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Wind Effect on High Rise Building

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ABSTRACT

A high-rise building was employed to evaluate similarities and differences of wind effect calculations done by using wind codes and standards. Evaluation was done in both ultimate and serviceability limit conditions. Member forces in columns, and beams compressive stress in shear walls and support reactions. Along and across wind, accelerations and drift indices were engaged to estimate serviceability limit state performances. wind directionality, and cross wind response, which are all important factors in wind design of tall buildings. This paper provides an outline of advanced levels of wind effect design, in the context of the Wind tunnel testing, which has the potential benefits of further refinement in deriving design wind loading and its effects on high rise buildings.

Keywords : Wind Loading , Wind Effects, Wind Acceleration, High Rise Building

I. INTRODUCTION

Wind: Wind means the motion of air in the atmosphere. The response of structure to wind depends on the characteristics of the wind. From the point of view of assessing wind load, it is convenient to divide the wind into two categories: 'Rotating and Non-rotating' winds. Rotating winds are caused by Tropical cyclone san tornadoes. The wind speed caused by These may exceed 200km/h. The duration of such winds at any Location varies from 2to5 minutes in the case of tornadoes storms and about 3to4 day in case of tropical cyclones. Non-rotating winds are caused by differential pressures and thus move in preferred direction. These are also called 'Pressure System 'winds and when they persist for distances like50-100km,are termed as 'Fully developed pressure system winds'. Thunder storms are rectilinear winds of high speed lasting only a few minutes and start as a strong vertical down draft, from clouds Which spread laterally on reaching the ground. They last for 2to5 Minutes and wind speed can exceed 200km/h. As wind is a randomly varying dynamic phenomenon, it has significant dynamic effect on buildings and structure especially on high-rise flexible structures Code sand Standards utilize the "gust loading factor"(GLF)approach for Estimating dynamic effect on high-rise structures. The concept of GLF was first introduced by Davenport in 1967.The last few decades have been witnessed substantial progress in the understanding of the characteristics of wind, as well as the response to the various kinds of structures, and several modifications of GLF. on first GLF model by Davenport. Most leading Codes and Standard have been adopted these changes and according to the need of the hour Indian wind code has been reviewed and Proposed Draft Code has been prepared. Indian wind code stipulates that buildings and structures with a height to minimum lateral dimension ratio of more than about5.0,and buildings and structures whose natural frequency in the first model is less than 1.0Hz shall be examined for the dynamic effects of wind. The Detailed procedure prescribed in the dynamic analysis of Indian code, is based on the value obtained from various figures. Hence, error may creep in the values read from such graphs ,especially from the log-log plots. However ,due to the simplicity of the procedure ,the design engineers are more comfortable in the static procedure for analyzing the typical low ,medium and high rise buildings which are widely constructed. It is, therefore necessary to develop simple guidelines for choosing the method of analysis so that the design office may use it for the assessment of the structural response .Hence ,a comprehensive comparative study of the methods given in Indian wind code is undertaken to investigate the effect of the variation of building geometry on wind loads.

Ahsan Kareem "Structure Analysis And Design Of Tall Building", IJRET (2003)Pp56-99

Ahsan pay tribute to the "father of wind engineering ,"Jack E.Cermak for his many valuable and pioneering contributions to the subject, followed by a reflection on there cent developments in wind effects on structures and an outlook for the future. This discussion encompasses the following topics: modeling of wind field; structural aerodynamics ;computational methods; dynamics of long –period structures ;model– to full-scale monitoring ;codes/ standards and design tools; damping and motion control devices.

Holmes J et.al "Aero Dynamic Shape Effect on Tall Building" Wind engineering, India,(1990)Pp237-242

Holmes discusses the progress made in understanding wind loads On structures, and related aspects of wind engineering, emerging Issues in2003,and prospects for the next forty years. Although the name' wind engineering 'was coined in the nineteen-seventies, resulting in the International Conference on 'Wind Effects on Buildings and Structures 'becoming the International Conference On 'Wind Engineering'in1979,the foundations of modern wind engineering were firmly set in the early nineteen-sixties Several papers in the Is International Conference on Wind Effects on Buildings and Structures at Teddington,U.K.in1963 set the scene For the next forty years.

Ning Lina et.al "Local wind forces acting on rectangular prisms.Proceedings of 14th National Symposium on Wind Engineering",(4–6December1996),Japan Association for Wind Engineering,Tokyo,pp.263–268.

Studied nine models with different rectangular cross-sections and Were tested in a wind tunnel to study the characteristics of wind Forces on tall buildings. The data was briefly reported In the Present paper, local wind force on tall buildings are investigated in terms of mean and RMS force coefficients ,power spectral density ,and span wise correlation and coharence. The effects of three parameters, elevation, aspect ratio, and side ratio, on bluff body flow and there by on the local wind forces .The overall loads and base moments are obtained by integration of local wind forces. Comparisons are model with result obtained from high–frequency force balances in two wind tunnels.

HOLMES J et .al "Wind Loading Study For Tall Building With Similar Dynamic Properties In Orthogonal Direction"(1986),Pp267-282

performed extensive experimental work on the fluctuating pressure measurements using a small diameter connecting tube to transmit the pressure from the connecting point ,or tap ,to the pressure transducer. Their authentic work has provided sufficient guidelines to develop arrange near optimum systems for the measurement of fluctuating pressure on models of the buildings in wind tunnels .In the present study the choice of tubing system for pressure measurements is largely based on the work of Holmes and Lewis. Directions using two cross-wire hotwire probes of Dantec Dynamics make at different heights from the test section floor. The mean wind speed ,wind speed and integral length

scale are obtained at different discusses mode shape corrections and reviews processing methodologies for the determination of the overall wind loading and response of tall building country boundary layer up to a level of 30to35 meters in full scale. Unusual structural shapes arising out of daring architectural forms Need wind tunnel studies to assess the wind forces on such Structures .Paper presents the results of a wind Tunnel model testing of a 60m high war memorial at Jammu. The Test results are particularly useful in the design of the shield and Its attachments with the tower.

Fujimoto k et.al. "wind loading on high rise building "IJRET, (1975),Pp90-96

Have tested a1:400 scaled aero elastic model of rectangular tall Building (1:1.2:3.75)in smooth flow and two boundary layer flows. Values of along wind and across wind response are presented versus reduced velocity and a relationship is established. Experimental gust factors are compared with Davenport(1967).A Four mass model was also tested in natural wind and contribution Of higher mode is reported to be negligible on displacements anabout10% on accelerations .world's major building codes and standards is conducted in this study ,with specific discussion of their estimation of the along wind ,across wind and, torsional response ,where applicable ,for a given building. The codes and standards highlighted this study are those of the United States, Japan ,Australia ,the United Kingdom ,Canada, China and Europe. In addition ,the response predicted by using the measured power Spectra of the along wind ,across wind and torsional responses for Several building shape tested in a wind tunnel are presented and A comparison between the response predicted by wind tunnel data And that estimated by some of the standards is conducted. This Study serves not only as a comparison of the response estimates By international codes and standards , so introduces a new Set of wind tunnel data for validation of wind tunnel-based Empirical expressions.

Cermak T et.al "Adverse local wind load induced by adjacent Building "journal of structural engineering, ASCE,(1977),pp816-820 states that:

"A common procedure is to mount the model on a set of gimbals fixed to a rigid platform placed beneath the wind tunnel floor. Two pairs of mutually perpendicular helical springs attached To a rod rigidly fixed to the structural shell and passing below the Gimbals provide the desired natural frequencies. Strain-gauges Attached to the spring mounts can be used to give a voltage Output proportion of sway amplitude .Adjustable magnetic Damping is provided conveniently by attaching to the support rod. A metal plate that passes between the poles of an electromagnet. Variation of current through the magnet permits control of critical damping ratio". A very simple and useful alternative system designed by Kareem & Cermak (1975)may be constructed by clamping the building base to two leaf springs placed perpendicular to each other and fixed to a rigid frame mounted in the wind tunnel floor. Strain–gauges mounted on the spring's measure the deflections .Damping for this system is provided by pneumatic dampers attached to a rod extending beneath the wind tunnel floor.

Parera A.et.al, "WIND AND EARTHQUAKE RESISTANT BUILDING",MARCELDEKKER,(1978)pp11-34

studied the interaction between along wind and across wind vibrations of tall slender structures(1:1:6.3)using one degree-of freedom and two degree-of-freedom aero elastic models .A new gimbals system to allow either on developed. Cermak contributed significantly towards the laboratory have treated various aspects of ABL characteristics and simulation in detail .Wind tunnel design criteria have been established. Mathematical similarity criterion has been discussed and governing equations have been formulated .Uses of short test section wind tunnels with vortex generators and grids have been outlined .Closed-circuit meteorological wind tunnel have been designed with flexible ceilings and temperature control facility. A new wind tunnel testing technique has been developed which makes use of integrated local pressures ,measured by a Synchronous Pressure Acquisition Network(SPAN),to determine Overall wind-induced response. The integrated pressure modal Load or IPML Technique has the potential of addressing all of the limitations of The conventional high-frequency force-balance technique while Still maintaining the same advantages that at technique has over The aero elastic modeling. Outlines the approach and presents Several experimental results including comparisons with data from matched high frequency force-balance tests.

Nakayama H et.al."The criteria to motion in tall building."ASCE(1995)pp103-115.

Presented their study on a super tall building with tapered cross section. In first part the study is aimed at comparing the various Wind tunnel modeling techniques. In the second part results of Unsteady Aerodynamic forces measured using manifold pressure taps at Nine levels are presented .Also effects of edge configurations and Tapering are studied .It is concluded that mode shape correction Factors currently used for twist modes, are conservative. The analysis how that with a geometrics ratio of 1:200 to 1:150,the simulated boundary layer can be considered as the Simulation of has given an evaluation and comparison of seven of The correlations between base moments is found to be significant When calculating the response for coupled modes .In the present Paper ,local wind forces on tall buildings are investigated in terms Of mean and RMS force coefficients ,power spectral density ,and span wise correlation and coherence. The effects of three parameters ,elevation" aspect ratio ,and side ratio, on bluff body flow and there by on the local wind forces are discussed. The overall loads and base moments are obtained by integration of local wind forces. Comparisons are made with results obtained from high-frequency force balances in two wind tunnels. Simulation of atmospheric boundary layer inside the test section of the open type wind tunnel at the Department of Civil Engineering ,Ruhr University, and Bochum, Germany is attempted. Trapezoidal spire so as tripping fence are used for horizontal vortex generation ,while the elliptical shark fins are used for vertical vortex generation .Square grids are also used to increase the level of turbulence in flow. Velocity data are obtained in two heights. These values are compared with corresponding field data obtain able from Engineering Science Data Unit (ESDU).

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