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ANALYSIS AND DESIGN OF THE SKY SCRAPER STRUCTURE SUBJECTED TO WIND LOAD USING SOFTWARE ETABS 2015

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Abstract — *Wind is a phenomenon of great complexity because of the many flow situations arising from the interaction of wind with structures. Wind is composed of a multitude of eddies of varying sizes and rotational characteristics carried along in a general stream of air moving relative to the earth's surface. Effect of wind on sky scraper structures shows that if the structures are not well designed and constructed with and adequate strength it leads to the complete collapse of the structures. Specific lateral loading due to wind load along with vertical gravity loads is important for finding the behavior of the tall buildings. As the height of a building becomes taller, the amount of structural material required to resist lateral loads increases drastically. The design of Sky scraper buildings essentially involves a conceptual design, approximate analysis, preliminary design and optimization, to safely carry gravity and lateral loads. The design criteria are strength, serviceability and human comfort. The aim of the structural engineer is to arrive at suitable structural schemes, to satisfy these criteria. In the present study, the limit state method of analysis and design of Sky scrapers under wind load as per IS codes of practice is described. Analysis and design the Sky scraper structure under the effect of wind force by using ETABS-2015 that is the ultimate integrated software package for the structural analysis and design of buildings. Indian standard code of practice IS-875 (Part 3: 1987) for wind guidelines and methodology are used to analyzed and designed building.*

Keywords- *Sky scraper structure, wind force, IS-875 (Part 3: 1987).*

I. INTRODUCTION

Developing of the sky scraper structure in world increasing drastically, which is going to add in the history of World's Tallest Structures? Developing the sky scrapers start at a very early stage. In general, for design of Sky scraper buildings both wind as well as earthquake loads need to be considered. According to the provisions of Bureau of Indian Standards for wind load, IS 875(Part 3):1987, height of the structure, wind velocity, wind direction necessitates dynamic analysis for wind load.

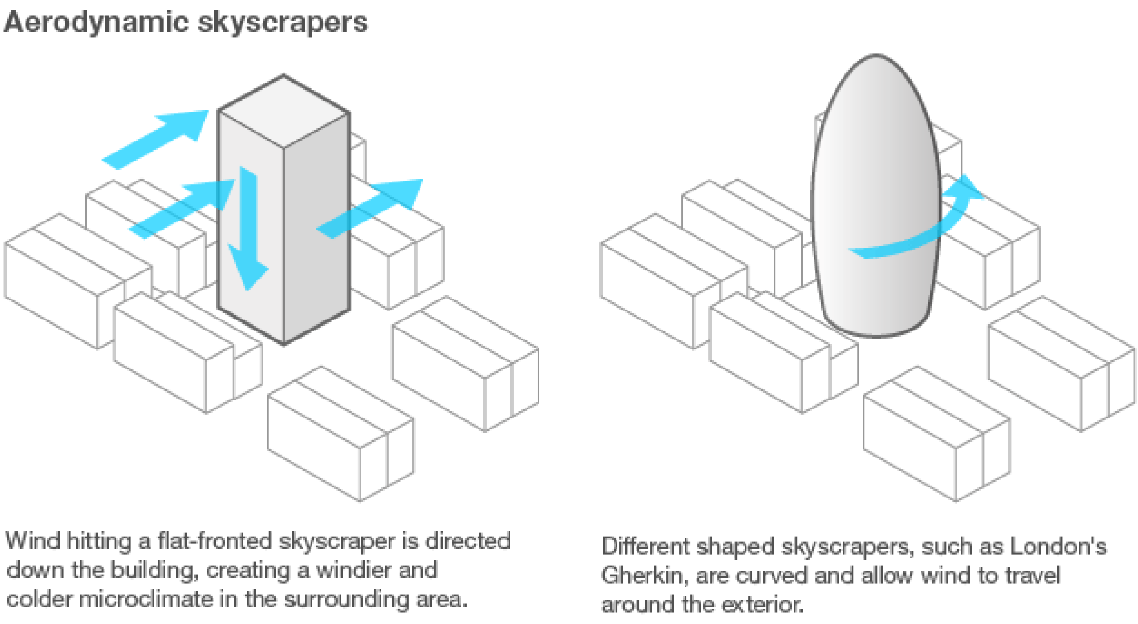

Figure 1. Wind Force on Sky scrapers.

II. LITERATURE REVIEW

A. Wind Loading on Tall Buildings; EJSE Special Issue: Loading on Structures (2007).

P. Mendis, T. Ngo, N. Haritos, A. Hira; "Simple quasi-static treatment of wind loading, which is universally applied to design of typical low to medium-rise structures, can be unacceptably conservative for design of very tall buildings. On the other hand such simple treatment can easily lead to erroneous results and under-estimations. More importantly such a simplified treatment for deriving lateral loads does not address key design issues including dynamic response (effects of resonance, acceleration, damping, structural stiffness), interference from other structures, wind directionality, and cross wind response, which are all important factors in wind design of tall buildings. Author provides an outline of advanced levels of wind design, in the context of the Australian
Wind Code, and illustrates the exceptional benefits it offers over simplified approaches. Wind tunnel testing, which has the potential benefits of further refinement in deriving design wind loading and its effects on tall buildings, is also emphasized."

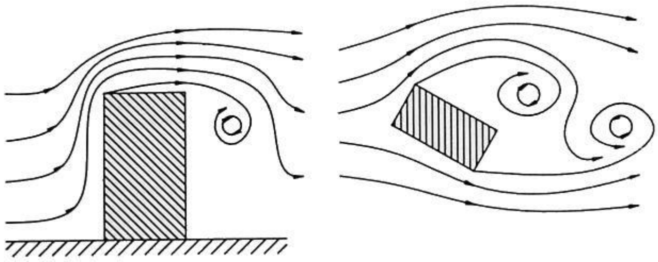

Figure 2. Generation of Eddies

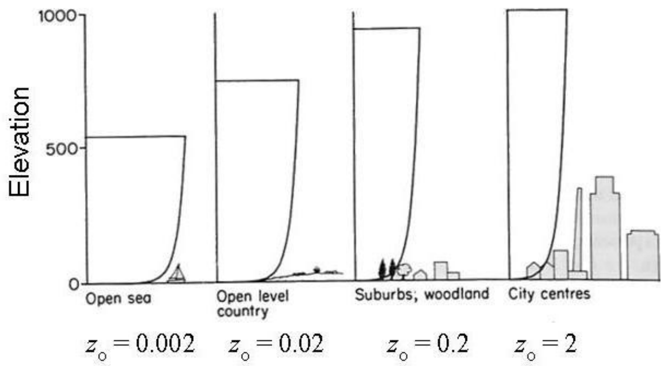

Figure 3. Mean wind profiles for different terrains.

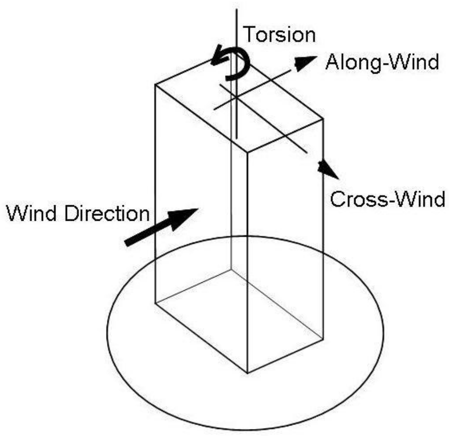

Figure 4. Wind Response Directions

At the end authors concluded the general design requirements for structural strength and serviceability assume particular importance in the case of tall building design as significant dynamic response can result from both buffeting and cross-wind wind loading excitation mechanisms. 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.

B. Wind Tunnel and Full-Scale study of Wind Effects on A Super-Tall Building; Journal of Fluids and Structures 58(2015) 236–253

Jun Yi, Q.S.Li; "This paper presents the analyzed results from a combined wind tunnel and full-scale study of the wind effects on a super-tall building with a height of 420 m in Hong Kong. In wind tunnel tests, mean and fluctuating forces and pressures on the building models for the cases of an isolated building and the building with the existing surrounding condition are measured by the high-frequency force balance technique and synchronous multi-pressure sensing system under two typical boundary layer wind flow fields. Global and local wind force coefficients and structural responses are presented and discussed. A detailed study is conducted to investigate the influences of incident wind direction, upstream terrain conditions and interferences from the surroundings on the wind loads and responses of the high-rise structure. On the other hand, full-scale measurements of the wind effects on the super-tall building have been performed under typhoon conditions. The comparative study shows that the wind tunnel testing can provide reasonable predictions of the structural resonant responses. The resonant displacement responses are comparable to the background displacement responses so that the contribution of the background responses to the total displacement responses should not be underestimated.

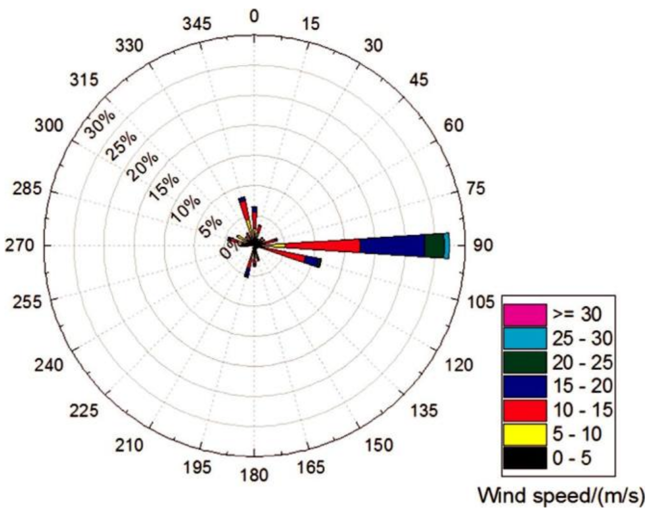

Figure 5. Wind rose of 10 min mean wind speed during the typhoons from 2008 to 2013.

The conclusion of the thesis includes, the mean global wind force coefficients decreased as the ground roughness increased. The mean and fluctuating coefficients of the local wind forces under different wind directions showed that the interference effects of the surrounding buildings on the local wind forces were noticeable mainly below the height of 0.6H (H is the height of the target building). From the measurements of damping, it was found that the overall fundamental modal damping ratios of the super-tall building in the two orthogonal directions mainly varied in the range of 0.5–2.0% during typhoons. It appears that a damping value between 1.0% and 1.5% is reasonable for the wind-resistant analysis of a super-tall building for serviceability consideration.

C. Secondary Bracing Systems for Diagrid Structures in Tall Buildings; Science Direct, Engineering Structures 75 (2014) 477–488.

Giovanni Maria Montuori , Elena Mele, Giuseppe Brandonisio, Antonello De Luca; "In this paper the authors define a framework for assessing the ''local'' structural issues in the design of diagrid tall buildings, and present a methodology for establishing the need for a specific secondary bracing system (SBS) as a function of the diagrid geometry. Further, design criteria for secondary bracing systems are worked out and applied to some 90 story building models, characterized by perimeter diagrid structures with different module height and diagonal cross sections. all analyzed diagrid models exhibited problems concerning stability of interior columns (i.e. multi-storey buckling modes) and/or local flexibility (excessive inter story drift); the above local problems are completely solved after the introduction of a SBS at the central core location, and, against a modest increase of structural weight (about 3%), any flexural engagements in the diagrid member is eliminated.

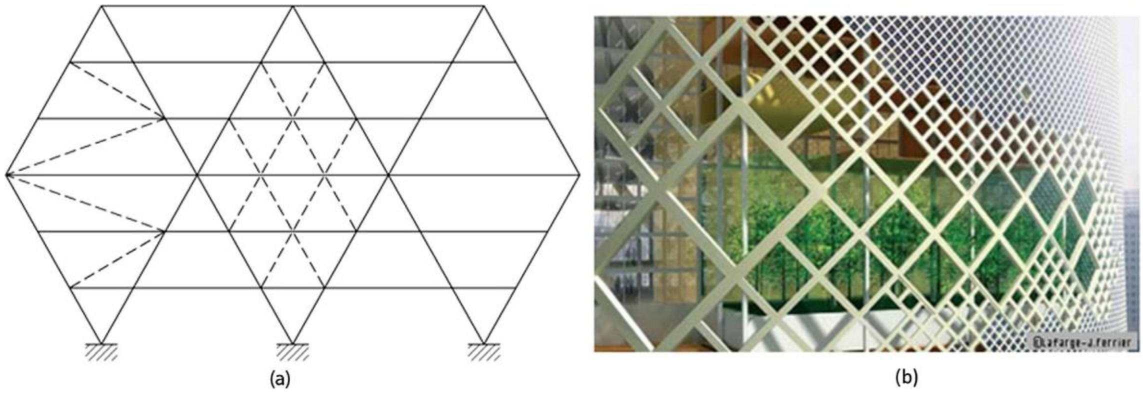

Figure 6. (a) Examples of local bracings placed within the diagrid module; (b) the structural façade of the Hypergreen Tower.

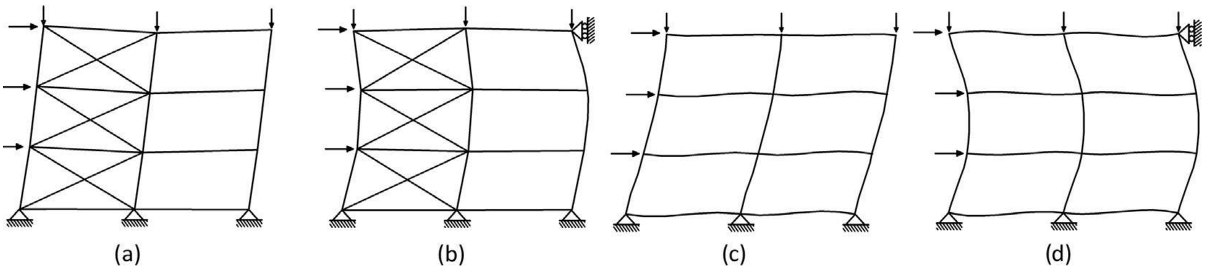

Figure 7. Deformed configuration under horizontal forces for a) common CBF; (b) secondary bracing system CBF; (c) common MRF; (d) secondary bracing system MRF.

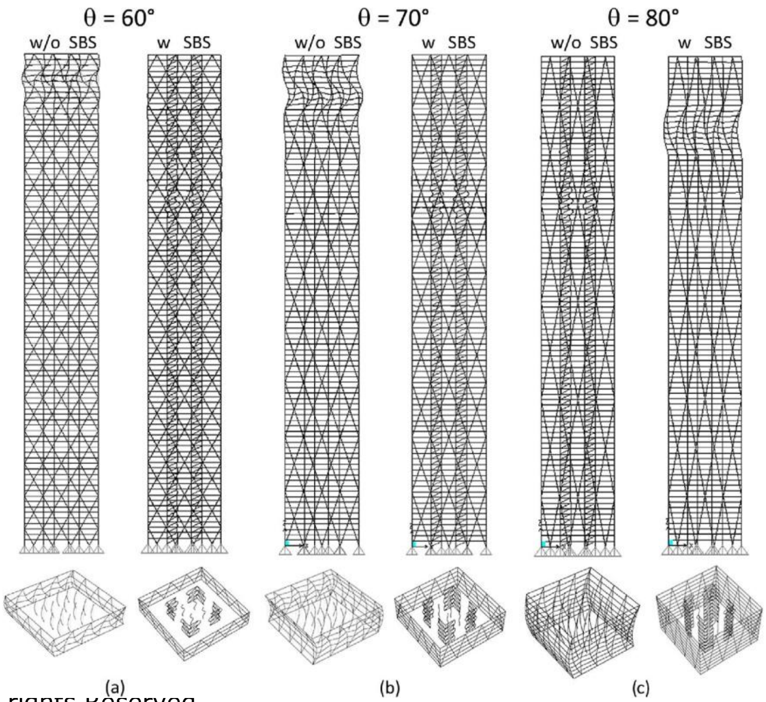

Figure 8. Results of the elastic eigenvalue analyses for model with and without SBS (a) 60L; (b) 70L; (c) 80L.

In this paper, Diagrid structures represent very efficient tubular solutions for tall buildings since address global strength and stiffness demands under wind loads engaging the axial behavior of the diagonal members. In this paper the authors define a framework for assessing the structural issues in the design of diagrid tall buildings, and present a methodology for establishing the need for a specific secondary bracing system (SBS) as a function of the diagrid geometry. the extraordinary efficiency of diagrid would suggest a tube configuration, with core structure only resisting gravity loads, and SBS avoiding the occurrence of the local flexibility effects.

D. Study of Seismic and Wind Effect on Multi Storey R.C.C., Steel and Composite Building; International Journal Of Advances in Engineering And Technology, ISSN 2231-1963,Vol.6, Issue 4, Page no: 1836-1847 (Sep 2013)

Baldev D. Prajapati & D. R. Panchal; "Engineers, designers and builders are trying to use different materials to their best advantage keeping in view the unique properties of each material Structurally robust and aesthetically pleasing building are being constructed by combining the best properties at individual material & at the same time meeting specific requirements of large span, building load, soil condition, time, flexibility & economy high rise buildings are best suited solution. Also Wind & Earthquake (EQ) engineering should be extended to the design of wind & earthquake sensitive tall buildings. This paper discusses the analysis & design procedure adopted for the evaluation of symmetric high rise multi-storey building (G+30) under effect of Wind and EQ. forces. In these building R.C.C., Steel, & Composite building with shear wall considered to resist lateral forces resisting system."

NOTATIONS:-
• (S+B) = Steel + Bracing
• (SSBC) = Steel secondary beam composite
• (SSBC+B) = Steel secondary beam composite + Bracing
• (SABC) = Steel all beam composite
• (SABC+B) = Steel all beam composite + Bracing

Author conclude that S.F. & B.M. is more in the RCC, STEEL & (S+B) building. But, when we use the composite beam in the (SSBC), (SSBC+B), (SABC) & (SABC+B) building the forces are reduced due to the reduced the section. Displacement is within the limits for all building RCC, STEEL and COMPOSITE.
Support reaction is maximum in the RCC building which linearly reduce to RCC to (SABC+B) building in the WIND, EQ. ZONE-III and EQ. ZONE-IV type building.
Composite steel-concrete is relatively a new design concept in the Indian context and no appropriate updated codes are available for the design of same. The present work not only eliminates the costly experimentation required but also facilitates design with multiple options for the steel sections and shear connectors with adequacy checks.

III. CONCLUSION

From the above literature we conclude that

1) Any Sky scraper structure must analysis and design by code IS 875 (part 3) : 1987.
2) Provide bracing system in the Sky scraper structure, gives more resistance to lateral loads.

If the Sky scraper structure design under the wind load, then damages can be reduces.

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