Electronic Supplementary Materials

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Aerodynamics and countermeasures of train-tail swaying inside single-line tunnels

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S1 Calculated particle distribution of the train aerodynamics sub-model

As shown in Fig. S1, the calculated particles with 6 levels are constructed in the computational domain, in which the particle resolution of level 1 is 0.002H, and the particle resolution of level 6 is 0.064H. Furthermore, the total number of particles is about 23.8×10^6.

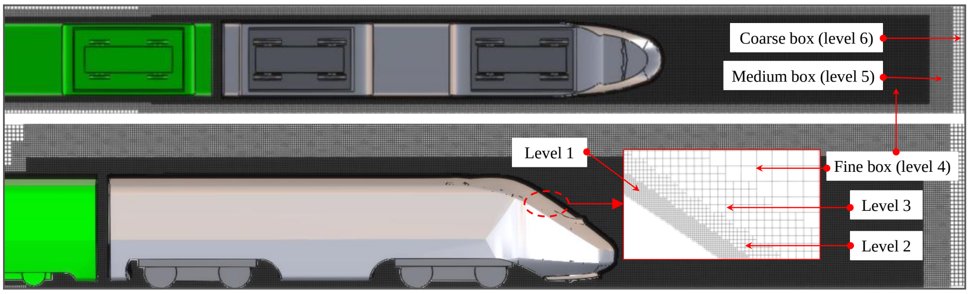

Fig. S1 Calculated particle distribution

S2 Track lateral irregularity

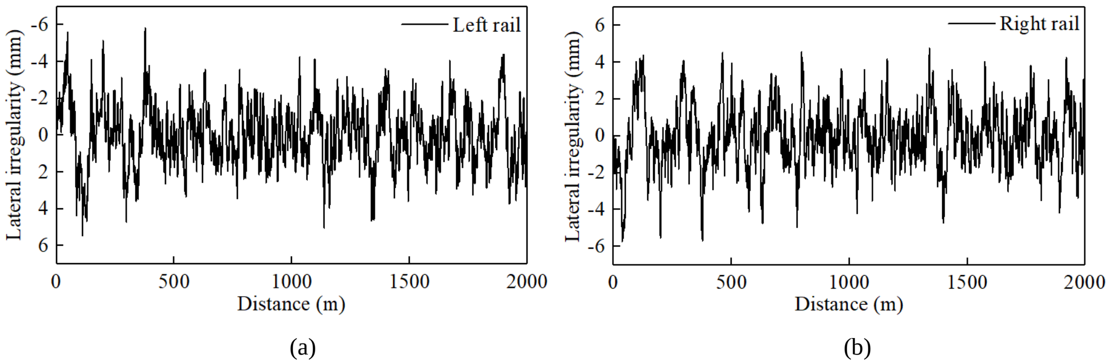

Fig. S2 Track lateral irregularity: (a) left rail; (b) right rail

S3 Ride comfort index

Table S1 Ride comfort index for motor vehicle

Standard	Value	Level
Sperling index	$W_y \leq 2.75$	Excellent
	$2.75 < W_y \leq 3.10$	Medium
	$3.10 < W_y \leq 3.45$	Qualified

S4 The measured lateral stiffness and damping

By applying slight excitation to the train tail, the train tail sways laterally and then converges gradually, and the lateral dynamics response of the train model is shown in Fig. S3. From the waveform within 1−2 s, it can be seen that the lateral natural frequency f of the train is about 8 Hz.

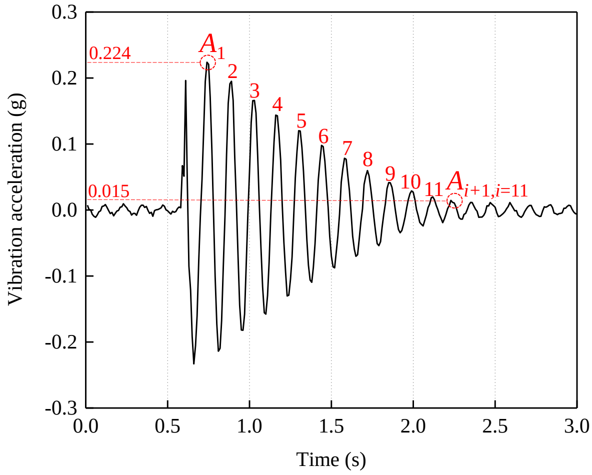

Fig. S3 Dynamic response measurement of train tail

Then, according to the Eq. (S1), the lateral damping coefficient ζ of the train model is 0.04, the lateral stiffness k is 500 N/m, and the lateral damping c is 0.8 N s/m.

$$\begin{cases} \zeta = \ln \dfrac{A_1}{A_{i+1}} \Big/ \sqrt{4\pi^2 i^2 + \left(\ln \dfrac{A_1}{A_{i+1}}\right)^2} \\ k = (2\pi f)^2 \cdot m \\ c = \zeta \cdot 2\sqrt{m \cdot k} \end{cases} . \tag{S1}$$

S5 Calculated particle distribution of the 1/25 scale train aerodynamics model

To accurately simulate the aerodynamic characteristics of the train wake, three refinement boxes are established around the train, and the details of particle distribution in the computational domain are shown in Fig. S4. In the transient numerical calculation based on the particle method, the resolution of coarse particle in the far field (level 7) is 0.128h, the fine particle near the train surface (level 1) is 0.002h, and the total number of particles is about 13.6×10^6.

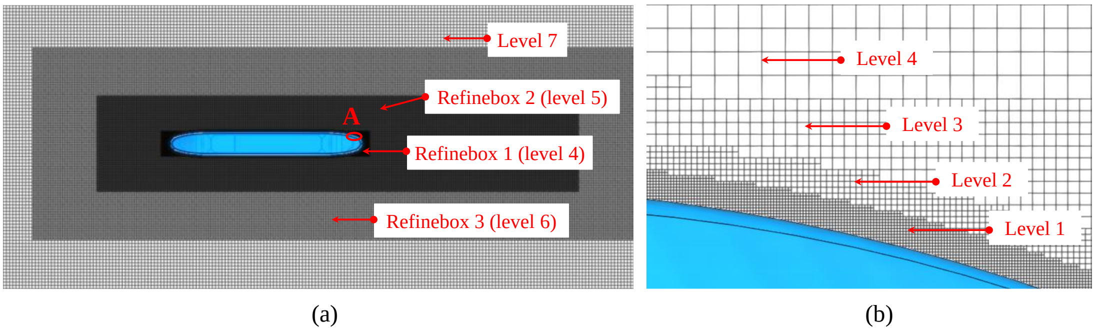

Fig. S4 Computation particle: (a) top view; (b) enlarged view of position A

S6 Optimization of the installation arrangement of the yaw damper

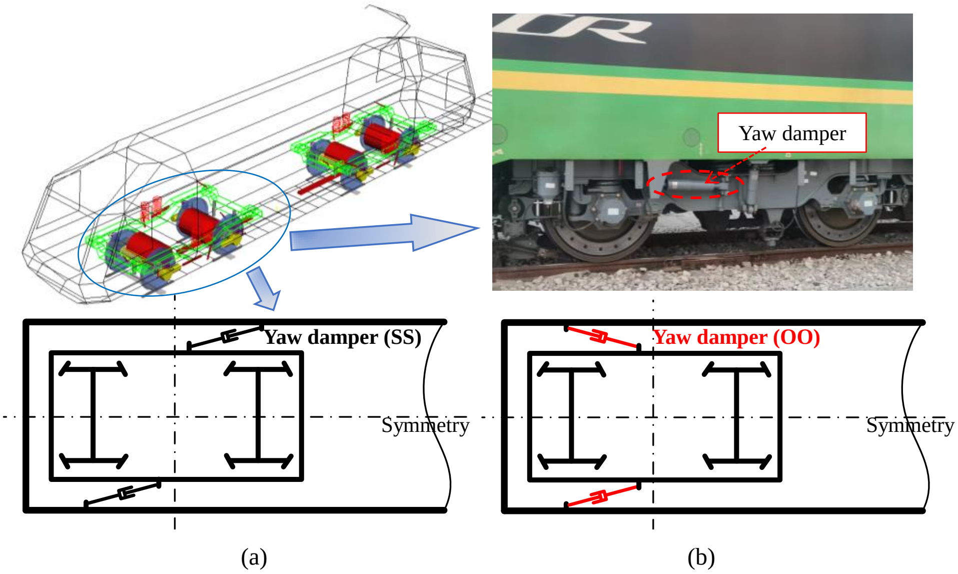

Fig. S5 The arrangement of yaw dampers: (a) skew symmetry; (b) opening outward