in April 2005 based on the Kyoto Protocol adopted at the 3rd Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3). As a result, the city is promoting a modal change from automobiles to safe, comfortable public transport, supporting the smooth flow of people and goods. These efforts include constructing subways, supporting new forms of public transport, such as light rail transit (LRT), promoting transportation demand management policies, and improving barrier-free transport. Subways have low environmental burdens, make effective use of urban space, and stimulate local development. Consequently, Kyoto is positioning subways as its key urban transport infrastructure and is actively promoting subway construction.

## Moving Towards Subway Construction

Kyoto's first transportation projects started with the city tram opened in 1912. The city's transportation systems

were subsequently unified in 1918 by the purchase of Kyoto Electric Railway, which began operation in 1895 as Japan's first tramway. The city continued building urban transport infrastructure with the start of bus services in 1928, which played a central transport role in the city. However, the city trams could not respond to the sudden rise in private car ownership and population migration away from the city centre in 1960s. As a result, gradually declining finances forced closure in 1978 when city buses became the chief public transport. At this time, the Kyoto municipal government viewed urban transport as part of overall urban administrative planning rather than as a separate issue. The city investigated its role in land use, road construction, industry promotion, housing and other plans, and decided to gradually shift the transport system away from a combination of city trams and buses to a combination of efficient rapid urban railways and buses. Based on this decision, surveys were held on the basic concept for a future modern transport system and plans were made to construct two subways—the Karasuma Line and the Oike Line (today's Tozai Line)—as the backbone of a rapid urban railway network.

Construction of the Karasuma Line running north-south under the city started in 1972 with commercial services



Series 10 trains on Karasuma Line. The busy Karasuma Subway Line celebrated its 25th anniversary on 29 May 2006. (Kyoto Municipal Transportation Bureau)

beginning in 1981. This was followed by construction of the Tozai Line, which opened for service in 1997 and passes east–west under the city centre area to connect the city centre with the Yamashina and Daigo districts and then on to the Uji City district. These two lines now comprise the Kyoto Municipal Subway with a total operation length of 28.8 km, forming Kyoto’s main public transport arteries. They are used by about 310,000 passengers per day and serve the city’s 1.47 million residents as well as large numbers of domestic and overseas tourists.

## Overview of Lines

### Routes

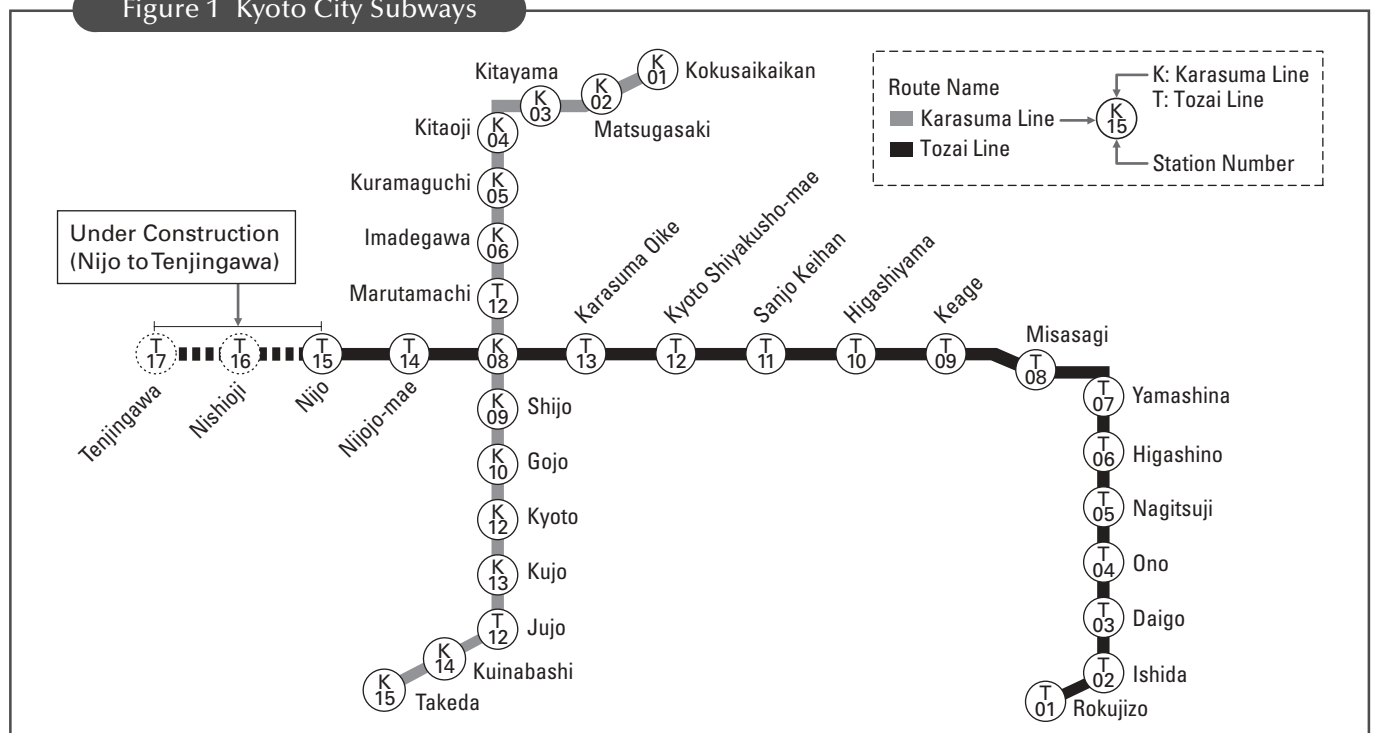
The first 6.5-km section of the Karasuma Line opened between Kitaoji Station and Kyoto Station in May 1981. It was subsequently extended section-by-section; the Kyoto–Takeda section (3.4 km) opened in June 1988, the Kitayama–Kitaoji section (1.2 km) in October 1990, and the Kokuzaikaikan–Kitayama section (2.6 km) in June 1997. The line has played a major role in building communities in the north of the city and improved access to the Kyoto International Conference Hall, contributing greatly to Kyoto’s international convention functions. It takes about 27 minutes to traverse the 15 stations between Kokuzaikaikan and Takeda (13.7 km) and there are interchanges with the Tozai Line at Karasuma Oike Station, the Hankyu Kyoto Line at Shijo Station, and the JR West lines and Kintetsu Kyoto Line at Kyoto Station. Through operations have been running over the Kintetsu

Kyoto Line since August 1988. In addition to local through operations between Kokuzaikaikan Station and Shin-Tanabe Station (29.7 km) on the Kintetsu Kyoto Line, through operations have also been running between Kokuzaikaikan Station and Kintetsu-Nara Station (49.1 km) on the Kintetsu-Nara Line since March 2000, with express services on the section south of Takeda Station. These through operations linking the historic cities of Kyoto and Nara, greatly improve convenience for commuters, students, and domestic and overseas tourists.

After the start of the Tozai Line service between Daigo Station and Nijo Station (12.7 km) in October 1997, the Rokujizo–Daigo extension (2.4 km) opened on 26 November 2004 to directly link the eastern Kyoto districts of Yamashina and Daigo and the Uji City district with the city centre area, dramatically increasing transport convenience. In addition, the expanded network also helped activate community building in southern Kyoto Prefecture. The current Tozai Line links the 15 stations between Rokujizo Station and Nijo Station (15.1 km) in about 30 minutes and has interchanges with the JR West Nara Line and Keihan Electric Railway Uji Line at Rokujizo Station, the JR West Tokaido main line and Kosai Line and the Keihan Electric Railway Keishin Line at Yamashina Station, the Keihan Electric Railway Keihan main line at Sanjo Keihan Station, the Karasuma Line at Karasuma Oike Station, and the JR West San’in main line at Nijo Station (Fig. 1).

Trains on the Keishin Line trains also have track rights and operate over the Misasagi–Kyoto Shiyakusho-mae section, directly linking Otsu City with city centre Kyoto.

Figure 1 Kyoto City Subways





Platform at Karasuma Oike Station on Tozai Line. The Karasuma Line crosses the Tozai Line at Karasuma Oike Station, which has people-friendly spaces and structures including an art gallery, wall relief, and arched ceiling. It was voted one of the 100 best stations in the Kinki region in 2001. (Kyoto Municipal Transportation Bureau)

## Facilities

Kyoto has worked to make its subways barrier-free (Table 1) based on the Kyoto City Outline for People-Friendly Community Building project established in 1995 and the national Transportation Accessibility Improvement Law, 2000. The city has worked to improve access for all people, including children, the elderly, and people with disabilities, to both new and existing facilities.

In addition, efforts are being made to create facilities meeting customers' needs while increasing customer convenience and revenues. These include installing displays in some stations showing the arrival time of the next city bus at the nearest bus stop to improve bus access from the subway, using station space effectively by providing mini-convenience stores, juice kiosks and other concessions, ensuring mobile phone reception in stations, etc.

Moreover, when Tozai Line services started between Rokujizo and Daigo in 2004, each station in the system was assigned an alphanumeric code marked on all station signs and added to English announcements in trains. All station signs are in Japanese, English, Chinese, and Korean to provide easy-to-understand guidance for overseas visitors.

## Status of Tozai Line Nijo–Tenjingawa Extension

### Overview

The new project to extend the Tozai Line by 2.4 km between Nijo and Tenjingawa is making steady progress with revenue service schedule to start in FY2007. The work extends from Nijo Station, the current terminus at the west end of the Tozai Line, westwards under Oike Street, through Nishioji Oike, and finally to a new terminus at Tenjingawa Station (provisional name). The total project cost of ¥52.5 billion (US\$1 = ¥118), which is well under the initial estimate of ¥74.5 billion, has been funded by public money from the national Highway Trust Fund since FY2003.

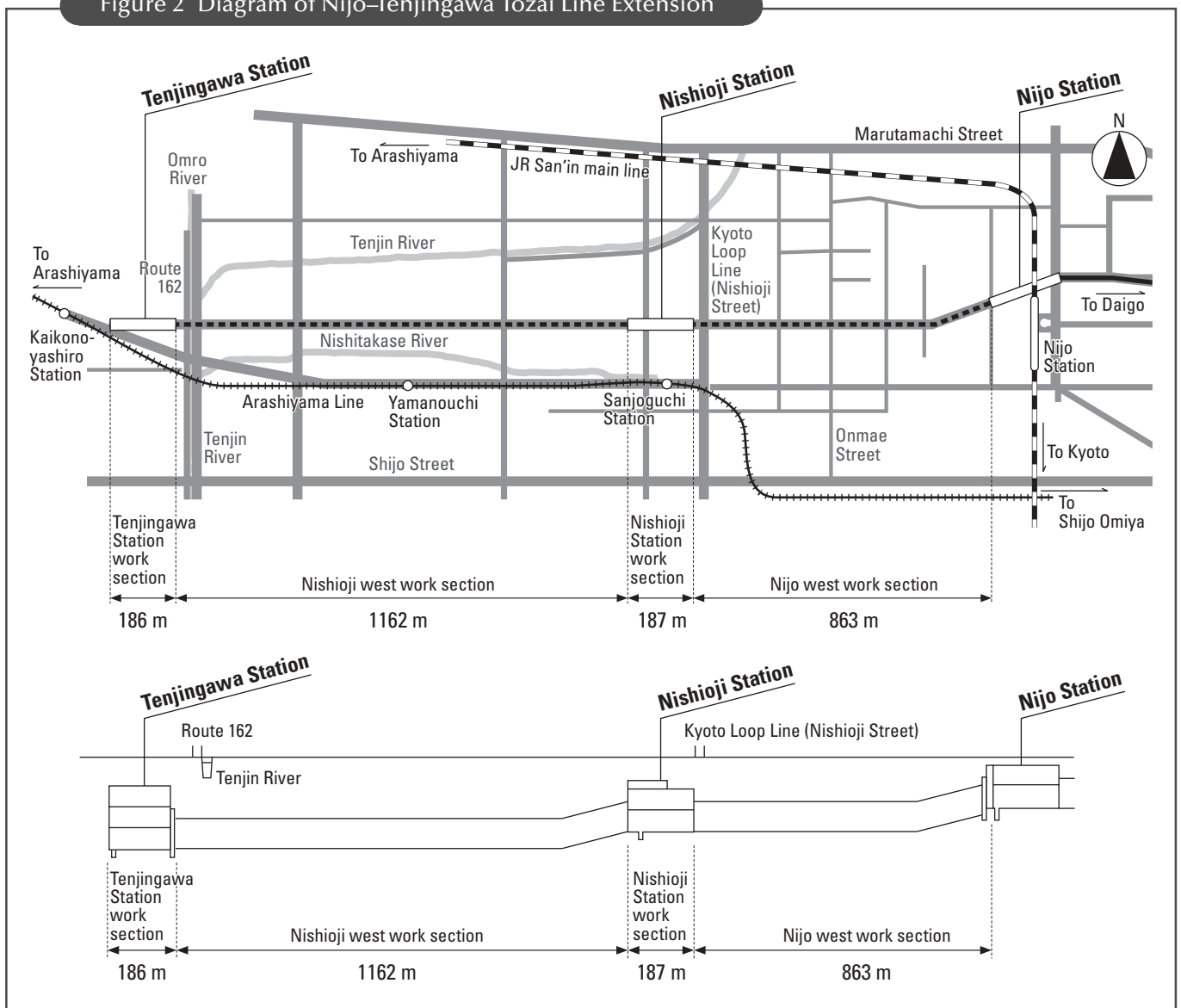
The extension will create new urban infrastructure in western Kyoto and the connection at the Tenjingawa terminus to the Arashiyama Line of Keifuku Electric Railroad will form a convenient network. It is entirely underground and the work is divided into four sections: Nijo west; Nishioji Station; Nishioji west; and Tenjingawa Station. The construction method is divided by work section with stations constructed by the cut-and-cover method, and tunnel sections between stations bored by the shield method (Fig. 2).

Groundbreaking began in November 2002 after a business permit was obtained in May 2001 and pile-driving started in May 2003. The main station structures have been completed and backfilling and entrance/exit work is underway. Boring of the shield tunnels between stations was completed in December 2005 and the tracks are now being laid, bringing the civil engineering phase to a close.

Table 1 Status of Main Barrier-free Facilities

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| <ul style="list-style-type: none"> <li>• Installation of elevators and escalators (all stations), air-conditioning (all stations), and cooling and heating (all trains)</li> <li>• Installation of devices to prevent falling between train cars (all Karasuma Line trains) and platform doors (all Tozai Line stations)</li> <li>• Installation of audio guidance in elevators and at automatic ticket gates</li> </ul> | <ul style="list-style-type: none"> <li>• Installation of tactile floor tiles for visually impaired people</li> <li>• Display of emergency information on destination displays in trains (Tozai Line) and at platforms (Karasuma Line)</li> <li>• Installation of multi-purpose toilets, provision of Braille toilet guidance, and elimination of height differences at toilet entrances (Tozai Line)</li> </ul> |
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Figure 2 Diagram of Nijo–Tenjingawa Tozai Line Extension



## Nijo west work section

The Nijo west work section extends 863.2 m from Nijo Station to the new Nishioji Station using shield method. A start pit (cut-and-cover method: two-level reinforced-concrete structure) was constructed on the west side of Nijo Station, and concrete-segment lined tunnels (5700-mm OD, 5140-mm finished ID) were bored by two earth pressure balanced shield machines (5480-mm OD, parallel single track).

The shield machine cutting head uses glass-fibre-reinforced urethane for the shield earth retaining wall (SEW), allowing the shield machine to cut directly. This ensures safety as the shield machine advances, reduces the amount of required ground improvement, and cuts construction costs. To minimize the effect on surrounding ground and buried structures during tunnel excavation, the westbound tunnel was driven first, and then the

eastbound tunnel was driven while maintaining a constant distance from the west tunnel.

## Nishioji Station work section

The Nishioji Station work section extends 186.8 m; the station building is a two-level structure constructed by the cut-and-cover method with a cut width of 14 to 19 m and depth of 20 to 24 m. The section contains a large-diameter (1650 mm) feeder pipe carrying raw water from the Lake Biwa Canal to the Yamanouchi Water Treatment Plant, as well as a 1000-mm water supply pipe. Both are high-pressure pipes, so underpinning was not possible and the pipes were moved behind the earth retaining wall. Since the water flow could not be stopped even temporarily when moving the pipes, large-diameter non-interruptible switching valves were manufactured to perform the switchover.

## Nishioji west work section

The Nishioji west work section extends 1162 m from Nishioji Station to the new Tenjingawa Station and is being bored using the shield method. The tunnel (9300-mm OD, 8600-mm finished ID) was constructed using concrete segments while boring with a single double-track large cross-section shield machine (9480 mm OD). The start pit was constructed in the Tenjingawa Station work section as part of the station.

The Yamanouchi Water Treatment Plant is in this work section, so a large 1650-mm feeder pipe and many other important water facilities are buried here and the tunnel boring required many precautions.

In particular, Oike Street divides the Water Treatment Plant into north and south parts connected by an underground aqueduct carrying 135,000 m<sup>3</sup> of drinking water per day located some 150 m from the construction starting point. These facilities were constructed in the latter 1960s, and conditions made ground improvement and other auxiliary work difficult. Therefore, precision control was used when boring near this underground aqueduct with extra care when passing under it.

In addition, instead of using concrete to backfill the invert portion forming the track bed, cement was added to the excavated spoil to produce slurry, which helped cut both construction costs and the environmental burden.

## Tenjingawa Station work section

The Tenjingawa Station work section extends 186 m; the station building is a three-level structure constructed by the cut-and-cover method with a cut width of 12 to 16 m and depth of 24 to 28 m.

Development around the new Tenjingawa Station is being promoted in partnership with residents by integrated land readjustment, facilitating construction of a station plaza, new planned Oike Street, new Keifuku Electric Railroad station, Sakyo Ward Office, gymnasium, library, and public housing in conjunction with completion of the subway.

## Future plans

The Nijo–Tenjingawa extension is entering the busiest stage with various work on entrances and exits, tracks, structures, facilities, etc., all occurring at once in conjunction with the redevelopment around Tenjingawa Station. Therefore, work is being closely coordinated to assure safety while staying on target for the start of services in FY2007.

## Conclusion

The Kyoto municipal government has established its 'New Kyoto City Tourism Promotion Plan—Leisure, Charm and Easy New Start Plan 21' to publicize Kyoto's charm worldwide. The city is promoting policies and

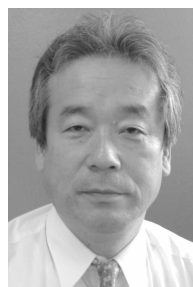
projects aimed at attracting 50 million visitors annually to Kyoto by 2010. The concept is to promote longer stays in Kyoto allowing visitors to thoroughly experience its many charms at a leisurely pace by relying on safe, convenient, and comfortable subways and facilities instead of automobiles.

Future plans involve a study of extending the Tozai Line from Tenjingawa to Rakusai and even to Nagaokakyo. Moreover, extension of the Karasuma Line south of Takeda Station is being studied with an eye to establishing a high-density urban district in the southern part of the city.

Furthermore, the 8th Report (October 2004) of the Council for Kinki Regional Transport, positioned the Tozai Line between Tenjingawa and Rakusai (7.7 km) and the Karasuma Line between Takeda Station and the interchange with the Keihan main line (4.4 km) as 'desirable new routes for mid- to long-term construction of the rapid railway network in the Kyoto–Osaka–Kobe area' and broadly indicated a need for construction.

In particular, early construction of the western Tozai Line extension is seen as a key transport facility, aiding development of western Kyoto, and advancing the city's industrial promotion strategy (Kyoto Super Techno City Concept) by fostering cooperation between industry, academia and government with projects such as the Kyoto University Katsura Campus and the Katsura Innovation Park.

The subways in Kyoto serve many passengers but construction and maintenance require colossal investment and the financial situation remains severe. However, the city intends to continue developing safe, secure, and comfortable subways as a driving force in its urban development based on the Kyoto City Basic Program and the 8th Report of the council for Kinki Regional Transport.



**Toshikazu Kubota**

Mr Kubota is Director General of the Construction Division at Kyoto Municipal Transportation Bureau. He graduated in engineering from Osaka City University before joining the Bureau where is the Manager of Rapid Urban Railways.