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Thermal-induced upwarp buckling analysis of CRTS II slab ballastless tracks experiencing joint damage

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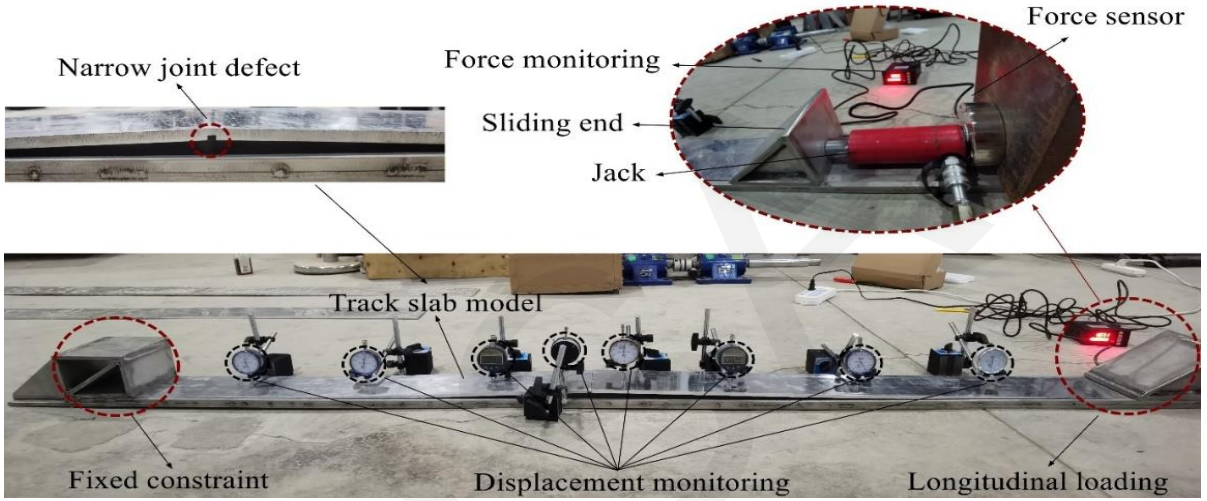
Characteristics of the upwarp buckling deformation

Experimental testing



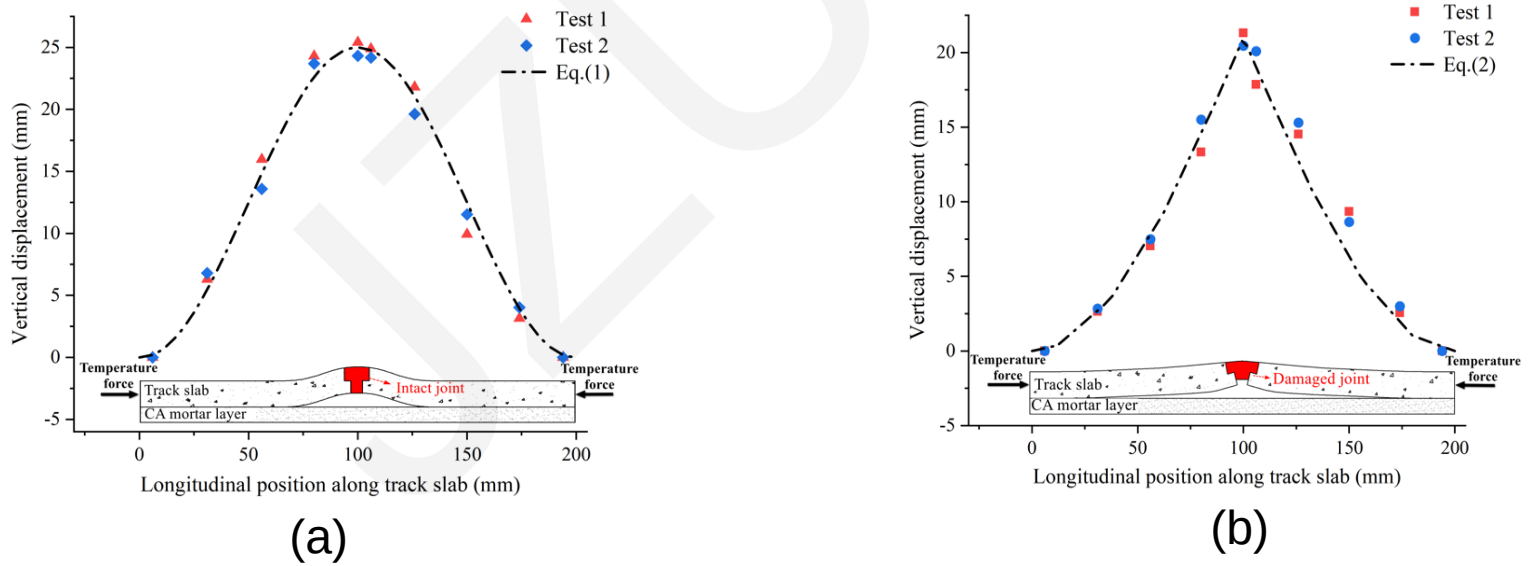


Fig. 1. Vertical displacement of the track slab model: (a) intact track slab model; (b) track slab model with a narrow joint defect

Theoretical analysis

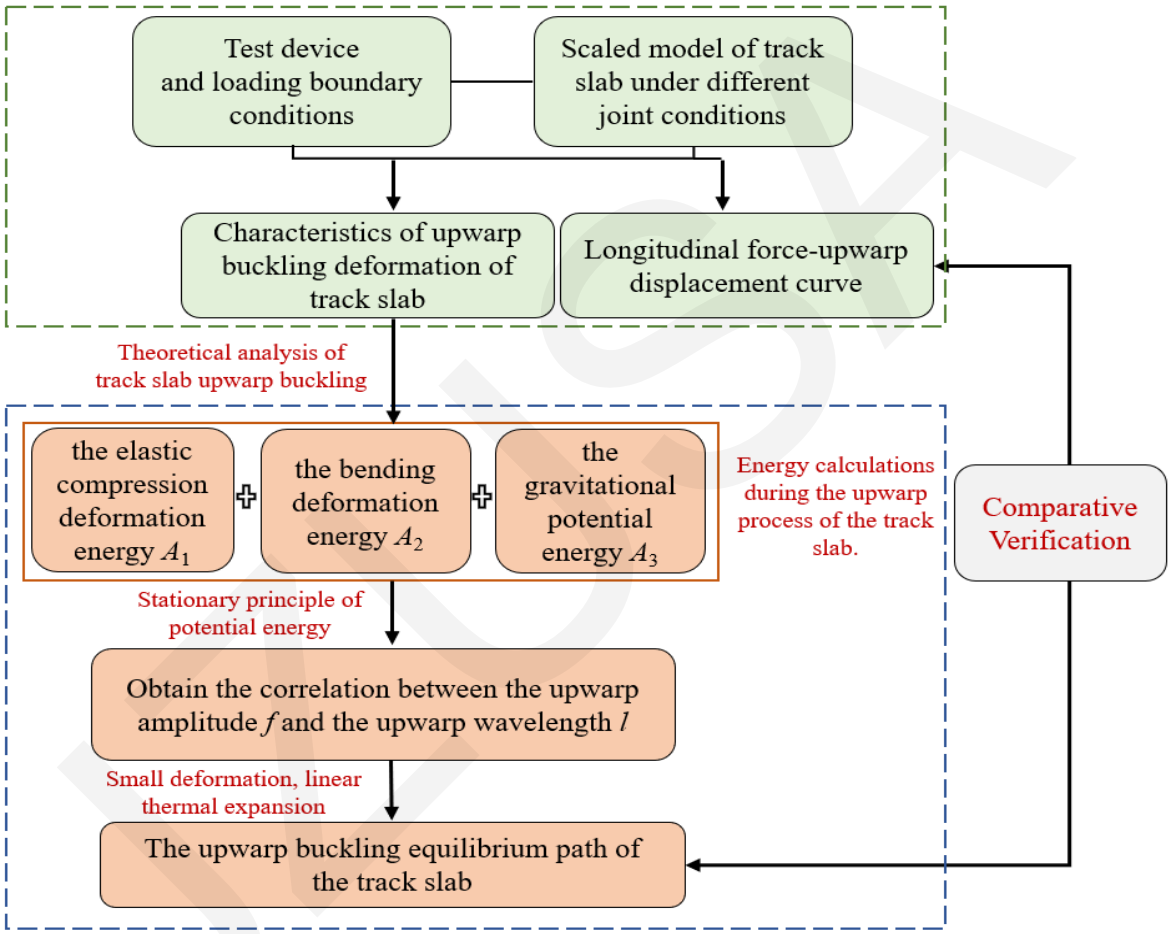


Fig. 2. Calculation workflow used in this study

The upwarp buckling equilibrium path of the track slab

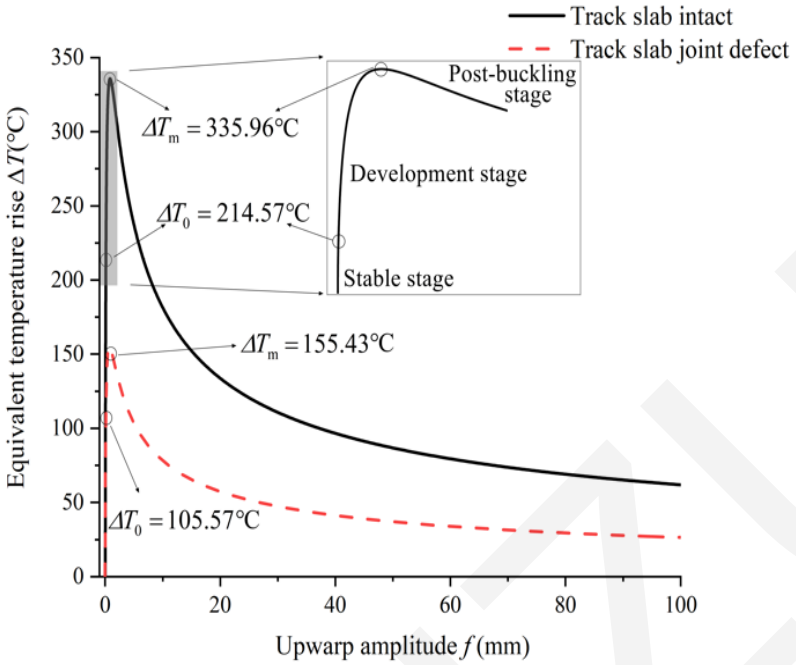


Fig. 3. The upwarp buckling equilibrium path of the track slab

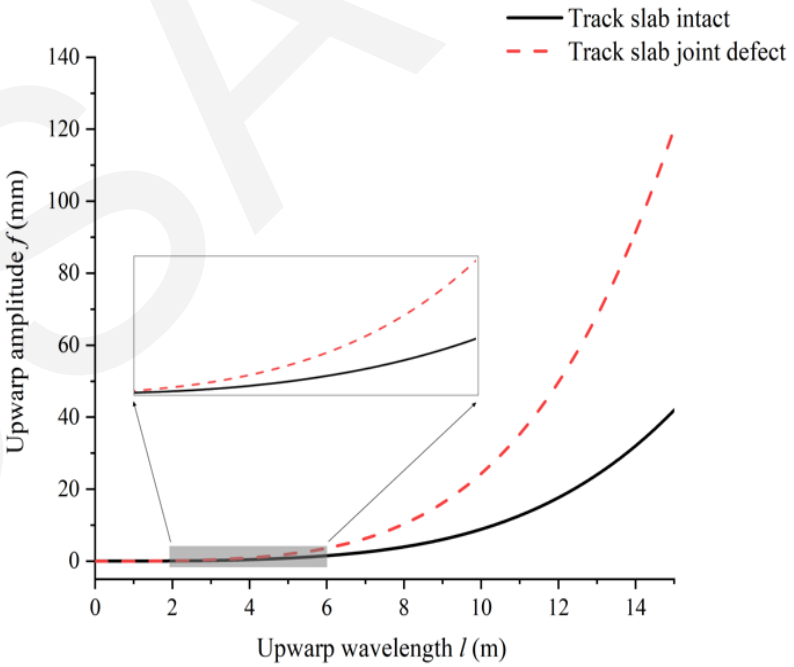
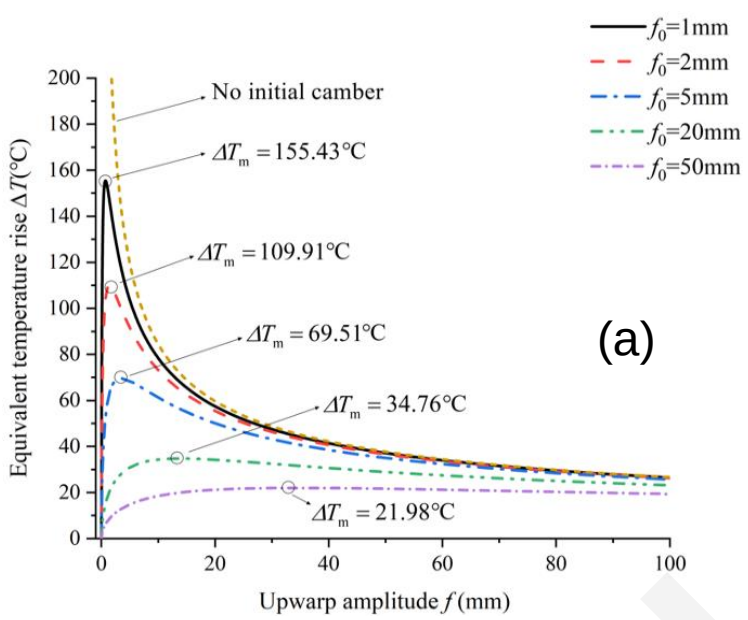
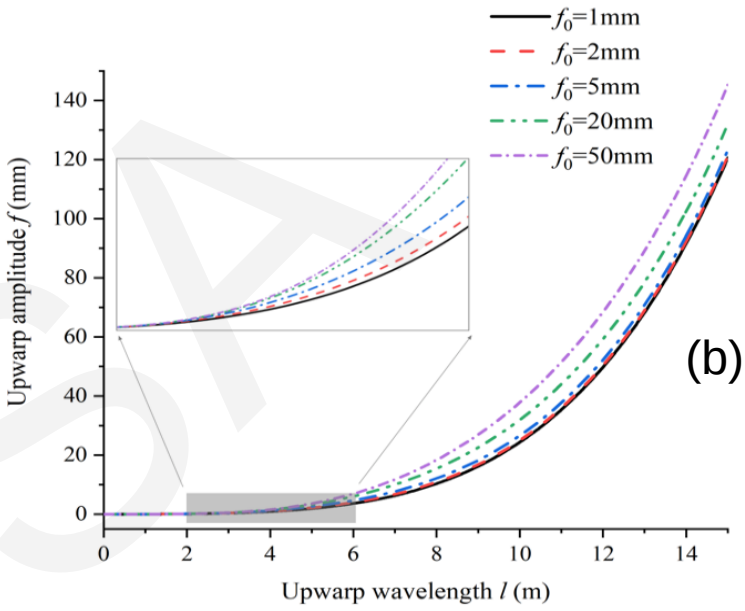


Fig. 4. Variation of upwarp amplitude f with upwarp wavelength l

The effect of initial upwarp amplitude f_0





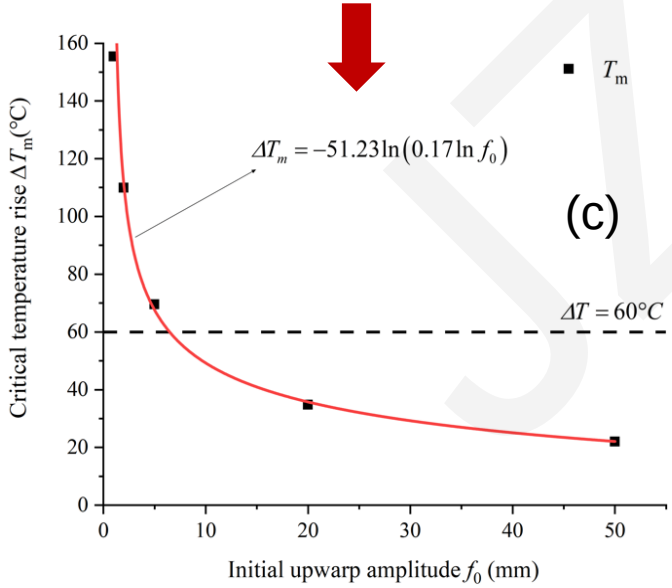
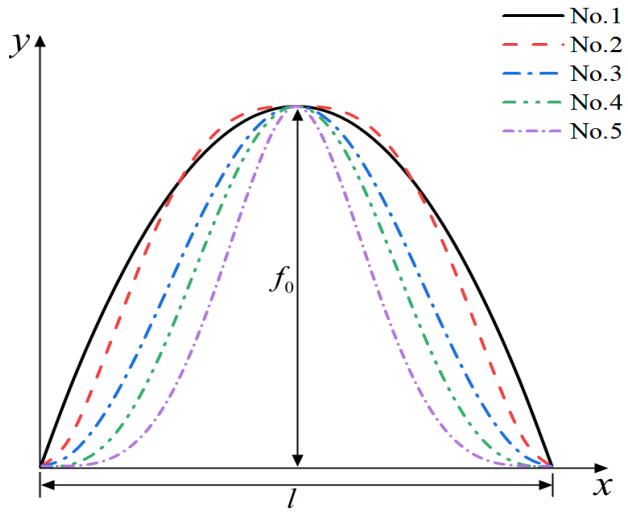
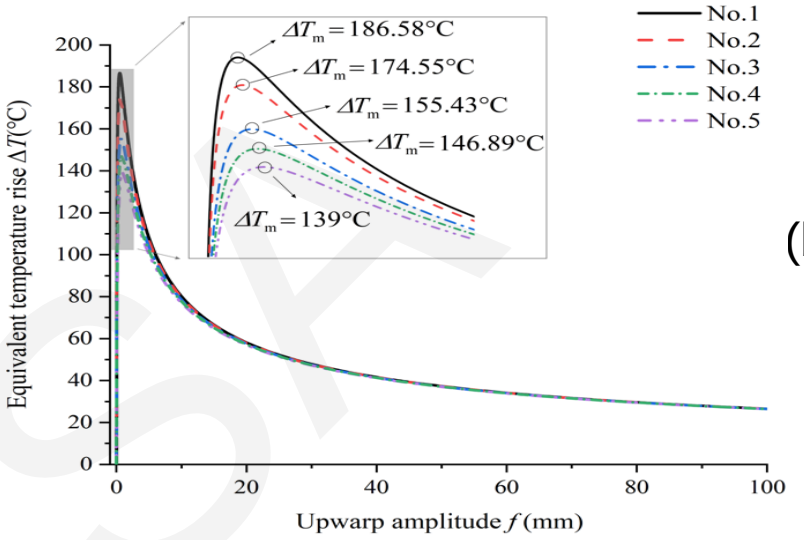


Fig. 5. Effect of f_0 : (a) upwarp buckling equilibrium path; (b) variation of f with l ; (c) Variation of ΔT_m with f_0

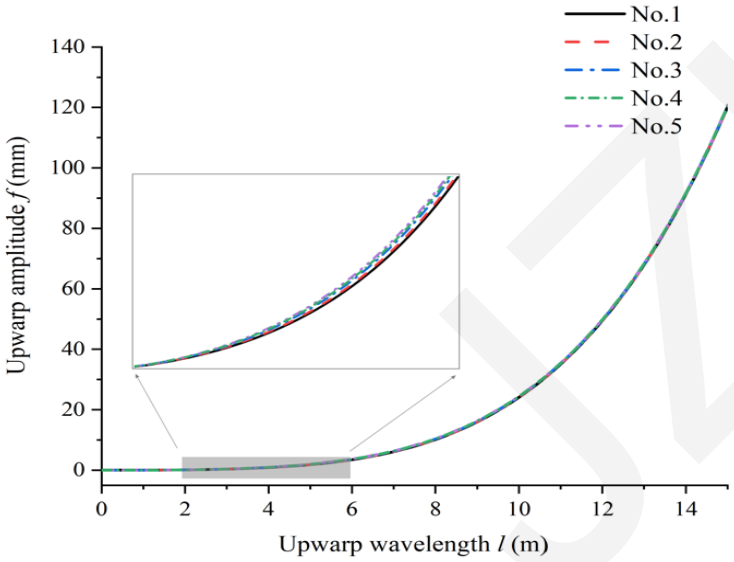
The effect of the initial upwarp curve



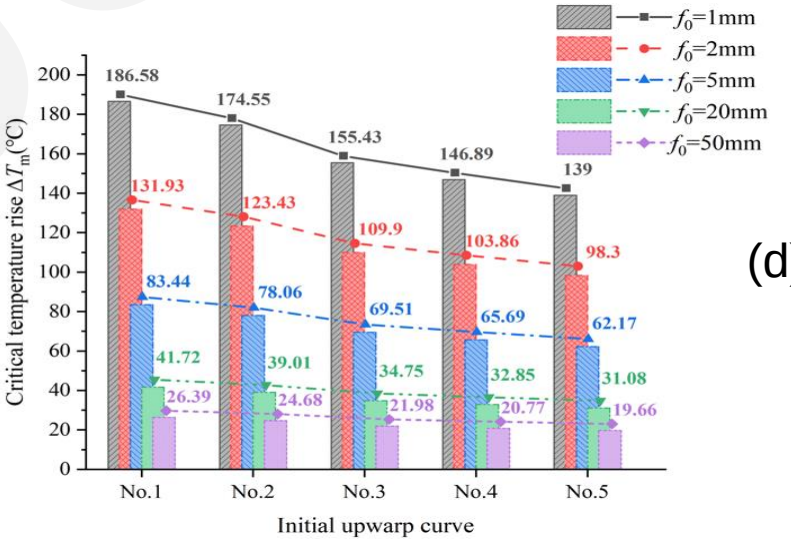
(a)



(b)



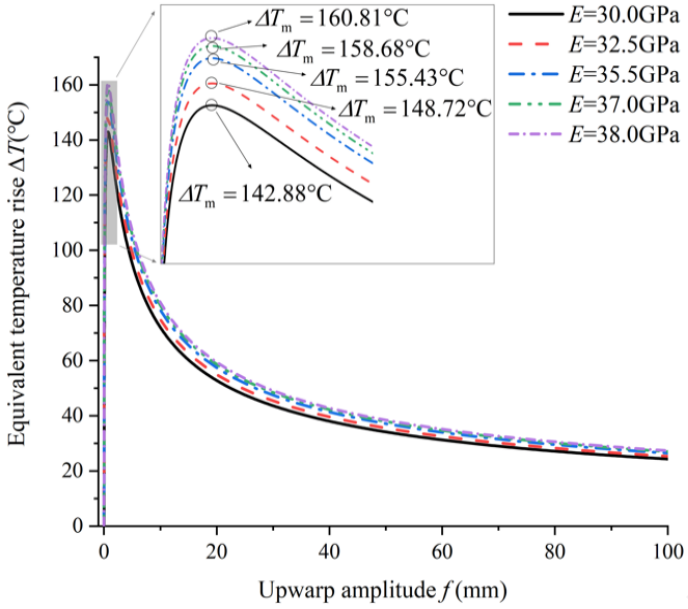
(c)



(d)

Fig. 6. Effect of the initial upwarp : : (a) initial upwarp curves; (b) upwarp buckling equilibrium path; (c) variation of *f* with *l* ; (d) Variation of ΔT_m with the initial upwarp curve

The effect of the elastic modulus E



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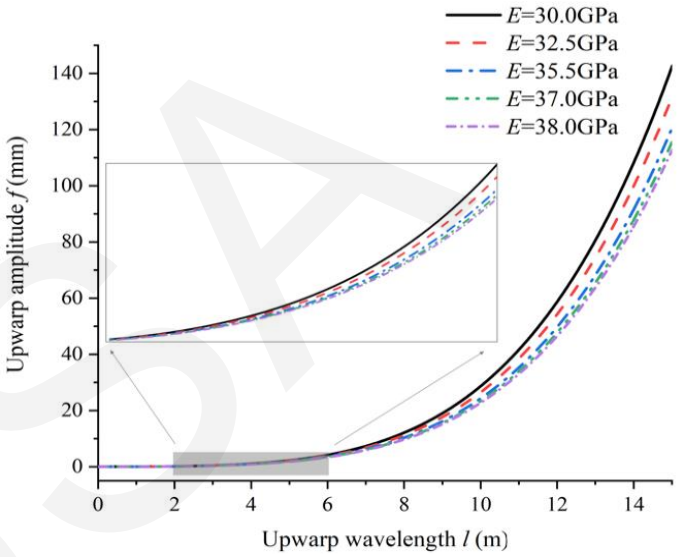

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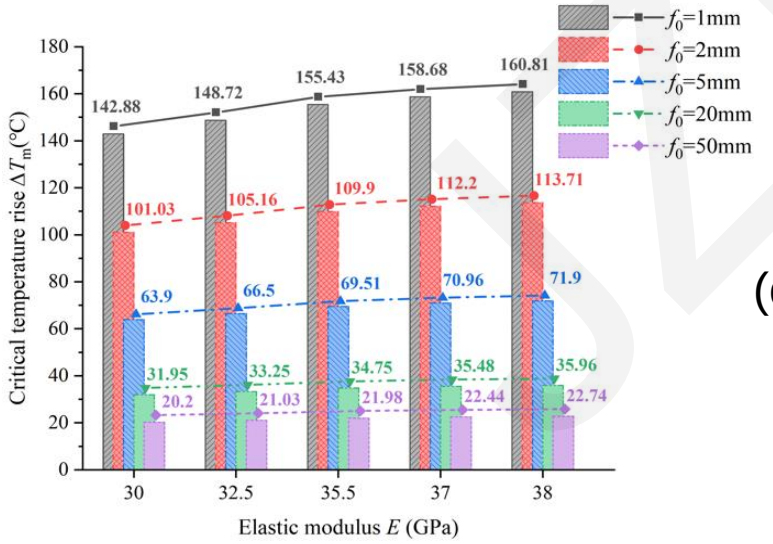
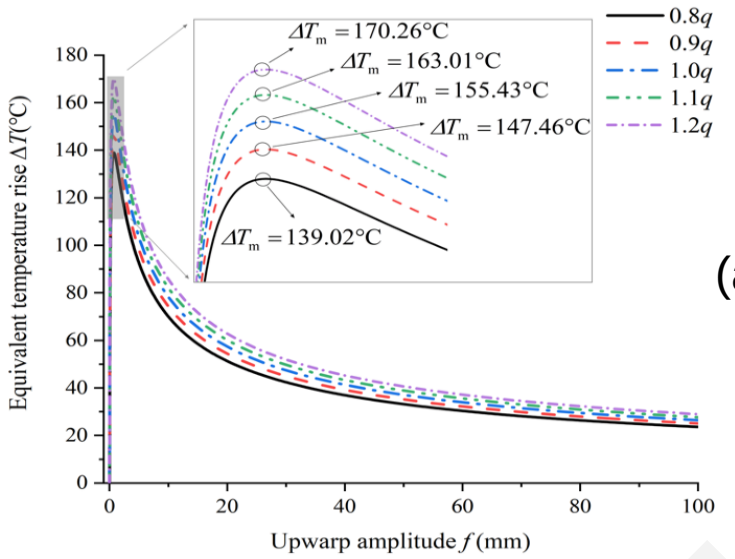


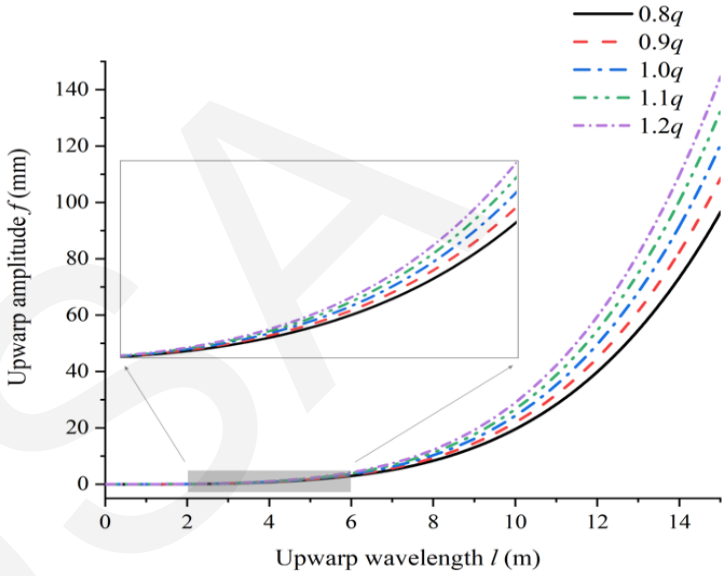
(c)

Fig. 7. Effect of E : (a) upwarp buckling equilibrium path; (b) variation of f with l ; (c) Variation of ΔT_m with E

The effect of the gravity load q



(a)



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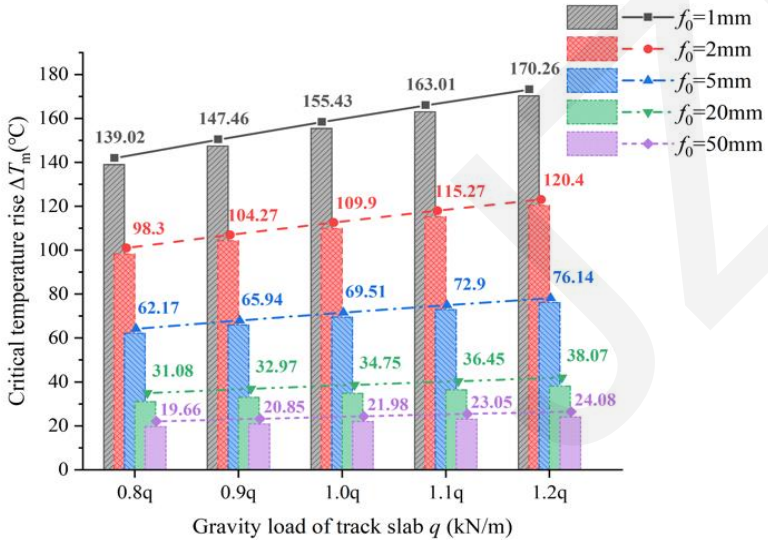
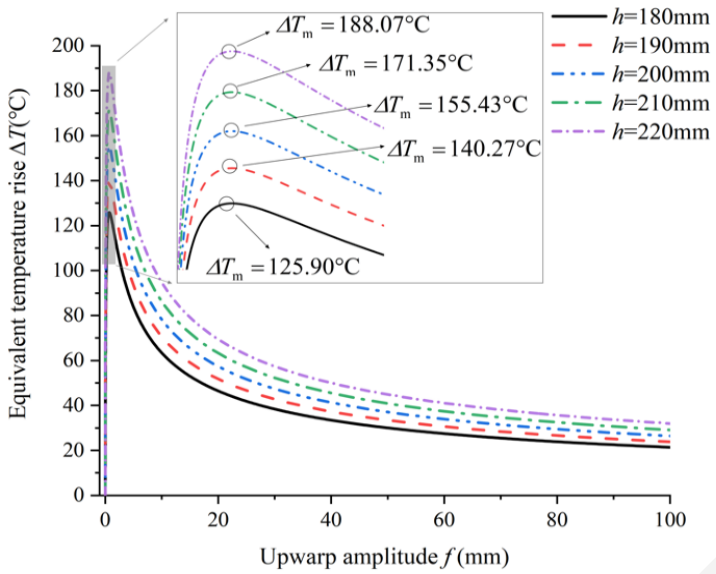


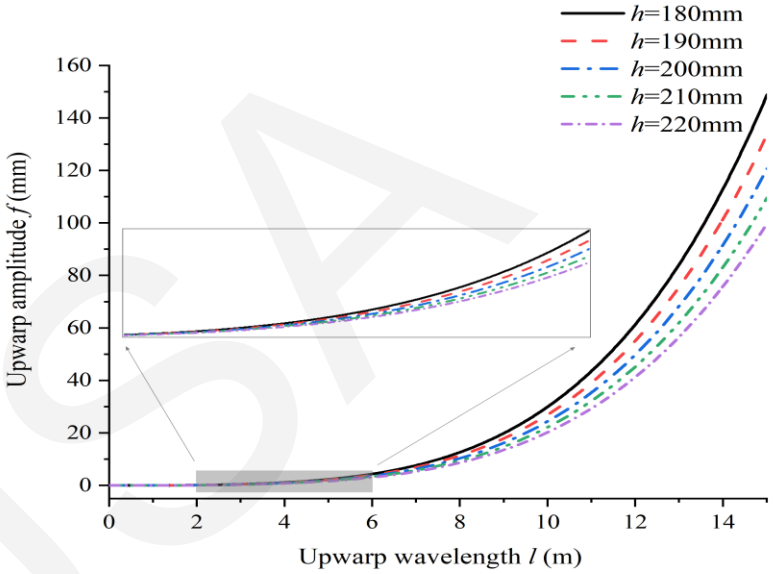
(c)

Fig. 8. Effect of q : (a) upwarp buckling equilibrium path; (b) variation of f with l ; (c) Variation of ΔT_m with q

The effect of track slab thickness *h*



(a)



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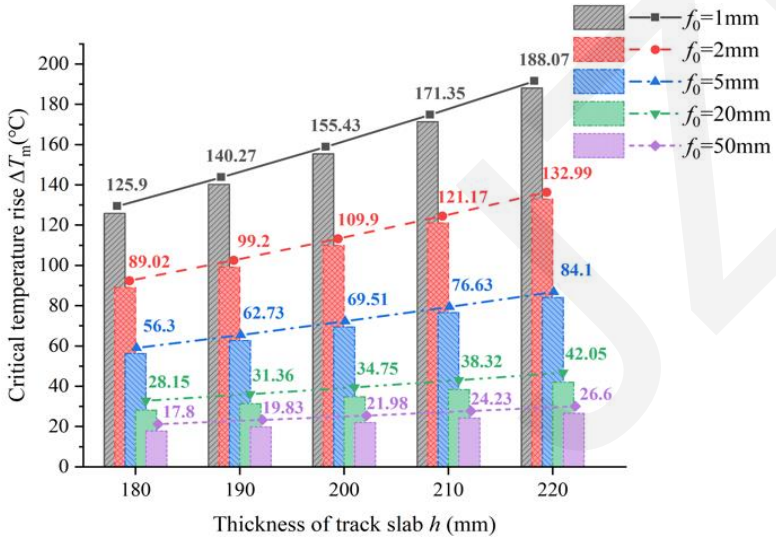

(c)

Fig. 9. Effect of *h* : (a) upwarp buckling equilibrium path; (b) variation of *f* with *l* ; (c) Variation of ΔT_m with *h*

Conclusions

- The upwarp deformation of the track slab in the narrow joint damage state generally presents an inverted 'V' shape.
- The upwarp buckling development of the track slab undergoes three stages: stability, upwarp de-velopment, and post-buckling. Narrow joint defects will cause a significant decrease in the upwarp buck-ling critical temperature rise
- As the initial upwarp amplitude gradually in-creases, the buckling mode transitions from 'sudden buckling' to 'progressive buckling' behavior.
- The upwarp buckling critical temperature rise of the track slab decreases as the boundary constraint of the initial upwarp curve intensifies.
- The upwarp buckling critical temperature rise of the track slab changes linearly with the elastic mod-ulus, gravity load, and thickness of the track slab.