Flow instability under an elongated plate above the ground

Masahiro Suzuki[a] and Nobuyuki Okura[a]

Meandering flow typically appears under high-speed trains. When the train passes through a tunnel, this flow causes uncomfortable lateral vibration on the train. A computational study suggested that the meandering flow under the train body interfered with the tunnel wall, causing pressure fluctuations on the side of the vehicle which in caused the train to vibrate[1]. However, the mechanism of meandering flow generation has not been well understood. Recently, Okura et al. have successfully reproduced a similar meandering flow using a simple experimental model with two parallel elongated plates placed in a uniform flow, simulating the space between the ground and the vehicle body[2].

Trains run on the ground. In the study, therefore, Okura's model was computationally examined by modifying it to a more realistic, but still simple, model of flow between an elongated plate and the ground in a uniform flow. Cases of moving ground were also considered to simulated train travel. A flat plate of 2.5 h in width and 100h in length was placed at a distance of h from the ground in a uniform flow. Large eddy simulations were performed using the Smagorinsky model.

The results are as follows. When the ground stopped moving, the flow between the plate and the ground decreased downstream due to the viscosity of the fluid. The difference between the velocity in the space between the plate and the ground and the velocity outside the plate then increased. This resulted in a shear layer with vortices on both sides of the plate due to the Kelvin-Helmholtz instability. This shear layer was then rolled up, creating clockwise and anti-clockwise vortices on both sides of the plate. These vortices interacted with each other and were arranged alternately like a Karman vortex street, resulting in a meandering flow. On the other hand, when the ground was moving, no meandering flow was observed. This was because the ground movement did not slow down the flow under the flat plate sufficiently, resulting in the flow not becoming unstable. When the flow was slowed down by attaching a barrier to the tip of the plate, a meandering flow was observed, even when the ground moved. It is presumed that the flow under the train meanders because the underfloor of the train is not flat but uneven, e.g. due to bogies, which slow down the flow.

[a] Dep. Vehicle and Mechanical Engineering, Meijo University, 1-501 Shiogamaguchi, Tempaku-ku, Nagoya 468-8502, JAPAN

[1] Suzuki et al., *J. Mech. Systems for Trans. and Logistic*s **1**, 281 (2008).

[2] Okura et al., *Nagare* **40**, 418 (2021).