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Flow loss characteristics in parallel confluence sections of tunnels

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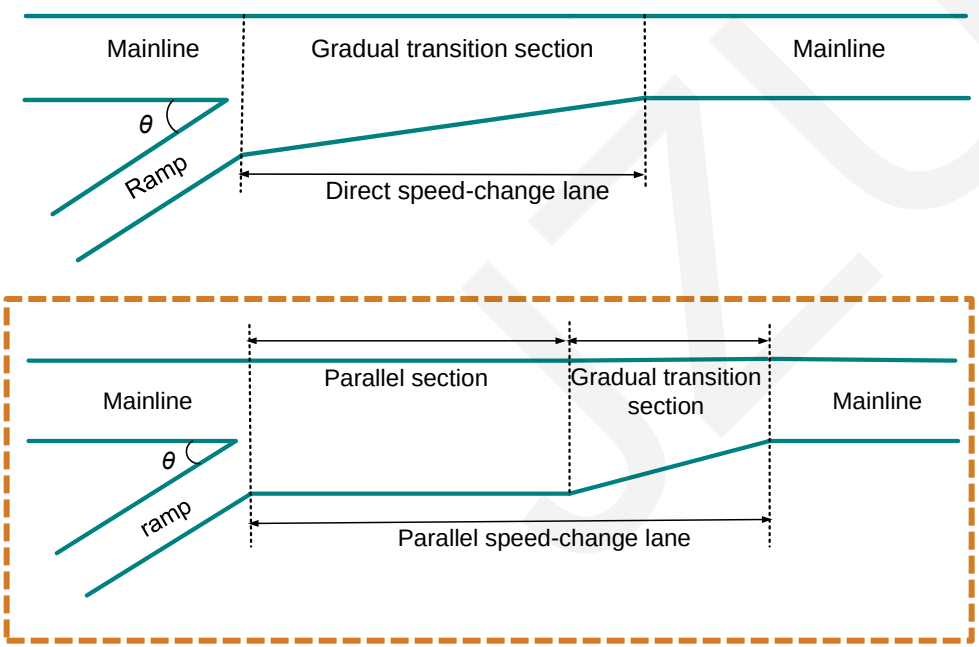
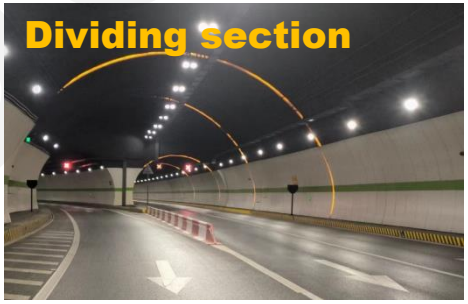
Research Objective

Local loss for direct dividing section (Numerous studies have been conducted)

Local loss for parallel converging section (Our Research Focus)





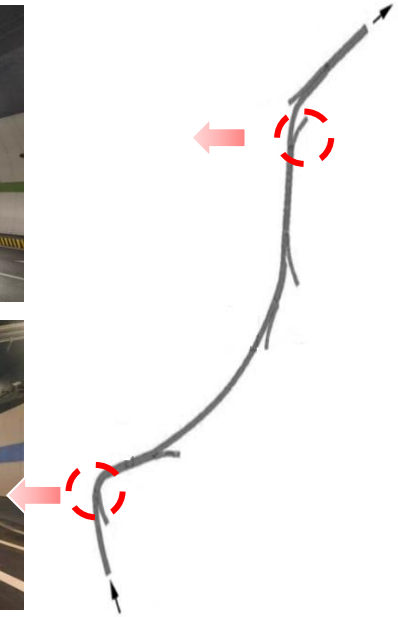


Fig. 2 Schematic diagram of tunnel bifurcation

Experimental Setup

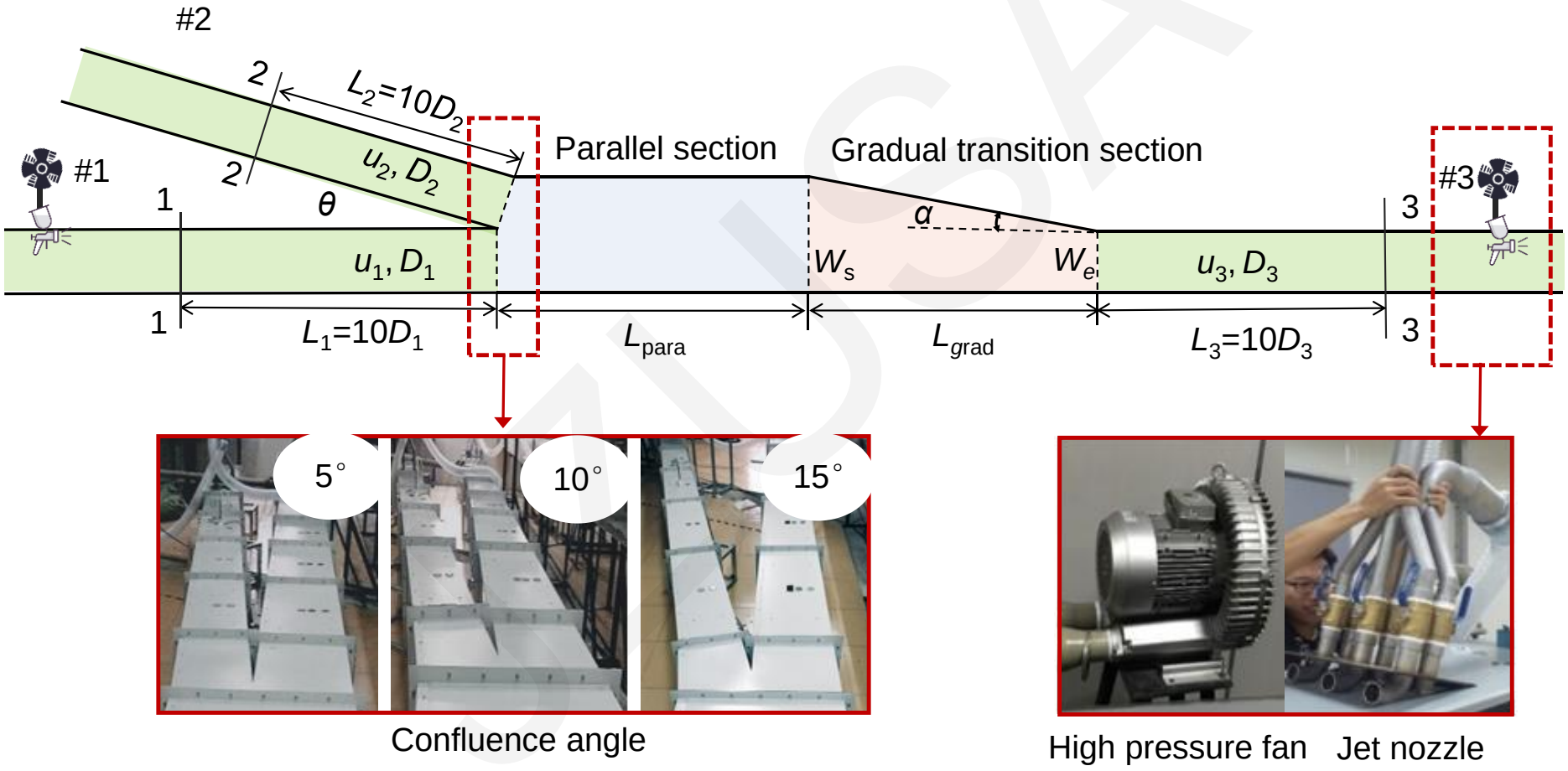


Fig. 1 Ventilation scale model tunnel experimental platform for the bifurcation tunnel

Effect of the confluence ratio *q*

- **Parallel Confluence Losses:**
  - Velocity Gradient Changes
  - Streamline Curvature
  - Flow Separation (Induced by Structural Abruptions & Jet Entrainment)
- **Flow Separation Location Features:**
  - $q\downarrow$: at the upper part of the junction
  - $q\uparrow$: near the mainline side of the confluence section

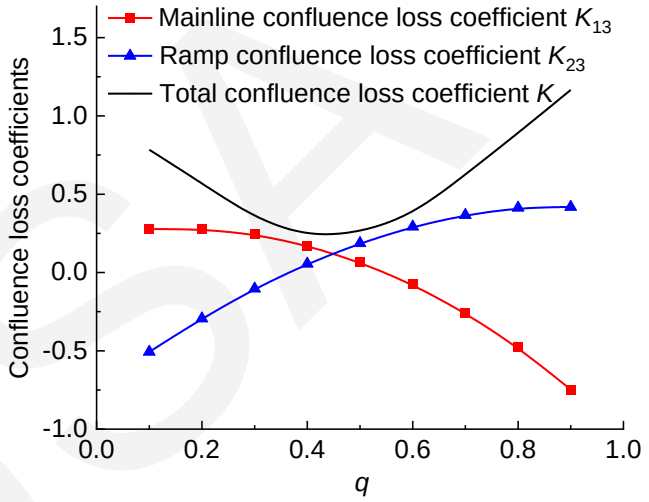


Fig. 3 Variation of the loss coefficients in the parallel confluence section

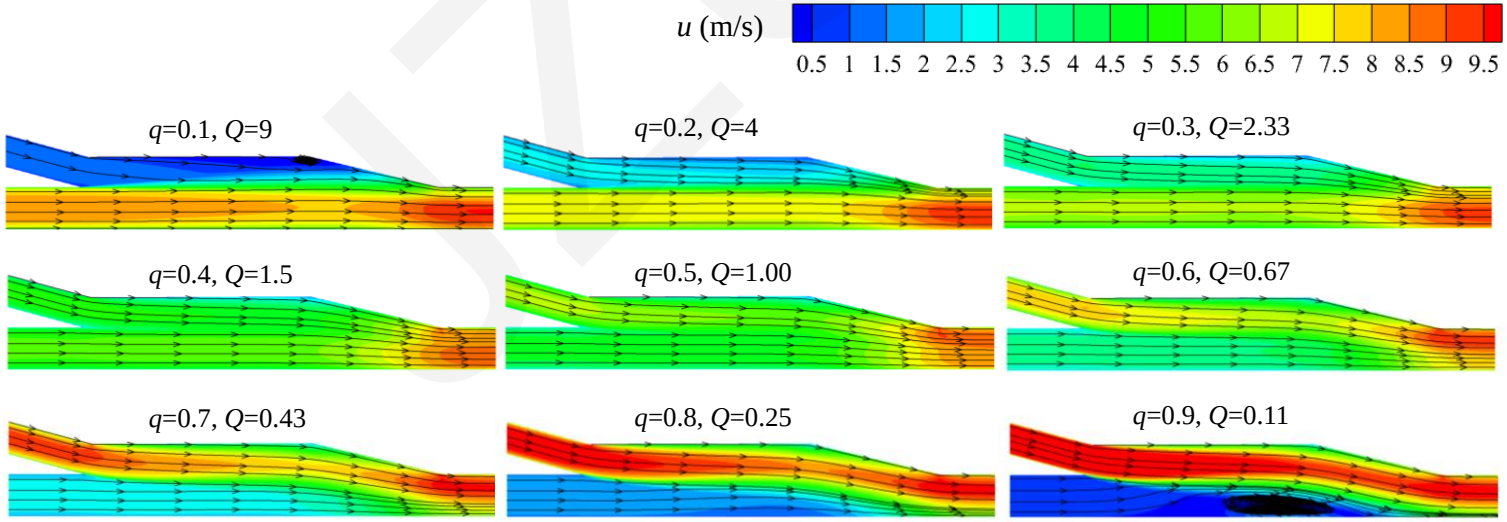


Fig. 4 Flow structure of the parallel confluence section at $\theta = 15^\circ$

The effect of the confluence angle θ

- For small q: K, $|K_{13}|$and $|K_{23}|$ are almost unaffected by θ
- For large q: K, $|K_{13}|$and $|K_{23}|$ decrease with the increase of θ

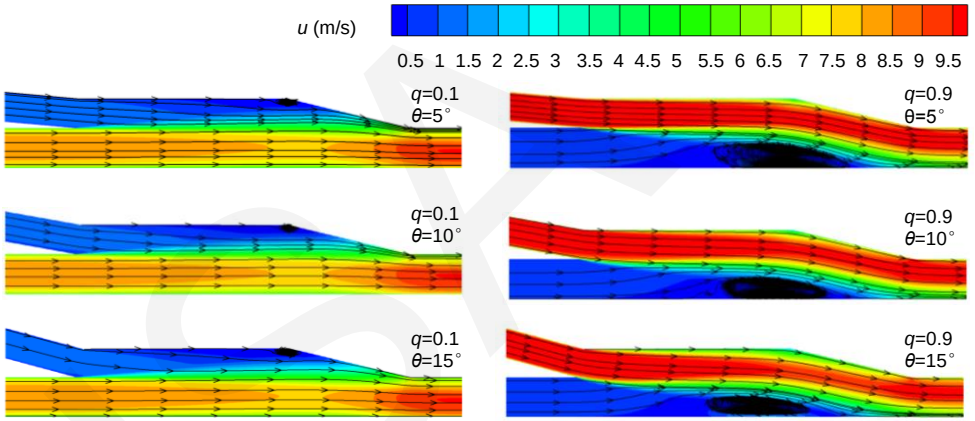


Fig. 7 Flow structure of the parallel confluence section

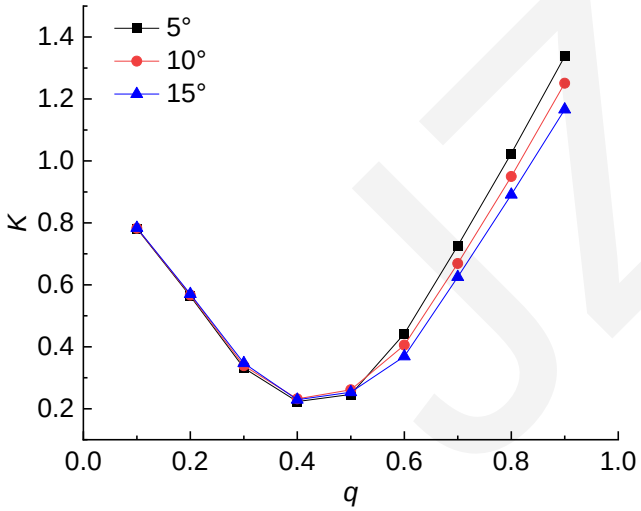


Fig. 5 Total loss coefficient in the parallel confluence section

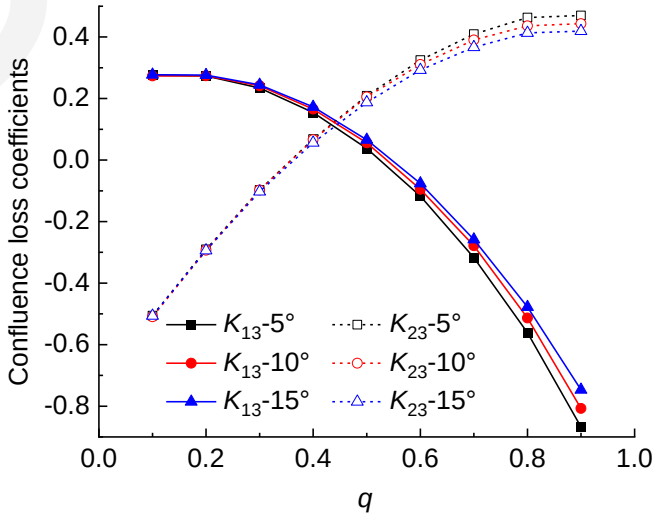


Fig. 6 Loss coefficients of the mainline and ramp in the parallel confluence section

Predictive model of loss coefficients in the parallel confluence section

$$K_{13} = \xi_{13}' + k\left(\xi_{\text{para}} + \xi_{\text{grad}}\right)$$

$$K_{23} = \xi_{23}' + k\left(\xi_{\text{para}} + \xi_{\text{grad}}\right)$$

$$\xi_{13}' = \frac{2\varphi\left[1-(1-q)^2 - q^2\varphi\cos\theta_{13}\right]}{\varphi + \frac{1}{2}\cos\theta_{13}} + (1-q)^2 - 1$$

$$\xi_{23}' = \frac{2\varphi\left[1-(1-q)^2 - q^2\varphi\cos\theta_{23}\right]}{\varphi + \frac{1}{2}\cos\theta_{23}} + q^2\varphi^2 - 1$$

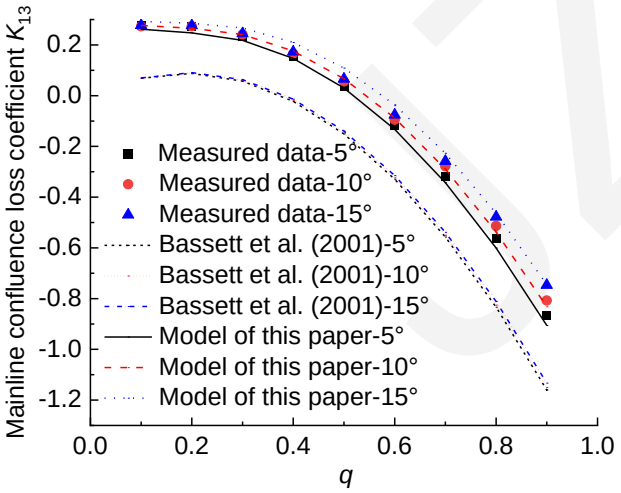
$$\theta_{13} = 17.31 + 4.535q - 1.168 + \theta$$

$$\theta_{23} = 41.32q - 0.498 - \theta - 23.62$$

- **local loss of the flow field due to "sudden expansion-gradual contraction" effects**

$$\xi_{\text{para}} = \lambda\frac{L_{\text{para}}}{D_{\text{para}}}\left(\frac{W_s}{W_e}\right)^2$$

$$\xi_{\text{grad}} = \frac{\lambda W_e^2}{2H\tan\alpha}\left[H\left(\frac{1}{2W_e^2} - \frac{1}{2W_s^2}\right) + \left(\frac{1}{W_e} - \frac{1}{W_s}\right)\right]$$



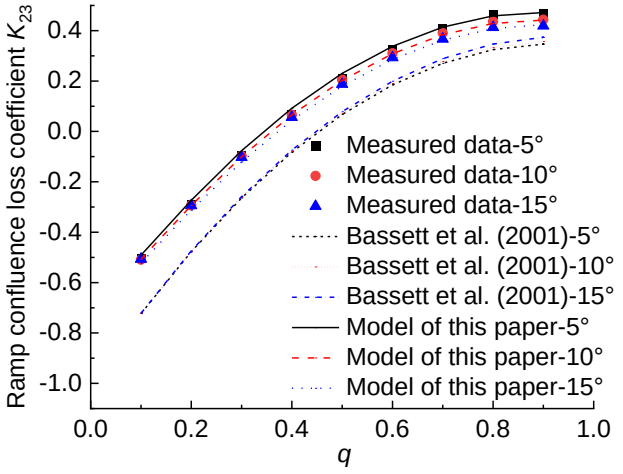


Fig. 7 Comparison of the proposed formula, Bassett's formula calculation results, and test results