The 2024 World Congress on
Advances in Civil, Environmental, & Materials Research (ACEM24)
19-22, August, 2024, The K hotel, Seoul, Korea

Flying characteristics of wind-borne debris by empirical models of tornadic flows

*Yong Chul Kim[1)]

[1)] *Department of Engineering, Tokyo Polytechnic University, Atsugi 243-0297, Japan*
[1)] kimyc@arch.t-kougei.ac.jp

ABSTRACT

Using empirical models of tornadic flows, flying characteristics of wind-borne debris were investigated for lots of releasing points for several heights. Fluctuating wind speed was generated by the power spectral density with a constant power and power spectral density from numerical simulations using inverse Fourier transform. The governing equations of wind-borne debris shown below were solved using a constant acceleration method for a time interval of 10^{-3} second for the total wind speed by a summation of the mean components from the existing empirical models of tornadic flows and fluctuating components from the power spectral densities. The effects of the tornadic models, releasing heights and the fluctuating components on maximum horizontal flying speed, maximum horizontal flying distance, maximum vertical flying height and impact loads were discussed.

・*X*-direction:

$$\frac{d\dot{x}}{dt} = \frac{\rho C_D A}{2m}(U_X - \dot{x})\sqrt{(U_X - \dot{x})^2 + (U_Y - \dot{y})^2 + (U_Z - \dot{z})^2}$$

・*Y*-direction:

$$\frac{d\dot{y}}{dt} = \frac{\rho C_D A}{2m}(U_Y - \dot{y})\sqrt{(U_X - \dot{x})^2 + (U_Y - \dot{y})^2 + (U_Z - \dot{z})^2}$$

・*Z*-direction:

$$\frac{d\dot{z}}{dt} = \frac{\rho C_D A}{2m}(U_Z - \dot{z})\sqrt{(U_X - \dot{x})^2 + (U_Y - \dot{y})^2 + (U_Z - \dot{z})^2} - g$$

・Impact load:

$$W_M = \frac{mU_{H,\max}^2}{L_{\min}}$$

REFERENCES

Kim, Y.C. and Matsui, M. (2017), "Analytical and empirical models of tornado vortices: A comparative study", *J. Wind Eng. Ind. Aero.,* **171**, 230-247.

Kim, Y.C. and Tamura, Y. (2021), "Empirical numerical model of tornadic flow fields and load effects", *Wind Struct.,* **32**(4), 371-391.