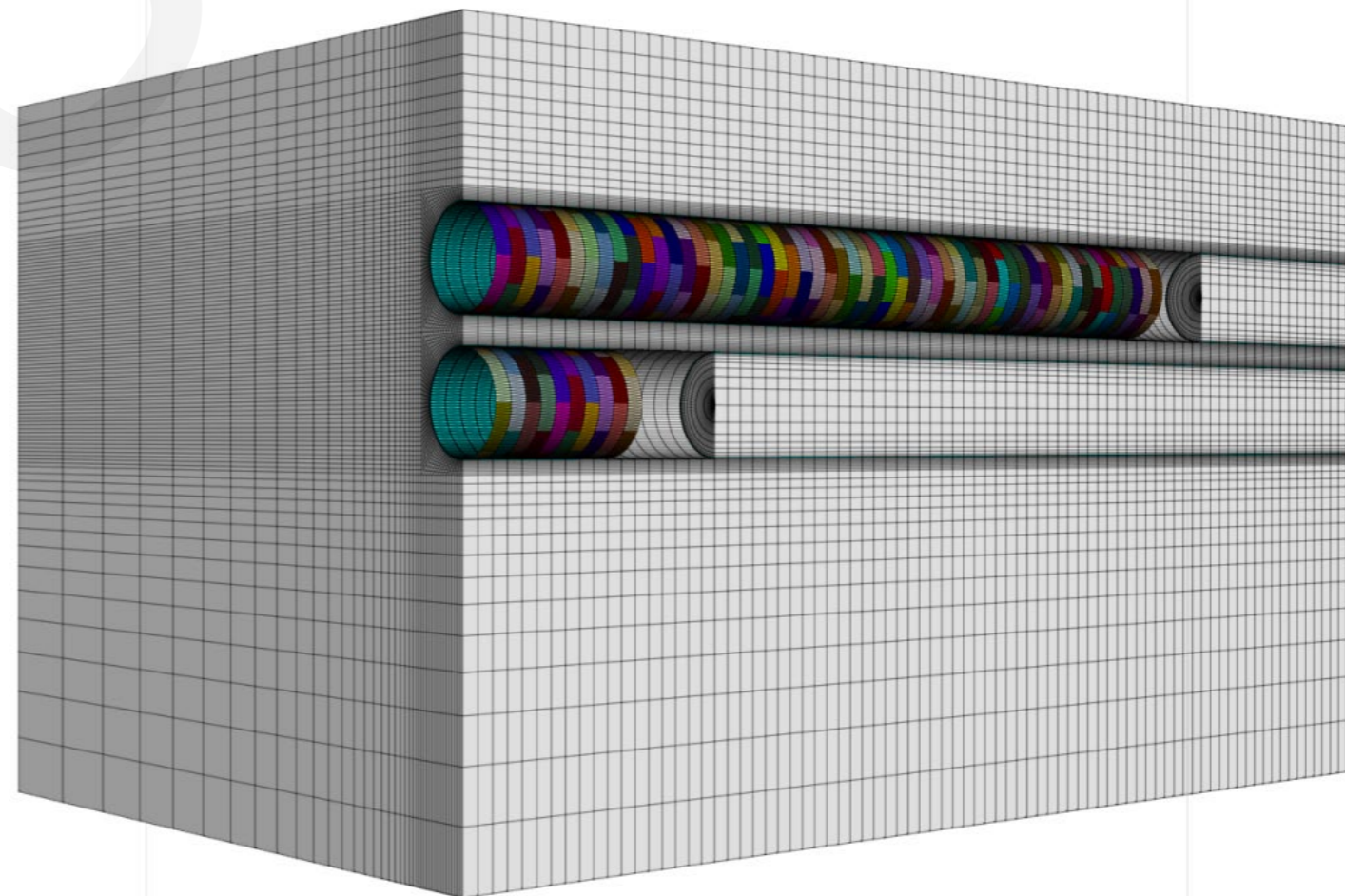


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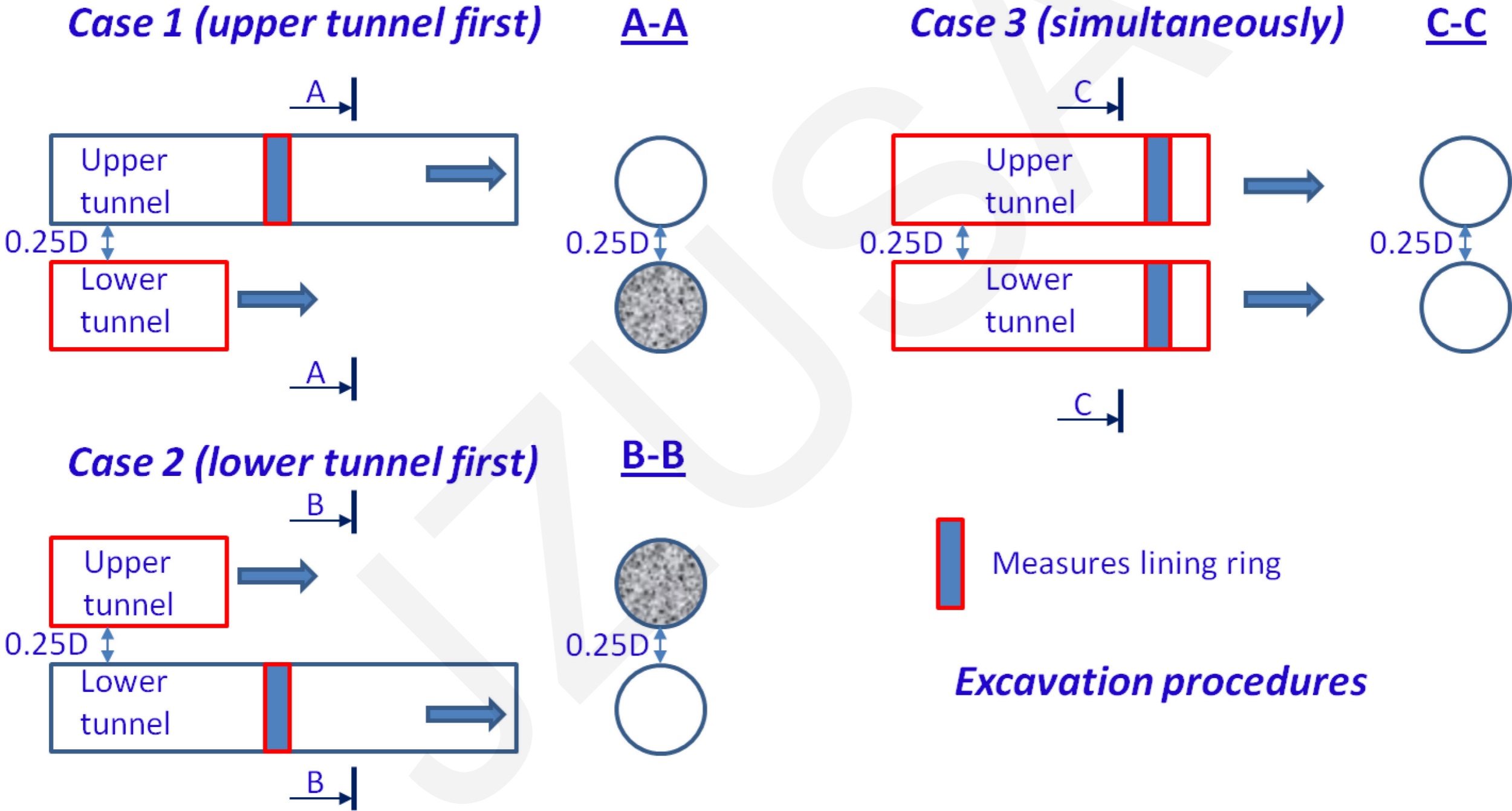
Three-Dimensional Numerical Simulation of Mechanized Twin Stacked Tunnels in Soft Ground

Key words:

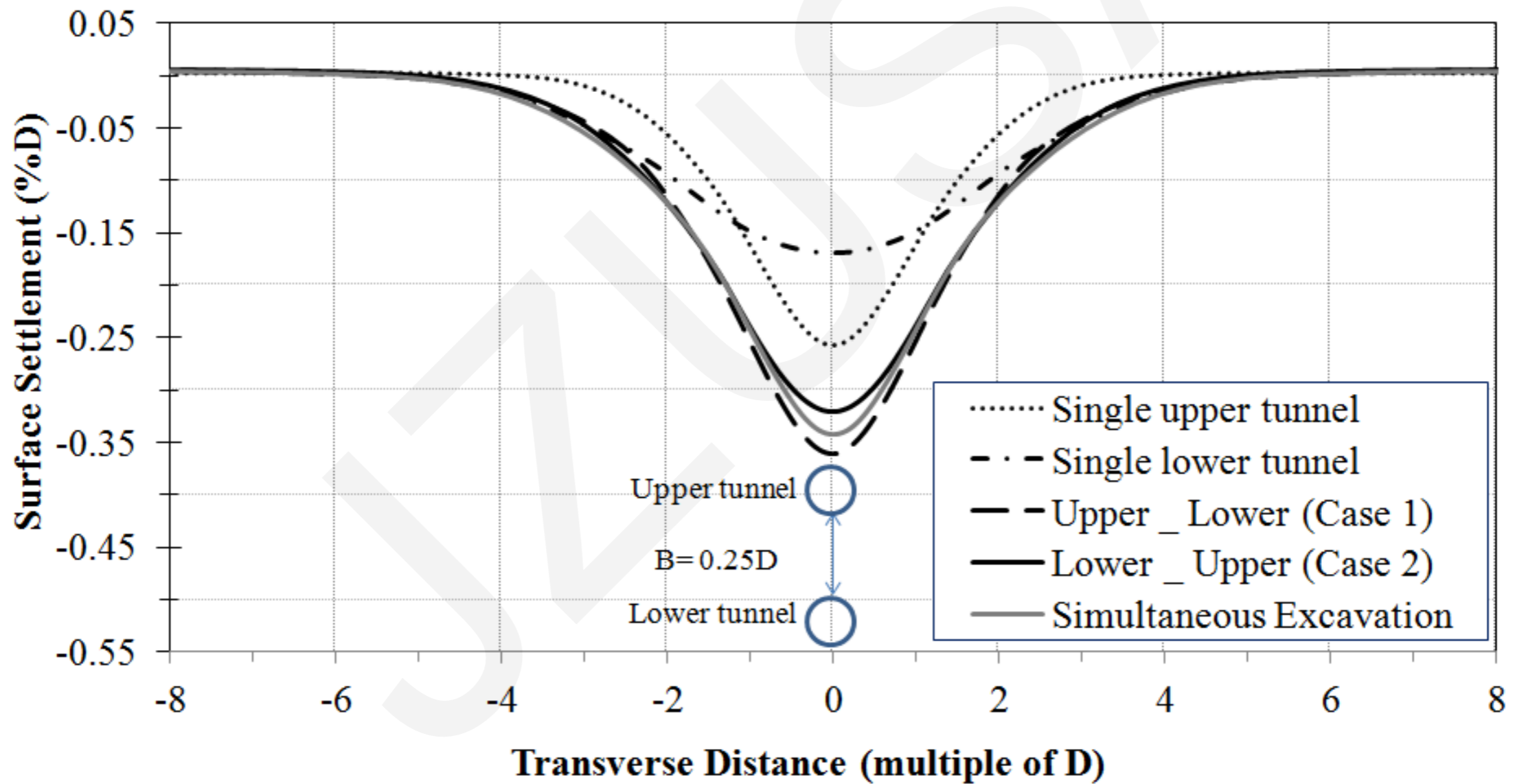
3D modelling, Stacked tunnels, Segmental tunnel lining, Lining response, Surface settlement, Tunnel support



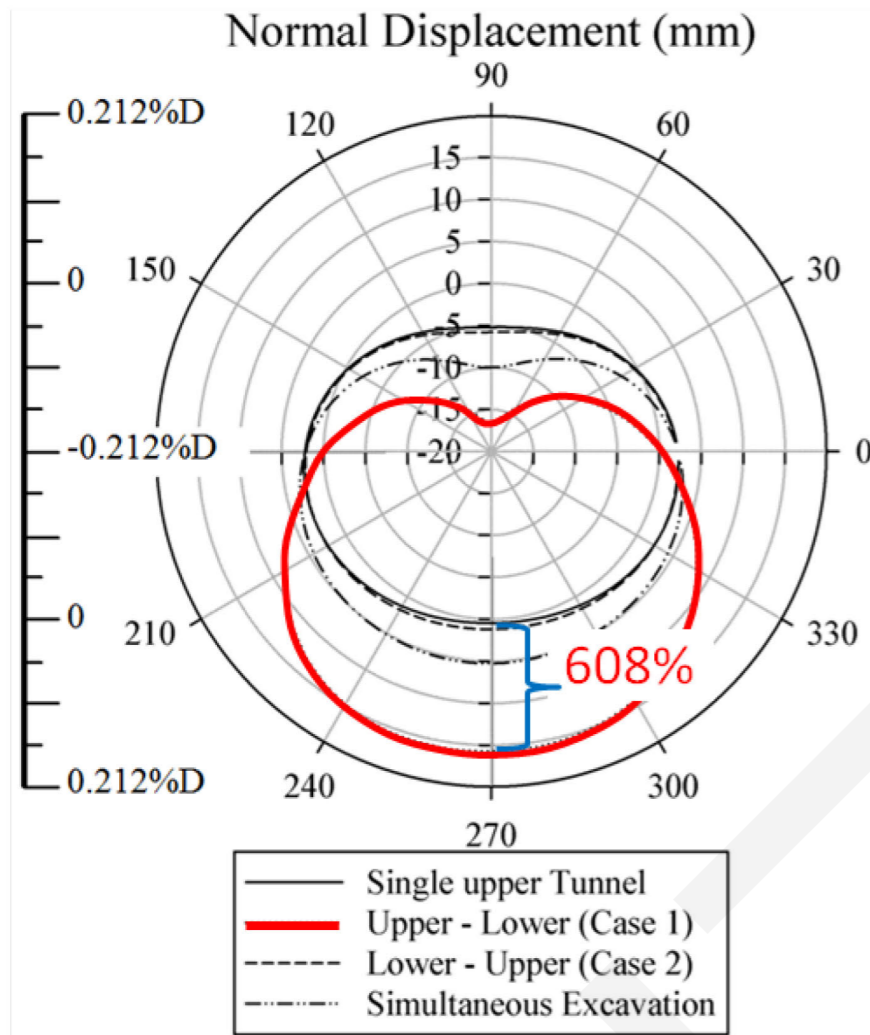
Objectives: - Impact of a tunnel excavation on an existing tunnel;
- Influence of the tunnelling procedure



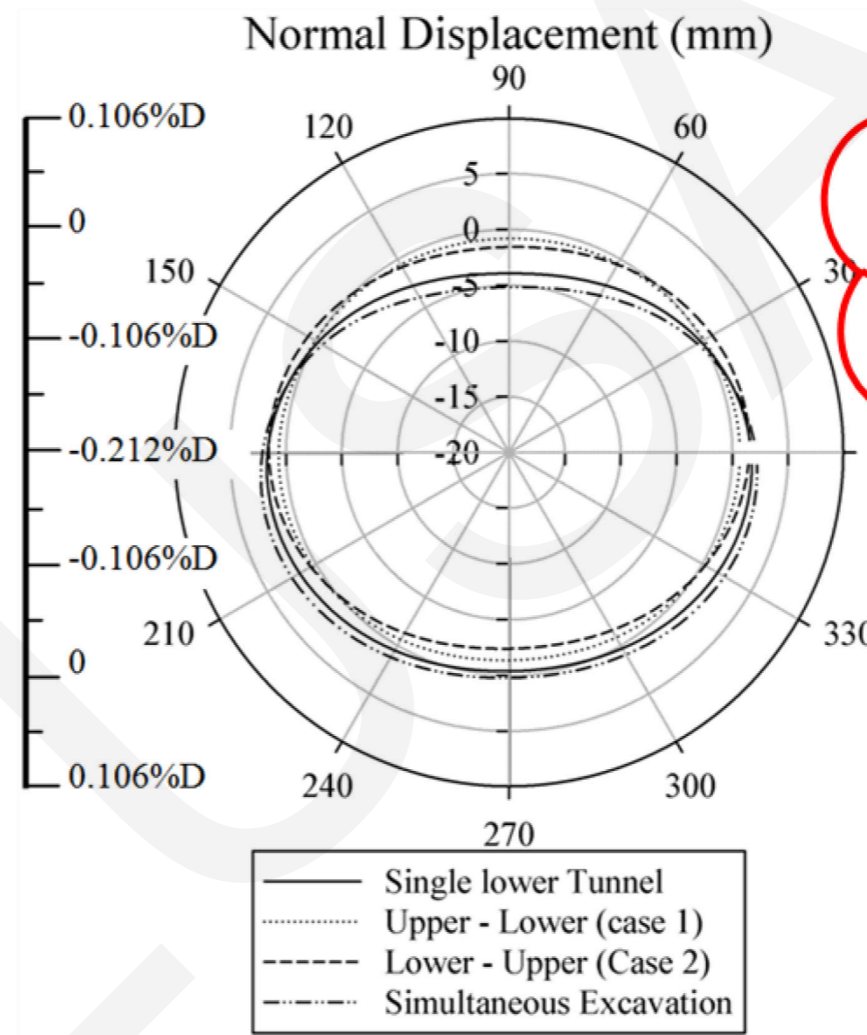
Comparison of the settlement trough in the transverse section of the stacked tunnels for different construction procedures



● Normal displacement in the tunnel lining



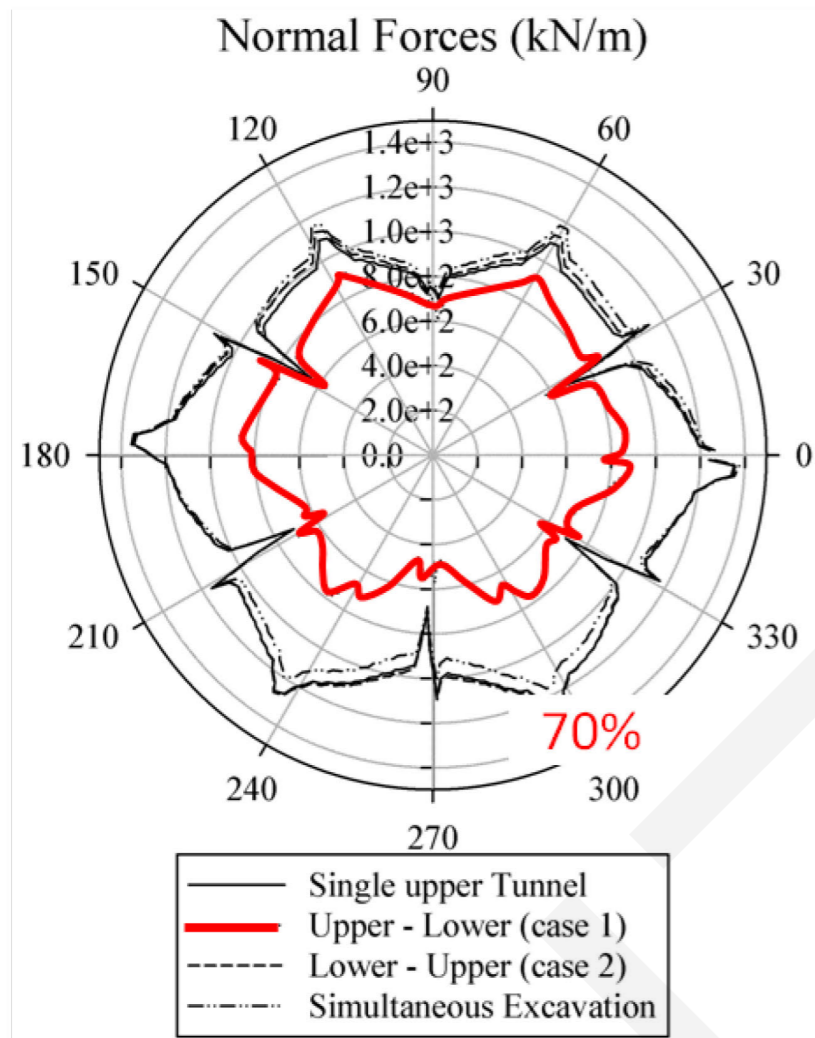
Comparison of the normal displacement in the **upper** tunnel lining



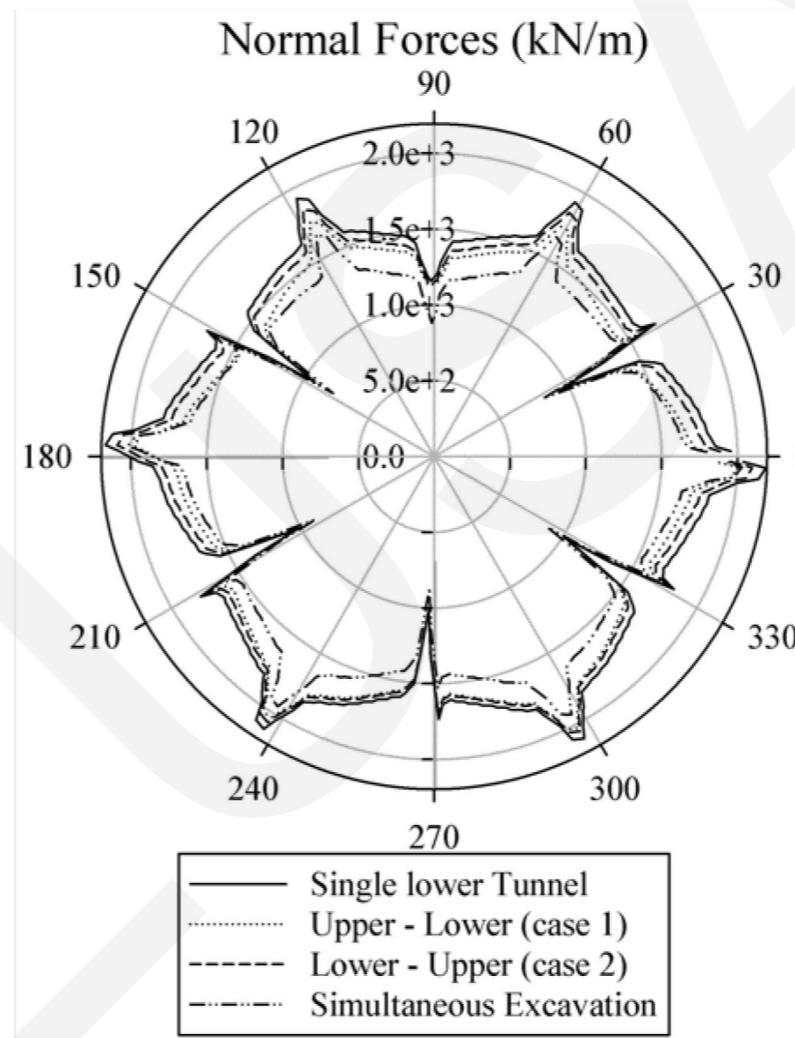
Comparison of the normal displacement in the **lower** tunnel lining

Normal displacement in the upper tunnel is affected more by the tunnelling procedure than the lower tunnel, particular in case 1

● Normal forces in the tunnel lining



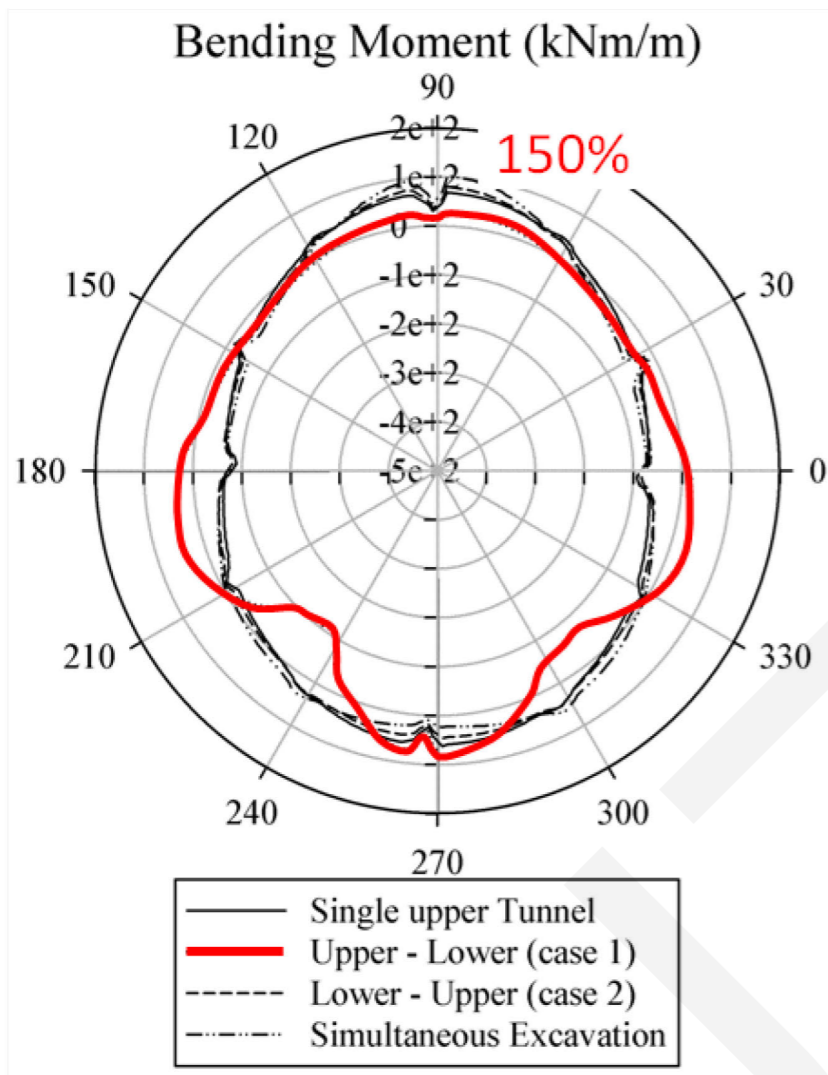
Comparison of the normal forces in the **upper** tunnel lining



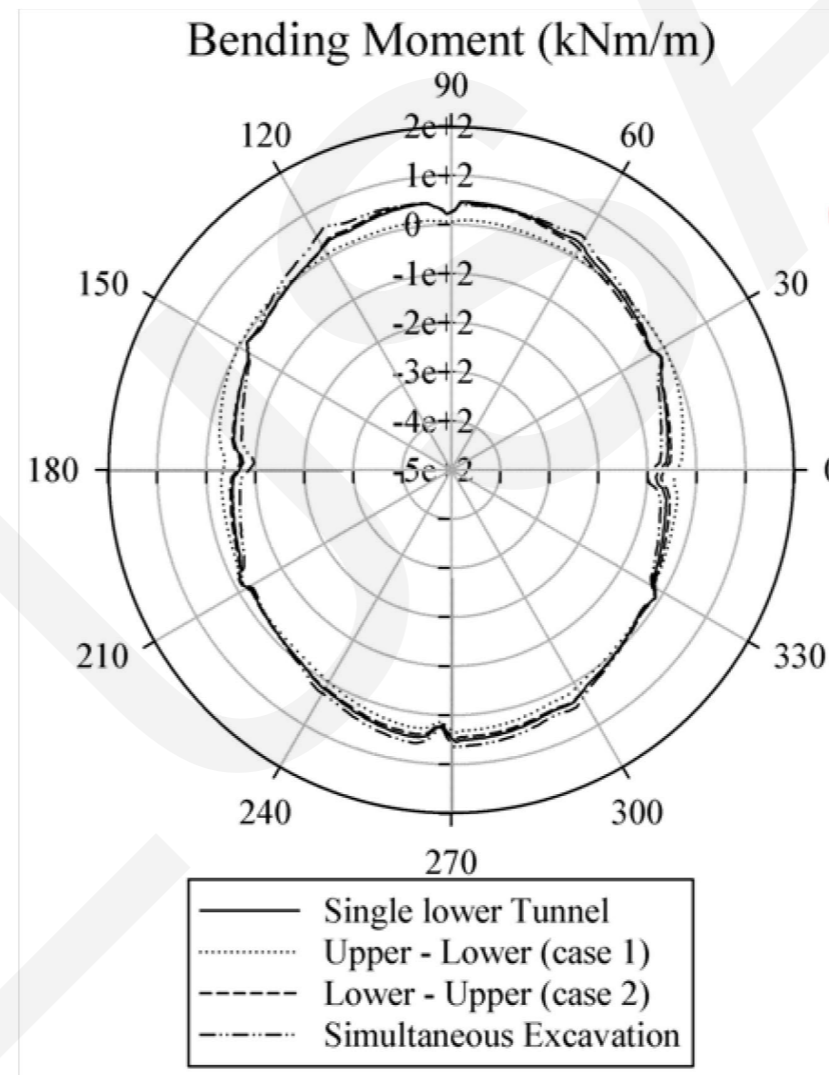
Comparison of the normal forces in the **lower** tunnel lining

Normal forces in the upper tunnel is affected more by the tunnelling procedure than the lower tunnel, particular in case 1

● Bending moment in the tunnel lining



Comparison of the bending moment in the **upper** tunnel lining



Comparison of the bending moment in the **lower** tunnel lining

Bending moment in the upper tunnel is affected more by the tunnelling procedure than the lower tunnel, particular in case 1

Conclusions:

- Greatest impacts between stacked tunnels are observed in case 1 (when the upper tunnel is excavated first).
- Stacked tunnel excavation causes an increase in the surface settlement. The excavation of the upper tunnel first causes a greater surface settlement than those of the other two cases;
- Case 1 leads to smaller normal forces than case 2.
- Internal forces in both stacked tunnels for simultaneous excavation case (i.e., case 3) are greater than those obtained for successive excavation cases (i.e., case 1 and case 2);
- Successive excavation of stacked tunnels cause an increase in the maximum bending moment in the upper tunnel and a decrease in the bending moment in the lower tunnel at the final state;
- The upper tunnel is strongly influenced by the excavation procedure for all cases.