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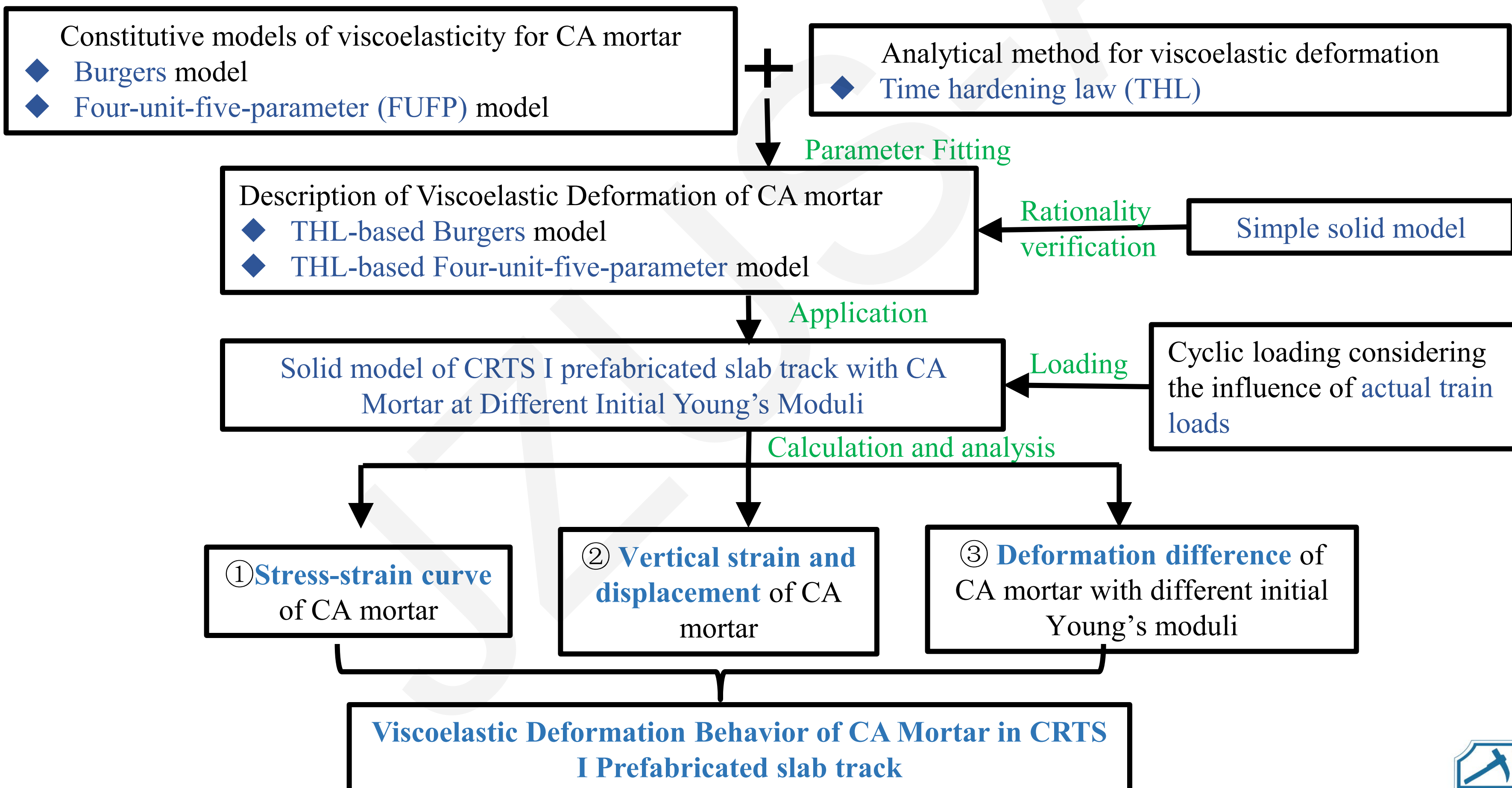
Viscoelastic deformation behavior of cement and emulsified asphalt mortar in China railway track system I prefabricated slab track

Juan-juan REN, Hao-lan LI, Xiao-pei CAI,
Shi-jie DENG, Ji WANG, Wei DU

Key words: CRTS I prefabricated slab track; CA mortar; Initial Young's modulus; viscoelastic deformation; time hardening law

FLOW CHART


Constitutive models of viscoelasticity for CA mortar
Burgers model
Four-unit-five-parameter (FUFP) model
+
Analytical method for viscoelastic deformation
Time hardening law (THL)
Parameter Fitting
Description of Viscoelastic Deformation of CA mortar
THL-based Burgers model
THL-based Four-unit-five-parameter model
Rationality verification
Simple solid model
Application
Solid model of CRTS I prefabricated slab track with CA Mortar at Different Initial Young's Moduli
Loading
Cyclic loading considering the influence of actual train loads
Calculation and analysis
①Stress-strain curve of CA mortar
② Vertical strain and displacement of CA mortar
③ Deformation difference of CA mortar with different initial Young's moduli
Viscoelastic Deformation Behavior of CA Mortar in CRTS I Prefabricated slab track

PARAMETER FITTING & RATIONALITY VERIFICATION

Burgers model: $\varepsilon(t)=\sigma_0\left[1/E_1+t/\eta_1+\left(1-e^{-t\tau}\right)/E_2\right]$

Four-unit-five-parameter model: $\varepsilon(t)=\sigma_0\left[1/E_1+\left(1-e^{-Bt}\right)/MB+\left(1-e^{-t\tau}\right)/E_2\right]$

Time hardening law: $\frac{d\varepsilon_c}{dt}=A\sigma^n t^m.$

↓ Parameter Fitting

Table 2 Parameters of the time hardening law for CA mortar

Stress	Burgers model			Four-unit-five-parameter model		
σ (×10^6 Pa)	A (×10^{-8})	m	n	A (×10^{-8})	m	n
0.05	3.549	-0.7374	0.5670	4.230	-0.8274	0.6082
0.10	3.613	-0.7876	0.5908	5.815	-0.9069	0.6056
0.30	3.869	-0.7776	0.6227	8.248	-0.8943	0.6117
0.50	3.652	-0.7794	0.6240	7.772	-0.8746	0.6124
Mean	3.677	-0.7675	0.5935	6.131	-0.8762	0.6085

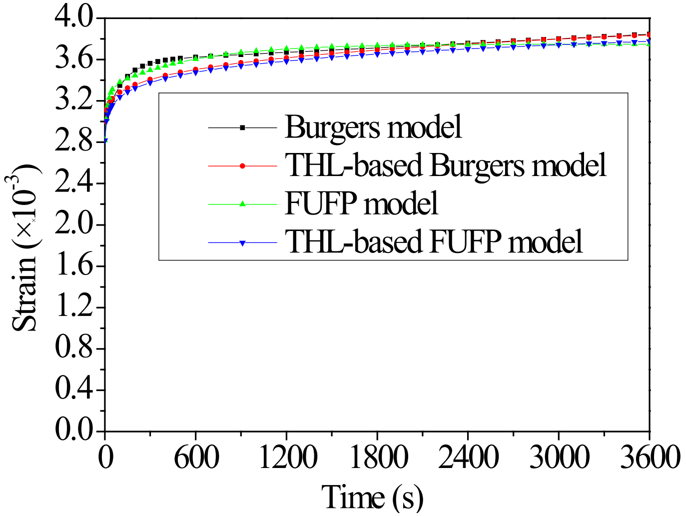


Fig. 5 Strain comparison of CA mortar between models

Rationality verification

MODELLING OF CRTS I PREFABRICATED SLAB TRACK

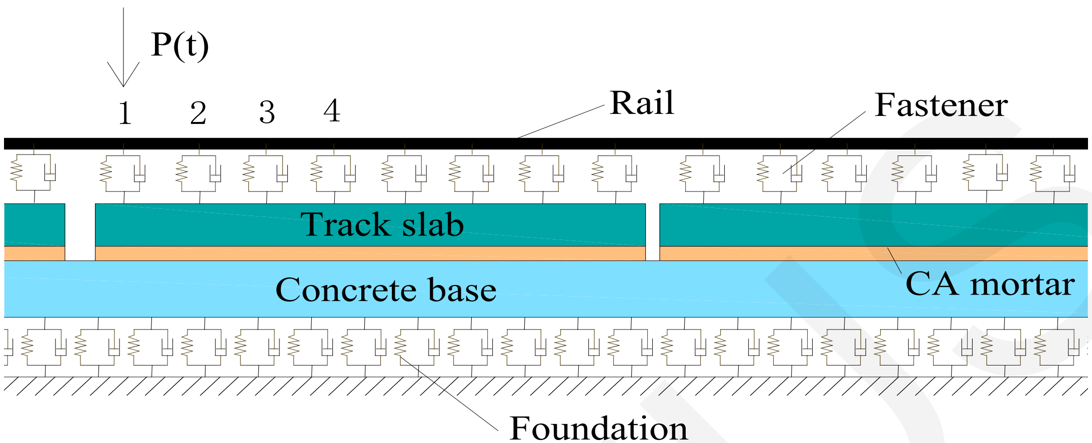


Fig. 6. Mechanical schematic diagram of CRTS I prefabricated slab track

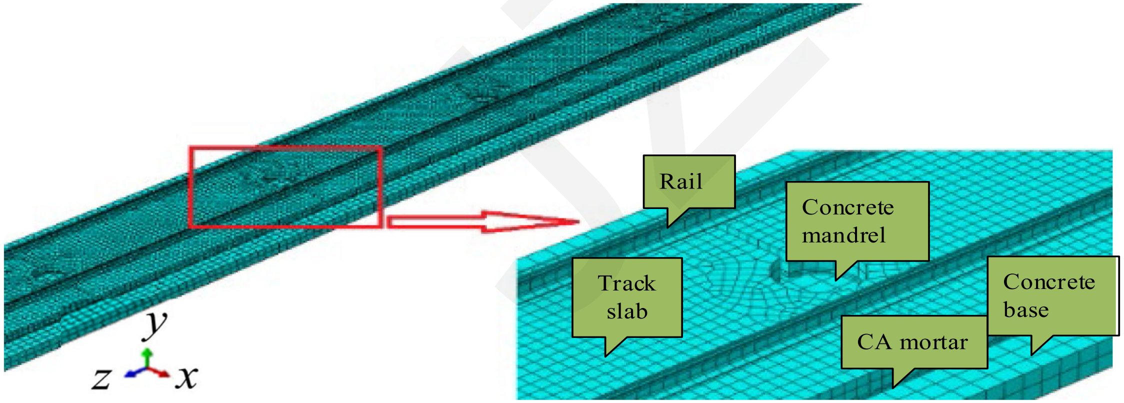


Fig. 7. Finite element model of CRTS I prefabricated slab track

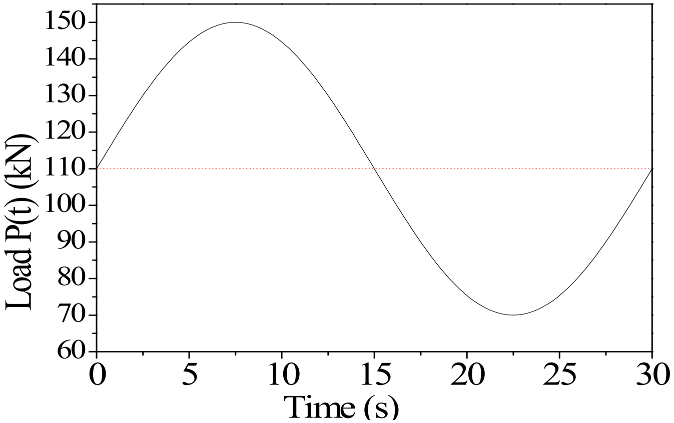


Fig. 11 One-cycle of the cyclic loading curve

RESULTS & CONCLUSIONS

- The parameters of the THL of CA mortar for the Burgers model, namely *A*, *m* and *n*, are 3.677×10^{-8}, 0.5935, and -0.7675 respectively, and they are 6.131×10^{-8}, 0.6085, and -0.8762 respectively for the FUFP model. It is verified that the THL-based models can well predict the viscoelastic deformation of CA mortar. Additionally, the deformation of the THL-based Burgers model is slightly larger than that of the THL-based FUFP model.

- The stress-strain curve of CA mortar displays characteristics of cyclic softening under cyclic loading. The strain increment between two adjacent cycles decreases rapidly and tends to level off with cycles. A higher initial Young's modulus corresponds to a more rapid decrease.

- The vertical viscoelastic strain mainly appears at the end of a CA mortar layer and concentrates at the edge, with longitudinal distribution being about 2.5 fasteners' spacing.

- When the initial Young's modulus of a CA mortar increases from 100 MPa to 500 MPa, the strain decreases, so does the strain difference before and after cyclic loading. Nevertheless, the variation has little effect on the displacement of the mortar. The displacement difference before and after cyclic loading of CA mortars with different initial Young's moduli is mainly in the range of 0.2 mm to 0.6 mm, in which part of the deformation is non-elastic and irreversible.