Special edition paper

Development of a Technique to Predict Track Irregularity by Analyzing Frequently Obtained Data


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The Technical Center at JR East is developing a "track monitoring device" to collect data frequently. Running tests are currently underway using a train in operation running on the Keihin-Tohoku Line. We tried to predict changes in track irregularity by analyzing acquired data. As a result, we became able to confirm detailed track irregularity by frequently obtained data. In addition, we were able to confirm the quantity of improvement after repair of the track. In this way we catch changes in track conditions and can judge the most suitable time for repair of the track. We are continuing with work in research and development to make the most suitable decision-making by the frequent accumulation of data.

●Keywords: Frequently obtained data, Prediction of deterioration, Measurement cycle, Linear approximation

1 Introduction

With track monitoring using a train in operation on the Keihin-Tohoku and Negishi lines (Fig. 1), we have literally accumulated "big data" over more than a year since the start of running tests. This article will report the findings obtained by analyzing the accumulated data as well as report the possibilities of a new technique to predict track irregularity.

Fig. 1 Train for Keihin-Tohoku and Negishi Lines

2 Calculation of More Accurate Values (True Values)

Measurement data is values that include measurement errors and the like. Accordingly, it is not the actual values (true values). We cannot know the true values, but we can figure out values closer to true values using a statistical method. As more correct values can be estimated from a greater number of parameters (data) in statistical methods, we can say that more data would be more desirable.

Fig. 2 shows track irregularity monitoring data (of 130 measurements) in two months (from June 1 to July 30, 2014) at a given point. Fig. 3 shows the data of Fig. 2 as frequency distribution. Since the progression of track irregularity in those two months was just around 0.04 mm, we show the actual data as-is without taking into consideration that progression. Fig. 2 and 3 illustrate that the resulting data included some data that seems to be measurement errors. However, we can easily pick out just the data without errors by statistical data processing because the frequency and range of distribution of those errors are clear. Fig. 4 is the distribution of the data picked out. We set a threshold between -6.5 mm and -5 mm of the measurement data

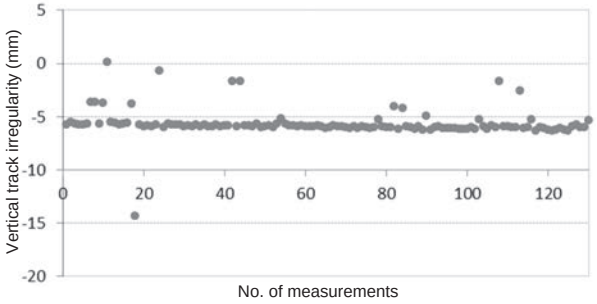

Fig. 2 Vertical Track Irregularity Seen per Number of Measurements

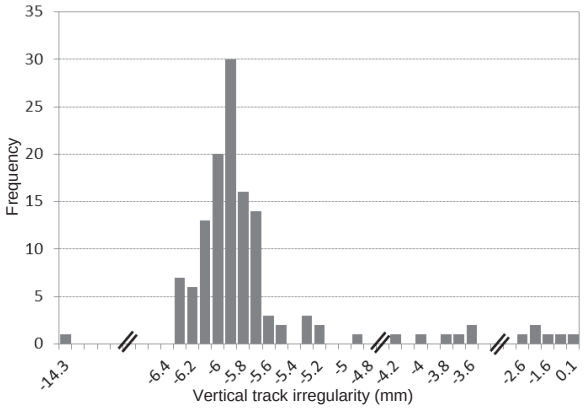

Fig. 3 Distribution of Vertical Track Irregularity

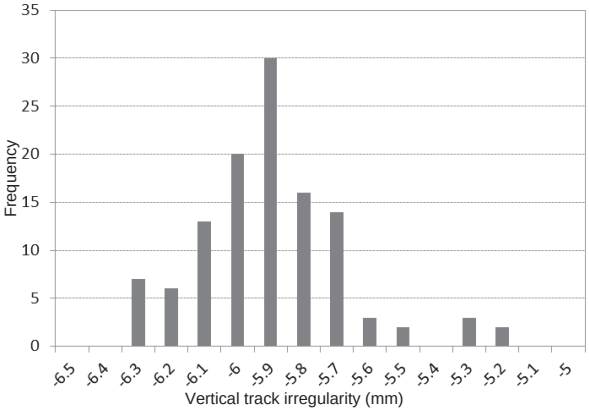

Fig. 4 Distribution of Vertical Track Irregularity Excluding Measurement Error Data

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and picked out the data by excluding data over that threshold. By averaging the data picked out, we become able to predict the true value at an accuracy of 0.1 mm. That will greatly exceed the accuracy of measurement using the East-i inspection car.

Estimation this time was made with 130 instances of measurement data for two months. By dividing the period into a month or a week, it will be possible to grasp the change in a shorter period.

3 Considerable Improvement in Prediction Accuracy by Linear Approximation

Fig. 5 to 7 show the changes in track irregularity for the past two years. The data obtained using the East-i inspection car is data measured four times a year (total eight times), and the data measured using a train in operation is data from the start of measurements (July 2013) to July 31, 2014.

Fig. 5 is a graph of the change in track irregularity at a point where no track repair work was conducted for the past two years. Both the data taken by East-i and that by a train in operation show the same tendency. Therefore we can estimate change in track irregularity similarly by linear approximation from either data taken by East-i or that by a train in operation.

Fig. 6 is a graph of the change in track irregularity at a point where track repair work was conducted once in the period of measurement by a train in operation. Predicting the change by linear approximation based on data measured using the East-i, the change will be 0.78 mm/100 days when using the data of three measurements after the repair work (Approximation 1), 0.36 mm/100 days when using the data of the latest two measurements (Approximation 2), and 0.67 mm/100 days when using the data of the four measurements before the repair work (Approximation 3). Comparing the data obtained by a train in operation shown in the graph, we can see that the prediction based on the data of the latest two measurements (0.36 mm/100 days) is valid because the prediction using the data of three measurements after the repair work (0.78 mm/100 days) includes the amount of initial subsidence immediately after the work. In contrast, it is impossible to determine only from the data from East- i what value is valid, so the value of 0.78 mm/100 days would be normally adopted for the worst-case scenario, leading to overestimation.

Fig. 7 is a graph of the change in track irregularity at a point where many track repairs were conducted. At such a point, it is quite difficult to predict deterioration using data measured by East-i only. Even if estimated, the accuracy would be significantly low.

Based on those, we can say it is possible to predict track deterioration at the same cycle as measurement using East-i at points where no track repair work was carried out, while that is difficult at points where repair work was done. Contrastingly, it was revealed that frequently obtained data using a train in operation allows prediction of track deterioration at higher accuracy.

The effects of repair work also can be accurately evaluated, even taking into account initial subsidence. This can be used for various different simulations to decide on the track repair schedule.

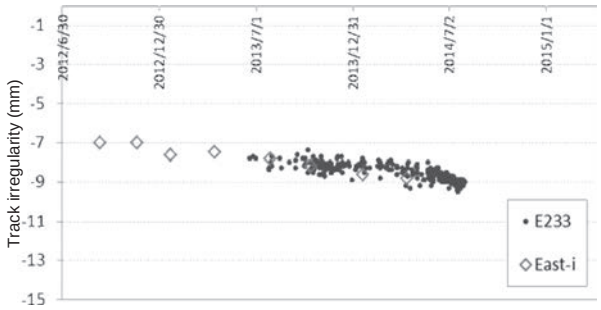

Fig. 5 Changes in Vertical Track Irregularity at Point Without Repairs

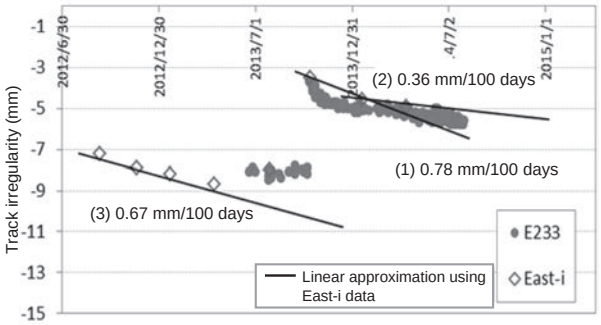

Fig. 6 Changes in Vertical Track Irregularity and Amount of Deterioration at Repaired Point

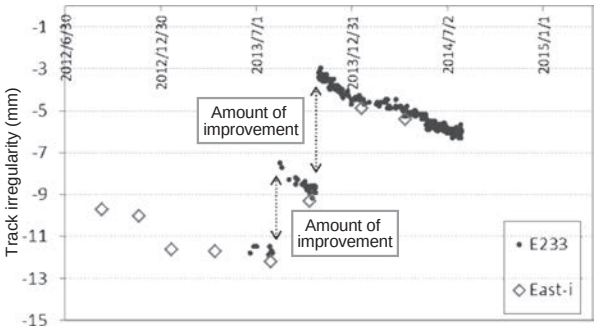

Fig. 7 Changes in Vertical Track Irregularity at Point Repeatedly Repaired

4 Conclusion

Frequently obtaining track measurement data allows us to follow changes in track irregularity in more detail. It also enables visualization of the amount of track improvement after repairs, which was difficult to perceive at the conventional measurement cycle. By making use of those results, we will be able to decide what is the best timing for maintenance while identifying changes in irregularity of individual tracks. When handling data obtained frequently, however, we have to consider the method of handling and storing such data as the data volume increases. The time required for calculation in data analysis also needs to be taken into account. As a future issue, we need to develop a method to optimize the data handled from the viewpoint of big data analysis based on those requirements.

By further accumulating data, we plan to make full use of the advantage of frequently obtaining data and proceed with research and development on optimal maintenance according to the condition of individual sites.