Improvement to Expand Deployment of "Next-Generation Turnouts"

Koji Oike*

Masakatsu Tatekawa*

Toshiyuki Konishi*

More than 300 sets of the "next-generation turnout (2000-type)" have been installed mainly in the greater Tokyo area since 2002. This has brought about various effects including reduction of transport disorders due to turnout failure, reduction of maintenance costs, and reduction of the number of items to be inspected. For further introduction of 2000-type turnouts, we investigated the possibility of cost reduction. As a result, we achieved 30% material costs reduction and confirmed that strength of the "grid type sleeper" and fatigue durability of the "slide base plate" meet performance requirements.

●Keywords: Next-generation turnout, Grid type sleeper, Raised base plate, Cost reduction

1 Introduction

JR East developed the next-generation turnout (2000-type) with aims such as reducing transport disorders due to turnout failure, reducing maintenance costs, and reducing the number of items to be inspected. Since fiscal 2002, more than 300 sets of that turnout have been installed (a process called "cartridge replacement") to switches mainly in the greater Tokyo area. The next-generation turnout is an innovative type achieved by reviewing the overall functions of turnouts and actively introducing outstanding components procured overseas. Introduction of the next-generation turnout has demonstrated many functional advantages, so we studied reduction of its material costs, aiming to expanding its deployment. This paper will cover the development so far.

2 Research on Cost Reduction to Expand Deployment

2.1 Review of Sleeper Structure

Material costs account for approx. 30% of the total costs of grid type sleepers with which the track maintenance period has been extended by improving rigidity of track panels (seven times more rigid in lateral direction, two to three times more rigid in longitudinal direction). We thus streamlined those sleepers ("slim grid type sleeper") to cut their material costs while maintaining the current structure. The targets we reviewed for streamlining include extending intervals between rail fastenings, reducing the number of cross sleepers, downsizing the widths of short and cross sleepers, using thinner steel plates, and modifying welding specifications. Table 1 shows a comparison between conventional and slim grid type sleepers.

As slim grid type sleepers use thinner steel plates and have larger interval between rail fastenings, we checked the strength by FEM analysis using a grid type sleeper for a 60k No. 12 turnout as the analysis model. The maximum stress was less than the allowable stress of 100 MPa when load A of 98 kN was applied in the direction perpendicular to the center of the rail on the short sleepers (P1 in Fig. 1). The results suggested that modifying specifications of the slim grid type sleeper would reduce costs by

Table 1 Comparison between Current and Slim Grid Type Sleepers

	Current grid type sleeper	Slim grid type sleeper
Interval (interval between rail fastenings)	750 mm	900 mm
Number of cross sleepers	6	4
Width of cross sleeper	300 mm	230 mm
Width of short sleeper	350 mm	250 mm
Steel plate thickness	12 mm	9 mm
Welding specification	Fillet weld thickness of 12 mm on perimeter of joint of longitudinal and lateral members	Fillet weld thickness of 10 mm on perimeter of joint of longitudinal and lateral members

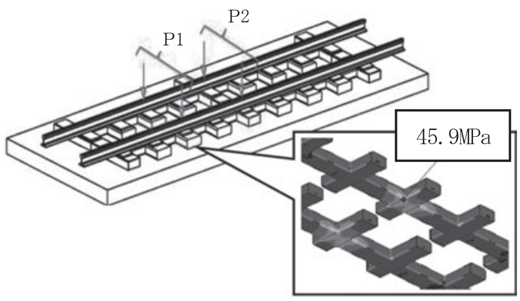

Fig. 1 FEM Analysis Results for Grid Type Sleeper

6.7% compared with material costs for cartridge replacement with the current next-generation turnout.

2.2 Review of Base Plates and Rail Fastening Method

2.2.1 Review of Rail Fastening Method

The current next-generation turnout lowers the risk of switching failures due to foreign objects caught in the turnout by adopting a raised base plate, which also enables fastening of the stock rail on both sides. However, the clips and risers of that type of base plate are procured overseas, increasing material costs. In order to replacing those with domestically procured components and reduce material costs, we examined a new method of fastening the stock rail on both sides in which flat springs and wedges are combined. In this new method, wedges are driven at the edges of flat springs to raise them and apply reactive force as the fastening force. Fig. 2 shows a comparison of base plates and fasteners of the current next-generation turnout and the reduced-cost type turnout.

*Technical Center, Research and Development Center of JR East Group

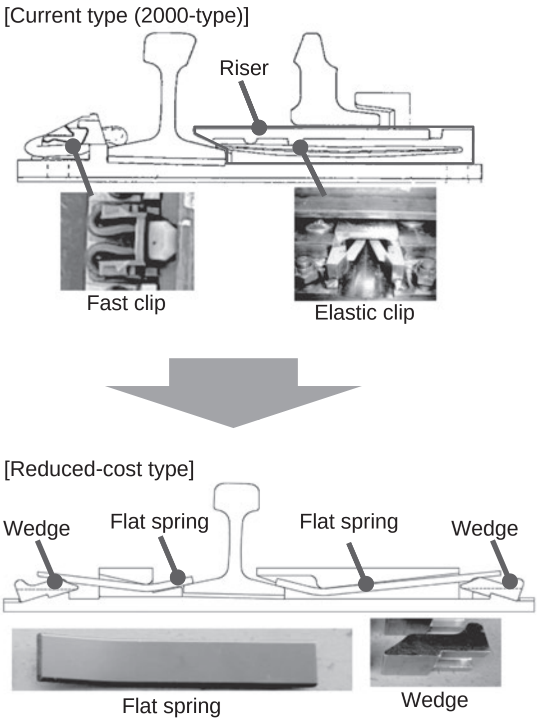

Fig. 2 Comparison between Current Type and Reduced-cost Type of Fastening Methods on Both Sides of Stock Rail

2.2.2 Performance Confirmation Tests

We produced a prototype rail fastener that adopted the new stock rail fastening method and carried out performance confirmation tests for it. Performance was evaluated by checking endurance limit diagrams based on the results of static loading tests and conducting biaxial fatigue tests. A pair of fasteners were tested, and loading conditions assuming live loads A (P_A,θ_A) and B (P_B,θ_B) were decided based on the basic test results (perpendicular, horizontal, and edge spring constants). In static loading tests, stress of the flat springs was measured only at the vertex (Fig. 3).

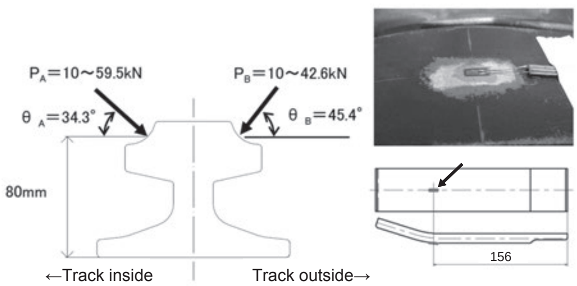

Fig. 3 Load Conditions and Stress Measurement Points

We calculated average and fluctuating stresses from the maximum stress σ_{max} and minimum stress σ_{min} that occurred on the fastening springs and evaluated those using the endurance limit diagram. Fig. 4 shows the evaluation results.

Stress that occurred on the flat springs was less than the second breakdown limit and second permanent settling limit both inside and outside the track, confirming that the flat springs having no problems in terms of fatigue durability. In addition, the amount of lateral displacement at the top of the head of a 60 kg rail calculated from the amount of vertical displacement at the top of the head

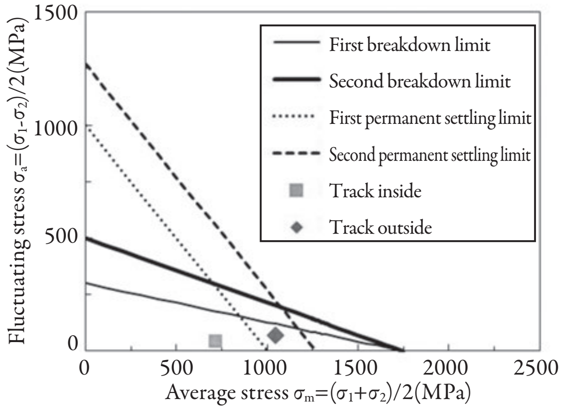

Fig. 4 Load Conditions and Stress Measurement Points

of the test rail was approx. 0.5 mm when a load equivalent to live load A was applied. This is less than the 7.0 mm gauge widening limit specified for conventional lines, so safety requirements were complied with.

Visual checks of the appearance after biaxial fatigue tests revealed no abnormalities such as breakage and wear with the components of the rail fastener, confirming that there were no problems in terms of durability. Furthermore, no remarkable changes in displacement and rail tilting were found with the test rail even after applying loads 1 million times. Those test results demonstrated prospects that adopting the new rail fastener could reduce material costs over those with cartridge replacement for the current 2000-type by 17.2%.

3 Conclusion

The development thus far can be summarized as follows.

- In order to expand deployment of the next-generation turnout (2000-type), we researched cost reduction, produced a reduced-cost prototype, and conducted performance confirmation tests using that prototype. The results demonstrated that there were no problems in terms of structure.
- The results of material costs estimation suggested that streamlining grid type sleepers and modifying rail fasteners of the base plate (adopting domestic components) would cut material costs by approx. 25% compared with the current type.
- We are planning to next make a prototype of the whole switch and carry out further performance confirmation tests using a full-scale track tester.

Reference:

1) Minoru Obi, Yuichiro Hori, "Jisedai Bungiki no Kaihatsu" [in Japanese], *JREA*, Vol. 46, No. 7 (July 2003)

2) Kinya Sato, Masakatsu Tatekawa, "Jisedai Bungiki no Kaihatsu to Donyu Jokyo" [in Japanese], *JREA*, Vol. 52, No. 10 (October 2009)