Visualization and LASER measurements on flow field and sand movement on sand dune

Yusuke Sakamoto¹, Daisuke Aoshima¹, Itsuki Nakamura¹, Takahiro Tsukahara¹, Makoto Yamamoto¹, Yasuo Kawaguchi¹

¹:Department of Mechanical Engineering, Tokyo University of Science, Chiba, Japan, yasuo@rs.noda.tus.ac.jp

**Keywords:** Wind tunnel, Sand dune, Erosion, PIV, LDV, Visualization,

In desert, the installation of obstacles on/around sand dunes is one of promising methods to suppress wind-blown sand movements. There exist some researches about effects of obstacles, such as a fence. In our previous study, we investigated the effect of the small fence, which was installed on a dune, on sand movement from the dune. It is found that the erosion was suppressed in the upstream of the fence, but enhanced in the downstream of the fence. Thus it is important to suppress the separated flow, which induces high turbulent intensity. In this study, we investigated the effect of a porous fence to control the wind-blown sand movement downstream of fence.

Before describing details of laser measurements, let us explain an experimental setup. The present experiment has been made with a wind tunnel of 250 mm × 250 mm cross-section. The model dune was installed at the bottom of a wind tunnel and 0.5 m downstream from the entrance of test section of a wind tunnel. The initial shape of the model dune was a triangular prism. The nominal mean sand-particle diameter was 115 μm. The fence (of 20 mm height and 1 mm thickness) was installed at x/h = 100 mm (from the foot of the dune) on the dune surface. We tested four types of porous fences, which had different porosities: ε = 0% (nonporous fence), 10%, 30%, and 50%. These fences had a geometric porosity (percentage of open area).

First we measured a flow field around the dune and its erosion process. The former was measured with LDV system. Note that LDV measurement was made only for the metallic prism (without erosion), which represents the initial shape of the model sand dune. To measure the process of sand-dune erosion, the dune surface was visualized using a laser sheet (see Fig. 1). These results are shown in Fig. 2 as schematic diagrams. The surface erosion can be classified into four types based on the magnitudes of the streamwise velocity (U) and the streamwise turbulent intensity (Urms). Area-1 is a sedimentation area because both U and Urms were small. Area-2 is intensively eroded region, in which a grid turbulence, i.e., separated flows from apertures of the porous fence, gives rise to large Urms. A critical friction velocity (threshold of the air-flow velocity about sand movement) is affected by the magnitude of turbulent intensity. Since a high turbulent intensity makes the critical friction velocity lower, sand particles moved away from Area-2 even in the low-velocity air flow. In Area-3, both U and Urms were large. For the case of porous fence, the sand erosion was slower than the case of non-porous fence in this area, since the separated shear flow was weak and a calm flow. Area-4 is the calm flow region. It seems that small-scale vortices generated by the porous fence were quickly diffused in Area-4. We measured a flow field around a fence by a PIV system.

In Fig. 3, the critical friction velocity and the velocity along the bottom wall are compared. Here, Ucri was derived from the empirical correlation proposed by Shimazu et al. (2008). For the case of the non-porous fence, Ucri is larger than |U| throughout this measurement area. When the 30%-porosity fence was installed, there exists an area where sand movement occurs because of |U| > Ucri. This region corresponds to the upstream side of Area-2.

In the full paper, we discuss the effect of fence porosity on a dune erosion and on flow field around a dune.