

RTRI Develops a Method for Determining Rail Replacement Cycles Based on Evaluation of Rail Soundness against Fatigue

—Contributing to Extended Rail Service Life—

The Railway Technical Research Institute (RTRI) has developed a method for determining rail replacement cycles by quantitatively evaluating rail condition using an index representing the soundness of rails against fatigue caused by repeated train passages (hereafter “soundness against fatigue”).

1. Background

- Rails are replaced when abnormalities such as defects, wear or corrosion occur due to the service environment; otherwise, they are replaced in accordance with the predetermined cumulative gross tonnage of trains passing over them.
- In current practice, the indicative timing for rail replacement based on cumulative gross passing tonnage (hereafter “replacement cycle”) is set by adding a safety margin to the time at which damage originating at the rail base is expected to begin due to fatigue accumulation caused by repeated train passages. These replacement cycles vary depending on the number of trains and other conditions. In the shortest cases, they are about ten years.
- In reality, however, soundness against fatigue differs depending on the service environment and its relationship with the timing at which rail replacement is actually required is not uniform. Some rails have only a low level of fatigue accumulation and therefore have a low likelihood of fatigue damage even if they exceed the replacement cycle, while, although rare, other rails have a high level of fatigue accumulation and may suffer fatigue damage even before they reach the replacement cycle.
- Since no method has been available to quantitatively determine whether the soundness of a given rail against fatigue is high or low, railway operators have had no choice but to replace rails uniformly once they reach the replacement cycle.
- Therefore, to reduce the workload and other resources associated with rail replacement work while ensuring safe train operation, the development of a method for quantitatively evaluating the rail soundness against fatigue and determining their condition has been anticipated (Fig. 1).

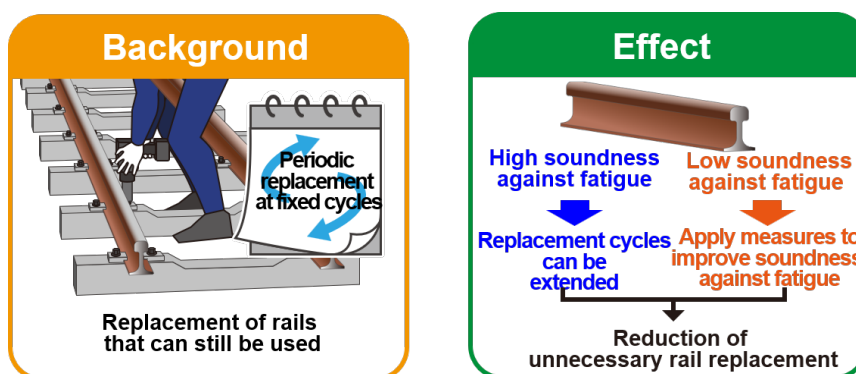


Fig. 1: Developed method

2. Developed method and key features

- RTRI has developed a method for quantitatively calculating the rail soundness against fatigue by estimating the stress generated at the rail base using the gap between sleepers and ballast and the irregularity of railhead. The gap between sleepers and ballast is calculated from the longitudinal level irregularity of track, and the irregularity of railhead is calculated from the acceleration of the axle boxes supporting the axles, both of which are measured by track inspection cars (Fig. 2).

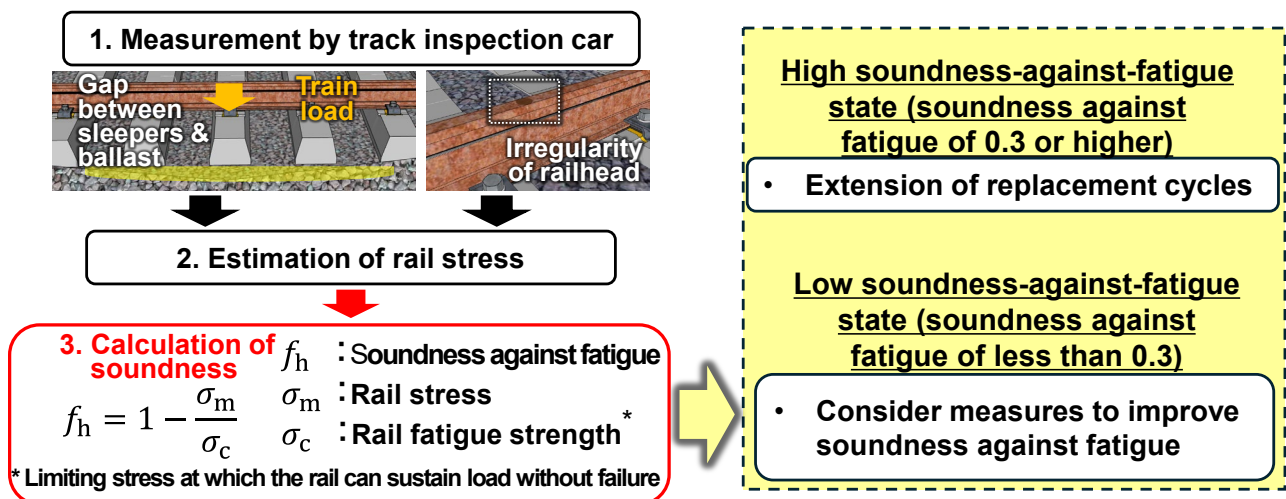


Fig. 2: Method for calculating rail soundness against fatigue

- Using this method, rails that are assessed as being in a high soundness-against-fatigue state, with a soundness-against-fatigue value of 0.3 or higher, can remain in service beyond the prescribed replacement cycle, thereby allowing the replacement cycle to be extended.
- Conversely, for rails that are assessed as being in a low soundness-against-fatigue state, with a soundness-against-fatigue value of less than 0.3, it is also possible to extend the initial replacement cycle and continue using these rails by improving their soundness against fatigue through measures that reduce the gap between sleepers and ballast and the irregularity of railhead.
- By introducing this method, railway operators no longer need to carry out rail replacement work uniformly once rails reach the replacement cycle, and are therefore expected to reduce the workload and other resources associated with rail replacement.

3. Future applications

This method has been implemented as a new function in the latest version (Ver. 4.3) of LABOCS, a track maintenance management database system developed by RTRI and already in use by railway operators. By importing data into this system, railway operators can calculate the soundness of rails against fatigue.

Therefore, railway operators that are already managing track inspection data using LABOCS can immediately make use of this evaluation method.

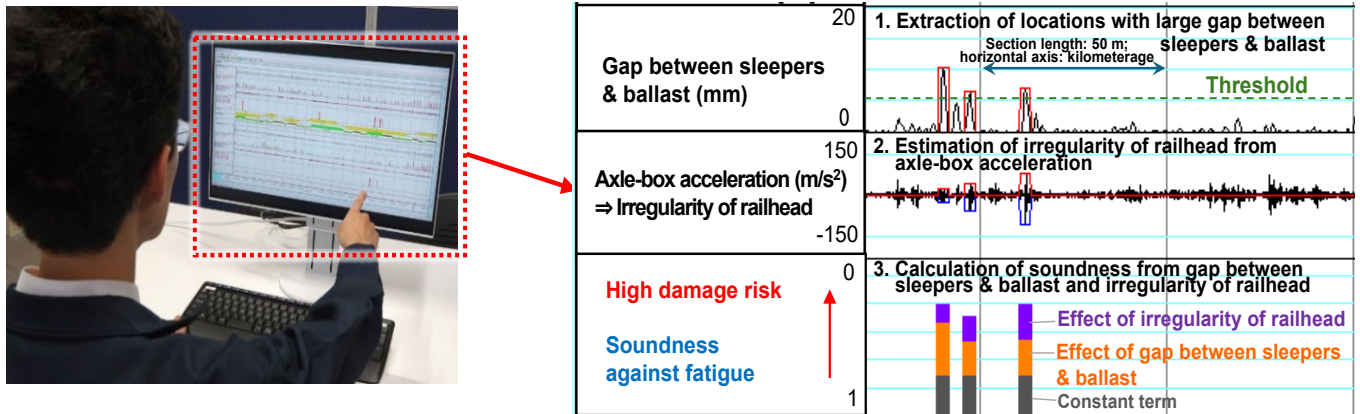


Fig. 3: Example of using rail soundness against fatigue with LABOCS

Reference

- “Extension of Rail Replacement Cycles Considering Soundness against Fatigue,” RTRI Technology Forum 2025

<https://www.rtri.or.jp/events/forum/2025/echr2f000000096c-att/forum2025-B08.pdf>