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Study of Wind Force on a High Rise Structure by using Davenport's Gust Factor Approach

Ayush Agarwal[1] and Jaswant Singh[2]

[1]M. Tech. Scholar, Department of Civil Engineering,
CBS Group of Institutions, Jhajjar, Haryana (India)

[2]Assistant Professor, Department of Civil Engineering,
CBS Group of Institutions, Jhajjar, Haryana (India)

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Abstract

Any high rise structure can vibrate in both the directions of along wind and across wind due to the flow of wind. Modern high rise structures designed to satisfy lateral drift requirements, still may vibrate excessively during wind storm. These vibrations can cause some threats to the High rise structure as buildings with more and more height becomes more vulnerable to vibrate at high speed winds. Sometimes these vibrations may even cause discomfort to the occupants even if it is not in a threatening position for the structural damage. That’s why an accurate knowledge of building motion is an essential prerequisite for serviceability. There are two approaches to find out the Response of the High rise structures to the Wind loads. One is Analytical approach given by Davenport and mentioned in the IS 875: part 3 -1987 is used which is only legit to a regular shape building but for an irregular shaped building we use wind tunnel testing method. This thesis deals with the analytical studies carried out on a high rise structure named IREO VICTORY VALLEY TOWER - C going to be built in SECTOR 67, GARUGRAM, HARYANA which is 147m in height, consists 41 floors. The experimental results have been projected to estimate the full scale values by using appropriate scaling laws. The analytical values in the along wind direction have been obtained using the Davenport's ‘Gust Factor Approach'(1967). The building is tested in a boundary layer flow corresponding to terrain category - III, as defined in IS: 875-part-3, 1987, (α= 0.18 as per IS: 4998) at a wind speed of 38 m/s at model top for standalone situations.

Keywords: *Wind Force, High Rise Structure, IREO Victory Valley Tower.*

1. Introduction

In recent years, especially in the crowded cities where land prizes are becomes extremely high, now a day’s buildings with more than 30 floors , which are also called high rise structure are started to be designed and constructed all over the world. When we talk about buildings, these are defined as a structures used by the people as shelter for living, working or storage. On the other side the technical advancement has provided the opportunity of design and construction of more slender and tall structures which are inveigled by the wind action more. Due to flexibility of building, wind can interact with it so the wind induced oscillations can be significantly magnified. In order to analyze the response of such high rise structures under wind effects we use Davenport's ‘Gust Factor Approach'.

There are two main effects of wind on the High rise structures:

- First is, wind exerts forces and moments on the structure and its cladding
- Second one is, wind distributes the air in and around the building mainly termed as Wind Pressure

Sometimes due to unpredictable nature of wind, during some Wind Storms it can upset the internal ventilation system of the building. For that why the study of air-flow is become more important during the planning and designing of a building and its environment.

Wind load are studied on four main groups of building structures:

i. High rise Building

ii. Low rise Buildings

iii. Equal-Sided Frame Buildings

iv. Roofs and Cladding

Almost no researches are made in the first two categories as the structure failures are rare, either the roofing or the cladding designs are not carefully designed, and wind pressures and suctions are receiving more attention particularly at these points. But as we know High rise structures are flexible and are acceptable to produce a vibrations at high wind speeds in all the three directions(x, y, z) and even the design codes do not incorporate the expected maximum wind speed for the entire life of the structure and also not consider the high local suctions which cause the damage to the structure.

2. Analytical Analysis the Analytical Response of Victory Valley Tower C

Davenport's Gust Factor Method and Code Procedure

Given:

α	=	0.18	
Z (ref)	=	10	m
Plan length	=	85	m
Plan width	=	70	m
Height of building	=	147	m
Bulk density	=	110	Kg/m^3
Face width	=	85	m
Face depth	=	70	m
Interval	=	10	m
Natural period	=	5.10	sec.
Critical damping	=	0.035	

From IS 875: part 3 – 1987

V_b	=	38	m/sec.
K_1	=	1	
K_2	=	0.50	(at height 10 m)
K_3	=	1	
V_{ref} (at 10m)	=	$V_b * k_1 * k_2 * k_3$	
	=	38 *1*0.50*1	
	=	19	m/sec.

At top of building

K_1 = 1

K_2 = 0.84 (At 147 m)

K_3 = 1

V_z = 38 *1*0.84 *1

= 31.92 m/sec.

V_z / V_G = $(Z / Z_G)^{\alpha}$

V z = $V_G (Z / Z_G)^{\alpha}$

= $19(147/10)^{0.18}$

= 30.8 m/sec

P z = $0.6(V_z)^2$

= $0.6*(30.8)^2$

= 570 N/m^2

<u>For Gust Factor (G):</u>

T = 3600 sec.

Building frequency n_0 = 1/Natural period

= 1/5.10

= 0.196

m_0 = building mass/m height

= ρ_b*B*D

= 110*85*70

= 654500 Kg/m

3. Conclusions

In the analytical method of the analysis we used Davenport 'gust factor approach' to calculate wind force on a high rise structure, which is named as Victory Valley Tower –C, Even the Storey Wise Lateral Forces obtained on the 10m interval heights by Davenport Approach of IS 875: part 3-1987 code can be seen in the table 4.3. The total wind force on the structure is also concluded.

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