Opening of Tohoku Shinkansen Hachinohe-Shin-Aomori Section

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1. Introduction

The Tohoku Shinkansen is a high-speed railway line linking the Tohoku region with Tokyo via Aomori City, Hachinohe City, and Morioka City. The approximately 675-km shinkansen line is an important transport artery that traverses the Tohoku region. It is instrumental in the region's development.

Since construction of the Tohoku Shinkansen started in November 1971, the line has launched services in phases, beginning with the Omiya-Morioka section in June 1982, the Ueno-Omiya section in March 1985, and the Tokyo-Ueno section in June 1991.

The Morioka-Hachinohe section was opened in December 2002 as a projected shinkansen line. With the opening of the final Hachinohe-Shin-Aomori section (81.8km), the Tohoku Shinkansen can now offer services for the whole line, 39 years after the start of construction.

This article introduces various facilities and structures of the Tohoku Shinkansen (Hachinohe-Shin-Aomori section) as an agglomeration of the technological expertise of the Japan Railway Construction, Transport and Technology Agency (JRTT).

2. Route of Tohoku Shinkansen (Hachinohe-Shin-Aomori Section)

After Hachinohe Station, the Tohoku Shinkansen departs immediately from the Tohoku main line, changing direction from northeast to northwest. After passing through several shallow tunnels in the mounds of the hilly area, the shinkansen line heads toward newly constructed Shichinohe-Towada Station (Fig. 1).

The shinkansen line then goes through a tunnel at the foot of Mt. Hakkoda north of the Ou mountain range to reach Shin-Aomori Station, which is shared by the JR Ou main line.

About 60% of the route is tunnel sections, including the 26.5-km long Hakkoda Tunnel.

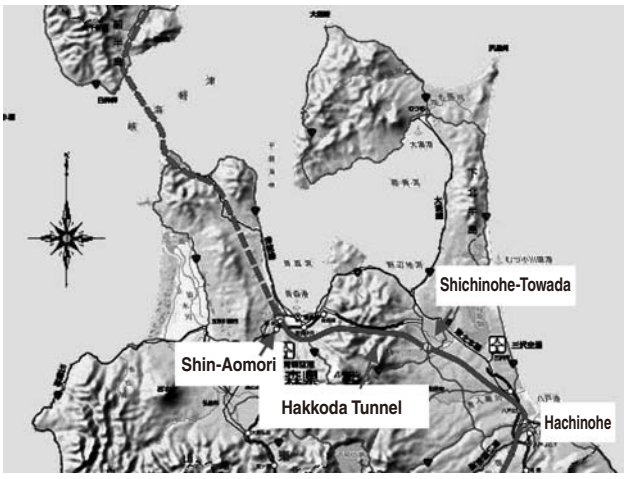

Fig. 1 Tohoku Shinkansen route map

The Shinkansen has five large bridges that are over 100 meters long. Among them, the Sannai Maruyama Bridge, which has four spans with a total length of 450 meters, is a shinkansen bridge that has the largest span (150m).

Except for the Shin-Aomori Station vicinity, curve radious of the Shinkansen is over 4,000 meters with the steepest grade at 20‰.

After the shinkansen service reached Hachinohe, the shortest trip between Tokyo and Shin-Aomori was 3 hours and 59 minutes via Shinkansen (Tokyo -Hachinohe section), and the conventional line (Hachinohe-Aomori section). Thanks to the launch of shinkansen service for the Hachinohe-Shin-Aomori section, the section between Tokyo and Shin-Aomori can now be covered in as quickly as 3 hours and 20 minutes.

Photo 1 Inside Hakkoda Tunnel

Photo 2 Sannai Maruyama Bridge

3. Account of the construction

(1) Tunnel construction

Of the 19 large and small tunnels, the Tamogino Tunnel was the first one that was bored through in 2003, followed by the Moyadaira Tunnel and Gonohe Tunnel in 2004.

The 26.5-km long Hakkoda Tunnel is the world's longest double track tunnel on land. Of the six construction sections, excavation of the Nashinoki section located at the end of the shinkansen line was first started in 1998. The tunnel was bored through in February 2005.

A considerably wide area around the Hakkoda Tunnel is covered by altered rocks from mineralization (hydrothermally altered

rocks rich in pyrite). The pyrite in the mineralized rocks reacts to the underground water and oxygen in the air, resulting in acid mine drainage that impacts the surrounding environment.

For this reason, an independent standard was set up for the Hakkoda Tunnel construction project to determine how to dispose of the excavated soil so that the soil could be sorted and disposed of properly and quickly to protect the environment.

Advancing horizontal boring was carried out throughout the line to find out in advance the conditions of soil and underground water in the foreground. While integrating different treatment methods for the altered rocks and the regular soil into the boring cycle, JRTT carried out the excavation of the tunnels carefully despite the challenges of fault fracture zones and sudden gushes of spring water. The excavation was completed early in six years and seven months (Photo 1).

(2) Viaduct and bridge construction

Viaduct construction began with the Funaoka Viaduct (L=316 m) in Aomori City in March 2001 to facilitate testing of the water sprinkler snow melting system, followed by the construction of the Shiriuchi Viaduct at the first section after Hachinohe Station in April of the same year. Since then, viaduct construction went into high gear.

In April 2009 the last beam of the Shin-Aomori Station Viaduct was installed, connecting the main structures into one.

The Sannai Maruyama Viaduct located at approximately 2km from Shin-Aomori Station passes near the Sannai Maruyama Site. This Special National Historical Site is the largest Jomon settlement site in Japan.

Since this bridge crosses National Route 7 the Aomori loop road and River Okidate consecutively, it requires a 150-m span, which is the largest span used for a shinkansen bridge. It is an extradosed prestressed concrete bridge with four spans (75m+150m+150m+75m), with a total length of 450 meters (Photo 2).

(3) Snow-damage measures

The area of the Tohoku Shinkansen (Hachinohe-Shin-Aomori section) from around the entrance of the Hakkoda Tunnel to Aomori City is a heavy-snow zone with the probability of having maximum snow depth of over 2 meters every ten years. The Tohoku Shinkansen uses the water sprinkler snow melting system, which was last adopted by the Joetsu Shinkansen, to ensure safe operation and reliable services.

Snow melting tests were conducted on the abovementioned Funaoka Viaduct because this cold area has an average winter temperature below 0℃ and the lowest temperature at -20℃. It was determined that the water sprinkler snow melting system would have specifications shown in Table 1.

After all seven snow melting bases, water pipes, sprinklers, and other facilities had been installed; tests were conducted over a period of two years from 2008 to 2009 to validate their functions in order to ensure that there would not be any problems for the shinkansen operation (Photo 3).

Table 1 Specifications of water sprinkler snow melting system

Volume of water sprinkled	1.0 liter/minute/m^2
Designed temperature of water sprinkled	10. 6℃ ～ 11. 8℃
Operating method	Heated water circulation system (except for the area at the exit of the Hakkoda Tunnel)
Water for melting snow	Spring water from the Hakkoda Tunnel and water from rivers
Sprinkler interval	Installed in a zigzag pattern at 6-m intervals

Photo 3 Water sprayed from a sprinkler

(4) Track construction

The manufacture of track slabs began after the plan to construct facilities for the launch of service was approved in December 2005.

From 2006, the transport of rails began. A rail-laying ceremony was carried out at the Hakkoda Tunnel. The rails were laid sequentially at sections where the civil engineering works had been completed.

Approximately 80.5km (98%) of the track structure in the section between Hachinohe and Shin-Aomori use slab tracks, a standard track type for the projected shinkansen lines.

The viaduct sections use the conventional flat track slabs. The sections inside tunnels, which are not subject to the impact of snow, use frame-shape track slabs with hollow space between the rails (Photo 4).

The number of rail fastening devices for each track slab (standard 5 m in length) was reduced from eight on each side of the slab to seven, making the track slabs more affordable.

The construction was progressing smoothly. In November 2009, the last rail was fastened inside Shin-Aomori Station.

Photo 4 Flat slab (left) and frame-shape slab (right)

(5) Electrical works

Electricity for the Hachinohe-Shin-Aomori section is supplied using single-phase alternating current in standard 25kV voltage. Three substations have been newly constructed at the Shin-Shichinohe, Shin-Aomori, and Aomori car depots; as well as two sectioning posts (SP) and four sub-sectioning posts (SSP).

At the Shin-Shichinohe substation, which receives electricity in ultra-high voltage, it is the first time for a projected shinkansen line to use the new type connected transformer (roof delta connected transformer).

High tension simple catenary, which excels in high-speed power collection, is used as the overhead line for the shinkansen line due to the transport demand and economic efficiency. The PHC (precipitation hardened copper alloy) simple catenary, which is made of the PHC trolley line and is almost 100% recyclable, was developed in order to protect the environment and reduce environmental impact (Photo 5).

The electrical works were carried out at the same time while the tracks were being laid; the installation proceeded steadily and was completed successfully.

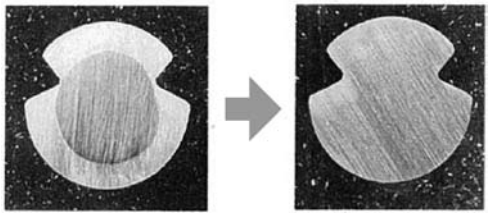

Photo 5 CS trolley line (left) and PHC trolley line (right)

(6) Architecture works

Architecture works of Shichinohe-Towada Station was started in August 2008 and construction of Shin-Aomori Station building was started in October 2008. While the construction was carried out in tandem with the civil engineering, track, and electrical works, the stations were completed in February 2010 (Photo 6).

Photo 6 Shichinohe-Towada Station

Shichinohe-Towada Station is an over-track station with of two opposite platforms and two tracks. The floor height of the platform is 2 meters lower than the surrounding soil, making it a semi-underground station.

The station design is based on the concept of "a peaceful station that portrays rich nature and history." The overall shape is divided into three parts. The large space at the center symbolizes the expansiveness of the Hakkoda mountain range, the east side represents the rows of pine trees on the Oshu Kaido (route), and the curvature of the glass façade signifies the Hakkoda mountain range and the gentle shape of the back of a Nanbu Uma(southern horse).

Photo 7 Shin-Aomori Station

Shin-Aomori Station is an elevated station with two island platforms and four tracks (Photo 7).

The design concept— "From Jomon to the Future: comfortable and relaxing northern station that makes one feel nostalgic" —is reflected in the station's design.

The outer walls on the right and left sides represent the history of and nostalgia for the secluded villages in the Jomon Era. The middle part is a glass space, symbolizing the bright future of Aomori. Together, they form an image of "Jomon" and "Future."

4. Conclusion

Despite the price increases of steel and other materials during the construction, the use of new technologies and implementation of various cost-reduction measures can keep construction cost for the Hachinohe-Shin-Aomori section within the budget (approximately 459 trillion yen) originally approved.

Opening of the complete Tohoku shinkansen up to Shin-Aomori will contribute considerably to the revitalization of Aomori's local economy. Further growth is expected when the Hokkaido shinkansen, which will have an extension from Shin-Aomori Station to Shin-Hakodate (tentative name), starts offering services.

NEWS

◯ **Tohoku Shinkansen opened completely between Tokyo and Shin-Aomori**

The Tohoku Shinkansen has started the full service between Tokyo and Shin-Aomori on December 4, 2010. It is expected that the Tohoku Shinkansen plays the role as the public transportation facilities for the activation of the regional economy and industry in the north-northeast area including Aomori.

The number of train operation per day is 15 services between Tokyo and Shin-Aomori, one service between Sendai and Shin-Aomori, and one service between Morioka and Shin-Aomori, respectively.

According to the utilization trend during one week after opening, the ridership taken the both inbound and outbound of limited express "Hayate" between Hachinohe and Shin-Aomori averages out at approximately 6,500 per day (116% compared with the same week a year ago).

◯ **High Speed Railway Seminar in Los Angeles**

On January 14, 2011, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) held a seminar on 'California High-Speed Railways' in Los Angeles, California, USA. Mr. Sumio MABUCHI, Minister of MLIT at that time was the leader of the mission to promote Japanese high-speed railway technologies to California, and was accompanied by the board members of the three JR Railway Companies; Mr. Satoshi SEINO, President of JR East, Mr. Tsutomu MORIMURA, Senior Executive Director managing Overseas High-Speed Railway Projects of JR Central, and Mr. Toshihiko AOYAGI, Executive Director of JR Kyushu. They showed the state of the art railway technologies of Japan as mainly used in Shinkansen.

This was the second seminar ever held in USA with the Minister of MLIT, though the seminar itself was the third time. The first one was conducted in June, 2010, under the title 'High Speed-Railway Seminar in Chicago'. The projected plan of the High-Speed Railway in California is to renovate the route between San Francisco and Anaheim with the length of about 740km, and to connect in 2 hours and 40 minutes by running at the top speed of 350km/h. It is aimed to start the commercial service in 2020, 9 years later.

The seminar was co-sponsored by the three ministries, ie, MLIT, Foreign Affairs of Japan, and Economy, Trade and Industry; and Institution for Transport Policy Studies, Oversea's Railway Promotion Council and JETRO.

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