Effect of Wind Deflector Inclination Angle on Sediment Transport of Wind-Sand Flow Behind the Plate (Postprint)

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Abstract

Through field experiments, the wind speed characteristics and sediment transport flux features in the leeward action zone of wind deflectors on the middle and upper parts of mobile sand dunes were investigated. The results indicate that wind deflectors at different angles affect distinct regions of wind speed enhancement behind the board. The maximum wind speed within the action zone generally occurs at 1.5 m behind the board. The 45° wind deflector demonstrates a significant wind speed acceleration effect at 1.5 m behind the board, whereas at 3.0 m behind the board, the 25° wind deflector exhibits a more pronounced acceleration effect, and at 4.5 m behind the board, the 35° wind deflector shows a notable influence. Wind deflectors can effectively increase the total sediment transport flux behind the board, with medium-angle wind deflectors in the 30°–45° range having a significant effect on enhancing sediment transport flux. Specifically, the 45° wind deflector shows a relatively high enhancement effect on sediment transport flux at 1.5 m behind the board, the 40° wind deflector shows a relatively high enhancement effect at 3.0 m behind the board, and the 30° wind deflector shows a relatively high enhancement effect at 4.5 m behind the board.

Full Text

Effect of Dip Angles of Wind Guide Plate on Sediment Discharge behind the Plate

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Abstract

In this study, field experiments on the effect of wind guide plate in preventing wind-drift sand were carried out so as to reveal the characteristics of wind speed and sediment discharge behind the wind guide plate. The purposes of the study were to explore the effects of wind deflector on wind velocity and sediment discharge in the middle and upper parts of mobile dune. The results showed that the area where the wind speed was increased behind the wind guide plate was different from the different dip angles of the plate. In general, the maximum wind speed occurred behind the plate for 1.5 m, and the effect of increasing wind speed of the wind guide plate with 45° was significant behind the plate for 1.5 m, that with 25° was significant behind the plate for 3.0 m, and that with 35° was significant behind the plate for 4.5 m. The wind guide plate could be used to effectively increase the total sediment discharge behind the plate, in which the effect of increasing sediment discharge of the mid-angle wind guide plate in a range of 30°–45° was more obvious. The effect of increasing sediment discharge of the wind guide plate with 45° was significant behind the plate for 1.5 m, that with 40° was significant behind the plate for 3.0 m, that with 30° was significant behind the plate for 4.5 m.

Keywords: wind guide plate; wind-sand flow structure; mobile dune; sediment discharge; Ulan Buh Desert

3 Results and Discussion

The experimental results demonstrate that wind speed enhancement zones behind wind guide plates vary significantly depending on the plate' s dip angle. Generally, the maximum wind speed increase occurs at a distance of 1.5 m behind the plate. Specifically, the 45° dip angle shows significant wind speed enhancement at 1.5 m behind the plate, the 25° angle shows significant enhancement at 3.0 m behind the plate, and the 35° angle shows significant enhancement at 4.5 m behind the plate.

Wind guide plates can effectively increase total sediment discharge in their lee. The sediment discharge enhancement is particularly pronounced for mid-angle plates (30°–45°). The 45° plate shows significant sediment discharge increase at 1.5 m behind the plate, the 40° plate at 3.0 m, and the 30° plate at 4.5 m.

Z 1 Table 1 The relationship between sediment discharge and height behind the wind guide plates (Logarithmic function)

Sediment Height	1.5 m behind plate	3.0 m behind plate	4.5 m behind plate
0–2 cm	y = 1.594ln(x) + 1.223, R^2 = 0.982	y = 1.458ln(x) + 0.862, R^2 = 0.981	y = 2.578ln(x) - 0.382, R^2 = 0.987
2–5 cm	y = 2.127ln(x) + 0.064, R^2 = 0.991	y = 1.870ln(x) + 0.087, R^2 = 0.995	y = 3.635ln(x) - 0.495, R^2 = 0.992
5–10 cm	y = 2.237ln(x) - 0.350, R^2 = 0.995	y = 0.774ln(x) + 0.450, R^2 = 0.992	y = 0.824ln(x) + 0.904, R^2 = 0.998
10–20 cm	y = 0.860ln(x) + 0.318, R^2 = 0.994	y = 0.395ln(x) + 0.832, R^2 = 0.965	y = 1.216ln(x) + 0.389, R^2 = 0.961
20–40 cm	y = 1.011ln(x) + 0.975, R^2 = 0.977	y = 1.027ln(x) + 0.513, R^2 = 0.975	y = 1.259ln(x) + 1.212, R^2 = 0.939
40–60 cm	y = 1.225ln(x) + 1.039, R^2 = 0.996	y = 1.855ln(x) + 1.073, R^2 = 0.968	y = 3.169ln(x) + 0.289, R^2 = 0.980
60–80 cm	y = 1.754ln(x) + 1.691, R^2 = 0.985	y = 0.858ln(x) + 1.179, R^2 = 0.997	y = 3.865ln(x) - 0.032, R^2 = 0.992
80–100 cm	y = 1.060ln(x) + 0.043, R^2 = 0.996	y = 0.868ln(x) + 0.326, R^2 = 0.968	y = 1.268ln(x) + 0.080, R^2 = 0.988

Z 2 Table 2 The relationship between sediment discharge and height behind the wind guide plates (Power function)

Sediment Height	1.5 m behind plate	3.0 m behind plate	4.5 m behind plate
0–2 cm	y = 2.051x^0.346, R^2 = 0.909	y = 1.094x^0.655, R^2 = 0.963	y = 0.829x^0.775, R^2 = 0.982
2–5 cm	y = 0.700x^0.508, R^2 = 0.972	y = 1.332x^0.380, R^2 = 0.917	y = 1.379x^0.471, R^2 = 0.980
5–10 cm	y = 2.400x^0.358, R^2 = 0.928	y = 0.838x^0.431, R^2 = 0.967	y = 1.135x^0.345, R^2 = 0.988
10–20 cm	y = 1.503x^0.344, R^2 = 0.932	y = 1.526x^0.282, R^2 = 0.938	y = 0.395x^0.671, R^2 = 0.968
20–40 cm	y = 1.643x^0.372, R^2 = 0.891	y = 0.949x^0.677, R^2 = 0.970	y = 0.747x^0.469, R^2 = 0.948
40–60 cm	y = 0.924x^0.273, R^2 = 0.936	y = 0.847x^0.552, R^2 = 0.941	y = 1.64x^0.534, R^2 = 0.929
60–80 cm	y = 1.618x^0.272, R^2 = 0.964	y = 0.646x^0.557, R^2 = 0.915	y = 1.184x^0.220, R^2 = 0.972
80–100 cm	y = 0.725x^0.381, R^2 = 0.927	y = 0.506x^0.389, R^2 = 0.969	y = 0.064x^0.619, R^2 = 0.997

Z 3 Table 3 Characteristic values of wind-sand structure in 0–10 cm layer behind the wind guide plate

Parameter	1.5 m behind plate	3.0 m behind plate	4.5 m behind plate
Q2-10 (0–)	[data]	[data]	[data]

Note: Table 3 data was incomplete in the original manuscript.

4 Conclusion

Based on the experimental results, wind guide plates with dip angles between 30° and 45° are most effective for increasing sediment discharge in the lee of the plate. The optimal angle varies with distance from the plate: 45° is most effective at 1.5 m, 40° at 3.0 m, and 30° at 4.5 m. These findings provide practical guidance for the design and deployment of wind guide plates in desertification control projects.

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Note: Figure translations are in progress. See original paper for figures.