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MEL Consultants New High Reynolds Number and Full Scale Wind Engineering Wind Tunnel

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Abstract

MEL Consultants have just completed a new 1MW Wind Tunnel facility primarily for wind engineering applications. The facility has two identical closed circuit wind tunnels with blockage tolerant working sections 4.8m wide by 2.2m high and with a length of 14.4m for boundary layer development and a 5.7m diameter fully automated turntable. The two wind tunnels can be combined to give one working section 11m wide by 4m high for testing large aeroelastic models and full scale prototype facade elements.

Introduction

One of the limitations of wind tunnels in which boundary layer and turbulence intensities are developed to model the fluid mechanics involved in the interaction between structures and the natural wind is that they have generally not been big enough or with high enough wind speeds to adequately model Reynolds number effects for other than sharp edged structures. Similarly there have been very few wind tunnels that can adequately model turbulence effects on large aeroelastic wind tunnel models such as for full bridge and tower modelling. The objective in designing and building the new MEL Consultants wind tunnels was to address these deficiencies. In additions the specifications for the new wind tunnels were to incorporate a contraction and screens to be able to model the low turbulence levels associated with Terrain Category 1 profiles and noise suppression features to enable acoustic measurements to be made on facade elements in the full scale working section.

Wind Tunnel Circuits

The wind tunnel facility is based on two identical wind tunnels running alongside each other. The two wind tunnels can be run independently or joined together to provide one large working section for full scale facade or full model bridge testing. Figure 1 shows a view looking into the two separate main working sections.

The overall layout of the wind tunnel circuits is shown in Figure 2 and a view of the circuit is shown in Figure 3. In summary the components are as follows:

- Fan and Straightener Unit
- Rapid Diffuser, Screens and Contraction
- Main Working Sections
- Large Working Section
- Turning Vane Corners and Top Return
- Top Working Sections
- Contracting Corners into Fan

Details of these components will be given in the following Sections

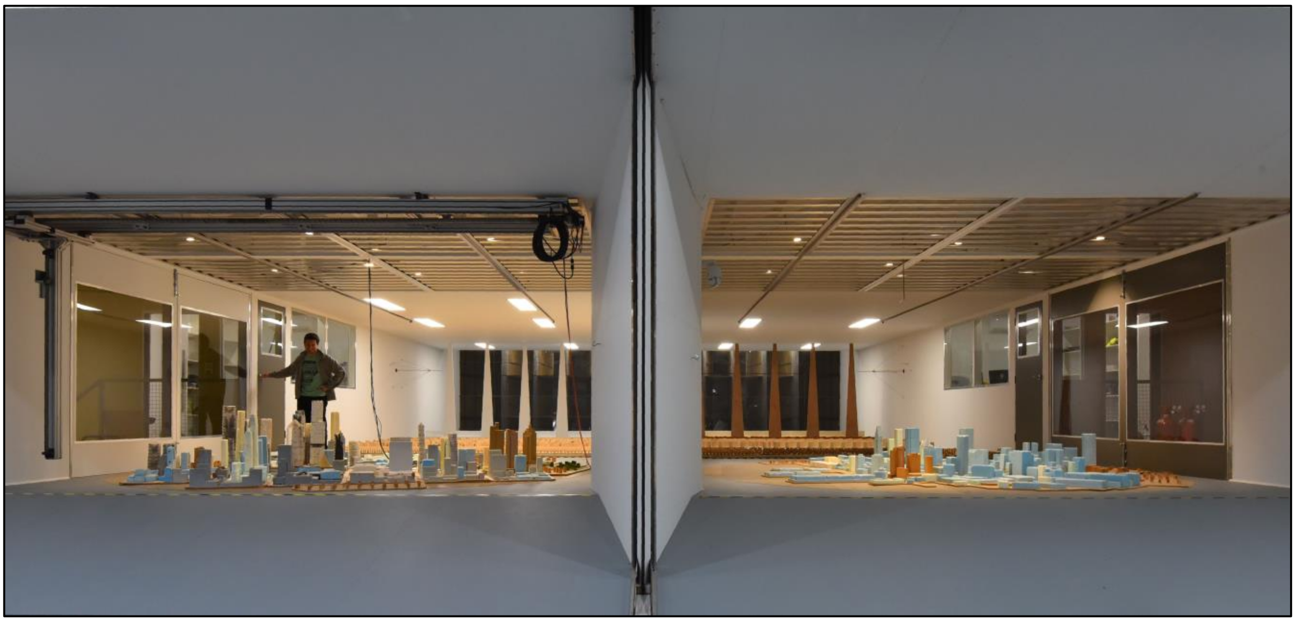

Figure 1. View of the two 4.8m working sections from the 10.4m working section

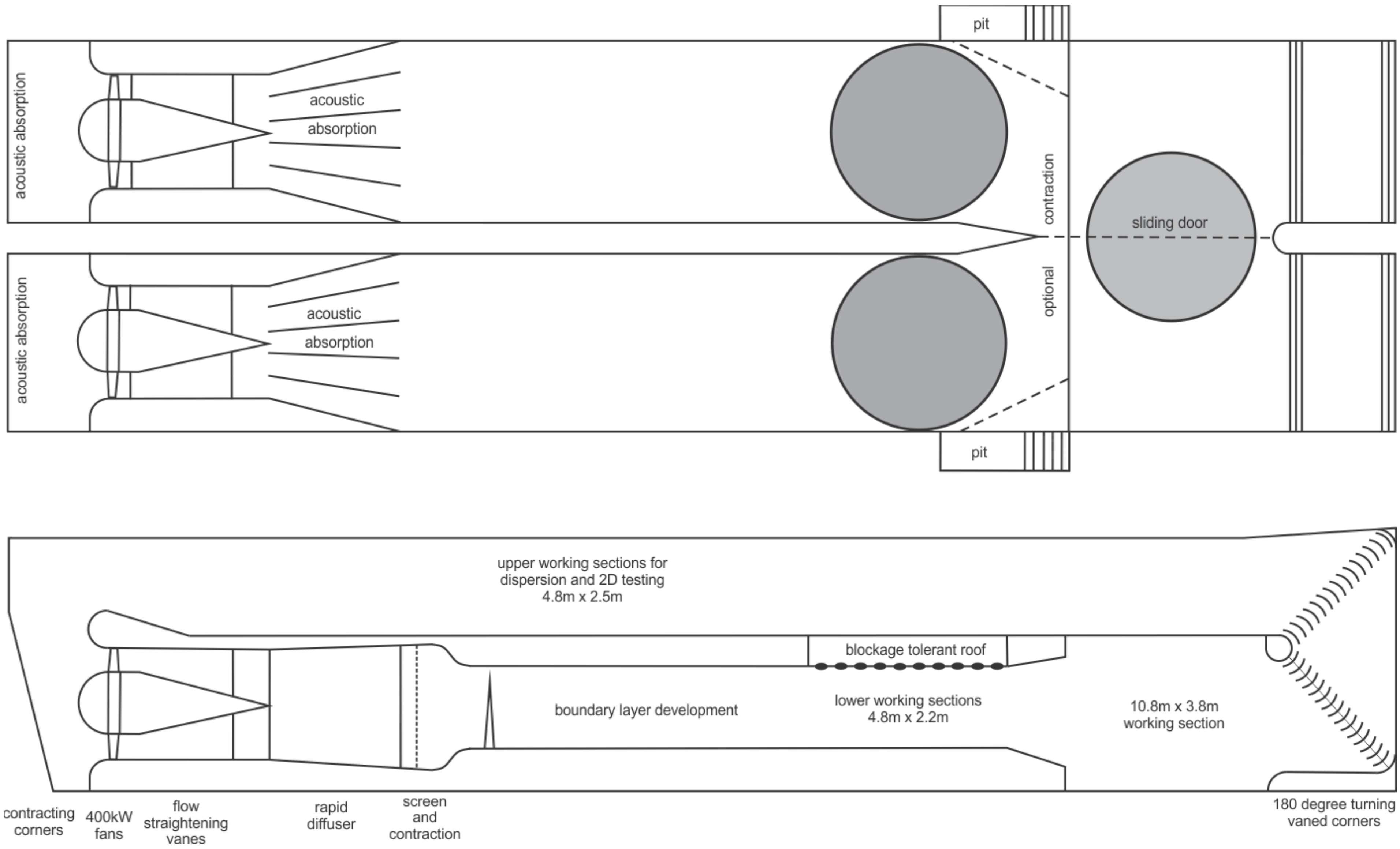

Figure 2. MEL Consultants boundary layer wind tunnels

Fan and Straighteners

Each 3m diameter fan is driven by a 450kW variable speed synchronous motor. The variable speed is facilitated by a variable frequency drive unit. The blades are also variable pitch to accommodate a range of circuit loss conditions. The blade elements of the fan are based on a RAF6E section and have been designed on the potential vortex theory, with eight blades having relatively high solidity varying from approximately 0.5 at the root to 0.16 at the tip. There are five, 2.4m chord, cambered straighteners to take out the fan swirl.

Rapid Expansion

There is a rapid expansion section between the fan section and the screened settling section. The rapid expansion is made up of ten 3m long cells expanding from 9 sq m to 16 sq m. The cells are made up of acoustic absorption panels.

Screens and Contraction

The screen at the beginning of the settling section consists of two layers of flywire screening. The contraction is two dimensional with an area ratio of 0.6 to achieve a turbulence intensity of 3% at the start of the boundary layer development section.

Boundary Layer Model Development

The boundary layer development consists of a plate step followed by flat plate triangular vortex generators and surface roughness, all are variable to provide a range of natural wind boundary layer models.

4.8m x 2.2m Working Section and Blockage Tolerant Roof

The main working sections are 4.8m square by 2.2m high with a 4.7m diameter turntable in the floor and a blockage tolerant facility in the roof.

The turntables are very massive to permit the mounting of aeroelastic models and are fully automated.

The blockage facility has following the design development work by Parkinson and Glanville and Kwok. Specifically the space above the aerofoils is 4.8m by 4.8m and 0.9m depth. The aerofoils are flat ellipses (thickness to chord ratio of 0.2) with an open air ratio of 0.55.

10.4m x 3.8m Working Section

By sliding back a connecting door the two wind tunnels can be joined together to make one large wind tunnel with a working section 10.4m wide by 3.8m high. The working section can be made into an open jet section by using the optional contraction to make a jet approximately 7m wide by 3.5m high.

The large working sections can be used for large scale models to further extend the high Reynolds number capability, and for full aeroelastic bridge models. With the incorporation of the acoustic absorption features on both sides of the fan this working section is also used for full scale facade testing for both acoustic and dynamic response measurements.

Figure 3. Elevation view of the wind tunnel circuit and control rooms

Vaned Corners and Return Section

The circuit then goes through two sets of turning vanes to return along the top horizontal leg. The turning vanes are based on a gap to chord ratio approximately between 0.2 and 0.3 in an arithmetic progression.

Dispersion and 2 D Working Sections

The top working sections are 4.8m wide by 2.5m high and 25m long. One of these working sections is dedicated to dispersion testing as it is long enough for the model to be located about two thirds the way along for boundary layer development and then have a downstream distance from the model of 10m to permit far field measurements as well as near field measurements around buildings. The other working section will be fitted with the two dimensional test rig for testing bridge deck sections and for high Reynolds number 2D testing.

Contracting Corners into Fan Intake

The vaneless contracting corners turning the flow through 180^0 into the fan contraction are based on historic hydraulic foot-pump technology. The fundamental principle is that no corner vanes are required if the flow can be continuously accelerated to ensure favourable pressure gradients throughout the corner. This background was further developed by MEL Consultants using a small scale model to optimise the angle of the end wall and distance from the fan to produce uniform flow across the fan disk.

Conclusions

The end result of the development of these wind tunnels is to provide a wind tunnel testing facility that will cater for the broad range of wind engineering requirements for commercial and research activities at high Reynolds numbers within turbulent boundary layer models and grid turbulence.