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Finite element model updating methodology and application to flexible resonance of high-speed railway vehicles

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Complex High-Speed Train Carbody In Service

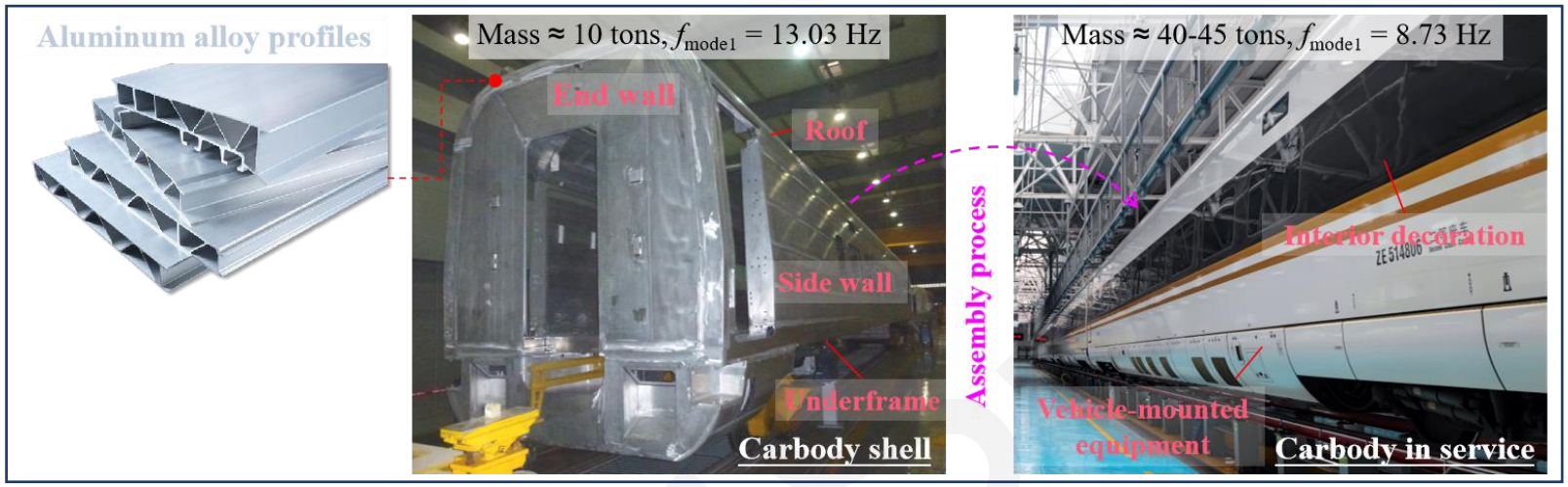


Fig. 1 Difference in appearance between the carbody shell and the carbody in service

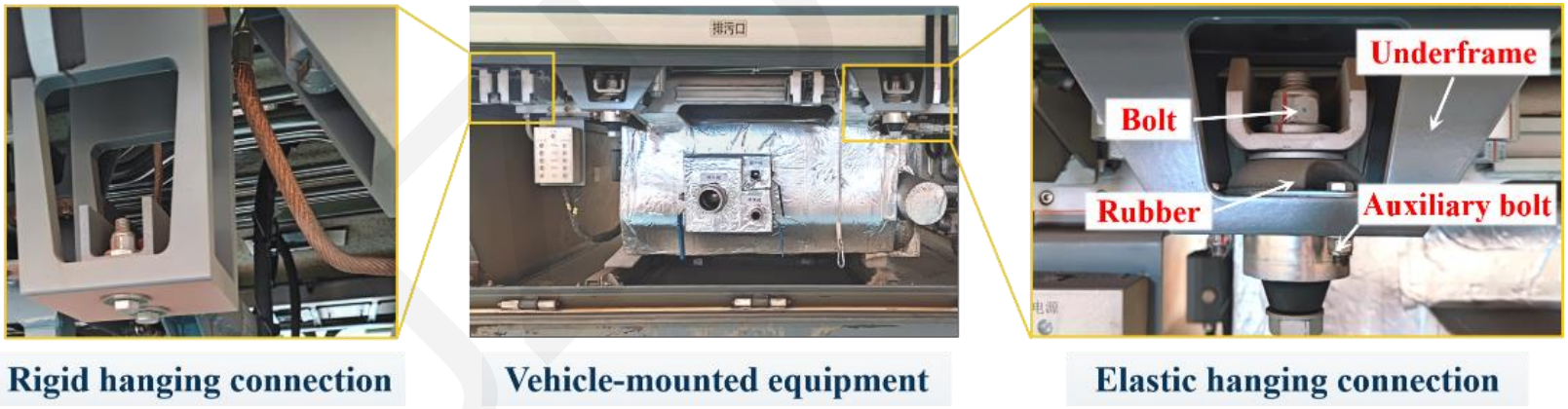
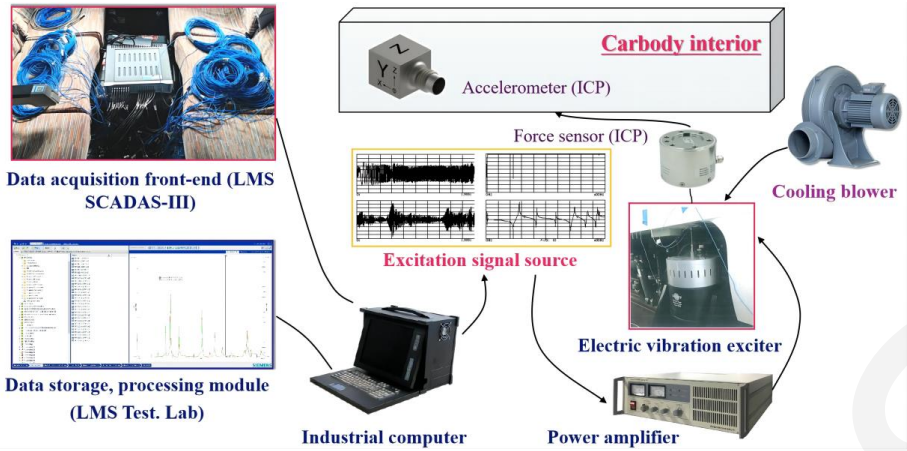
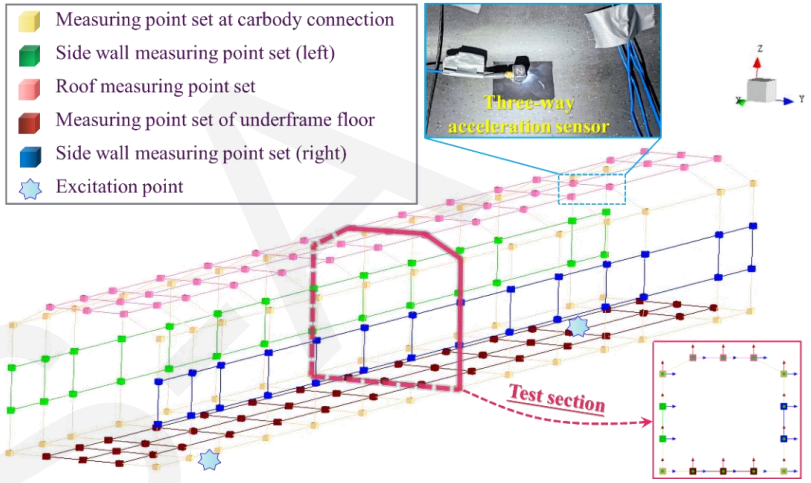


Fig. 2 Equipment under the carbody underframe: Elastic hanging and rigid hanging connection

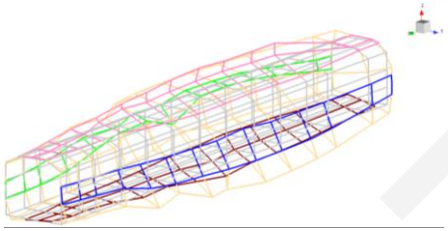
Carbody Modal Test



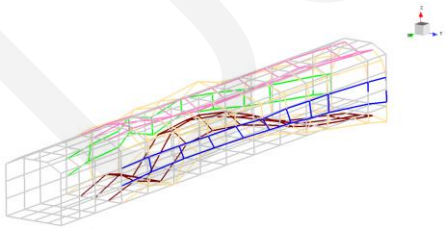
The flowchart of the carbody modal test



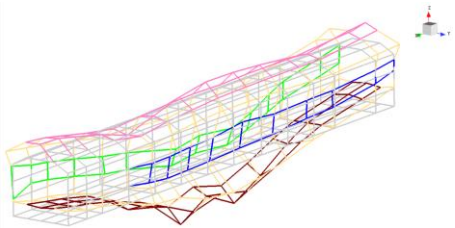
Layout of measuring points



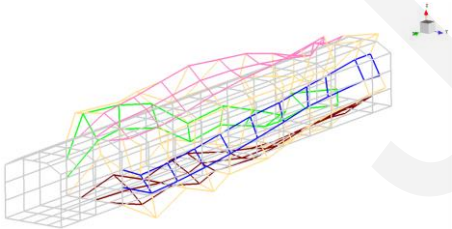
Mode 1| f_1 = 8.73 Hz | 2.34%



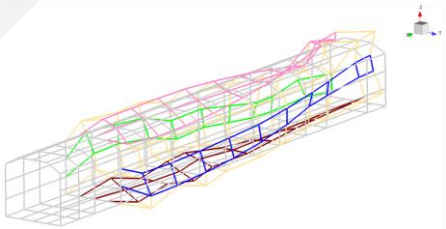
Mode 2| f_2 = 12.59 Hz | 0.96%



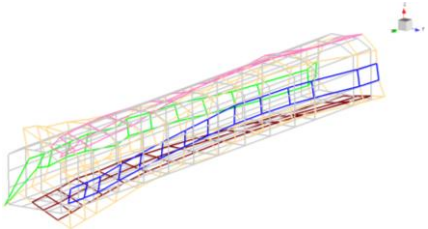
Mode 3 | f_3 = 13.62 Hz | 0.54%



Mode 4 | f_4 = 15.86 Hz | 2.11%



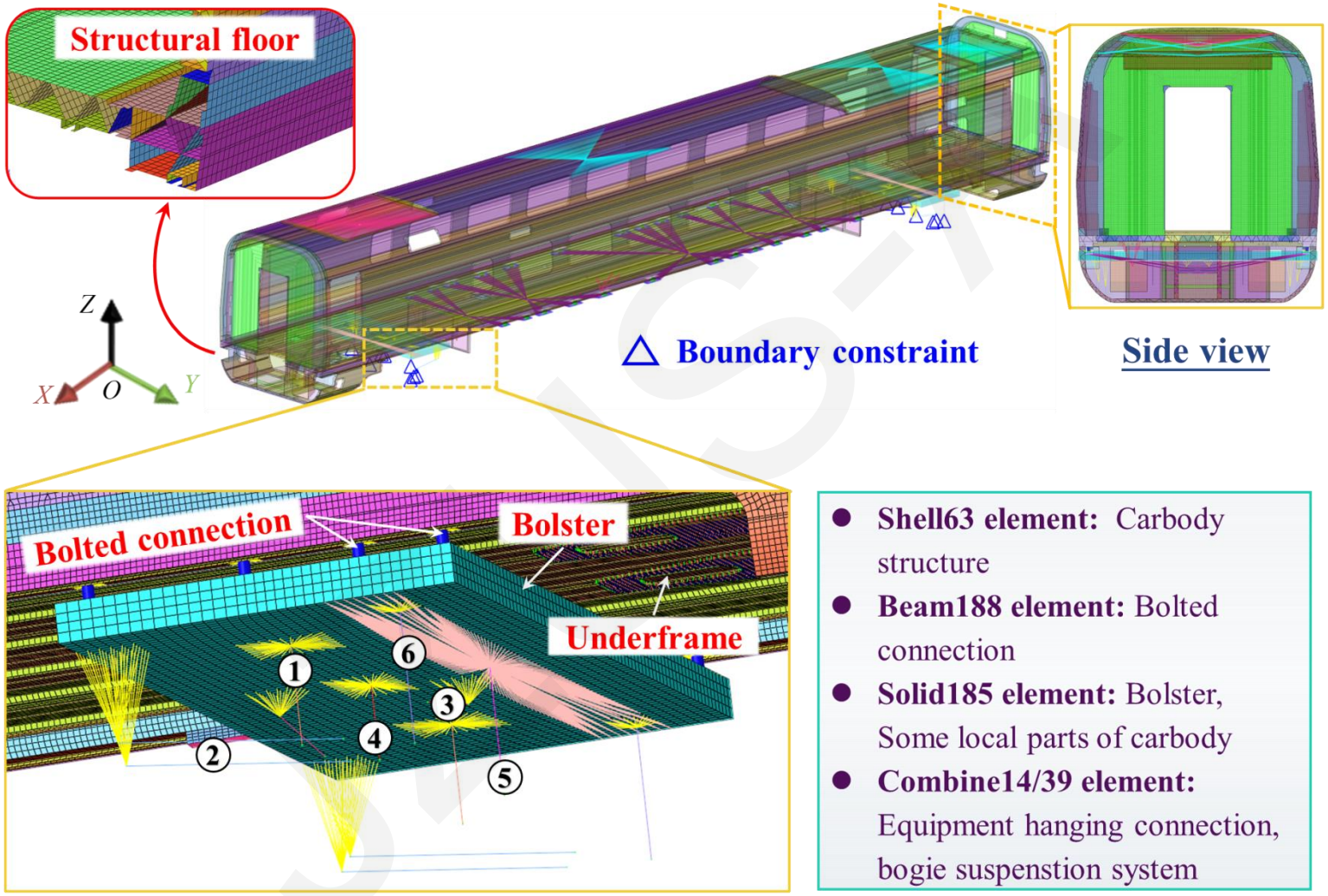
Mode 5 | f_5 = 17.79 Hz | 1.66%



Mode 6 | f_6 = 19.04 Hz | 1.02%

Fig. 3 Experimental modal parameters of the carbody

FE modeling of Carbody



1-Air spring, 2-Anti-yaw damper, 3-Secondary lateral damper, 4-Traction rod, 5-Anti-rolling torsion bar, 6-Secondary vertical damper

Fig. 4 Carbody FE model in operational service

Model Updating Methodology

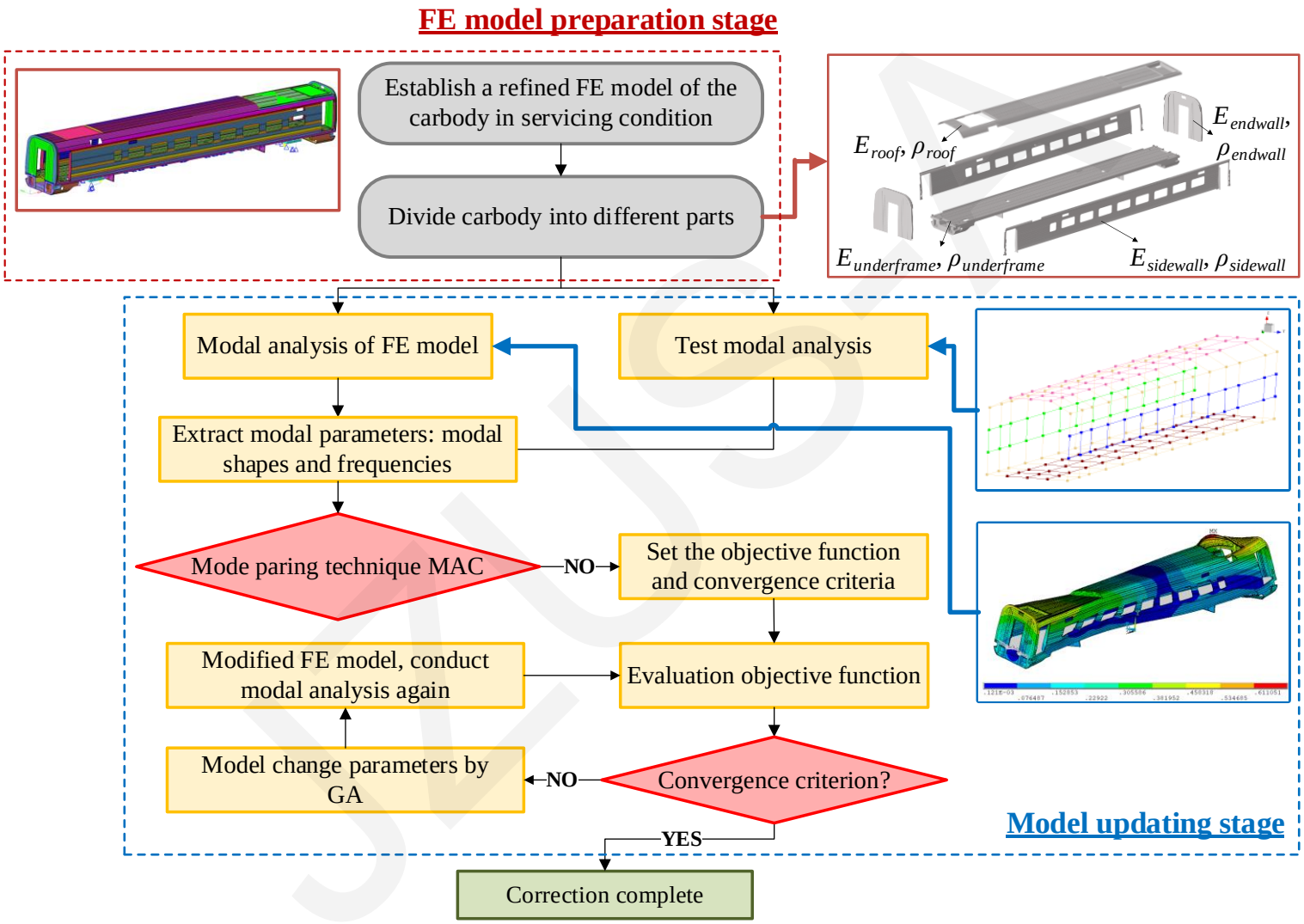


Fig. 5 The carbody FE model updating process used in this study

Experimental Verification

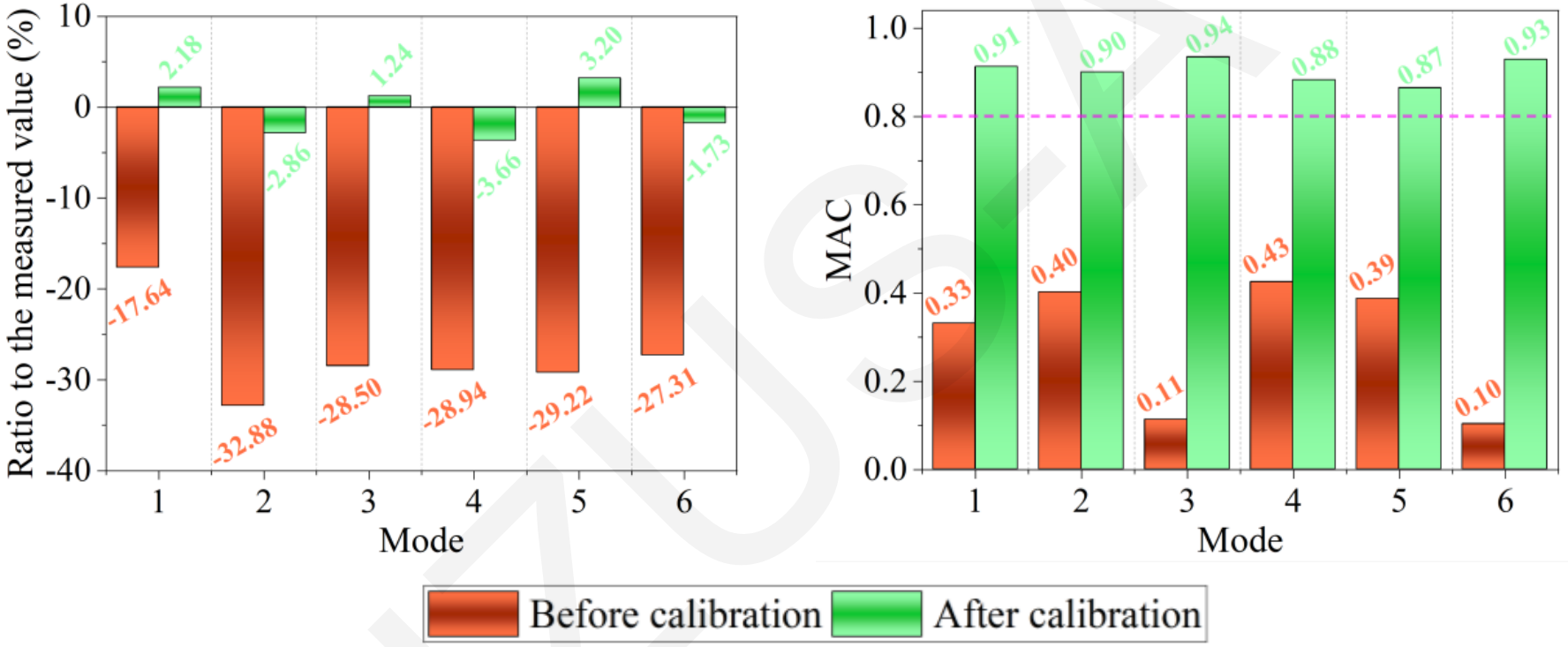
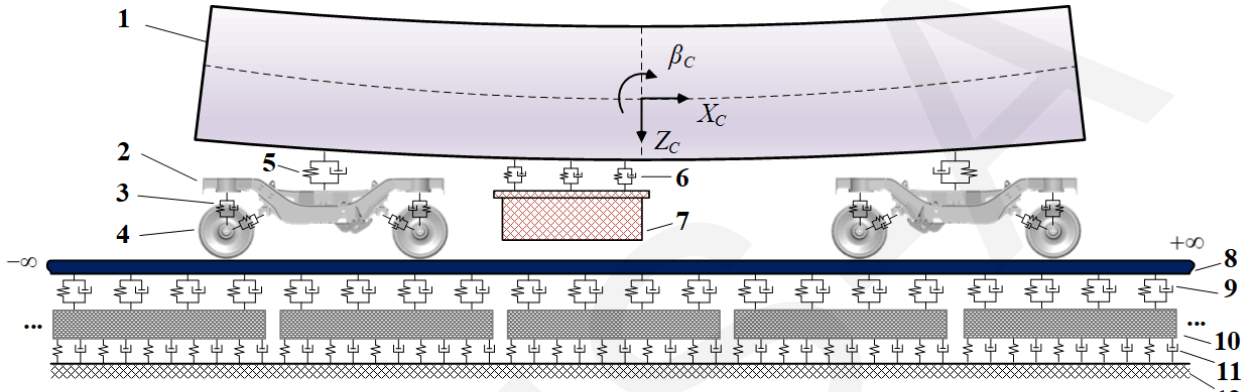


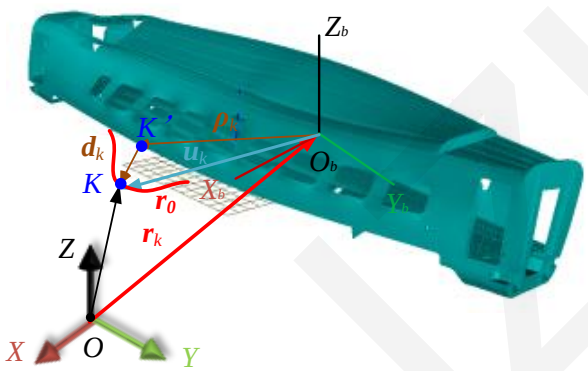
Fig. 6 Errors between experimental and numerical modal responses, before and after calibration: Natural frequencies and MAC indicator

Application in the flexible resonance

■ High-speed Train Vehicle-Track Voupled Model



1-Carbody, 2-Bogie frame, 3-Primary suspension, 4-Wheelset, 5-Secondary suspension, 6-Equipment connection, 7-Vehicle-mounted equipments, 8-Rail, 9-Fastenings and rail pad, 10-Track slab, 11- Foundation connection, 12-CA asphalt mortar layer and subgrade



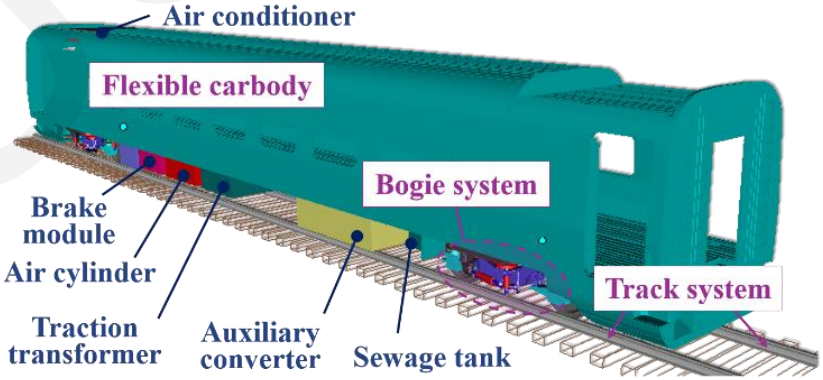


Fig. 7 Schematic view of the high-speed vehicle-track coupled dynamics model: (a) Layout of high-speed railway vehicle multibody dynamics model with flexible carbody; (b) Floating reference frame for the carbody; (c) Dynamic simulation model established in Universal Mechanism.

Application in the flexible resonance

■ Simulation difference before and after updating

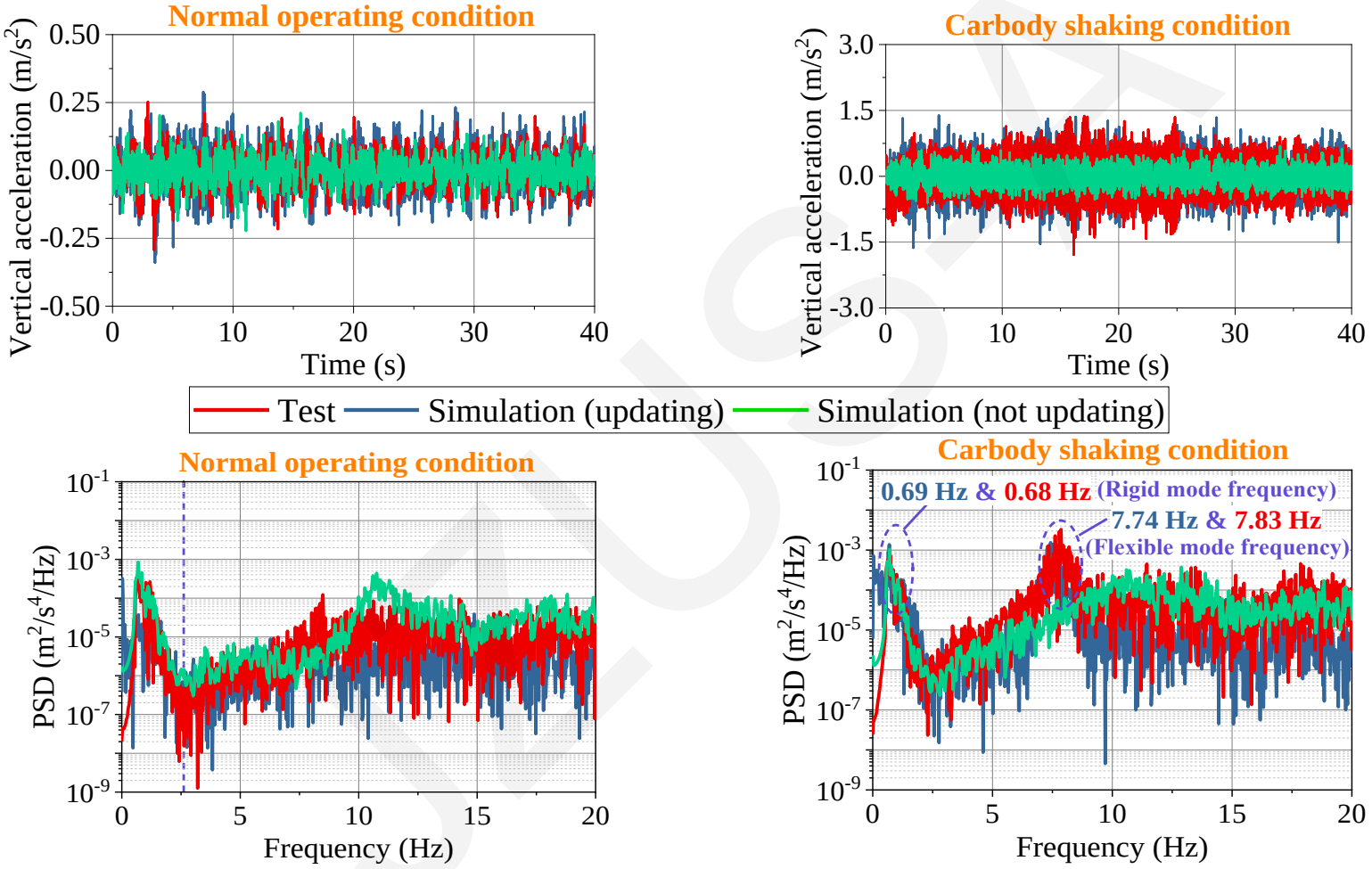


Fig. 8 Time histories and PSD diagrams of carbody middle floor accelerations under simulation (before and after updating) and test (350 km/h)

Conclusions

- The proposed correction method based on EMA and GA can effectively eliminate model errors.
- The material parameters of the in-service carbody differ significantly from those of the original aluminum alloy.
- The updated model can accurately predict abnormal vibrations of the carbody.

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