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Interrelation of Architectural Form and Wind Climate on the Wind Performance of Supertall Towers

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1 Abstract

The architectural form of tall and supertall buildings is a fundamentally influential factor in the building's wind response. Under the action of wind, a tower's shape can significantly influence the building's occupant comfort levels, serviceability performance, as well as the effective wind loads which a structure must resist. As tall buildings advance to ever-increasing heights and, more recently, unprecedented slenderness ratios, the across-wind response, or lift response, of towers due to vortex shedding becomes the predominant contributor to wind response. The frequency and intensity of vortex formation off a bluff body is a function of the shape and width of the bluff body, and the speed of the flow. This is a critical relationship in wind engineering where fluid dynamics and architecture intersect, and is defined by the powerful Strouhal equation [1]. This paper shall investigate wind response as a function of the interrelation of the Strouhal number parameters with the structure's own dynamic properties, as well as the wind environment in which the building is located. In addition, the potential benefit of Critical Width and Critical Mean Recurrence Interval plots as initial indicators at the conceptual stage of tower design will be highlighted.

Keywords: Tall Buildings, Wind Engineering, Wind Tunnel Testing, Vortex Shedding, Strouhal Number, Shape Studies.

2 Introduction

The architectural form of tall and supertall buildings is a highly influential factor in the building's wind response. A tower's shape can significantly influence wind serviceability performance and the effective wind loads which the structure must resist. As tall buildings advance to ever-increasing heights and, more recently, to unprecedented slenderness ratios, the across-wind response, or lift response, of the tower due to vortex shedding becomes the predominant contributor to the tower's wind response.

Structural engineers have a long history of optimizing supertall buildings for different environmental effects, integrating architecture and engineering to achieve an optimum solution [2–4]. Projects such as Burj Khalifa in Dubai, UAE [5] and Tianjin CTF Finance Center, China [6] included the optimization of the structure's shape and dynamic properties to improve the building's wind response. Several studies have been conducted into the benefit of optimizing architectural form to improve a tower's wind performance [7–13]. This paper will parametrically explore these variables to highlight trends in shape, structural dynamics, wind climate and exposure. Additionally, it will investigate the performance of shapes with a given Strouhal number and any trends that relate the variables studied. Such parametric studies will provide designers with an understanding of the potential influence a building's architectural form can have

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