Effect of Large Scale Turbulent Structures on a Generic Tidal Current Turbine Support Structure.

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Work stream 1:Numerical and Physical Convergence.

Introduction

Turbulence in a tidal channel is composed of eddies ranging from small scale to large scale. The smaller scale eddies characterise the fine structures of turbulence and are nearly isotropic. The large scale turbulent structures contains most of the turbulent kinetic energy. Thus structural loading on any device exposed to such flow conditions may have an adverse effect during device installation and operation. Thus it is important to account and /or discount for the effects of these large structures on the loading on the device.

The Acoustic Doppler Current Profiler (ADCP) is currently the standard instrument for measuring tidal current velocities and associated higher moments in a tidal current channel, irrespective of known limitations. The velocity structure in a tidal current channel is site specific however, a well conducted ADCP experiment will produce a reasonable velocity profile for a typical tidal current channel.

Approach and Method.

The small scale eddies are random in natures they can be described by the Gaussian probability density function since they behave randomly. The large scale eddies which are produced due to their interactions with the mean flow are coherent in nature and their behaviour suggest that Large Eddy Simulation (LES) and Direct Numerical Simulation (DNS) are appropriate to reproduce an evolutionary relation of the coherent structure of turbulence [1].

ADCP Experimental velocity profile data from the Firth of Forth, has been used as input boundary condition into numerical simulation using LES.

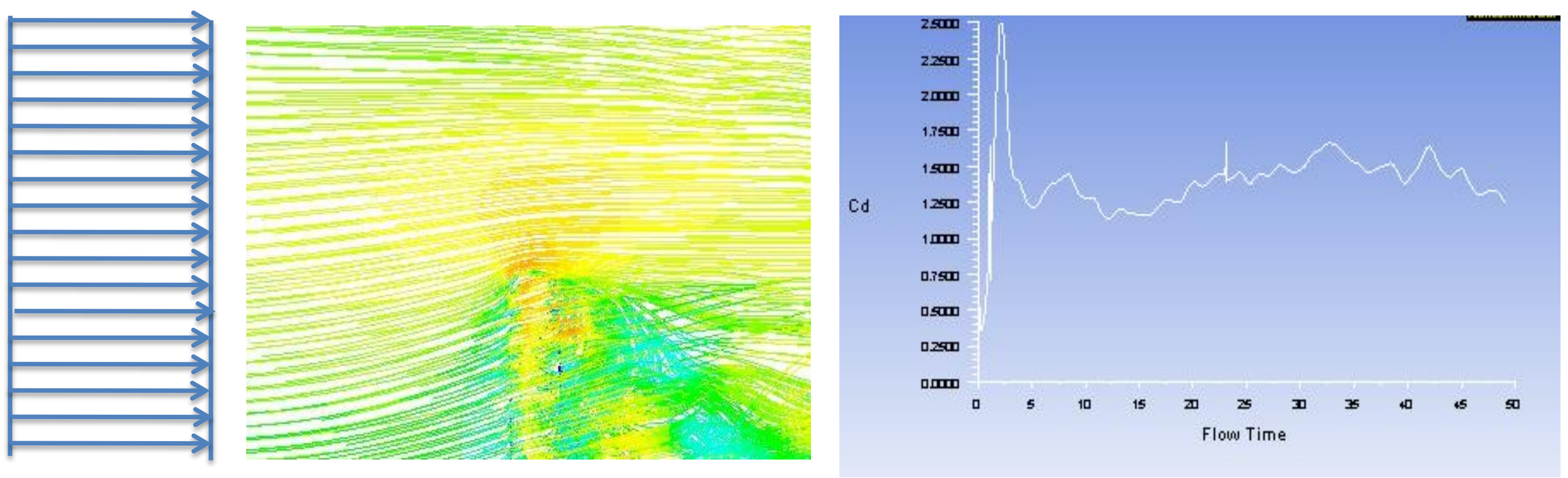
The vertical water column above the ADP was divided into 50 bins each 1m apart. The deployment period was for about 23 days.

Samples were collected with an autonomous sampling setting averaging one velocity sample over 1 minute every 10 minutes.

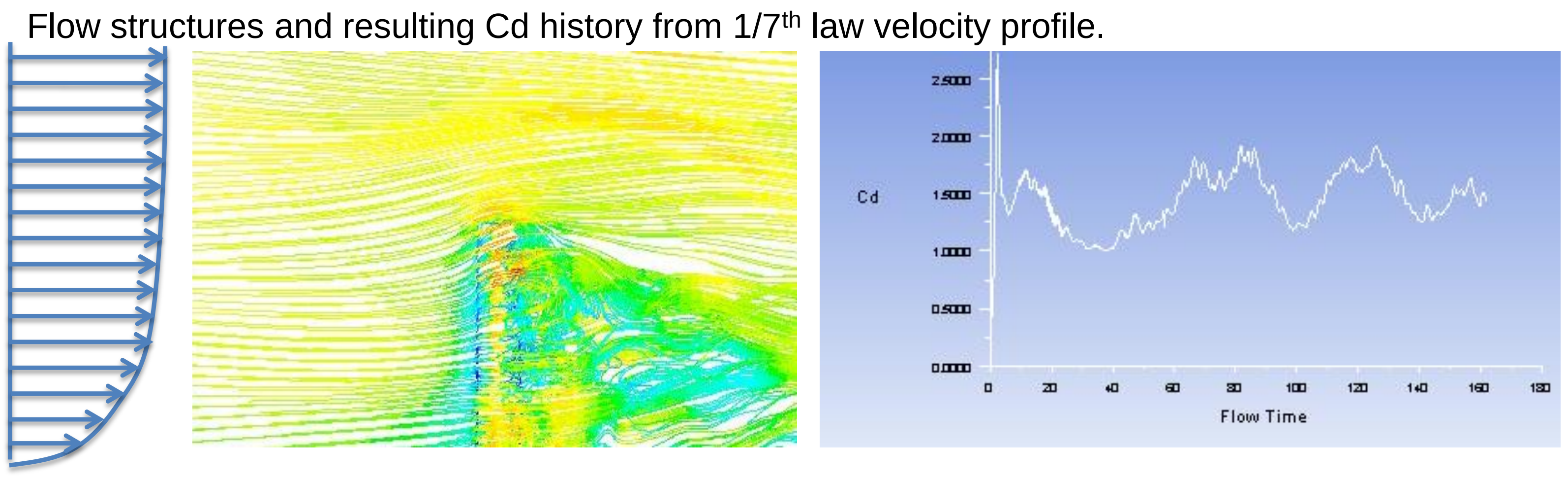
Results

The effect of upstream turbulent eddies on loading force is investigated by comparing results with uniform flow and assumed velocity profile of the 1/7th power law at the inlet boundary conditions. The figures below illustrate the flow structures and corresponding drag coefficient , Cd.

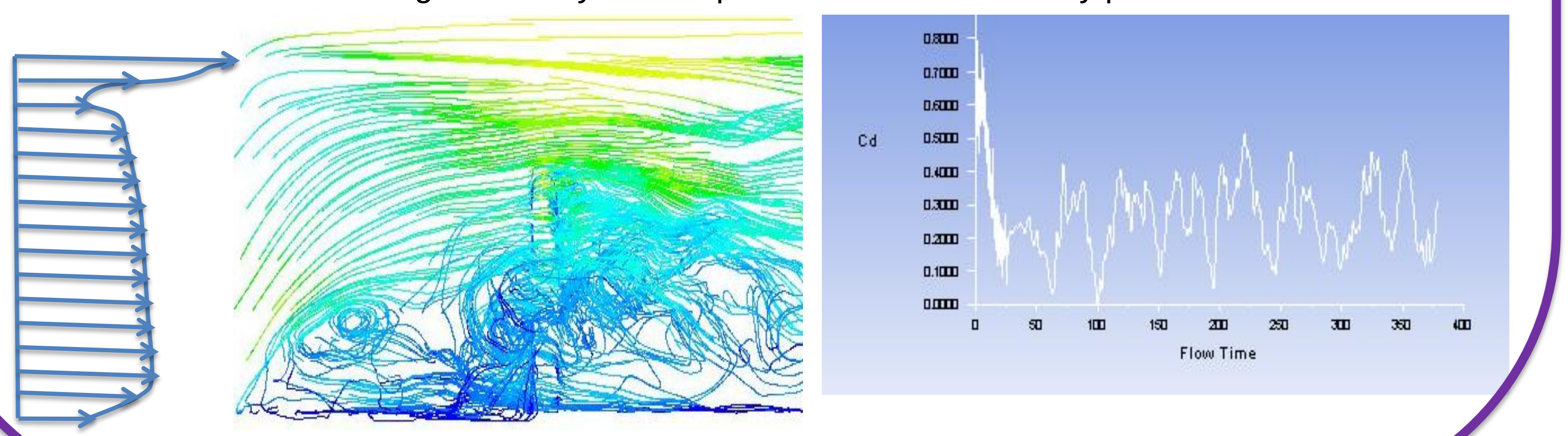
Flows structures and corresponding drag coefficients from uniform flow velocity profile



Flow structures and resulting Cd history from 1/7th law velocity profile.



Flow structures and resulting Cd history from experimental ADCP velocity profile- Firth of Forth.



Discussion/Conclusion

Drag coefficient has been calculated on a steady flow around cylindrical structures with results published [2]. Generally, the effect of turbulent flow results in a decrease in drag coefficient. The drag coefficient resulting from input uniform flow varies from a minimum of about 1.1 to a maximum of about 1.6. Similarly, the Cd from the 1/7th power law profile fluctuates between 1.0 and 1.8.

A real velocity profile from the ADCP produced much lower Cd values fluctuating between 0.1 and 0.5. This may be explained from the point of view of the reverse flow associated with the movement of the eddies therefore detracting from the effective drag coefficient of the device.

References

[1]. Nezu I, International Association for Hydraulic Research. *Turbulence in open-channel flows.* Rotterdam: Balkema; 1993.

[2]. Gunter S. On the force fluctuations acting on a circular cylinder in a crossflow from subcritical up to transcritical Reynolds numbers. *Journal of Fluid Mechanics.* 1983; 133:265-285.

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