WIND VORTEX NEUTRALIZERS FOR TALL BUILDINGS

INTRODUCTION

Modern tall buildings go higher and higher with the advances in structural Design and high strength materials. On the other hand, as the height and slenderness increase, buildings suffer from increased flexibility, which has negative effects in wind loading. Flexible structures are affected by vibration under the action of wind which cause building motion, and plays an important role in the structural and architectural designs. Hence, different design methods and modifications are possible in order to ensure the functional performance of flexible structures and control the wind induced motion of tall buildings.

WIND EXCITATION

The motion of tall buildings occurs primarily in three modes of action,

- Along wind
- Across wind and
- Torsional modes

Along wind motion:

Under the action of this wind flow, structures experience aerodynamic forces including the drag (along wind) force acting in the direction of the mean wind. The structural response induced by the wind drag is commonly referred to as the along wind response. The along wind motion primarily results from pressure fluctuations on windward (building's frontal face that wind hits) and leeward face (back face of the building).

Across wind motion:

The term across wind (Figure 1) is used to refer to transverse wind. The across wind response, is a motion in a plane perpendicular to the direction of wind. Buildings are very sensitive to across wind motion, and this sensitivity may be particularly apparent as the wind speed increases. For instance, the wind tunnel test of the Jin Mao Building showed that its maximum acceleration in across wind direction at its design wind speed is about 1.2 times of that of the in along wind direction (Gu and Quan, 2004).

Vortex-shedding phenomenon:

The most common source of crosswind excitation is that associated with 'vortex shedding'. Tall buildings are bluff (as opposed to streamlined) bodies that cause the flow to separate from the surface of the structure. At higher wind speeds, the vortices are shed alternately first from one and then from the other side. When this occurs, there is an impulse both in the along wind and across wind directions.

The across wind impulses are, however, applied alternatively to the left and then to the right. If the natural frequency of the structure coincides with the shedding frequency of the vortices, large amplitude displacement response may occur and this situation can give rise to very large oscillations and possibly failure.

AERODYNAMIC MODIFICATIONS AGAINST WIND EXCITATION

- Tapering- creating smaller surface areas at higher levels
- Setbacks -to slightly taper the building shape
- sculptured building tops

ROLE OF COMPUTATIONAL TECHNIQUES IN FINDING A BETTER SOLUTION

Wind-tunnel testing or CFD analysis?

Wind-tunnel testing and CFD are two methods at an almost equally detailing level but with different advantages and benefits for the customer. Recently Computational fluid dynamics is used as a sophisticated airflow modelling method and can be used to predict airflow, heat transfer and contaminant transportation in and around buildings.

CFD plays an important role in building design, designing a thermally-conformable, healthy and energy-efficient building. CFD calculations provide information which is not possible in expensive experimental methods, i.e. simulation of structures dynamically, various design changes and their effects within a short period of time.

Aerodynamic effects over a commercial building:

In this study a typical building is considered and analysed to study the flow characteristics using Computational Fluid Dynamics techniques.

How CFD?

- Creating a virtual design (using CAD softwares)
- Preparing a Computational Model (Using CFD pre-processing Softwares)
- Applying the boundary conditions (Real world physics)
- Setting the appropriate numerical methods and solvers
- Interpreting the results
- Suggesting design modifications accordingly

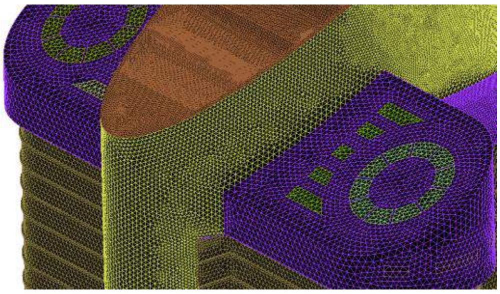

Figure 4 computational Grids

Figure 1 CAD Geometry of a building

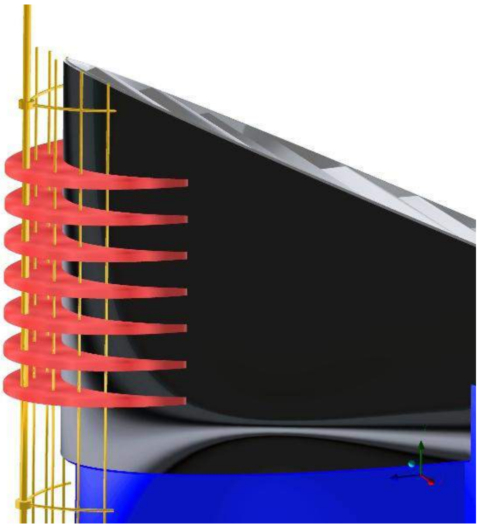

Figure 2 Introducing vortex dampers

Figure 3 wind screen protector

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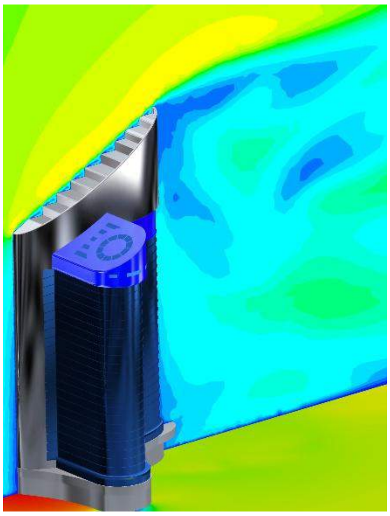

Figure 5 Velocity pattern

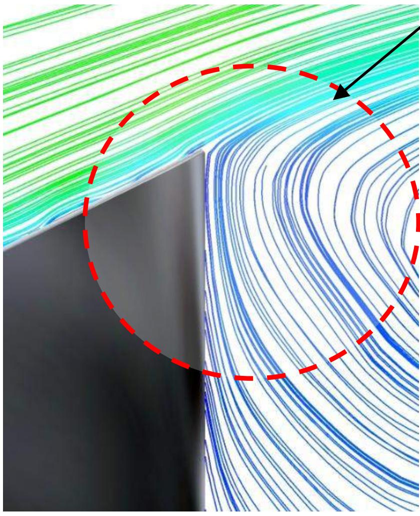

Figure 6 Wake behind building

Wake region

As the flow passing the building top, the flow tends to separate from the walls and creating a low pressure zone called as wake region.

With the presence of eddies and fluid vortices behind the building there exists an un desirable physics called vortex shedding and creating a noise level of about **180-200 dB** as shown in figure 9. This type of wind load may affect the working environment near that floor and also cause the windscreens to crack under vibration.

How to avoid the vortex shedding??

By introducing a rake like structures (figure 2) the wind vortex which is forming behind the building top walls will made to cancel each other by splitting the wake flow.

Figure 7 shows the formation of split and opposite vortices, which results in neutralizing each of their amplitude and reduces the noise level of about **40-65 dB** (figure 10)

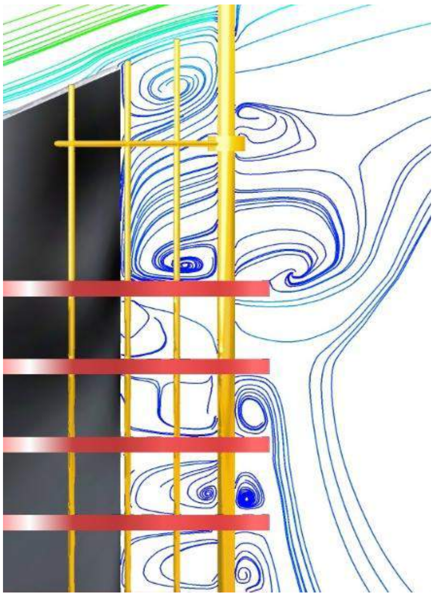

Figure 7 splitting and neutralizing the wind vortices using vortex dampers

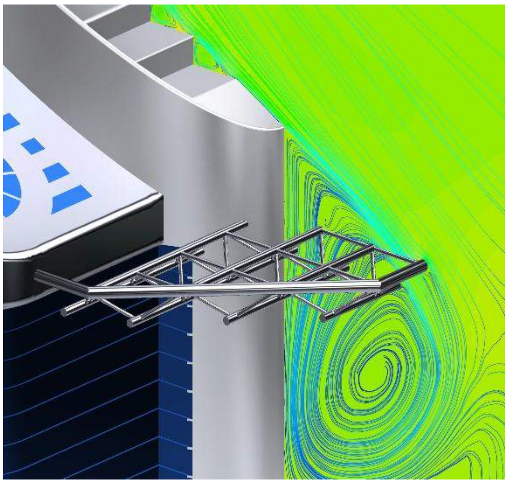

Figure 8 Wind screen protection

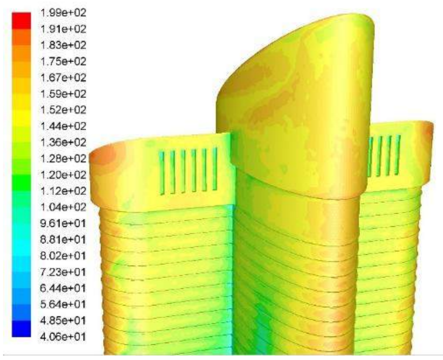

Figure 9 Noise level of 199 dB

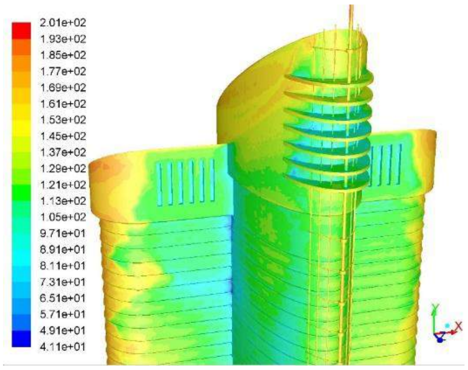

Figure 10 reduced noise level after modification

Another modification of introducing a net like structures (figure 3) will take up the direct wind load thus it protects the building walls where it may be constructed with glasses or some soft materials.

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