JR East is proceeding with introduction of next-generation 2000 type turnouts in the Tokyo area for the purposes of preventing failure of turnouts and reducing maintenance work. Installation of new turnouts is also scheduled in other areas where we plan to arrange lines and to build overpasses. We therefore developed a next-generation turnout for cold regions. We developed that next-generation turnout as an integrated system in close cooperation with the infrastructure engineers. We carried out performance tests in the laboratory and on commercial lines for cold region track equipment—elevated base plates and grid sleepers—successfully confirming that both exhibited the planned performance.

Keywords: Cold region, Next-generation turnout, Elevated base plates, Grid sleeper

1 Introduction

JR East is proceeding with introduction of next-generation 2000 type turnouts in the Tokyo area for the purposes of preventing failure of turnouts and reducing maintenance work. As of the end of March 2008, 185 sets of the next-generation turnout have been installed (Fig. 1); and a further 54 sets are planned to be installed by the end of fiscal 2008, for a total of 239 sets.

Meanwhile, installation of new turnouts is also scheduled in other areas where we plan to arrange lines and to build overpasses. We therefore developed a next-generation turnout for cold regions.

Fig. 1 Change in Number of Next-Generation Turnouts Installed
*Cassette switch: Only the switch part of the turnout is replaced as a cassette together with the grid sleepers.

2 Overview of Next-Generation Turnouts for Cold Regions

Next generation turnouts for cold regions are equipped with the following devices that can be applied to cold environments to prevent turnout failures and reduce maintenance work:

1) Heater cover for electric switches that can handle low temperatures
2) New electric snow melting device that has high heat efficiency
3) Air jet snow remover that works with the next-generation turnouts
4) Elevated base plates for cold regions
5) Grid sleepers for cold regions

To optimize the total system, we carried out the development of next-generation turnouts as an integrated system in close cooperation with the infrastructure engineers. This article will report on the development of elevated base plates and grid sleepers for cold regions.
3 Development of Elevated Base Plates for Cold Regions

3.1 Purpose of the Development
We developed elevated base plates for cold regions to enable use of the commercial frequency induction heating type electric snow melting device with high heat efficiency under development.

3.2 Structure of the Developed Electric Snow Melting Device
In order to enhance heat efficiency, the electric snow melting device needs cabling just under the sliding surface of the tongue rail of elevated base plates and making 6 mm-diameter cable holes at 20 mm intervals there. But the current elevated base plates for the next-generation turnouts lacked the thickness for those holes because the fastening spring inside the gauge of the stock rails was an obstruction (Fig. 3).

Accordingly, we developed new elevated base plates that included those fastening springs. The base plate consists of a lower panel on which the stock rail is laid, an upper panel that has the sliding surface of the tongue rail and cable holes and two bar springs that fasten the upper panel and the stock rail to the lower panel (Fig. 4). Cost reduction of the product and improvement of ease of assembly were also aimed for in the development.

3.3 Strength Analysis
Strength analysis of the developed bar spring and base plate was done by the Finite Element Method (Fig. 5).
That analysis confirmed that the strength of those was less than the structural ratio and the allowable stress of steel material.

3.4 Performance Tests
We carried out the following tests to check the performance of the developed elevated base plate.
1) Assembly Test
By assembling and disassembling the prototype, we measured the stress of the bar spring and the base plate, and checked workability in assembly. The stress of the bar spring was less than the elastic limit in any measurement. The stress at different points of the base plate was around 55% the elastic limit (around 70% in the analysis results). We also confirmed that workability in assembling was better than that of the existing elevated base plate (Fig. 6).
2) Measurement of Rail Holding Force
By applying lifting force to the rail at a constant velocity until the rail pad was pulled out, we continuously measured displacement of the rail and the stress of the bar spring and the base plate. The measurement results proved that the rail holding force met design requirements (12 kN per fastening point on each side, Fig. 7).

3) Rail Creepage Resistance Measurement Tests
We measured the load and the displacement of the rail by placing a load on the rail in the longitudinal direction at a constant velocity until continuous sliding occurred between the rail and the rail pad (until increase of load became unrecognizable). The results showed that the resistance to rail creepage of the new base plate was similar to that of the existing base plate (15.6 kN, Fig. 8).

4) Bar Spring Fatigue Test
Since fatigue breakage of the bar springs was a particular concern, we carried out biaxial fatigue tests under actual use conditions (Fig. 9). By repeating dynamic application of loads A and B, we measured strain and other factors.

The measurement results confirmed that the strain of the bar spring was less than the elastic limit. The graph of the durability limit of the spring steel also showed that the material had sufficient durability against breakage and permanent deformation of the spring (Fig. 10).

3.5 Evaluation Conclusion
Based on the strength analyses and performance checks, we confirmed that installation to commercial lines of the developed elevated base plate was feasible.

4 Development of Grid Sleepers for Cold Regions

4.1 Purpose of Development
We developed a grid sleeper for cold regions on which air jet snow removers could be installed and which could reduce labor in installation and maintenance of piping for compressed air.
4.2 Structure of the Developed Grid Sleepers
The developed grid sleepers have a built-in stainless pipe for jet air (Fig. 11). A groove is made on the upper surface of the grid sleeper to accommodate the pipe, and a flat cover with jet air holes is welded over the groove (Fig. 12, 13). This structure eliminated the need for a hole on the web of the stock rail for jet air piping.

1) Cross Sleeper (Synthetic) Bending Tests
Tests were conducted based on JIS E 1203 (synthetic sleepers) bending resistance loading tests. The test results showed no breakage even when applying a load greater than the standard value (Fig. 14).

2) Longitudinal Sleeper (Steel) Wheel Load and Lateral Force Application Tests
By attaching a strain gauge to the top and side surfaces of the sleeper, we measured strain caused by longitudinal and lateral loads. The measurement results proved that the longitudinal sleeper could sufficiently bear forces in practical use (Fig. 15).

4.3 Laboratory Performance Tests
We carried out performance tests in the laboratory to check the strength of the grooved grid sleeper. Those tests were done by applying design loads to main components.

4.4 Evaluation Conclusion
Based on the laboratory performance test results, we concluded that the grooved grid sleepers had no problems in terms of strength.

4.5 Test Installation to a Commercial Line
After the analyses and performance tests, we conducted test installation of next-generation turnouts for cold regions to a commercial line.
5.1 Selection of the Location of Test Installation
In selecting the location of test installation, we considered conditions in the individual component areas, train intervals and other construction situations. In the end, we decided to install the turnout as the No. 22 turnout (50N No. 10, simple turnout) in the yard of the Hanyuda station on the Shin’etsu main line (Fig. 16).

5.2 Test Installation
With the cooperation of Niigata Track Maintenance Technology Center and others, we carried out the test installation by replacing the switch part. In the night of January 14, 2008, we laid temporary rails to the place where the over-raise rail shifter and turnout were removed, and then moved the new switch together with the grid sleepers longitudinally and laterally to install them. The replacement of the turnout body (with a point machine installed) was completed within the 125-minute train interval and the performance tests of that point machine and other equipment was continued for approx. 60 minutes. Fig. 17 and 18 show the situation during and after the installation work.

5.3 Performance Test
We tested the performance of the next generation turnout for cold regions. As engineers in each area carried out checks on the items (machinery: air jet, power: electric snow melting device, signal: temperature of the point machine), track area engineers measured the changes of the dynamic stress of the rail fasteners and grid sleepers.

Measurements were conducted from March 11 to 14, 2008 on stress of the upper and lower base plates, stress of the spring clips. We also measured vertical and horizontal displacement of the rails and stress of the grid sleepers (Fig. 19, 20, 21).

Table 1 shows the measured trains. We carried out measurement using a conventional train, an express train and a freight train to estimate the affect of the different train speeds and weights.
6 Conclusion and Future Efforts

We developed a next-generation turnout for cold regions and conducted test installation of that to a commercial line. Since no particular problems were found from the perspective of the track equipment, we are planning to address issues related to practical use and check the long-term durability of that taking into consideration the machinery, power and signal test results.

In this development, people from the manufacturers that conducted joint development as well as other manufacturers and concerned construction companies and concerned sections of Niigata Branch Office lended gave us great support. We would like to take this opportunity to express our sincere thanks to all of those people.

Reference: