Effect of free-stream turbulence on wake flows of an array of square cylinders

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The wake flow characteristics of a cluster of two-dimensional sharp-edged bluff bodies are dictated by complex unsteady phenomena in both near and far fields. However, a thorough understanding of these characteristics is lacking, particularly with regard to the effect of free-stream turbulence (FST) on the wake flow. Freeman and Morel (1982) noted the absence of a rule of thumb to characterise wake flow length scales. This paper reports the results from the ongoing FUTURE project (https://www.surrey.ac.uk/research-projects/future). Large Eddy Simulations (LES) are carried out for clusters of 2x2, 4x4, and 8x8 arrays of aligned square cylinders with an infinite height separated by various spacings (i.e., 0.5*b*, *b*, 2*b*, 3*b*, where *b* is the cylinder width) in various flows (i.e., different incoming flow directions and turbulence quantities). For a cluster of 2x2 aligned square cylinders with smooth incoming flow, wavelet analysis of the instantaneous velocity in the wake region shows that the characteristic length and time scales are close to the cluster size 2*b* (Nguyen et al 2023). This phenomena is known as the "cluster effect" which is more prominent for large incidence angles. For instance, in a 45° wind, the dominant dimensionless vortex shedding frequency (i.e., the Strouhal number *St*) of a 2x2 cluster scaled by *2b* is equal to that of a square cylinder in isolation. For FST flows, wavelet analysis shows that by increasing the free-stream length scale equal to or greater than the cluster size (i.e., *3b*), the value of the dimensionless dominant shedding frequency *St* is evidently reduced (by 6% at least) compared to smooth inflow conditions. This finding highlights the crucial importance of the large FST integral scales on the wake dynamics. More results and analysis will be reported at the conference.

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[1] Bearman and Morel, *Progress in Aerospace Sciences*. **20**, 97 (1983).
[2] Nguyen et al., *Flow, Turbulence and Combustion*., (2023) revised MS under review.