Numerical study on failure propagation between two closely spaced tunnels

Key words:

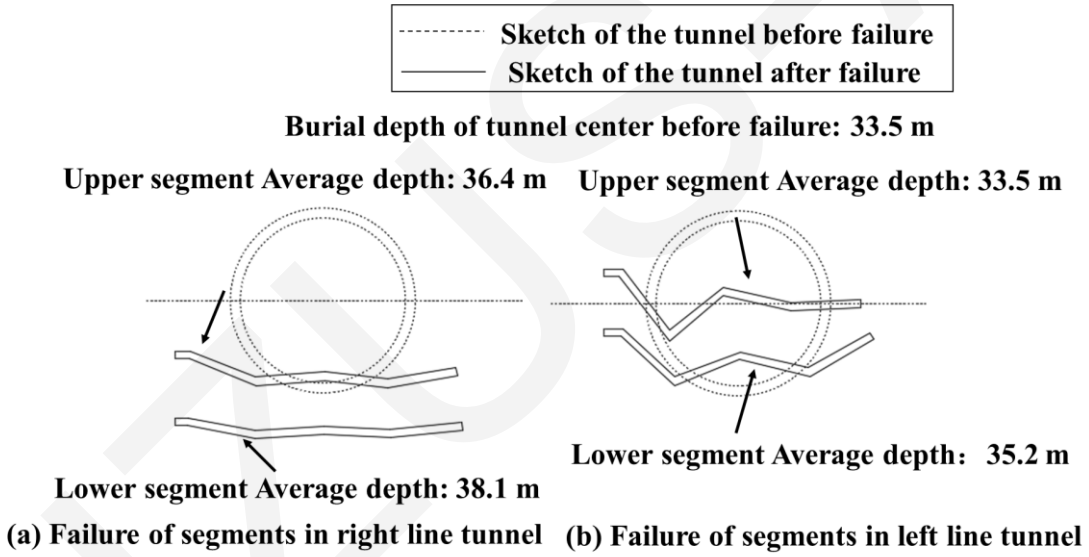
Failure propagation, Closely spaced tunnels, CEL

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Background

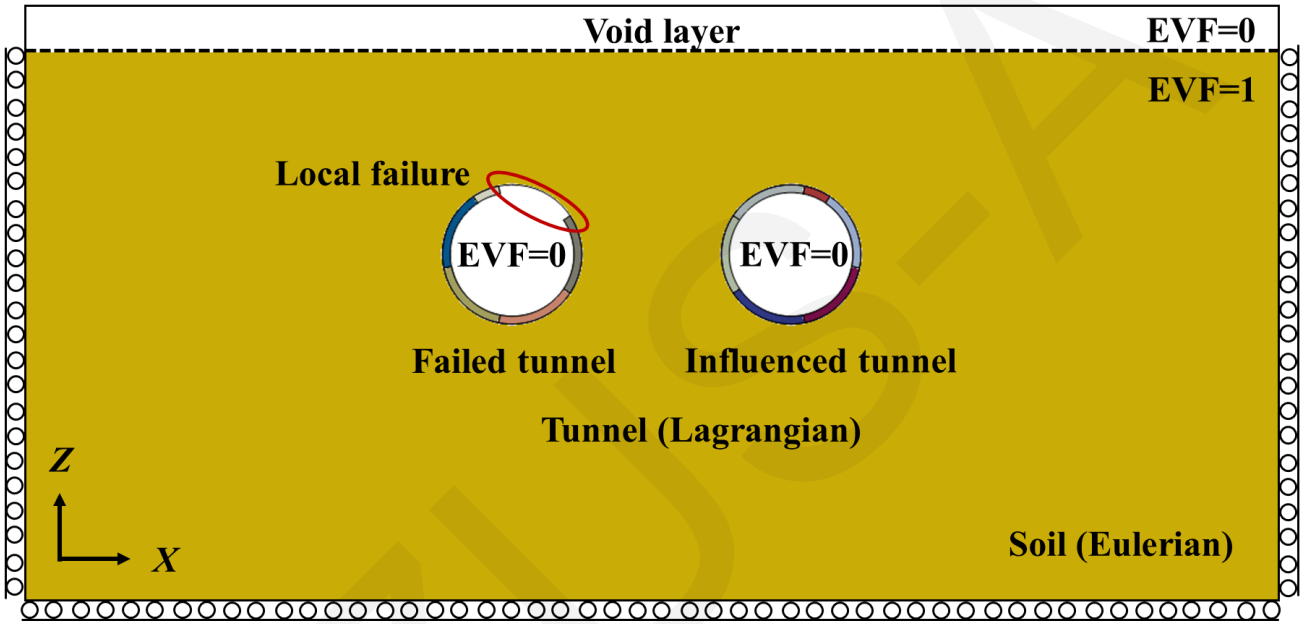
- The distance between tunnels is becoming smaller
- The failure of a tunnel may pose a threat to the safety of a neighbouring tunnel



Accident in Metro Line 4 in Shanghai

- In this article, we carried out numerical simulations to study the influence of a failed tunnel (FT) on an adjacent tunnel, referred to as an “influenced tunnel” (IT)

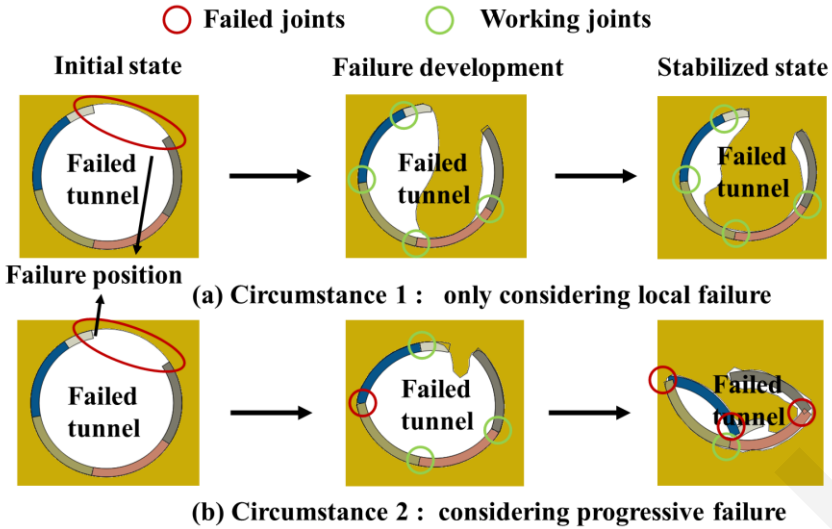
Method



Schematic of the CEL model

- Step 1: Activate the initial boundaries
- Step 2: Deactivate the two joints that were connected with the failed segment to trigger local failure in the FT
- The joints between segments were simulated by tensile springs, shear springs and bending springs

Analysis



Two circumstances considered

Case	Failed tunnel	Influenced tunnel	Buried depth	Central distance
Parallel	Left	Right		
Offset-1	Upper	Lower		
Offset-2	Lower	Upper	1 D	2 D
Overlap-1	Upper	Lower		
Overlap-2	Lower	Upper		

Different cases considered

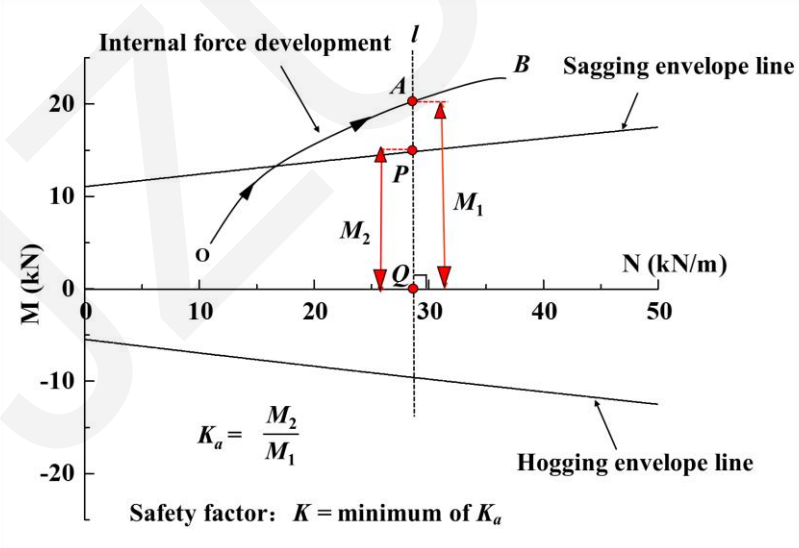


Diagram of the safety factor of the joints

Conclusions

- The sequence in which the joints in the IT went into an unsafe state mainly depended on the spatial relationships of the two tunnels
- In overlapping and offsetting cases, the influence of the failure of the upper tunnel on the lower tunnel was less than that of the lower tunnel on the upper tunnel
- In general, the joints in the IT were in a more dangerous situation when progressive failure occurred in the FT rather than only local failure.
- the degree of safety of the joints in the IT was the smallest for Offset-2. In this case, the IT was located at the shear band of the FT where the soil had a large deformation gradient.

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