Electronic Supplementary Materials

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Bogie active stability simulation and scale rig test based on frame lateral vibration control

Ya-dong SONG, Hu LI, Jun CHENG, Yuan YAO

State Key Laboratory of Traction Power, Southwest Jiaotong University, Chengdu 610031, China

Table S1 The scale bogie model parameters

Symbol	Definition	Value
m_{w}	Mass of the wheelset	14.7 kg
I_{w}	Yaw inertia of the wheelset	0.32kg m^2
m_{f}	Mass of bogie frame	14.5 kg
I_{f}	Yaw inertia of bogie frame	3.3 kg m^2
m_m	Mass of actuator	10.9 kg
k_{px}	Primary longitudinal stiffness per axle	20 kN/m
k_{py}	Primary lateral stiffness per axle	2.0 kN/mm
k_{sx}	Secondary longitudinal stiffness	1.3 kN/m
k_{sy}	Secondary lateral stiffness	1.3 kN/m
c_{sx}	Yaw damper damping	0
c_{sy}	Secondary lateral damper damping	2.0 kN s/m
f_m	Actuator suspension frequency	0.1 Hz
ξ_m	Actuator suspension damping ratio	0.3
l_{m}	Longitudinal distance from actuator suspension to bogie center	0.45 m
$2b$	Wheel base	0.56 m
$2l_0$	Distance of the contact spot	0.2986 m
$2l_1$	Lateral spacing of primary suspension	0.422 m
$2l_2$	Lateral spacing of secondary suspension	0.4 m
f_η	The lateral creep coefficient	10 kN
f_ζ	The longitudinal creep coefficient	10 kN
k_{gy}	The gravitational stiffness	0
$k_{g\psi}$	The gravitational angular stiffness	0
r_0	The wheel rolling radius	0.1 m
λ	Wheel–rail contact conicity	0.1
v	Speed	50 km/h

Data S1 The matrices of the bogie model

$$\boldsymbol{C}=\begin{bmatrix} \dfrac{2f_\eta}{v} &&&&&&& \\ & \dfrac{2l_0^2 f_\zeta}{v} &&&&&& \\ && \dfrac{2f_\eta}{v} &&&&& \\ &&& \dfrac{2l_o^2 f_\zeta}{v} &&&& \\ &&&& c_{sy}+2c_{my} && -c_{my} & -c_{my} \\ &&&&& l_2^2 c_{sx}+2l_m^2 c_{my} & -l_m c_{my} & l_m c_{my} \\ &&&& -c_{my} & -l_m c_{my} & c_{my} & \\ &&&& -c_{my} & l_m c_{my} && c_{my} \end{bmatrix}$$

$$\boldsymbol{K}=\begin{bmatrix} k_{py}+k_{gy} & -2f_\eta &&& -k_{py} & -bk_{py} && \\ \dfrac{2\lambda l_0 f_\zeta}{r_0} & l_1^2 k_{px}+k_{g\psi} &&&& -l_1^2 k_{px} && \\ && k_{py}+k_{gy} & -2f_\eta & -k_{py} & bk_{py} && \\ && \dfrac{2\lambda l_0 f_\zeta}{r_0} & l_1^2 k_{px}+k_{g\psi} && -l_1^2 k_{px} && \\ -k_{py} && -k_{py} && 2k_{py}+k_{sy}+2k_{my} && -k_{my} & -k_{my} \\ -bk_{py} & -l_1^2 k_{px} & bk_{py} & -l_1^2 k_{px} && \begin{matrix} l_2^2 k_{sx}+2l_1^2 k_{px} \\ +2b^2 k_{py}+2l_m^2 k_{my} \end{matrix} & -l_m k_{my} & l_m k_{my} \\ &&&& -k_{my} & -l_m k_{my} & k_{my} & \\ &&&& -k_{my} & l_m k_{my} && k_{my} \end{bmatrix}$$

$$\boldsymbol{M}=\begin{bmatrix} m_{\mathrm{w}} &&&&&&& \\ & I_{\mathrm{w}} &&&&&& \\ && m_{\mathrm{w}} &&&&& \\ &&& I_{\mathrm{w}} &&&& \\ &&&& m_{\mathrm{f}} &&& \\ &&&&& I_{\mathrm{f}} && \\ &&&&&& m_m & \\ &&&&&&& m_m \end{bmatrix}$$

$$\boldsymbol{E}=\begin{bmatrix} 0 & 0 & 0 & 0 & 1 & l_m & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & l_m & 0 & 0 \end{bmatrix}^{\mathrm{T}}$$

$$\boldsymbol{Q}=\begin{bmatrix} k_{py} & 0 & k_{py} & 0 & 0 & 0 & 0 & 0 \end{bmatrix}^{\mathrm{T}}$$

$$\boldsymbol{K}_{\mathrm{C}}=\begin{bmatrix} 0 & 0 & 0 & 0 & k_{d1} & k_{d1} & 0 & 0 & 0 & 0 & 0 & 0 & k_{v1} & k_{v1} & 0 & 0 \\ 0 & 0 & 0 & 0 & k_{d2} & k_{d2} & 0 & 0 & 0 & 0 & 0 & 0 & k_{v2} & k_{v2} & 0 & 0 \end{bmatrix}$$