A Literature Review on Human Comfort Criteria of Tall Building Under Dynamic Wind Loading

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Abstract- *The tall, light, flexible buildings may have large oscillating motions induced by wind or other causes that affect the comfort of the occupants. Wind induced motion in buildings may result in excessive vibrations such vibrations can cause discomfort conditions for occupants or damage to non structural elements. So it is essential to analysis the dynamic behavior of the tall building under the wind excitation which influences the human comfort. Human comfort limits are usually related to the acceleration values of buildings and some other parameters.*

In this review paper the study about different criteria and parameter used by different researchers on human comfort condition of a tall building under wind excitation. The parameters are peak acceleration, structural shape, damping, altitude of building, and place of constructions, methods of analysis and wind intensity as per different code used by different countries. On the above parameters Peak acceleration of building is essentials and major criteria for assessment of human perception.

Keywords- Peak Acceleration, Human Comfort,Vibrations, Wind Excitation, damping.

I. INTRODUCTION

Recently there has been a considerable increase in the number of tall buildings. These buildings are subjected to horizontal loads due to wind pressure acting on the buildings. The horizontal wind pressures act on vertical external walls and exposed area of the buildings. The development of new architectural forms of buildings and flexible structural systems are vulnerable to wind action. For desirable performance under comfort conditions of these buildings, we require better understanding of interaction between building and comfort parameters of the building under wind excitations. Wind is an important parameter in the design of tall buildings. Comfort assessment due to wind excitation is an important problem in tall building design. Comfort in buildings is generally defined by occupants' reactions and perception of wind vibration of buildings. Comfort conditions are generally assessed by examining accelerations of the building during wind excitation. Various structural codes provide formulae for estimation of maximum wind accelerations of top floor of a tall building. There is generally no accepted international standard for comfort criteria in tall buildings even tough accelerations are to be estimated accurately, rather there are several studies and resulting recommendations for this purpose. Human response to wind-induced vibration in tall buildings has traditionally been evaluated by the acceleration in the horizontal plane. Two different measures of acceleration have been used: the peak value which occurs during a period of time or the root mean square value averaged over this same period.

In present study we focus on the different criteria and parameter used by different researchers on human comfort condition of a tall building under wind excitation. For Indian provision the researchers generally used dynamic method i.e. gust factor method for dynamic wind force calculation as per IS 875(part3) 1987& 2015.On the above parameters Peak acceleration of building is an essentials and major criteria for assessment of human perception.

II. LITERATURE REVIEW

1)MdAhesan MdHameed!, Salman Shaikh P(2019) investigate the buildings of different shape such as regular plans and irregular plans. IS: 875 (Part- 3):2015 is the standard code of practice for design load of buildings and structures which was used to calculate the along wind load effect i.e. gust factor. To determine along wind load effect on different shapes of building using Indian standard, spread sheets are prepared. Further, all these shapes were analysed using finite element software package ETAB-2016. Each building is a 20 storied building with story height as 4m summing upto a total height of 80m. For, the purpose of analysis the plan area of regular shape like Square, Rectangular, Elliptical, Circular and Rectangle with two semicircle shapes kept same as well as the frame properties also kept equal

2)Nishant Raj Kapoor, Dr. J.P. Tegar (2018)intends to assess the human comfort parameters, based on the opinion and perception of different class of people and clusters of housing in Bhopal. The 350 questions were distributed and collected from the study area. The outcomes, revealed that the thermal comfort factor is dominating factor which is on top priority as compared to other four factors namely air quality, lighting, acoustic, and visual comfort. It also provide the ranking of comfort parameters based on perception of Bhopal residents, so based on the findings of research these comfort parameters can be improvised by different ways. The research outcomes having vital importance in developing country's prospect where judicious use of renewable energy sources will help in reducing cost and energy consumption and in long term achieving better human comfort and reduced health issues along with providing them a quality built infrastructure for life.

3)Prakash Channappagoudar, Vineetha Palankar, R. Shanthi Vengadeshwari, Rakesh Hiremath(2018)carried out the gust factor method analysis. It is more realistic particularly for computing the wind loads on flexible tall slender This paper deals with one such computation where a building in Pune is taken into consideration for analysis with respect to wind loads for different number of floors. Analysis is done for both codes of IS 875(Part 3):1987 and IS 875(Part 3):2015 for different parameters affecting the stability of building. This paper also includes important points of IS 16700:2017 which takes both the previous codes of Wind and Earthquake into consideration and specifies a new code of conduct for design of tall buildings ranging from 50 – 250 meters.

4) Er. Mayank Sharma, Er. Bhupinder Singh & Er. Ritu Goyal(2018)undertaken with the objective of critically examining the Gust Factor Method incorporated in the present Indian Standard for wind loads, IS 875 (Part 3) 1987. For the study 25 storied framed steel building having square shape in all the four terrain categories has been chosen. The wind loads induced at various heights, base shear and base moments for the building has been computed by Peak Wind Approach as well as Mean wind Approach associated with Gust Factor. Further hourly mean wind speed as obtained. The perusal of results reveals that the values obtained are consistently less than those obtained by the Gust Factor Method incorporated in the code. On comparison of results for Peak Wind Approach, Mean Wind Approach associated with Gust Factor and Gust Factor Method using hourly mean wind speeds based on hourly mean wind speed data, wide variations in the values has been observed.

5)Neethi B. Elsa Joby(2018) proposed tall building design platform that has the aim of determining the significance of aerodynamic modifications against wind excitation, which include modifications of building’s cross-sectional shape and its corner geometry, sculptured building tops, vertical openings through-building. As per wind analysis architectural modifications such as setback, tapering and sculptured building tops are very effective design methods of controlling wind excitation and many of the most elegant and notable buildings. Architectural modifications to corner geometry, such as chamfered corners, rounded corners, tapered corner can also significantly reduce wind induced response of buildings.

6)Aiswaria G. R* and DrJisha S. V(2018)investigate along and across wind loads acting on tall buildings located in terrain category IV having height varying from 90m to 240m have been computed as per the Indian standard code IS 875(Part 3): 2015 considering the effect of interference. The across and along wind load induced maximum base shears and base moments were compared to assess the governing wind load component acting on a tall RC framed building. It was deduced that the effect of along wind force is governing for up to a height of 150m in the case of long body orientation while it is the across wind force which is governing for all the buildings in case of short body orientation.

7)AthulyaUllas, Nimisha P(2017) Examine the lateral displacement on models of different shapes. The comparative study of effect of wind on buildings of various shapes such as Y, Plus and V. Buildings of plan shapes Y, Plus and V are modeled in ETABS 2016 and analyzed. It is observed that the storey force is same for all the buildings, i.e. the storey force does not change with the shape. The lateral displacement is found maximum for V shape building. The storey drift is observed maximum for Y shape as compared to that of other shapes and the lateral displacement and the storey drift are observed minimum for Plus shape building as compared to Y and V shape buildings and hence it is the most structurallystable shape among the selected shapes.

8)Rabi Akhtar, Shree Prakash, Mirza Aamir Baig(2017):- analyzed through modelling in three Dfinite element software used for the analyses is STAAD Pro. V8i(Series-4) with respect to Indian wind code IS 875 and its hand book. From the results it can be observed, when modelling a high-rise building in finite element software, that one model is often not sufficient to cover all different aspects. To see the global behaviour, one model can be used, and when studying the detailed results another model with a fine mesh, that have converged, is often needed. The same principle applies when evaluating horizontal and vertical loads, different models or methods are usually needed.

9) F .Ubertini ,F. Comodini,A. Fulco, and M. Mezzi(2017) proposed the numerical simplified parametric procedure in order to evaluate the return period of wind events causing human discomfort. A parametric investigation is then presented to evaluate the effects of salient parameters on comfort conditions. Th procedure is based on the nonlinear dynamic analysis of the structure modeled as a single-degree-of-freedom oscillator with hysteretic base isolators, the digital generation of time histories of turbulent wind velocity, and comfort evaluations based on international standards. Results demonstrate that discomfort conditions can occur a few times in a year, depending upon the wind-exposure of the site, what suggests considering this serviceability limit state in the design of base isolated buildings.

10)Tharaka Gunawardena, Shiromal Fernando, Priyan Mendis, Bhathiya Waduge, Dilina Hettiarachchi(2017) examine the response of tall buildings to wind forces is a critical design criterion and it requires both conventional force based designs as well as performance based solutions . the study, virtual wind tunnel modeling methods can introduce a quicker and more cost-efficient solution to finding wind pressure and acceleration based inputs for the design that are not sufficiently provided through design codes. With more such comparisons on real projects, virtual wind tunnel modeling can achieve a wider acceptance and validation. This is a very efficient tool for design development. However computational methods are not developed adequately to completely replace wind tunnel test.

11)Rohan Kulkarni, Dr .K. Muthumani(2016) concentrate on wind induced pressures which would be arises due to wind intensity and how pressure varies according to different shapes of buildings. The intensity of a wind load depends on how fast it varies and also on the response of structure. Ansys Fluent has been used for CFD analyses to study the wind induced response. it was found that Wind Pressure Coefficient is max in case of square, trapezium, rectangle plan shape and it is minimum in case of circular, hexagon and elliptical plan shape of tall building, the circular and elliptical plan shape of buildings is much better compared to the other plan shape of building in reducing of both Wind Pressure Coefficient as well as Total Drag Force on Building.

12) V. M. Passosa L. A. Feitosaa E. C. Alvesa M. S. Azevedoa(2016) analyzed different models for buildings with slenderness ratios of one to six by varying the type of slab construction system that is used between prestressed slabs and waffle slabs. It evaluate the instability parameters of the structure that result from variations of several general parameters, such as the thickness of the slabs, the sections of the columns, the coefficients that represent the physical nonlinearity of structural elements, the height of the typical floor plan and the characteristic strength of the concrete. The commercial software CAD/TQS version 17.11.8 is used to analyze and test these instability parameters. The analysis of models of prestressed slabs and waffle slabs showed that increasing the thickness of the lift columns (stiff core) did not significantly reduce the gz instability coefficient.

13) M. D. Burton1,K. C. S. Kwok,A. Abdelrazaq(2015) proposed a state-of-the-art report of occupant response to wind-induced building motion and acceptability criteria for wind-excited tall buildings. It provides background information on a range of pertinent subjects, including Physiological, psychological and behavioural traits of occupant response to wind-induced building motion. They show investigations and findings of human response to real and simulated building motions based on field studies and motion simulator experiments. General acceptance guidelines of occupant response to wind induced building motion based on peak acceleration thresholds, and Mitigation strategies to reduce wind-induced building motion through structural optimization, aerodynamic treatment and vibration dissipation/absorption

14)Mohamed I. Farouk(2015) carried out a three-dimensional numerical simulation has been developed using ‘‘CFD’’ software to check the comfort of the occupants at Lerkendal Hotel in Norway. The hotel is the third conventional highest building in Norway. The numerical model results have been compared to those obtained by codes, carried out by others. All the realistic conditions including the shape of the structure, the wind speed, the wind direction and the wind exposure are precisely considered. The numerical model results have been compared to those obtained by codes, carried out by others. The results showed good agreement between both studies. Therefore, CFD can be used to check the comfort of the occupant with a good accuracy.

15)Xin Zhao, Xiang Jiang (2015) A modal shape updating method is proposed in this paper to reduce the building acceleration by locally calibrating the modal shape near the floor where maximum building acceleration occurs. Due to its local impact nature, the expense of changing local curve of modal shape is lower comparing with that of changing vibration period. A real super tall building project is taken as an example in the last part of this paper to show the effectiveness and applicability of the proposed modal shape updating method. The results show that the modal shape updating method provides a powerful tool for wind-induced dynamic serviceability design of super tall building structures with slightly excessive wind-induced acceleration response.

16) S.H. El- Sherif, M.M. Hassan, H. M. Ahmed, and S.A. Mourad(2014) aims to investigate acceleration values due to wind loading for medium rise reinforced concrete buildings considering different floor systems through an extensive parametric study. A Total of 96 runs are performed using linear static and dynamic analyses. The considered parameters include floor structural system, number of floors, layout of shear walls, dimensions of structural elements, and floor height, the study focus is given to acceleration and drift values as measures of the human comfort levels in the studied structures. It was found that static loading is not always conservative when considering human comfort criterion and that dynamic analysis may be necessary to satisfy it.

17) Jumana Al Balushi and A. D. John(2014) evaluated the performance of tall building on human comfort on wind induced acceleration using ASCE7-10 method. The natural frequencies of all the buildings were determined by carrying out numerical analysis. The results of the along wind acceleration by ASCE7-10 method signify that the buildings with low structural damping increase their acceleration levels under even moderate wind speeds. Further, analysis results of different categories of surface roughness show significant change in the pattern between along-wind acceleration and structural damping. It is found that variation of acceleration values for varying damping and different surface roughness categories is not linear.

18) Srikanth1 and B VamsiKrishna(2014) have performed the tall building frame 20 to 80 stories are considered for wind load analysis. Equivalent static wind loads are computed using the provisions of IS: 875- 1987 PART-III. Analysis is conducted by using the package in two loading cases, i.e., vertical loads with or without wind loads. The resulting effects like beam moments, column moments, axial forces are compared. The criticality of the wind on tall building frames is examined and recommendations are given. The present study would lead to important and useful recommendations for the action of critical wind loads on tall building frames. Gust effectiveness factor method, which is rational and realistic, should be considered for the computation of wind loads in the case of very tall frames and structures. It becomes necessary to study the criticality of wind forces in the case of multi-storied frames particularly on more serve wind zones.

19)Samet Tozan, KadirGüler, BarışErkuş(2013) examine the comfort condition of a tall building under wind excitation using various structural codes. The lateral system of the building is a dual system of shear walls and moment frames. They considered a 31-story and 116.6 m tall office building in Istanbul Turkey having a floor system 30m-by-35m. Maximum top floor along wind and across-wind accelerations are estimated using various structural codes and design guidelines. Comfort conditions are assessed considering maximum accelerations of the top floor of the building due to wind excitation. It is shown that while different codes give different values of maximum accelerations, same or similar comfort condition is achieved. The conclusion is that there are no single occupant comfort criteria. Increase in weight decrease the displacement & Human psychology, culture and other social characteristics are very important for comfort criteria. It is considered that criteria given in one country may not be directly applicable in another country due to differences in social conditions.

20) M.F. Huang, C.M. Chan and Kenny.C.S. Kwok(2011) investigate an integrated wind-induced dynamic analysis and computer-based design optimization technique for minimizing the structural cost of general tall buildings subject to static and dynamic serviceability design criteria. Once the wind-induced dynamic response of a tall building structure is accurately determined and the optimal serviceability design problem is explicitly formulated, a rigorously derived Optimality Criteria (OC) method is to be developed to achieve the optimal distribution of element stiffness of the structural system satisfying the wind-induced drift and acceleration design constraints. Both peak resultant acceleration criteria and frequency dependent modal acceleration criteria are considered and their influences on the optimization results are highlighted.

21)Dae-Kun Kwon, AhsanKareem(2008). Examine the gust loading factor format used in codes and standards world-wide for the treatment of conventional boundary layer winds. It describe the overall wind load effects on structures under both gust-front and boundary layer winds and it reduces simply to the gust loading factor for the case of conventional boundary layer winds. This approach encapsulates both the kinematic and dynamic features of gust-front induced wind effects on structures which distinguish themselves from those experienced in conventional boundary layer flows, i.e., variation in the kinematics of the velocity profile and its effects on the associated aerodynamics; dynamic effects induced by the sudden rise in wind speed; non stationary of turbulence in gust-front winds; transient aerodynamics. To facilitate expeditious utilization of this framework in design practice and inclusion in codes and standards, the analysis framework and its workflow is introduced within a web-based portal.

22) P. Mendis, T. Ngo, N. Haritos, A. Hira(2007)analysed the advanced wind tunnel approach the Australian Wind Code The benefits of further refinement in deriving design wind loading and its effects on tall buildings, is also emphasized. tall building design as significant dynamic response can result from both buffeting and cross-wind wind loading excitation mechanisms. Serviceability with respect to occupier perception of lateral vibration response can become the governing design issue necessitating the introduction of purpose-designed Damping systems in order to reduce these vibrations to acceptable levels. Dynamic response levels also play an important role in the detailed design of façade systems. State of the art boundary layer wind tunnel testing, for determining global and local force coefficients and the effects of wind directionality, topographical features and nearby structures on structural response, is recognized as being particularly useful to tall building design. The emerging use of CFD codes, particularly at the concept design stage, is also noted as assuming increasing importance in the design of tall buildings.

23) R. Bashor, T. Kijewski Correa, A. Kareem(2005) has given the importance of damping in meeting these perception criteria, the study also explores the issues of amplitude-dependence and uncertainty in damping, with comparisons to recently collected full-scale data. In light of the uncertainties in both the occupant comfort criteria and damping value, and in the design wind speeds and other related parameters, a probabilistic framework is then introduced to evaluate a building's habitability performance at a variety of wind speeds. They demonstrated that a typical tall building can have a 30-40% probability of failure in the habitability limit state. This approach can then be used within a risk based decision making framework to further examine the habitability of a building as well as measures to enhance its performance.

24) Daryl Boggs (1995) investigate the acceleration appears to best indicator of building motion at present. Both rms and peak acceleration value are commonly used to represent building motion. The differences between two methods are examined, and the importance of making a rational selection of the appropriate motion index for future standards is emphasized. Human tolerance to motion lies somewhere between the extreme indexes of expected peak and root mean square values, averaged over a period of say 20to 60 minutes. The root mean square value is much simpler to evaluate, and more likely to result in consistency and uniformity among various agencies engaged in predicting vibration in a proposed building, or in evaluating the vibration in an existing building.

25)RNarasimha, Ushrinivasa(1984) deals with specification used in wind analysis as per coded provision given in the Indian code. The code shown to be inconsistent with available data on extremes. Thus, it is found that while the National Building Code specifies the highest wind loads on the east coast and western Gujarat, the observed extreme winds are highest in the eastern Genetic valley. As the consequence so funder-specification can be serious, a careful re-examination of the code. It is argued that although the available data on extremes may not be complete, they provide a more rational basis for formulating a building code; as wind loads become more important in construction engineering a serious effort at generating and analyzing the required meteorological data seems highly worthwhile. It also followed elsewhere for predicting extreme winds and the nature of gusts need to be validated for the country.

III. CONCLUSIONS

In this review paper study which is about the different criteria and parameter used by different researchers on human comfort condition of a tall building under wind excitation. The following conclusions can be made from the studies:-

- There is not a single universal criteria adopted for human comfort criteria.
- The different parameters on human comfort criteria are peak acceleration, structural shape, damping, altitude of building, place of constructions, methods of analysis and wind intensity etc for the tall building. On the above parameters Peak acceleration of building is essentials and major criteria for assessment of human perception.
- The different method used by different researchers on dynamic analysis on wind is gust factor method, CFD analysis, & wind tunnel analysis.
- For human comfort assessment the different codes are used by different researchers depends on used country like IS 875(PART3) 1984& 2015 for India, ASCE7-10, NBCC, AS/NZS 1170.2 ,EUROCODE 1-04, AIJ, EIT etc.
- For modelling different software are used for analysis like CSI SAP2000, CSI ETABS, CFD software, ANSYS, etc.
- By varying the elements like slab i.e. flat slab, normal slab and waffle slab are used.
- The different researcher has used different shapes of building like rectangle, T,L,C,H Shape, circular, hexagonal, octagonal etc. On the behalf of different shape circular and hexagonal predominately effect in gust analysis and wind analysis.
- Different structural forms are used by different researchers like tubular structure, rigid frame, braced structure etc with different stories and heights.
- Other factor such as terrain category, wind intensity, surface character tics like plain & sloping.

IV. FUTURE SCOPE

The above study of different research papers related to human comfort assessment of different location and country, we analysis the following gap for future work:-

- On the behalf above parametric studies the human comfort for Indian provision for different zone & different terrain categories of different structural forms is yet not is mention by any researcher and also by Indian wind code IS 875(Part3): 2015.
- There are no single acceptance criteria all over the world for assessment of human comfort for tall building.
- There are no provision mentioned for human comfort criteria in Indian standard IS 875 (part3) 1987 &revised code IS 875 (part3) 2015.
- Range of Perception level for human comfort for different peak acceleration is missing as per Indian tertiary in which comfort and uncomforted zone can be analysed.
- Assessment of best structural form and shapes suitable for human comfort criteria in different places of India. Parametric study of different zone of wind with different terrain profile on Indian with respect to wind.
- Programming for different manual calculation for different dynamic wind method.

REFERENCES

[1] MdAhesanMdHameed!, Salman Shaikh P "Effects of Wind Load On Rc Buildings By Using Gust Factor Approach" Journal of Emerging technologies and Innovative Research(JETIR) Volume 6, Issue 5nd ISSN-2349-5162 May 2019.

[2] Nishant Raj Kapoor, Dr. J.P. Tegar "Human Comfort Indicators Pertaining To Indoor Environmental Quality Parameters Of Residential Buildings In Bhopal" International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 07e-ISSN: 2395-0056p-ISSN:2395-0072 07 July 2018.

[3] Channappagoudar, VineethaPalankar, R. ShanthiVengadeshwari, RakeshHiremath" Parametric Comparison Study On The Performance Of Building Under Lateral Loads As Per Is 875(Part3):1987 And Revised Code Of Is 875(Part 3):2015" International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 05e-ISSN: 2395-0056p-ISSN:2395-0072 07 May 2018.

[4] Er. Mayank Sharma, Er. Bhupinder Singh &Er.RituGoyal"Gust Factor Method For Wind Loads On Buildings And Indian CodalProvisions " International Journal Of Engineering Sciences & Research Technology(IJESRT) Code: Ijess7: 2277-9655 March, 2018.

[5] Neethi B. Elsa Joby "Aerodynamic Modifications against Wind Excitation on Tall Buildings-Shape Optimization" International Journal of Engineering Research & Technology (IJERT) Vol. 7 Issue ISSN: 2278-0181, May-2018.

[6] Aiswaria G. R and DrJisha S. V " Along and Across Wind Loads Acting on Tall Buildings" 92 Second International Conference on Architecture Materials and Construction Engineering – AMCE 2018.

[7] AthulyaUllas, Nimisha P "Response of Buildings of Different Plan Shapes Subjected To WindVibrations" International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 05, e-ISSN: 2395 -0056 p-ISSN: 2395-0072 May 2017.

[8] Rabi Akhtar, Shree Prakash, MirzaAamirBaig " Study Of Comparison Between Static And Dynamic Analysis Subjected To Wind And Earthquake Load " International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 07, e-ISSN: 2395-0056, p-ISSN: 2395-0072 July -2017.

[9] F .Ubertini ,F. Comodini,A. Fulco, and M. Mezzi "A Simplified Parametric Study on Occupant Comfort Conditions in Base Isolated Buildings under Wind Loading" Hindawi Advances in Civil Engineering Volume2017, Article ID3524975, 3524975- 2017.

[10] TharakaGunawardena, Shiromal Fernando, PriyanMendis, BhathiyaWaduge, DilinaHettiarachchi "Wind Analysis And Design Of Tall Buildings, The State Of The Art" 8th International Conference on Structural Engineering and Construction Management, Conference Paper ICSECM2017-463, December 2017.

[11] RohanKulkarni, Dr .K. Muthumani "Shape Effects on Wind Induced Response of Tall Buildings Using CFD" International Journal of Innovative Research in Science, Engineering and Technology(IJIRSET) Vol. 5, Issue 3, ISSN(Online): 2319-8753, ISSN (Print): 2347-6710, March 2016.

[12] V. M. Passosa L. A. Feitosaa E. C. Alvesa M. S. Azevedoa " Analysis of instability of tall buildings with prestressed and waffle slabs " Revista IBRACON de Estruturas e Materiais On-line version ISSN 1983-4195Rev. IBRACON Estrut. Mater. vol.9 no.2 São Paulo Mar./Apr. 2016.

[13] M. D. Burton1,K. C. S. Kwok,A. Abdelrazaq "Wind Induced Motion of Tall Building Desining for Human Comfort" International Journal of High Rise Building, Vol. 4, No. 1, 1-6 ,March 2015.

[14] Mohamed I. Farouk "Check the comfort of occupants in high rise building using CFD" in Shams Engineering Journal , Received 18 February 2015; revised 3 May 2015; accepted 30 June 2015.

[15] Xin Zhao, Xiang Jiang " Optimization of wind-induced acceleration of super tall buildings by modal shape updating" 11th World Congress on Structural and Multidisciplinary Optimisation, Sydney Australia, 07th - 12th, June 2015.

[16] S.H. El- Sherif, M.M. Hassan, H. M. Ahmed, and S.A. Mourad" Human Comfort Study Of Medium Rise Reinforced Concrete Buildings Under Wind Excitations"International Conference on Structural and Geotechnical Engineering, AinShamsUniversity ICSGE 14:publication286392308, Conference Paper · December 2015

[17] Jumana Al Balushi and A. D. John “Effect of Wind and Structural Parameters on Wind-Induced Acceleration of RC Building" Proceedings of International Conference on Architecture and Civil Engineering (ICAACE'14), ISBN 978-93-84468-11-8, pp. 135-149, Dubai, December 25-26, 2014.

[18] Srikanth1 and B Vamsi Krishna “Study On The Effect Of Gust Loads On Tall Buildings" International Journal of structural and civil engineering research(IJSCER) ,ISSN 2319 – 6009, Vol. 3, No. 3, August 2014.

[19] Samet Tozan, KadirGüler, BarışErkuş “Study Wind Comfort Assessment of a Tall Building According toVarious Structural Codes" Second Conference on Smart Monitoring Assessment and Rehabilitation of Civil Strucutres(SMAR) 2013.

[20] M.F. Huang, C.M. Chan and Kenny, C.S. Kwok “Occupant comfort evaluation and wind-induced serviceability design optimization of tall buildings" Wind and Structures, Vol. 14, No. 6, 559-582, Received July 8, 2010, Revised February 14, 2011, Accepted April 7, 2011.

[21] Dae-Kun Kwon, Ahsan Kareem “Gust-Front Factor: A New Framework for Wind Load Effects on Structures" Journal of Structural Engineering. Posted ahead of print February 25, 2009. doi:10.1061/(ASCE)ST.1943-541X.0000010 , December 9, 2008.

[22] P. Mendis, T. Ngo, N. Haritos, A. Hira“Wind Loading on Tall Buildings" EJSE International, Special Issue: Loading on Structures 2007.

[23] Daryl Boggs “Acceleration Indexes for Human comfort in tall building, acceleration or RMS”Submitted for publication CTBUH Monograph Chpt. 13: Motion Perception Tolerance and Mitigation, July 1995.

[24] R Narasimha, Ushrinivasa “Specification of design wind loads in India”Centre for Atmospheric Sciences,Indian Institute of Science, , India Sttdhan & Vol. 7, Part 3,pp.259-274,November1984.