

Numerical study on failure propagation between two closely spaced tunnels

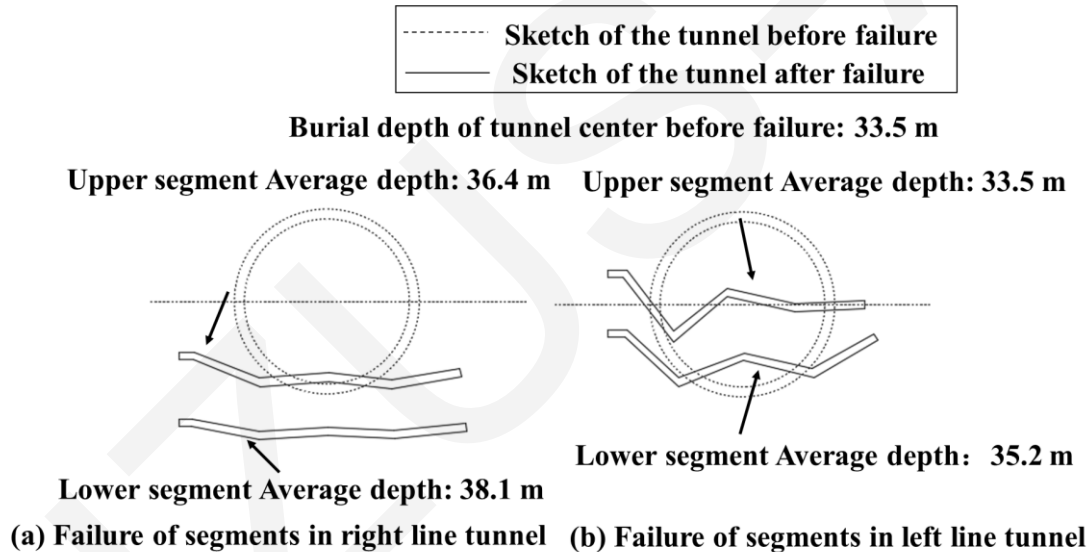
Key words:

Failure propagation, Closely spaced tunnels, CEL

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Background

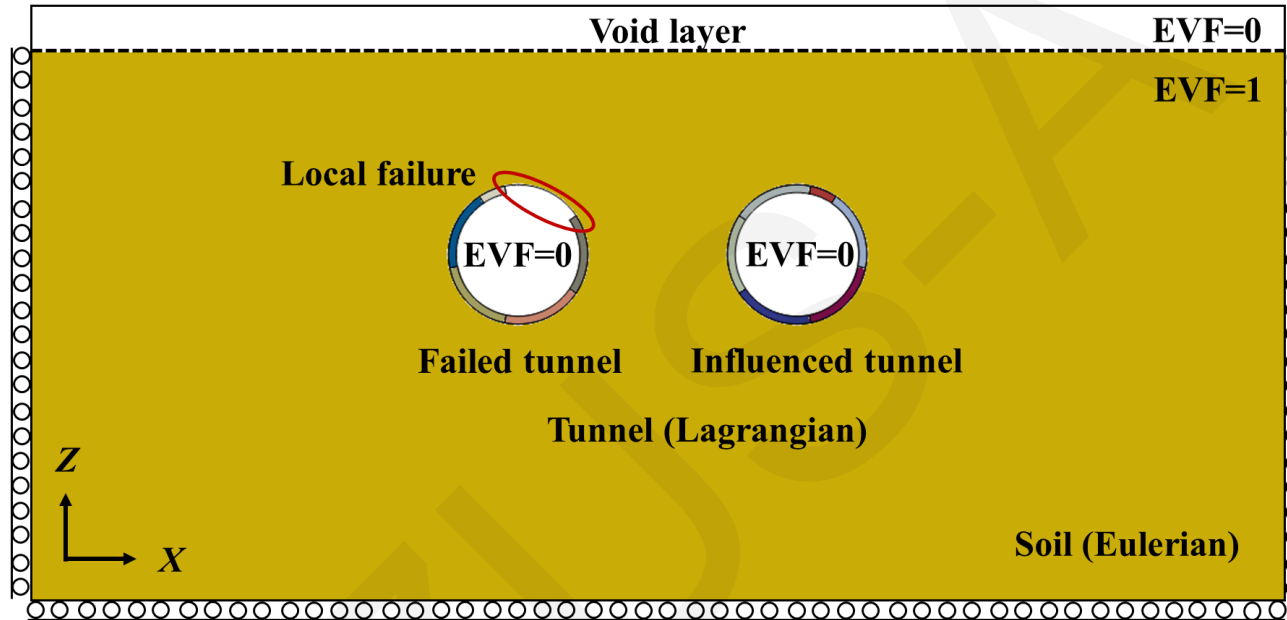
- The distance between tunnels is becoming smaller
- The failure of a tunnel may pose a threat to the safety of a neighbouring tunnel



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

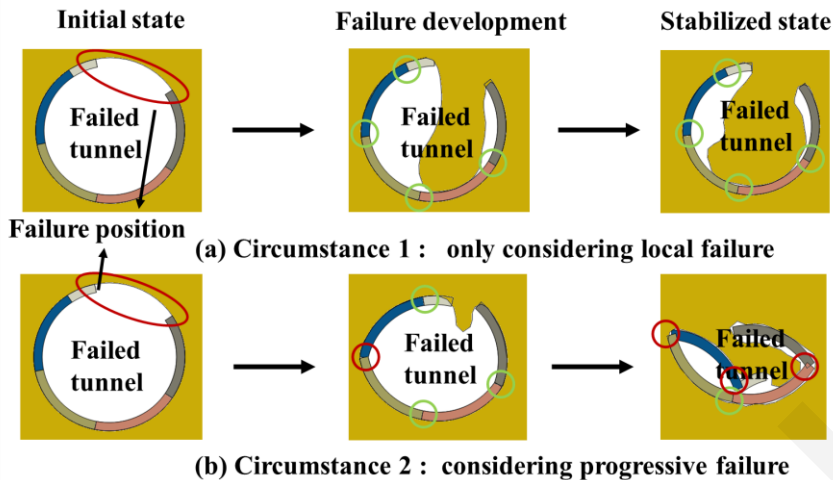


Schematic of the CEL model

- 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

○ Failed joints ○ Working joints



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		

Two circumstances considered

Different cases considered

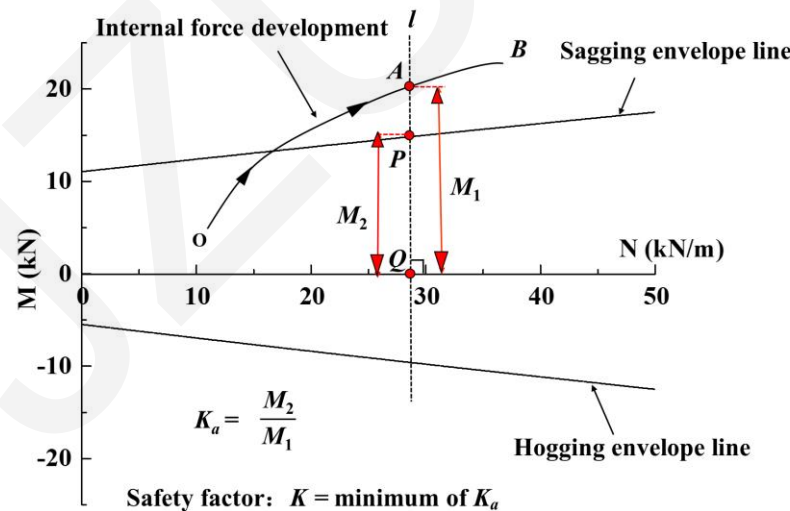


Diagram of the safety factor of the joints

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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