Fatigue Resistance Required for Rail Fastening Systems Considering Occurrence Tendency of Lateral Forces at Curved Sections of Narrow-Gauge Track

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My Profile

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Contents of presentation

1. Introduction
2. Outline of Japanese test method
3. Background of two-directional loading
4. Analytical reproduction of two-directional lateral forces
5. Standardization of two-directional loading test method

1. Introduction

- Three types of tests are applied to ensure fatigue durability of rail fastening systems worldwide.


Track | fastenings

Finding a comm

Most rail fastening specifications are based on criteria
Dr David Rhodes, director of railway consultancy D R
publish a new set of universal fastening standards nex

RAIL fastening systems occupy a unique position in the list of components that make up a modern railway track structure. At first glance they are a "commodity" product: mass produced parts of which thousands are used in every kilometre of track. But at the same time, they are safety critical elements which must work in a demanding environment.

Fastenings provide the crucial interface between the rails and the supporting structure. Under the severe and often unpredictable dynamic loading from passing trains they are mechanical engineering elements in a civil engineers' world.

Fastenings also affect vibration isolation, signalling track circuits, stray current protection and many other aspects of the system performance. It must be possible to leave them in the track for years wi maintenance and comes to change track geometry, it unfasten and re-fa

Knowing all of and maintainers how to be sure th will be met before use of a particula building hundred track. The answe technical specifica established in the constantly under technology advan

Most railway p departments base specifications on established sets o Europe, the Unite

In Europe, wor

Testing of fastening systems according to European (left), American (centre) and Japanese (right) standards.

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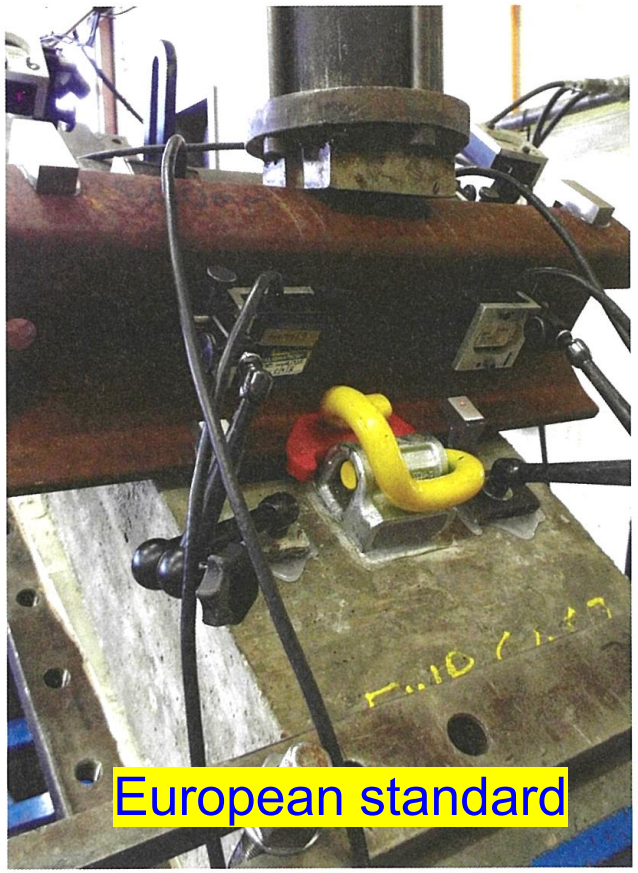
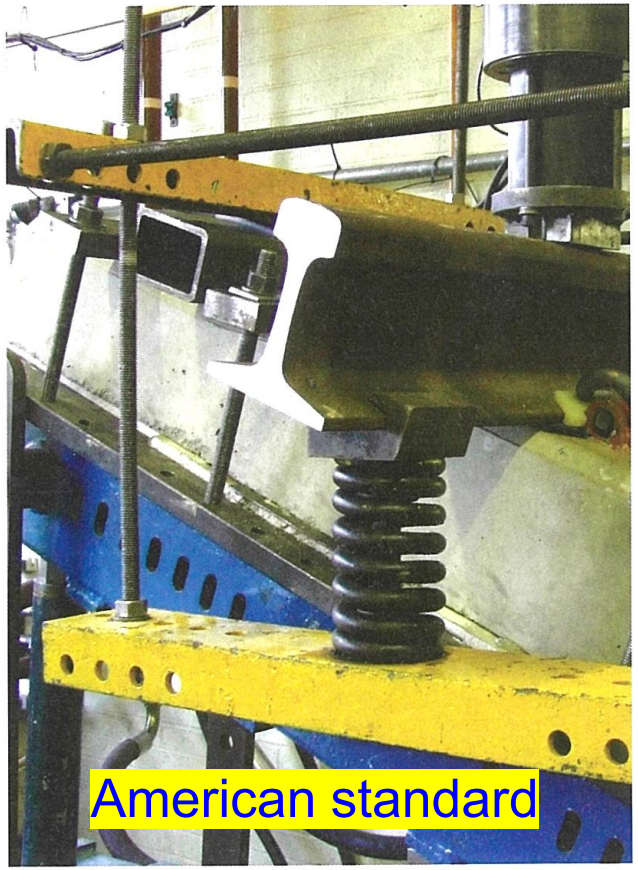
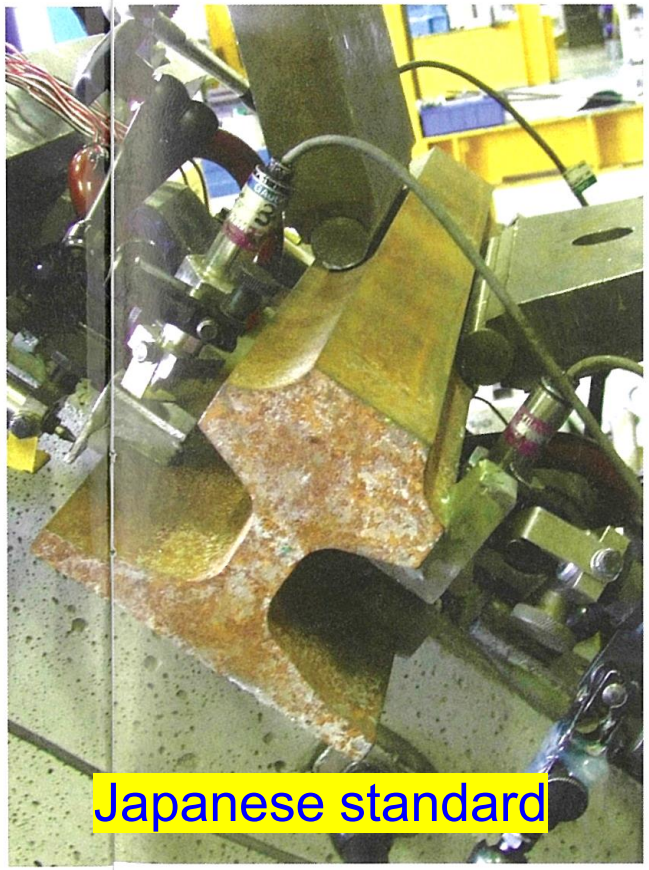
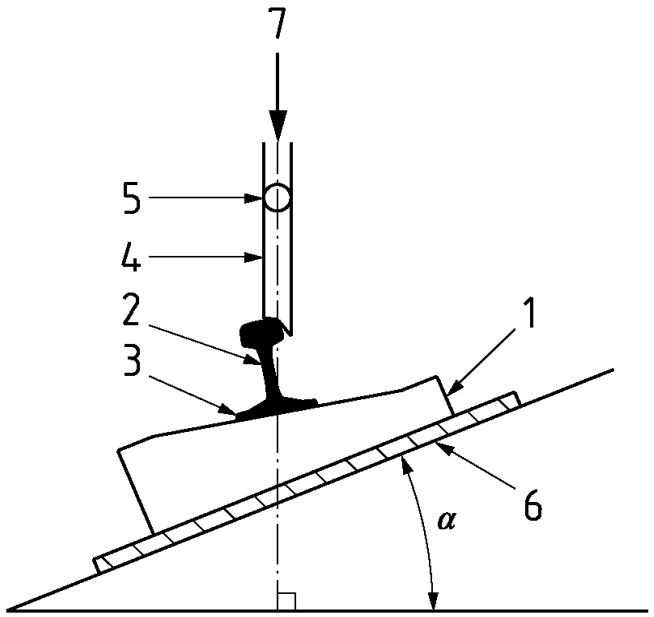
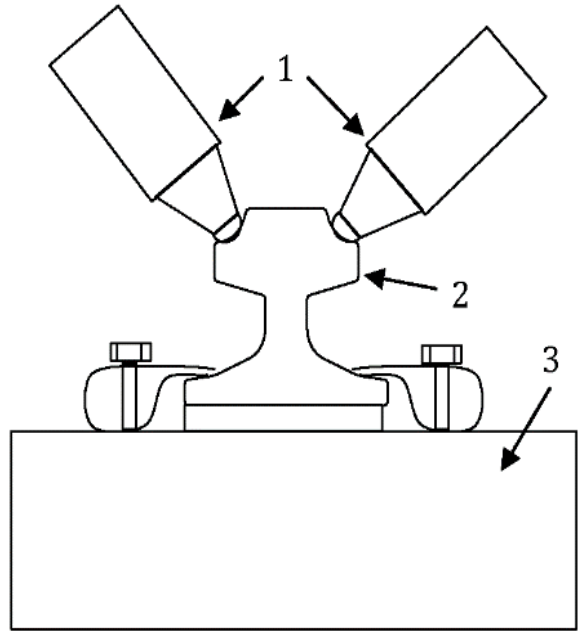






Testing of fastening systems according to European (left), American (centre) and Japanese (right) standards.

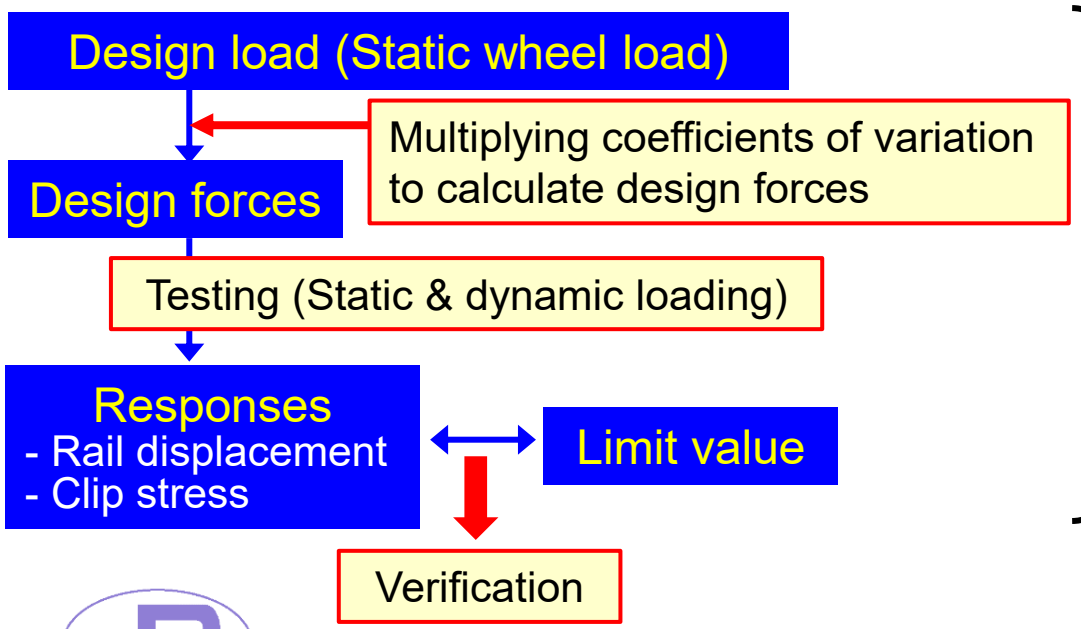
1. Introduction

	European test method	Japanese test method
Test load	Defined according to track categories	Calculated according to vehicle spec
Load application	One-direction	Two-direction
Cycles	3 millions	1 million
Items checked during testing	Not defined	- Rail displacement - Stress of rail clip
Test arrangement		

2. Outline of Japanese test method

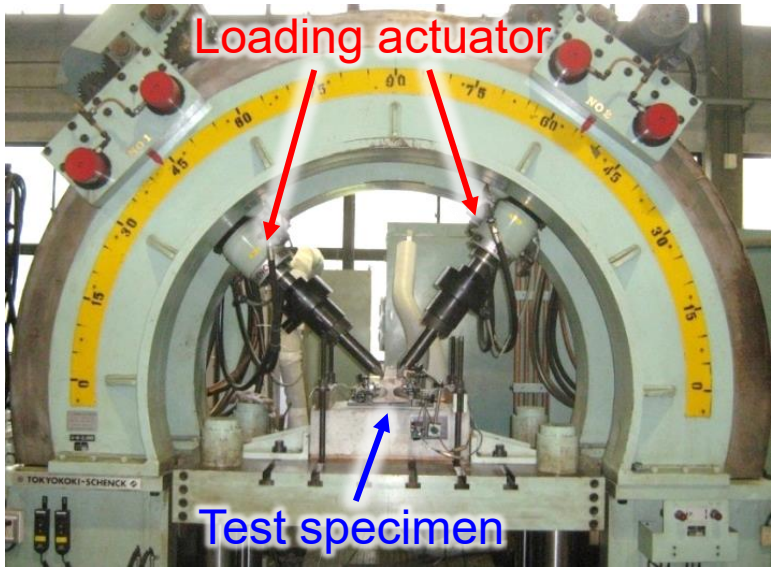
- Rail fastening systems used in Japan are designed and verified to comply with “Railway Structural Design Standard (track structures)”.
- Multiplication of design load and coefficients of variation defined in vertical and lateral directions separately provides design forces.

Process of safety verification



Standardized as ISO/TS 18973:2025

Overview of testing

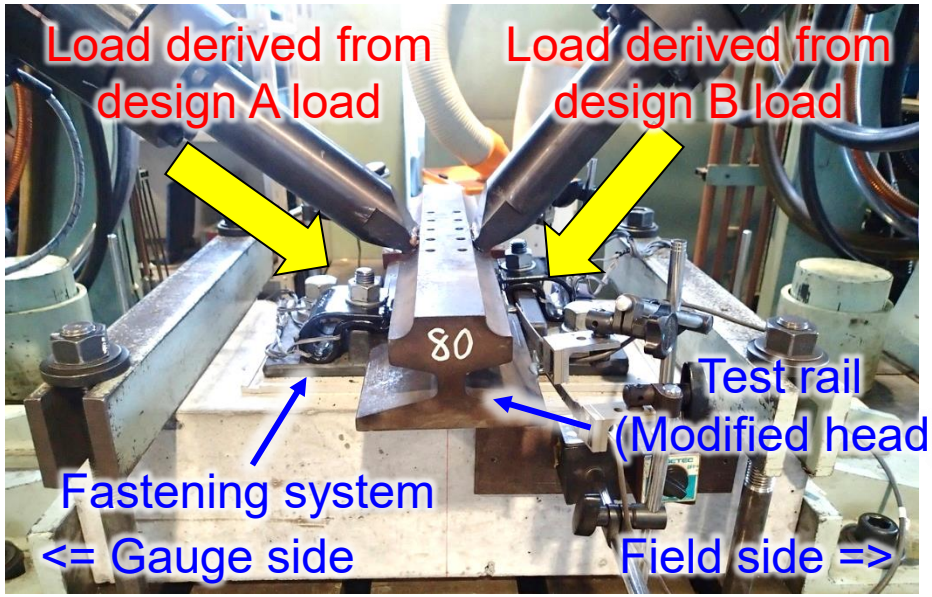


<= Gauge side Field side =>

2. Outline of Japanese test method

- Coefficients of variation for conventional lines are divided into three categories considering on-site measurements by curve radius.
- Design forces provide condition of two-directional static and repeated loading tests to verify track safety.

Setup of two-directional loading



Coefficients of variation for conventional line

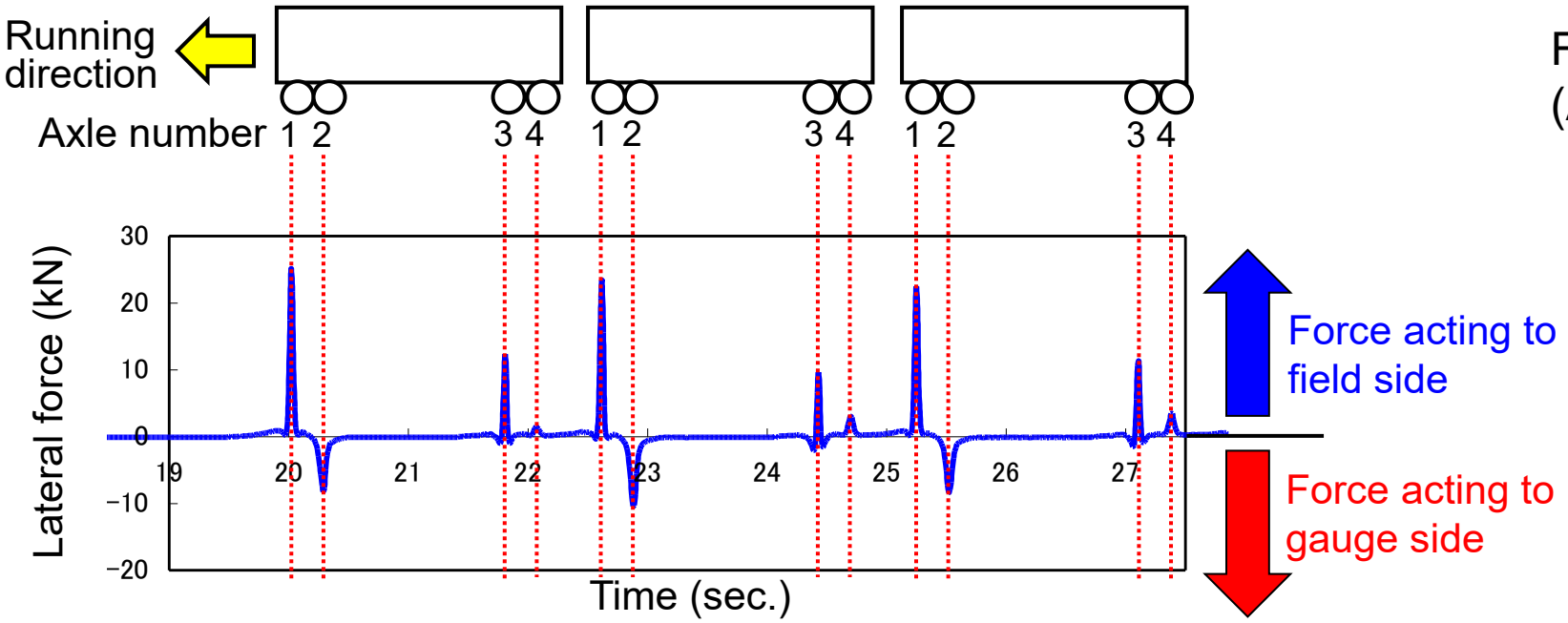
Design load type	Track alignment	Coefficient of variation	
		Design A load	Design B load
Wheel load	Tangent, Curve	1.3	1.15
Lateral force	Tangent, R>800m	0.4	0.2
	600m<R<800m	0.6	0.3
	R<600m	0.8	0.4

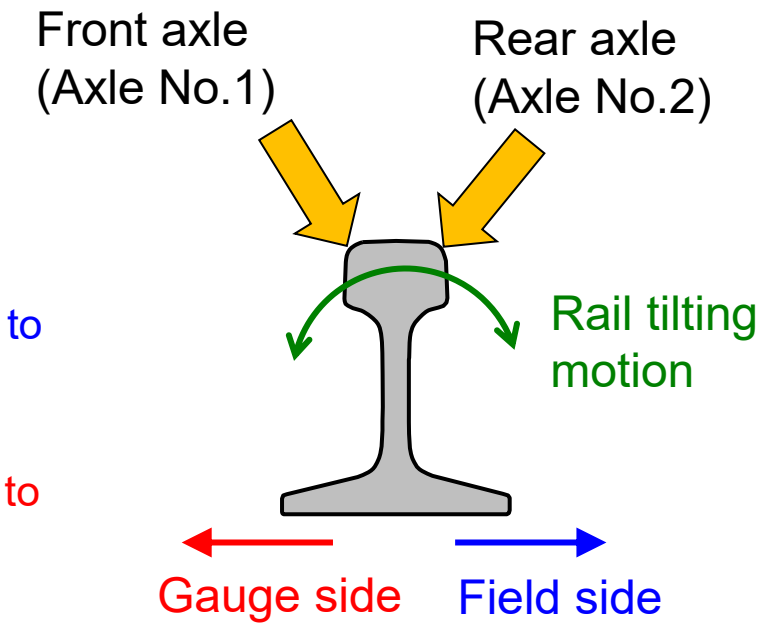
Design A load : Load that occurs very rare
Design B load : Load often occurs

3. Background of two-directional loading

- Two-directional loading reproduces out-of-phase lateral forces secured at measurement on a sharp curve track.

CASE 1 In-situ measurement of lateral forces at high rail
(narrow gauge, conventional vehicle, curve radius 160m, Japan)

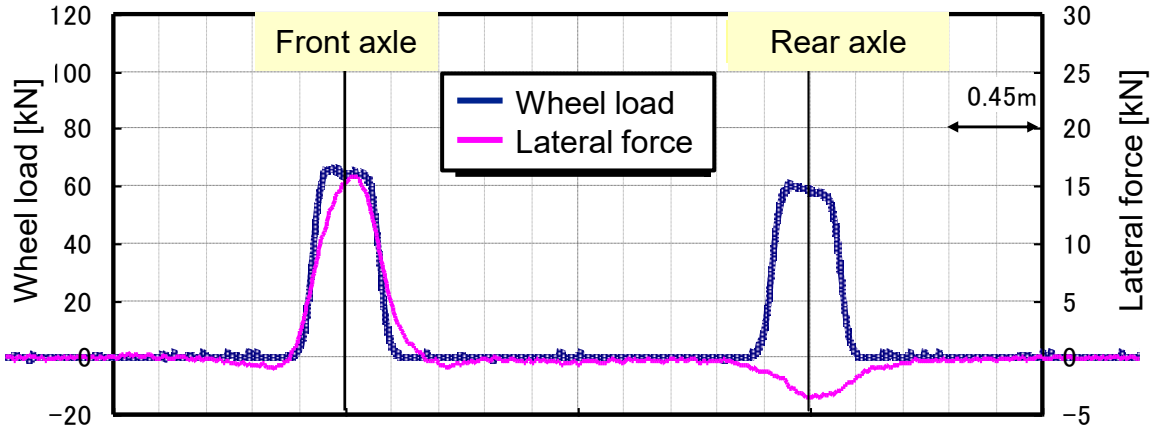


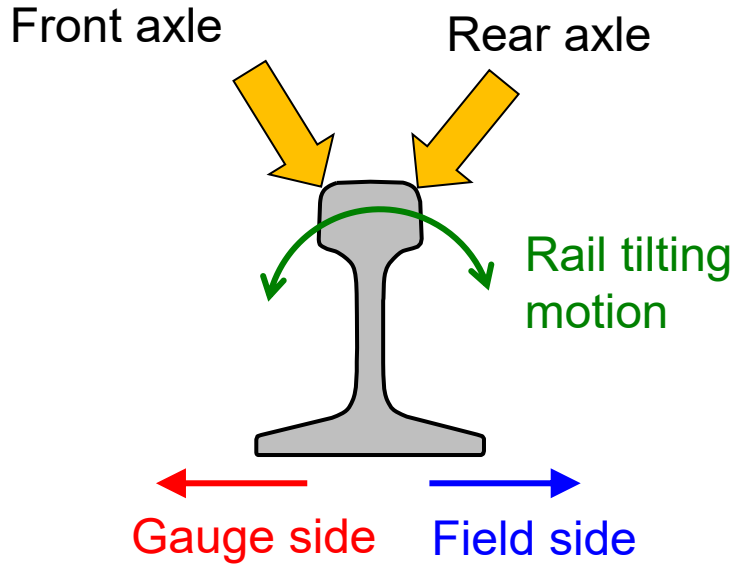


3. Background of two-directional loading

- Two-directional loading reproduces out-of-phase lateral forces secured at measurement on a sharp curve track.

CASE 2 In-situ measurement of lateral forces at high rail
(standard gauge, high-speed vehicle, curve radius 300m, Japan)



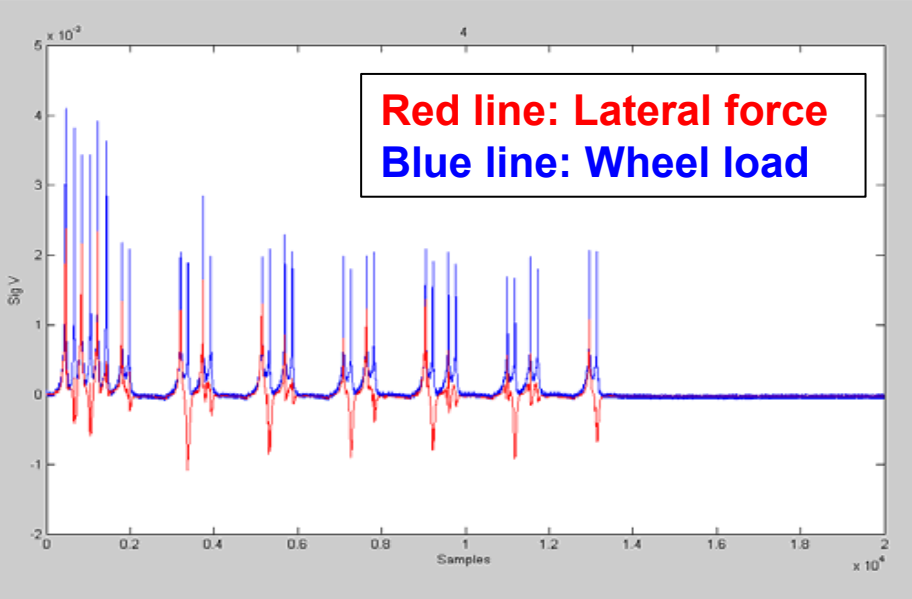


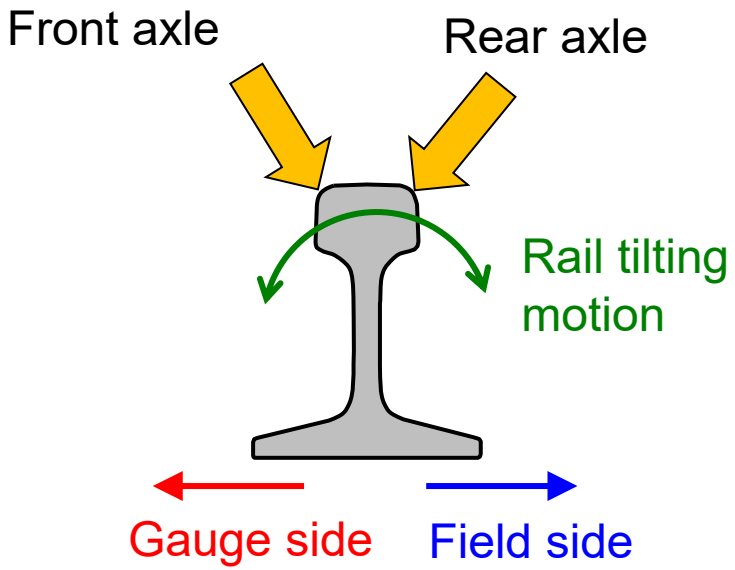
* H. Tanaka et al. Study On Corrugation Generated On High Rail In Sharp curves Based On The Contact Mechanics Between Rail And Rail (in Japanese). Journal of Railway Engineering. JSCE. 2009.

3. Background of two-directional loading

- Two-directional loading reproduces out-of-phase lateral forces secured at measurement on a sharp curve track.

CASE 3 In-situ measurement of lateral forces at high rail
(standard gauge, conventional vehicle, curve radius 480m, Italy)



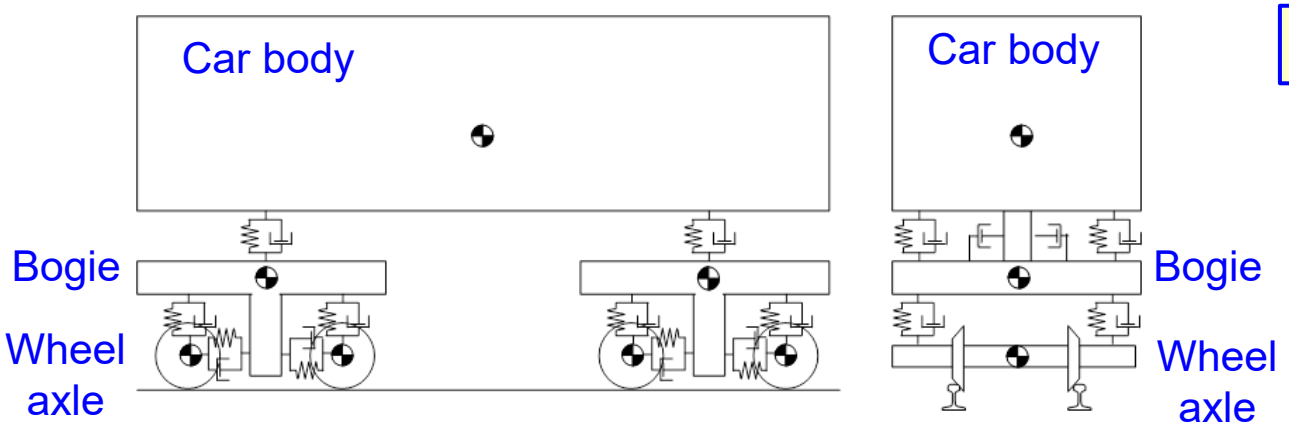


* Bracciali, A. & Folgarait, P. New Sensor For lateral &Vertical Wheel-Rail Forces Measurements. Railway Engineering Conference. 2004.

4. Analytical reproduction of two-directional lateral forces

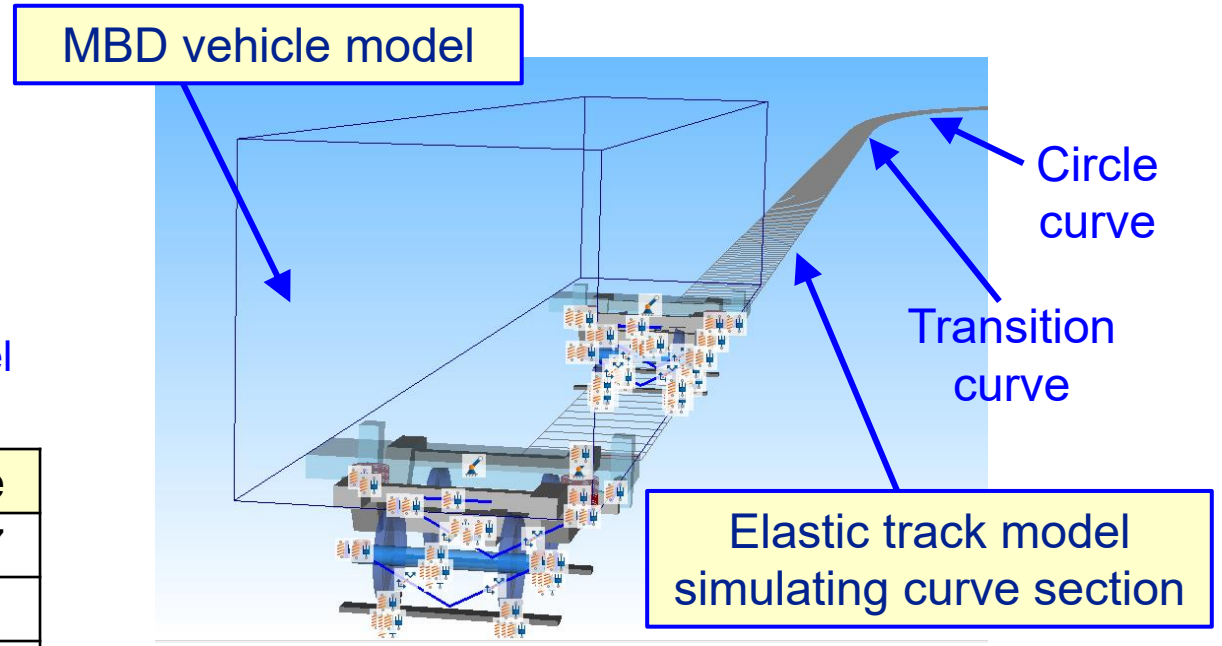
- An analytical study was conducted for reproducing the out-of-phase lateral forces generated on sharp curved track.

MBD vehicle model and main specification



Item	Unit	Value
Track gauge	m	1.067
Distance between the center of bogies	m	14.4
Distance between wheel in the bogie	m	2.1
Static wheel load	kN	71.0

Overview of running simulation

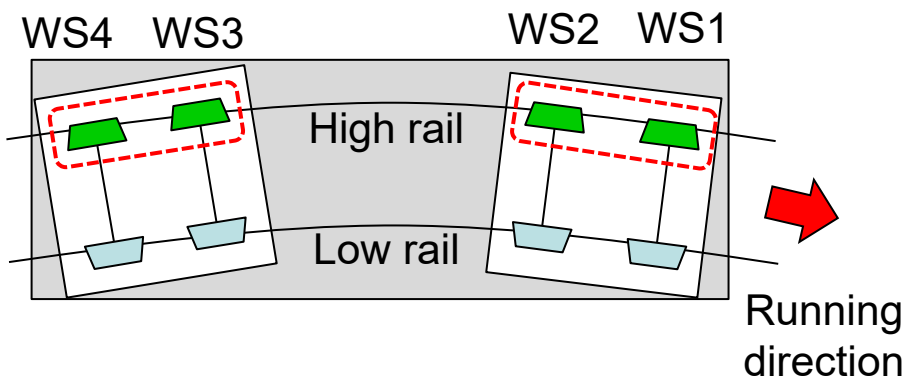


* Pre-post and solver: SIMPACK Rail 2018

4. Analytical reproduction of two-directional lateral forces

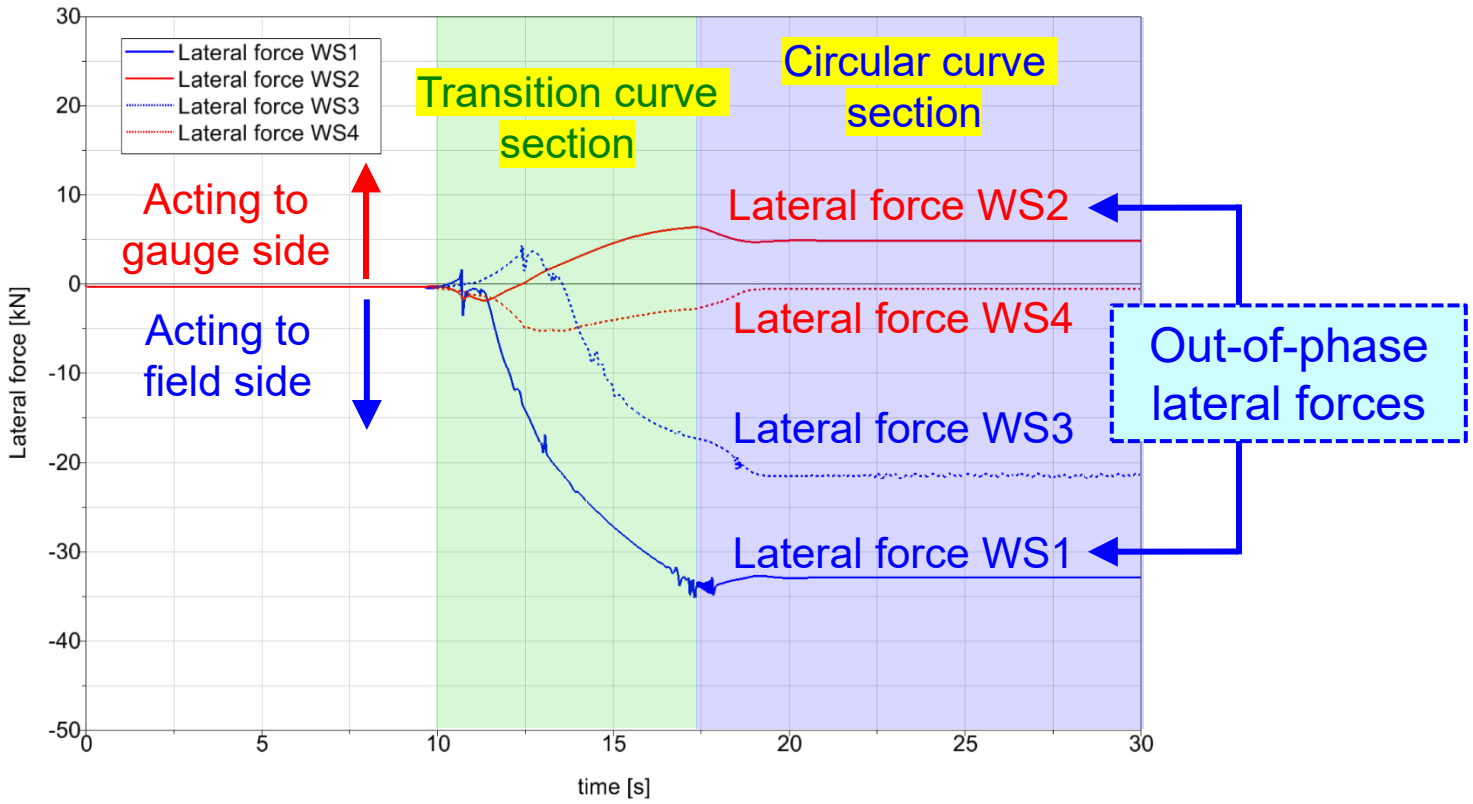
- Simulation reproduced the out-of-phase lateral forces like as the measured result on real track in sharp curve.

Simulation condition



Track gauge : Narrow (1067mm)
Running speed : 40km/h
Curve radius : 160m
Superelevation : 84mm (Equilibrium)

Simulated lateral force (high rail)



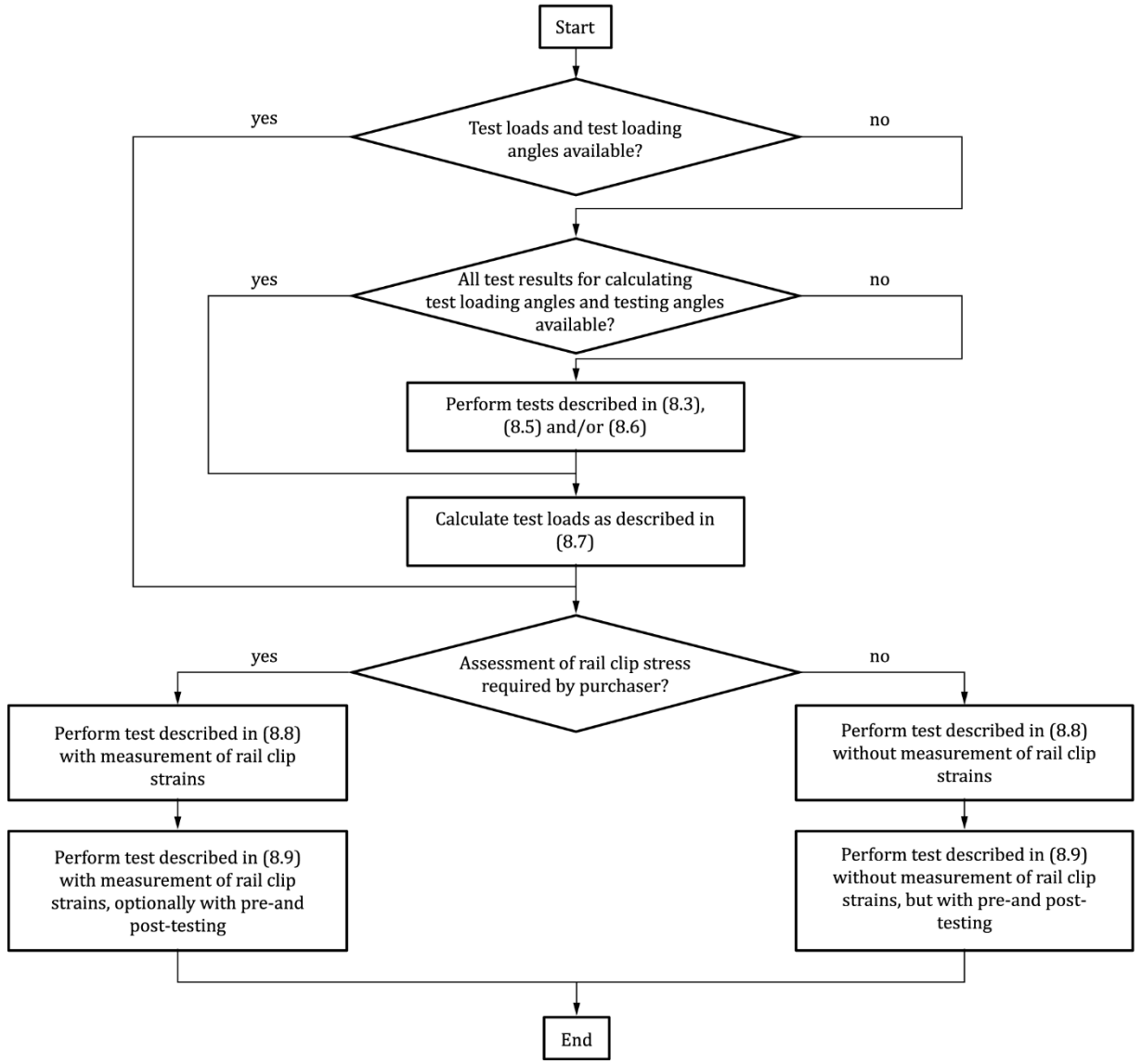
5. Standardization of two-directional loading test method

- CEN/TC 256/SC 1/WG 17 “Fastening systems developed EN 13146-4 “Effect of repeated loading” and published in 2003.
- ISO/TC 269/SC 1/WG 7 “Fastening systems” developed ISO 22074-4 “Test methods for resistance to repeated loading” and published in 2022.

- Test method of two-directional loading was not incorporated in ISO 22074-4 but was eventually excluded.
- Following publication of ISO 22074-4, the technical specification ISO TS 18973 “Two directional test method for resistance to repeated loading” was developed and published in 2024.

5. Standardization of two-directional loading test method

- Contents of ISO TS 18973
  - Test specimens
  - Test procedure
    - Clamping force
    - Uplift stiffness
    - Vertical stiffness
    - Lateral stiffness
    - Calculation of test load and loading angle
    - Static and repeated two-directional loading



Key takeaways

- Significant differences are present between the European and Japanese test methods for rail fastening systems.
- The Japanese test method for rail fastening systems requires two-directional loading to secure fatigue durability.
- The tendency of out-of-phase lateral forces on the operating track underpins the basis of two-directional loading.
- RTRI's research analytically reproduced the out-of-phase lateral forces on a sharply curved track.
- The test method for the two-directional loading has been developed as ISO TS 18973 and published in 2024.

Thank you for your kind attention!

…Any question?