Wind Engineering Joint Usage/Research Center
FY2017 Research Result Report

Research Field: Wind disaster and wind resistant design
Research Year: FY2017
Research Number: 17173003
Research Theme: Wind-induced response of solar wing under various wind environments

Representative Researcher: Q.S. Yang

Budget [FY2017]: 300,000Yen

*There is no limitation of the number of pages of this report.
*Figures can be included to the report and they can also be colored.
*Submitted reports will be uploaded to the JURC Homepage and etc…..

1. Research Aim

During the past several decades, researchers have devoted themselves to develop new energy, especially to develop the solar energy. Solar panel is the most common using in exploiting the solar energy. Recently, solar power generating systems have been increasing. Among all kinds of solar power generated systems, the ground mounted types are exactly common. But different kind of solar power generating system is used more efficiently in mountainous area, called solar wing.

Solar wing system is consist of solar panels, cables, columns and foundation. Using solar wing systems have lots of advantages, they are, double use of land, low maintenance cost and optimal energy yield etc. However, such cable-based solar wing systems are exactly sensitive to wind. And the investigation of aerodynamic characteristics of solar wings are far from sufficient. There should be much more researches, including full scale measurements and/or wind tunnel tests.

2. Research Method

In this research, wind Tunnel test will be conducted using a solar wing system having different panel shapes under various wind environments. Firstly, changing the panel shape. There are several kinds of panel shapes. Researchers will choose the typical kinds. So far, the aerodynamic characteristics of three kinds of panel shapes have been researched. Secondly, changing the turbulence of the wind flow. Three kinds of flow turbulence can be generated in the wind tunnel in TPU. There are: low turbulence flow, grid-generated flow and the boundary layer flow. Using the boundary layer flow is the last step but the most important work, and it will achieve the most reasonable results from the tests.

To design a reasonable wind tunnel tests of solar wings, several simulation rules between the real systems and the wind tunnel tests models should be satisfied. There are: length scale, velocity scale, mass ratio, Froude number, and elastic parameter. Considering the existing researches, in the experiments, the length scale of 1/13 and, the velocity scale of 1/3.7 will be used and the model

will be adjusted to have the 1st mode natural frequency of 4.06Hz and the 1st mode damping ratio of 0.28%. By using the laser sensors, the displacements various panels will be measured, and from the recorded data, the response characteristics of panels will be investigated focusing on the various aspects. Meanwhile, from the time history of the vertical displacements of each panel, mean coefficients and rms coefficients can be achieved to describe the vibrating phenomenon. Power spectrum can be used to judge the vibrating frequency. Also cross-correlation coefficient of different panels can show the vibrating correlation of the target panels. Other physical quantities also should be considered.

3. Research Result

Figure 1(a) shows the variation of fluctuating displacements for wind direction 0° for the BLF with α = 0.2. The abscissa indicates mean wind speed measured at the tip of the supporting column, and the ordinate indicates the normalized fluctuating displacements by column height (σ / H). The fluctuating displacements are defined as the standard deviation of the time series. Symbols in the figure represent panel positions and wind directions. The fluctuating displacements increase moderately with mean wind speed regardless of panel positions, and the inner panels (P5 and P8) show larger values than the outer panels (P2 and P11). The increase is almost proportional to the square of mean wind speed. Figure 1(b) shows the variation of fluctuating displacements for the BLF with α = 0.27. A similar trend was found to the BLF with α = 0.2, showing a moderate increase with mean wind speed, and showing maximum values at wind direction 30º. From Figure 1, it was found that the fluctuating displacement under the BLFs corresponds to a buffeting vibration, being proportional to the square of mean wind speed.

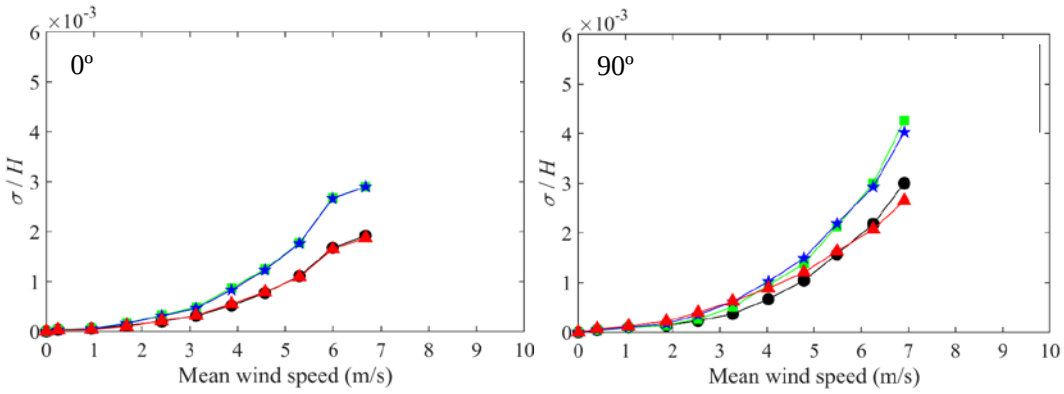


Figure 1 Variation of fluctuating displacements (a) α = 0.2 (left) and (b) α = 0.27 (right)

4. Published Paper etc.

[Underline the representative researcher and collaborate researchers]
[Published papers]
1. Y.C. Kim, Y. Tamura, A. Yoshida, T. Ito, W. Shan, Q. Yang, 2018, Experimental investigation of aerodynamic vibrations of solar wing system, Advances in Structural Engineering, Accepted.

2.

[Presentations at academic societies]
1. Y.C. Kim, W. Shan, Q.S. Yang, Y. Tamura, 2017, Effects of Panel Shapes on the Response of Solar Wing Structure, APCWE9, Auckland, New Zealand.
2.

[Published books]
1.
2.

[Other]
Intellectual property rights, Homepage etc.

5. Research Group
1. Representative Researcher

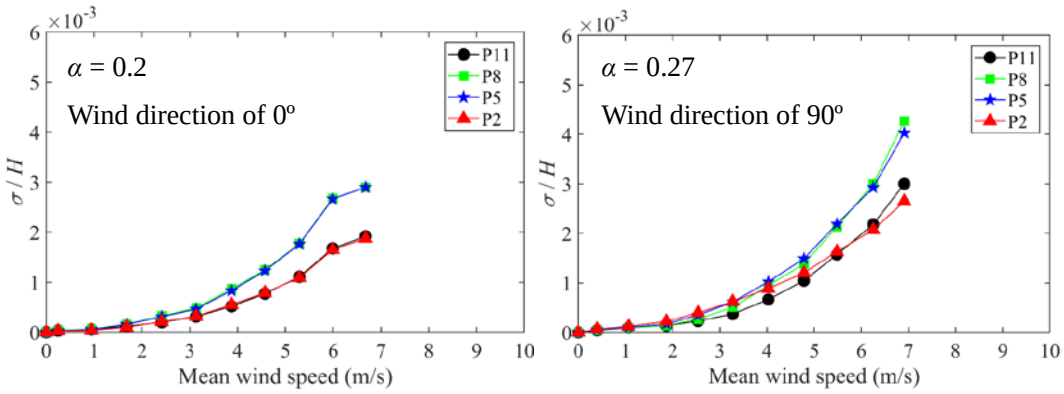
2. Collaborate Researchers
1.
2.

6. Abstract (half page)

Research Theme
Representative Researcher (Affiliation) : Q.S. Yang / Professor, Chongqing University, China
Summary(less than 300 words)・

Solar wing system is consist of solar panels, cables, columns and foundation. Using solar wing systems have lots of advantages, they are, double use of land, low maintenance cost and optimal energy yield etc. However, such cable-based solar wing systems are exactly sensitive to wind. And the investigation of aerodynamic characteristics of solar wings are far from sufficient. There should be much more researches, including full scale measurements and/or wind tunnel tests.

Left figure shows the variation of fluctuating displacements for wind direction 0° for the BLF with α = 0.2. The abscissa indicates mean wind speed measured at the tip of the supporting column, and the ordinate indicates the normalized fluctuating displacements by column height (σ / H). The fluctuating displacements are defined as the standard deviation of the time series. Symbols in the figure represent panel positions and wind directions. The fluctuating displacements increase moderately with mean wind speed regardless of panel positions, and the inner panels (P5 and P8) show larger values than the outer panels (P2 and P11). The increase is almost proportional to the square of mean wind speed. Right figure shows the variation of fluctuating displacements for the BLF with α = 0.27. A similar trend was found to the BLF with α = 0.2, showing a moderate increase with mean wind speed, and showing maximum values at wind direction 30º. From Figure 1, it was found that the fluctuating displacement under the BLFs corresponds to a buffeting vibration, being proportional to the square of mean wind speed.


×10-3
α = 0.2
Wind direction of 0º
P11
P8
P5
P2
σ / H
Mean wind speed (m/s)
×10-3
α = 0.27
Wind direction of 90º
P11
P8
P5
P2
σ / H
Mean wind speed (m/s)