Measurement on Wake of a Flat Plate in Ground Effect

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1. Introduction

Ground effect is the effect of the ground on the flow around objects such as trains and cars, moving closely along the ground surface. It is effective to use a moving belt that moves at the same speed as the uniform flow to simulate objects moving through the stationary air above the ground.⁽¹⁾ In the present study, we focus on a fundamental object, a flat plate, above the moving belt. We measure the wake of the plate for the cases with various aspect ratio and the gap between the plate and the ground.

2. Method

Fig. 1 shows a schematic diagram of the moving-belt system. We used a Gottingen-type low-speed wind tunnel which has a closed test section. The geometry of the flat plate is rectangle with chord length c , thickness t , and span length s . Reynolds number Re is defined by $U_\infty t / \nu$, where U_∞ is the velocity of the uniform flow and ν is the kinetic viscosity of fluid. We conducted experiment for a plate with aspect ratio $AR = 1.0, 2.0, 2.5$ and for various gap ratio h/c . For all cases, we set $s = 500$ mm and $c/t = 50$.

We measured the wake of the plate using a hot-wire anemometer at $x' = 50$ mm and $y' = 2$ mm. Next, we performed FFT analysis of velocity time series to obtain the Strouhal number St .

We also performed visualization of the flow around the plate using the smoke wire method for $AR = 1$ and $h/c = 0.5, 0.1, 0.02$ and $Re = 1300, 2500$. Moreover, we performed PIV analysis of the obtained images.

3. Results

3.1 Strouhal number

Fig. 2 shows the effect of gap ratio h/c upon St . When h/c is larger than 0.4, St is constant around 0.25. It shows St is not affected by the ground at $h/c > 0.4$. However, when the plate approaches to the ground, it is observed that St slightly increases from its free stream value and shows a peak at a certain value of h/c , which depends on AR .

3.2 Flow visualization

Fig. 3 shows the effect of gap ratio on wake structure. In Fig. 3(b), it can be seen that the wake is asymmetric due to the presence of the ground.

4. Concluding Remarks

It was found that the characteristics of vortex shedding changes as the flat plate gets closer to the ground. It is considered that the change is related to the asymmetry of the wake.

Fig. 1 Schematic diagram of the experimented apparatus (unit: mm).

Fig. 2 Effect of gap ratio h/c upon St at $Re = 2500$: St against h/c at aspect ratio $AR = 1.0, 2.0, 2.5$.

Fig. 3 Effect of gap ratio h/c on flow structure for $Re = 1300$. (a) $h/c = 0.1$; (b) $h/c = 0.02$.

Reference

- (1) Inoue, T., Okayama, T., Teraoka, T., Maeno, S., Hirata, K., *Wind-tunnel experiment on aerodynamic characteristics of a runner using a moving-belt system*, *Cogent Engineering*, 3, (2016), 1 – 13.