Large-Scale Turbulent Pressure Fluctuations Revealed by Ned Kahn's Artwork

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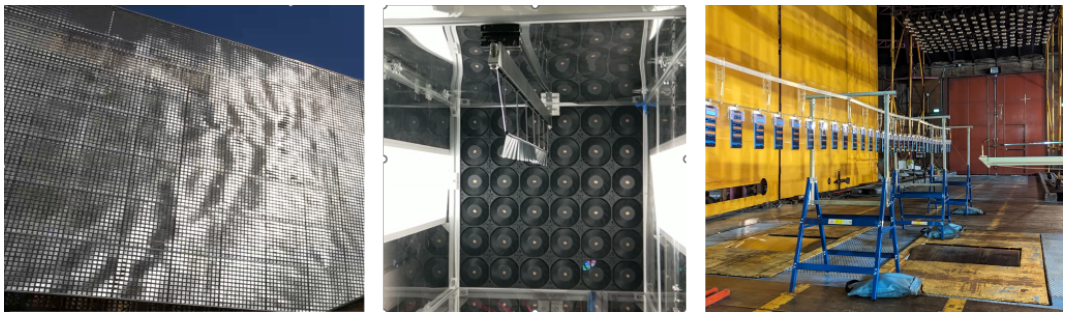

Figure 1. (left) One of Ned Kahn's kinetic facade exhibits, wave like patterns can be seen. (middle) Photography of our 1-dimensional chain of pendulums located at the center of the wind tunnel's test section. (right) large scale chain of telephones measurements in IAT wind tunnel.

Ned Kahn is an American artist who has implemented numerous exhibits inspired by the ephemeral nature. Amongst his works is the kinetic facade, which is composed of a matrix of small aluminium plates that cover facades of buildings. As the wind blows over the wall, the plates oscillate freely creating some wave-like large scale patterns (Fig.1a), that could be either wind generated waves [1], or the signature of turbulent pressure fluctuations [2].

To unravel the physical origin of these deformations, we designed in a wind tunnel a one-dimensional chain of coupled pendulum in a reduced version composed of rectangular plastic thin plates. We use fine nylon fishing wires to achieve a weak coupling between plates. In the absence of wind, the dispersion relation of the chain oscillatory motions follows the theoretical prediction (discrete sine-Gordon equation) :

$$\omega_0^2 = \omega_p^2 + 4\omega_w^2 \sin^2\left(\frac{kW}{2}\right), \tag{1}$$

Where ω_p denotes the natural frequency of a single pendulum, ω_w the elastic coupling frequency and W the distance between two plates. At the laboratory scale under the wind action, the dynamical response is either dominated by a resonance phenomenon, or a linear response to pressure fluctuations. From amateur video analysis on large-scale kinetic facades, we show that the plate oscillation is driven by the same resonant response mechanisms and the apparent wavy pattern corresponds to the most energetic Fourier mode propagating at the advection speed of pressure fluctuations. To better characterize the large scale turbulence, we have equally fabricated a large-scale chain of pendulums of 10 meters using smartphone embedded accelerometers and we have performed long measurements in the IAT large aerodynamic wind tunnel.

Références

1. M. J. Shelley and J. Zhang, *Annual Review of Fluid Mechanics*, **43**, p. 449-465, (2011)
2. S. Perrard, A. Lozano-Duran, M. Rabaud, M. Benzaquen, F. Moisy, *JFM*, **873**, (2019)