Special edition paper

Evaluation of the Effect of Speed Increase on Track Maintenance


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We tested the effect that increasing commercial operation speed will have on track maintenance with the following four issues through high-speed running tests using FASTECH360. First, we tested the effect on track components by measuring rail stress at the wayside in speed increase tests. As a result, no problems in terms of fatigue and breakage were found at normal track condition. Second, we made wind speed measurement and video evaluation of the effect of increased train draft on access by maintenance staff to maintenance passages and on the surface condition of ballasted tracks. From that, we studied the effect and the speed range at which countermeasures are needed. Third, we studied the method of track irregularity management. That was done by studying track irregularity chord length used for ride comfort control based on the vibration characteristics of FASTECH360. Then, to check running safety, we carried out running tests on the track with artificial irregularity and investigated the relationship between track irregularity and running safety indicators. Fourth, we evaluated the effect of damage to rubber ballast screens caused when ice drops off the train running at high speed in winter. This article will report those study results.

●Keywords: Rail stress, Slab surface stress, Train draft, Ballast surface wind, Track management, Countermeasure against snow dropping from trains

1 Introduction

Studies in evaluating the effect of Shinkansen operational speed increase on track maintenance can be largely classified into the following four subjects.

1) Effect on track components
2) Effect of train draft on maintenance work
3) Study of track management method
4) Effect of snow (snow dropping from rolling stock)

We have studied each of those in the FASTECH360 high-speed running tests. A summary of the study results is as follows.

2 Effect on Track Components

In the running tests for speed increase, we measured actual stress and irregularity generated to the track components at the wayside. The following are the results of evaluating train speed increase on rails, rail fastenings and track slabs from the viewpoint of the relationship between factors such as speed and generated stress. As lateral force increase in conjunction with speed increase had been already confirmed on curves, we measured factors such as generated stress at the high rail on curves.

2.1 Evaluation of Stress on Rails and Rail Fastenings

The measurement results of the stress on rails up to 360 km/h showed that stress tended to increase as speed increased, but that stress was within the specified fatigue limit. No problems in terms of fatigue and breakage were thus found at normal track condition.

Then we measured the stress on rail fastenings to evaluate fatigue from the viewpoint of the relationship between average stress and variable stress. The measurement results were within the specified fatigue limit and the plastic deformation limit. No problems were found in the normal track condition.

2.2 Evaluation of Stress on Track Slab Surface

Track slabs are difficult to replace, so the effect of speed increase on long-term durability of track slabs needs to be evaluated. When excessive tensile stress acts on the surface of the track slab and causes cracks, rainwater entering then repeatedly freezing and melting to enlarge cracks and eventually corrode reinforcement is a concern. We thus measured the dynamic stress generated on the slab surface by passing trains to evaluate the effect of the speed. The results of measurements up to 395 km/h confirmed that the maximum stress generated is within the standard for deciding running for prestressed reinforced concrete track slabs.

3 Effect of Train Draft on Maintenance Work

Train draft increases with increase in running speed. Increase of the speed of wind against the maintenance passage affecting access to the passage in train operating hours is thus a concern. Furthermore, if increased wind on the ballast surface kicks up ballast, rubber ballast screens usually used to cover ballast to prevent snow-related damage in winter need to be laid throughout the year. If those are laid all year long, removal and reinstallation of them on the work day is required in track maintenance work such as that using a multiple tie tamper, possibly restricting the length of the track maintenance work section. In light of the situation, we measured the speed of the train draft against maintenance staff on the maintenance passage and the ballast surface wind to evaluate their effects. In the evaluation, the wind speed was compared to that of a passing series E2 or E3 train at 275 km/h.

3.1 Evaluation of the Effect on Maintenance Staff on the Maintenance Passage

We measured the train draft on the maintenance passage using an installed three-dimensional ultrasonic anemometer. Train draft usually increases with the length of a train set, so we measured for coupled operation of FASTECH360 type E954 and E955 trains. The draft speed of the coupled train running at

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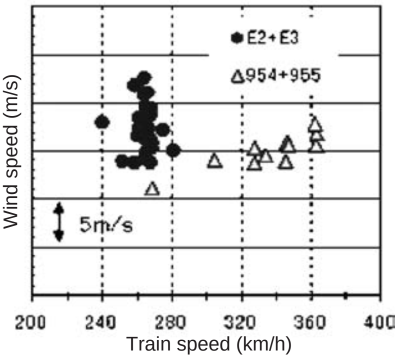

Fig. 1 Relationship between Train Draft Speed and Train Speed

360 km/h was equal to or less than that of a coupled train of series E2 and E3 at 275 km/h (Fig. 1). Thus, we have determined that foot patrols in the maintenance passages by tracks would be possible as before.

3.2 Evaluation of Ballast Surface Wind

Based on the speed increase test results using E2 series trains in 2003, we were concerned that ballast would be kicked up in the speed range greater than 320 km/h. We thus measured the speed of ballast surface wind in the speed increase test using FASTECH360 and photographed the ballast surface to identify the behavior of ballast.

No ballast moved in the speed range greater than 320 km/h, even though the wind speed was greater than that of the wind caused by an E2 and E3 coupled train at 275 km/h. But in the range greater than 340 km/h, we observed the possibility that ballast would roll out. Based on those results, we have anticipated that removal and reinstallation of rubber ballast screens involved in track maintenance work is OK as it is done currently even when commercial operating speed is increased to 320 km/h. But the smoothness of the bogies and underfloor equipment of the new rolling stock to be introduced in service has to be similar to that of FASTECH360 in that case. However, additional countermeasures will be required if the commercial operation speed is further increased.

4 Study on the Track Irregularity Management Method

We studied the track irregularity management method from the viewpoints of ride comfort control and running safety control. For ride comfort control, we studied what wave length range needs to be controlled in terms of track irregularity control according to FASTECH360's response characteristics in track irregularity. For running safety control, we focused on alignment that past studies showed would probably have great effect. We thus carried out running tests with artificial alignment to investigate the relationship between alignment and the running safety indicator (derailment quotient) and between lateral vibration acceleration and speed.

4.1 Ride Comfort Control

We found that lateral vibration acceleration peaked at wavelengths of around 30 - 50 m by analyzing the frequency of the car body vibration of FASTECH360. Since that was the wavelength range where measuring sensitivity of 40 m chord alignment was high, control with the 40 m chord should be effective as before. We also found in analyzing similarly for vertical vibration that the effect of acceleration at around 20 m wavelength was relatively large. Thus, control with the 20 m chord and 40 m chord should be effective.

Based on the above findings, we conclude that current control with the 20 m chord and 40 m chord will be reasonable for ride comfort control.

4.2 Running Safety Control

We know for the relationship between alignment and running safety that the need for control for the 20 m wavelength range close to the distance between two bogies increases in the high-speed range. That conclusion is based on past studies and the track measurement characteristics of alignment. We thus artificially set alignment of the 20 m wavelength range to the actual commercial line track and measured wheel load and lateral force in running tests to make evaluation with running safety indicators. The measurement results proved that at 320 km/h the running safety indicator (ratio of lateral force and wheel load) had much leeway in regard to the limit even when an individual alignment was at the current standard level.

Next, to see the relationship between lateral vibration acceleration and speed, we measured and organized the results of running in seven speed steps from 70 km/h to 320 km/h on the aforementioned section with artificial alignment. The results showed a high correlation between lateral vibration acceleration and speed (Fig. 2).

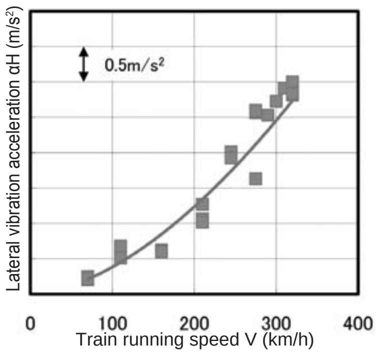

Fig. 2 Relationship between Lateral Vibration Acceleration and Train Speed

5 Effect of Snow-Related Damage

There are many regions of heavy snowfall in the operation area of JR East, making countermeasures against snow dropping off Shinkansen rolling stock running at high speed very important. We were concerned that the impact of dropping snow from trains running at 320 km/h might damage wayside equipment including rubber ballast screens laid in the ballast track sections. We thus inspected resistance of rubber ballast screens to dropping snow according to age of the screens. As a result, we found that impact could cause deep and/or many cracks on rubber ballast screens used for over 20 years and on those with a high percentage of reclaimed rubber. At present, we are proceeding with replacement of aged rubber ballast screens ahead of commercial operation at 320 km/h.

6 Conclusion

We evaluated in FASTECH360 high-speed running tests the effects of operation speed increase on track maintenance. In the future, we plan to make final checks by running tests using series E5 and E6 pre-mass production cars.