SPATIAL DISTRIBUTION CHARACTERISTICS OF SURFACE PRESSURE ON 2-D RECTANGULAR SECTION (B/D=5) IN 3-D FLUCTUATING FLOW

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1. Introduction

It is known that the spatial distribution of unsteady buffeting loads on line-like structures is generally assumed to be similar to that of oncoming wind fluctuations for the buffeting response prediction. Some literatures [Larose(1996), Kimura et al.(1997), Jakobsen(1997), Matsumoto et al.(2003)], however indicated that the span-wise coherence of buffeting loading or surface pressure exhibits larger than that of wind fluctuations. This can cause underestimation of the buffeting response prediction between the numerical analysis and the physical measurements that has been reported by several authors. Further studies on the mechanism of higher span-wise coherence based on the spatial distribution of surface pressure and the wind-structure interaction phenomena as well need to be carried out for more convincing and clarification. In this paper, the characteristics of the spatial distribution of surface pressure will be studied thanks to a series of physical measurements on 2-D rectangular bluff section with B/D=5 under the 3-D sinusoidal fluctuating flow.

2. Experimental apparatus and measurements

Experiments were carried out on the Kyoto University's wind tunnel, the open-circuit blower with the working section of 1.0m(width), 1.8m(height), 6.55m (length), the automatically-monitored wind velocity ranging from 0.5m/s to 30m/s. The sectional model of 300mm(width), 60mm(depth), 900mm(length) (B/D=5) was rigidly supported. Totally, 779 pressure holes (19 chord-wise holes and 41 span-wise holes) were arranged on the model surface. The 3-D sinusoidal fluctuating flow generators (see Fig.1) was located in the upstream 59cm from model's leading edge in which the frequency of fluctuating flow was fixed at 3Hz, moreover, it consists of the 3 parts: 2 side parts with motionless blades (Smooth flow) and the center one with moving blades (2-D fluctuating flow). All electric signals have been filtered at 50Hz low-pass filters. The unsteady surface pressures were measured on the area of chord-wise 300mm and span-wise 200mm by the multi-channel pressure measurement system of ZOC23, Scanivalve Co, Ltd with the sample rate at 1kHz for 100s. The reduced velocities (V_r=U/fD; U: wind velocity, f: frequency of moving blades, D: model depth) were set at various values: V_r=8.33, 9.5, 11.11, 12.46, 13.33, 16.67, 22.22. Some signal processing techniques such as the Band Pass Filter (BPF), the Phase Average Processing (PAP), the cross-correlation functions and coefficients were applied for the measured pressure data.

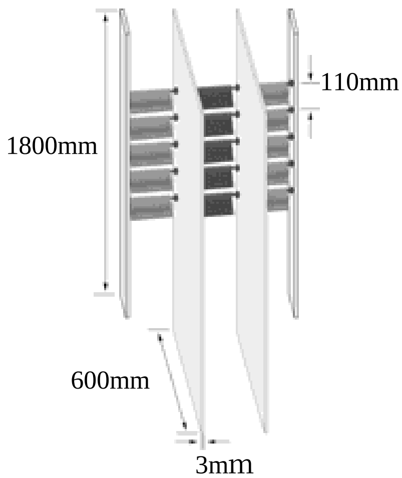

Fig.1. 3D sinusoidal flow generator

3. Results and discussions

3.1. Spatial distribution of surface pressure fluctuation: Fig.2 indicates the spatial distribution characteristics of pressure fluctuation on the model surface at each time intervals of one cycle T (T: cycle of the sinusoidal fluctuating flow). It can be revealed that the surface pressure expands not only chord-wise but span-wise direction, moreover, the span-wise mixture of pressure fluctuation between the 2-D fluctuating flow (center part) and the smooth flow (side parts) has strengthened with

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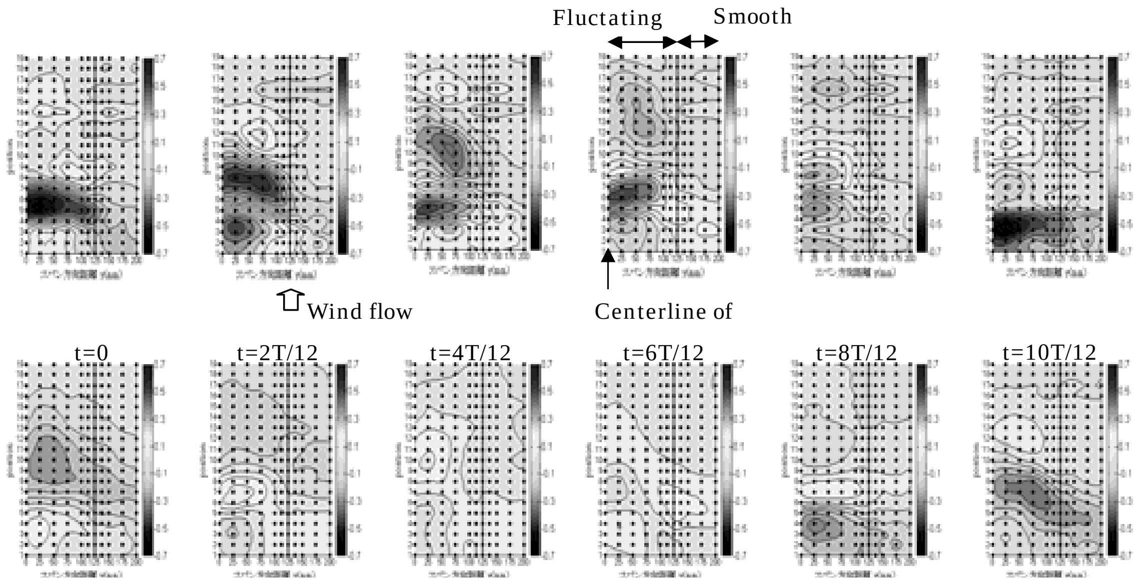

Fig.2. Spatial distribution of surface pressure fluctuation (V_r=8.33: upper row, V_r=22.22: lower row)

the increase of reduced velocities. The 2-D fluctuating flow trends to the dominantly chord-wise spreading in the low-range reduced velocities, whereas this flow spreads span-wise to mix strongly with the smooth flow in the high-range reduced velocities.

3.2. Comparison on chord-wise pressure fluctuation between 2-D and 3-D fluctuating flows: Fig. 3 shows the amplitude of chord-wise pressure fluctuation and the phase lag in comparison with the 2-D fluctuating flow at various reduced velocities. It can be easily seen from Fig.3 that the amplitude of chord-wise pressure fluctuation reduces with the increase of reduced velocities. The pressure fluctuation amplitude in the 3-D fluctuating flow exhibits lower than that in the 2-D flow due to the span-wise pressure distribution from the 2-D fluctuating flow to the smooth one, moreover, the peaks of amplitude in 3-D flow trend to move toward the reattachment point, whereas the peaks in 2-D flow seem to stay constant following the increase of reduced velocities.

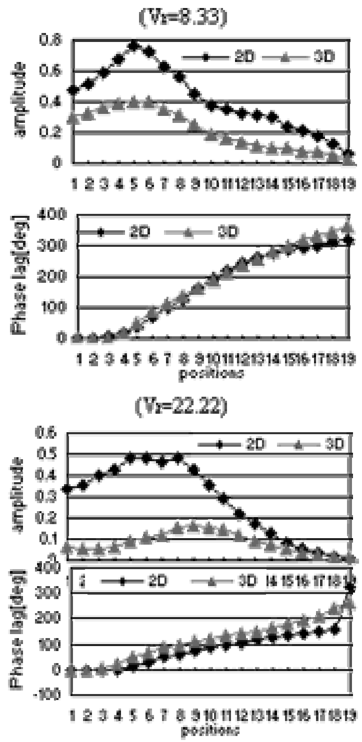

Fig.3. Amplitude of chord-wise pressure fluctuation and phase lag

4. Conclusion

In conclusion, the span-wise distribution of surface pressure plays important role on the 2-D bluff sections. The formations of dominant vortex shedding in low-range reduced velocities as well as the 2-D like formation of separation bubble and the movement of reattachment point in high-range reduced velocities, the spreading between two flows on the model surface are convincing to explain the surface pressure distribution.

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