ANALYSIS OF AERODYNAMIC MODIFICATION OF THE SHAPE OF THE TALL STRUCTURE – RESEARCH

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Abstract- The structures that are man-made are bluff- bodies. During the structural analysis of a tall building, its stability under wind forces is of a major concern. Being a bluff body, the aerodynamic study plays a critical role in the determination of the principal response of a high- rise building to wind forces. Wind action can reduce the proceeding of the whole structure

.because tall structures are in a continuous motion during wind circumstance hence ,it is essential for structural engineers to develop a system ,which can increase modal mass to reduced wind induced motion.

Now a days it is observed that urbanization area is abruptly increases, with increment in population. Hence, the land requirements are increases day by day to fulfillment the needs of residents. To fulfill the need, now a days in metro city multistory buildings are constructed. And it was observed that during structural analysis that wind action is play a very important role in the stability of tall buildings.

In present study an attempt has been made to minimize the impact of wind on tall buildings. The aerodynamics action will highly influences the high rise buildings. Because high rise buildings is continuous in motion during wind action and causes instability to building structures, which can causes hazardous impact to health as well as wealth.

In present study to minimize this impact, modification of aerodynamics action has been taken to reduced the impact of wind action on tall buildings. For this purpose fours cases has been studied, in which four different type of structural design which include cross sectional shape, corner geometry, sculptured buildings tops and vertical opening of buildings has been taken and studied against the wind action.

KEY WORDS: Aerodynamic shape , wind load , Drag coefficient ,Model analysis, Drag Force, Tall str

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I. INTRODUCTION

The lateral loads on the buildings is plays an important role in the design of high structures. The structures response to wind depends on the wind's characteristics. Tall buildings, usually designed for office or commercial use, are among the most distinguished definitions of space in American urbanism's twentieth-century architectural history. According to National Building Code 2005 building having height more than 15m of India is called a high rise building. Vertical growth of buildings has become an ultimate option available due to the rapid growth of population, the high cost and, for improvement in aesthetic view of city and restriction in horizontal growth due to less space. The Wind can be defined as the large-scale horizontal movement of free air .

In metropolitan cities the creative reinterpretations of the building type by architects, the inadequacy and high cost of land in urban areas, the desire to prevent disorganized urban expansion, the need to maintain significant agricultural production, the idea of skyline, the impact of cultural significance and prestige have all contributed to the fact that buildings may produce excessive construction movement, the dynamics nature of wind is a critical issue, negatively affecting occupancy comfort and serviceability.

Moreover, the human response to building motion is a very complicated phenomenon concerning both physiological and psychological features. In addition, excessive building movement can cause noise and crack

doors, damage non-structural elements such as curtain walls, break glasses, reduce fatigue life, elevator and equipment malfunction, and cause structural damage or even collapse.
Various design approaches and modifications are possible, ranging from alternative structural systems to the introduction of damping systems to ensure the functional efficiency of flexible structures and control the movement of tall buildings caused by wind. Among these approaches, an extremely important and effective design approach is aerodynamic structural modifications, including modifications of the cross-sectional form of the building and its corner designs, sculpted building tops, and horizontal and vertical openings by construction.

Now a days, it is assume that tall buildings are symbol of power, technology, landmark of metro cities but bedside of this if care was not taken before construction of these buildings it can cause undeniable negative effects on the quality of urban life.
To overcome this method several design and modification are possible. Ranging from alternative structural systems to the addition of damping systems in order to ensure the functional performance of flexible structures and control the wind induced motion of tall buildings. And one of the most important method is the aerodynamic modifications in architecture, including, modifications of building's cross-sectional shape and its corner geometry, sculptured building tops, and horizontal and vertical openings through building. By doing this the wind flow pattern around the tall structures can minimize the response of wind action around the buildings. An extremely important and effective design approach among these methods is aerodynamic modifications in architecture, including, modifications of building's cross-sectional shape and its corner geometry, sculptured building tops, and horizontal and vertical openings through building. By

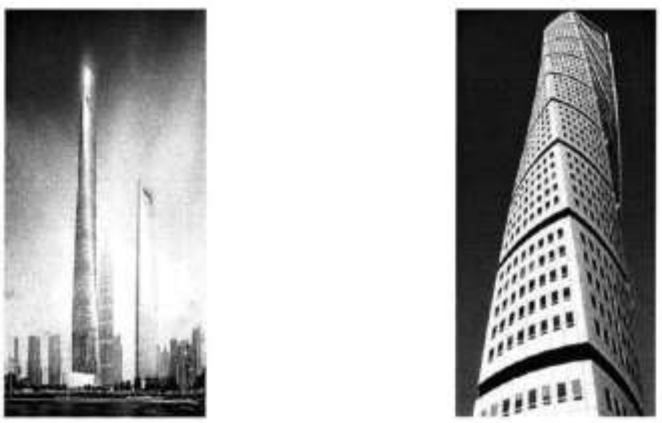

Fig 1.1 Shanghai Tower Under Cons

changing the flow pattern around the building, aerodynamic modifications in building shape,
i.e. an appropriate choice of building form, could moderate wind responses when compared to original building shape

II. OVERVIEW OF WORK

The salient objectives of the present study have been identified as follows:

- A comparative analysis can be done by taking the tall building models and with the different modifications with the given theories.
- To evaluate the effect of corner modification on buildings to resist the wind load.
- To evaluate the effect of setback on a building to resist the wind load
- Also the variations of the results obtained can be analyzed through different examples.
- Compression of tall structure and aerodynamically modify tall structures by software
- Development of a modified formula which will incorporate all the theories their assumptions to give a unified result.

III. LITERATURE REVIEW

Literature based on the modelling of multi-storey building using floating column and transfer beam under seismic behaviour. From the detailed literature review, inference is studied.

Paniagua and García (2015)

The adjoint method is used in this paper for the aerodynamic optimization of the nose shape of a train.
This method has been extensively applied in aircraft or ground vehicle aerodynamic optimization, but is still in progress in train aerodynamics.
Here we consider this innovative optimization method and present its application to reduce the aerodynamic drag when the train is subjected to front wind**.**

Elshaer , Bitsuamlak ,(2016)

In this paper Huge amount of resources is drawn to control loads and vibrations caused by wind.
Large portion of those expenses and materials can be saved by improving the aerodynamic performance of tall buildings. This improvement can be reached by modifying the outer shape of tall buildings locally at the corners or globally over the height and the width of the building.
In the current study, improving the aerodynamic performance of tall buildings is conducted by adopting a recently developed aerodynamic optimization procedure (AOP).

Elshaer et.al.(2017)

Numerical methodology to assess changes in wind load on buildings as a city develops is developed Generic and realistic city topology test cases are presented
Variation of wind-induced risk with the change in urban topology is examined for both the structural and cladding system. Large eddy simulation method is used
examines the change in wind loads on a typical tall building with generic surrounding configuration of different heights.the built environment of the Financial District, Toronto is examined for three development stages
mean wind pressures are reduced while fluctuations are increased as the urban environment becomes denser.

Ahmed Elshaer a, Girma Bitsuamlak b,

Wind is a critical load case in many civil engineering applications including tall buildings. Huge amount of resources is drawn to control loads and vibrations caused by wind. Large portion of those expenses and materials can be saved by improving the aerodynamic performance of tall buildings.
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Neethi B.(2018)

The structures that are man-made are bluff- bodies.During the structural analysis of a tall building, its stability under wind forces is of a major concern. Being a bluff body, the aerodynamic study plays a critical role in the determination of the principal response of a high-rise building to wind forces.Tall buildings can be susceptible excessive motion during wind events that can cause occupant discomfort and reduce the overall appeal of the structure. Further more ,these excessive motions can create high base loads, which can increase the cost of the structure

Ms. Ameena M Ansary1, at al,(2017)

The main objective of the present study is to evaluate the effect of corner modification, setback and stepping on tall buildings. Building models with a constant plan area of 1024 sq.m is considered for corner modification study and an area of 2500 sq.m for studying stepping and setback.

The models are compared in different aspects such as storey drift, storey displacement, column force, beam force, shell force, etc for different modifications

Jiming Xie(2012)

This paper summarizes the aerodynamic approaches that have been used in building design, and discusses the principles and effectiveness of these approaches. To provide a guideline for building aerodynamic optimizations,

this paper proposes an approach of assessing the effects of tapering, twisting and set-back, three common schemes in super-tall building design for wind response reductions with limited wind tunnel tests.

IV. DESCRIPTION OF STRUCTURAL MODEL

s. no	Model mesh	number of elements	Number of nodes
1	*Case-1*	*8945474*	*9107692*
2	*Case-2*	*8470921*	*8865089*
3	*Case-3*	*9098433*	*9163888*
4	*Case-4*	*8870938*	*9088336*

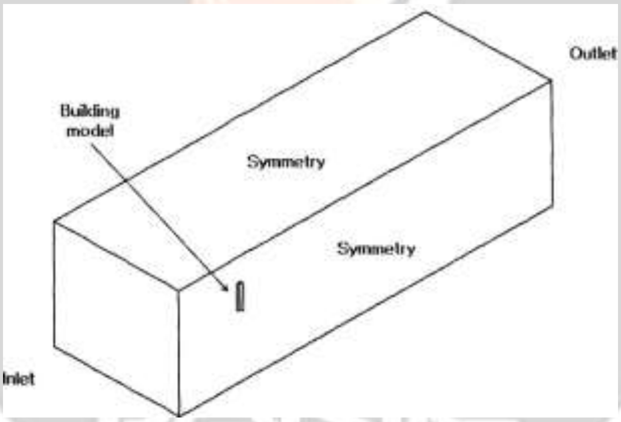
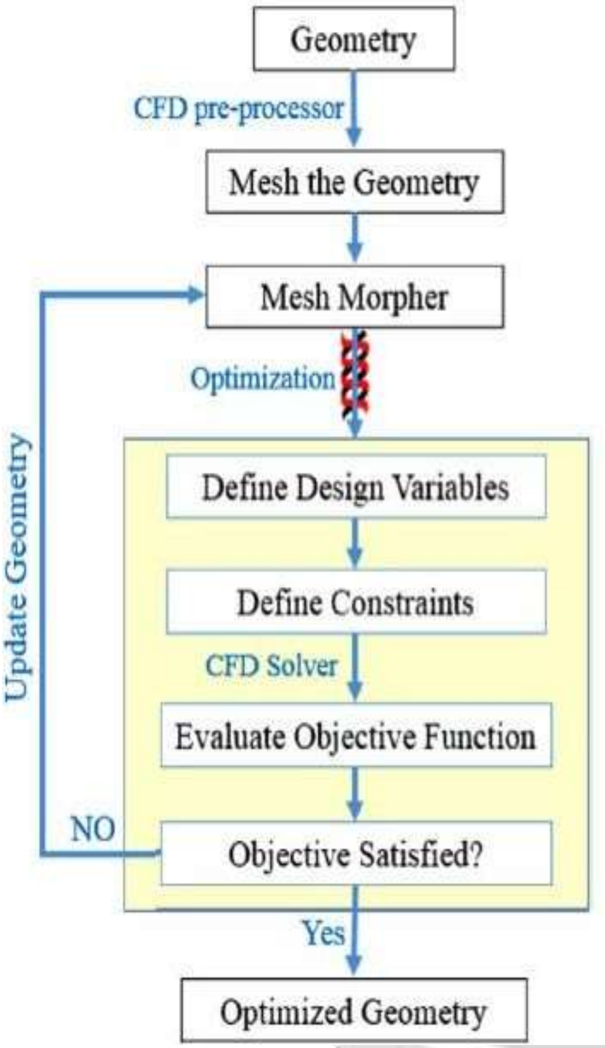


Fig. 4.1:Mess view of structure model

Geometry Detail of building models

Object name	Geometry
State	Fully defined
Types	Design modeller
Length x	310.0m
Length y	57.0m
Length z	110.0m
Volume	1.7137e+006 m3
Parameters	Independent

The domain constructed around the building model is of rectangular shape. It has 180 m length. The domain has 150 m width sideways and a height of 300 m from the base of the building model. The wind velocity applied is 140.4 kmph. The boundary condition applied for the inlet of the domain is velocity inlet and for outlet is out flow condition. All other four faces of the rectangular domain are assigned a wall condition Depth of the beam is kept constant to .02 m and all the other properties remain the same.



V. WORKING FLOW CHART

VI. RESULT

wind force coefficient and wind moment coefficient acting on the wall of each of various models. The reason that wind force coefficient of each model has the mean value of about 0.15 to 0.18 is that a certain force acts on the front face of a building model. As vortices are shed alternatively first from one side and then the other side after the flow develops, the feature that coefficient values fluctuate within certain ranges is shown. Wind force coefficient acting on left and right side of a building model has a mean value of about 0.0. For the force acting on these sides, vortices are shed alternatively to the left and the right side of a model, thereby inducing pressure difference. Like wind force coefficients in the direction of the wind and two sides of a building, wind moment coefficient shows similar patterns.

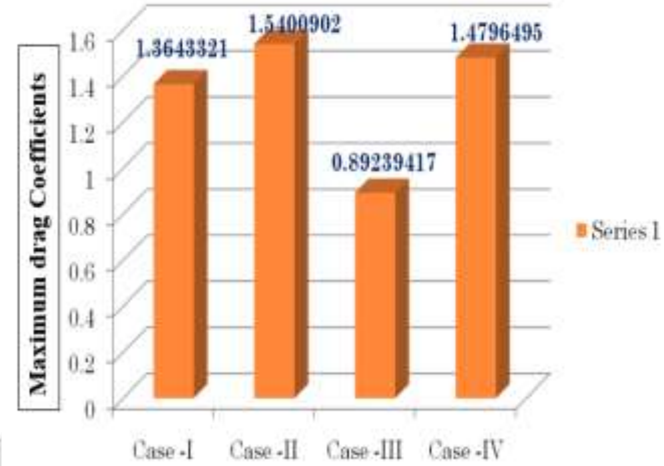


Fig. 6.1: **Variation of drag Coefficients at different height (kN-m)**

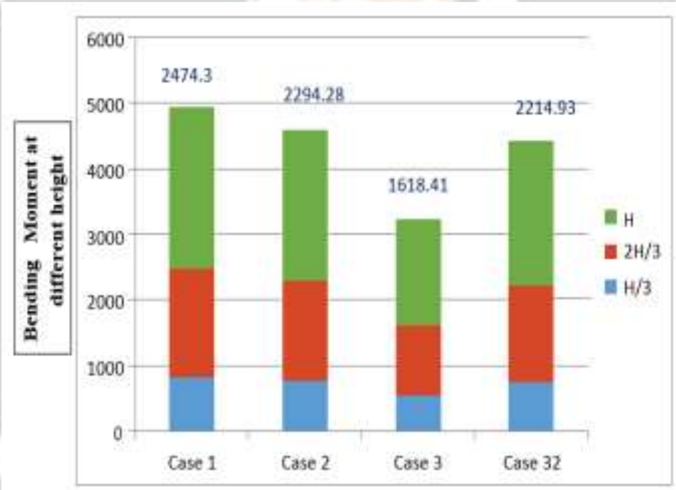


Fig 6.2: **Variation of bending moment at different height (kN-m)**

VIII. CONCLUSION

The following are the main findings of the present study –

- After calculating the factors, it was found that, Case-III (building with tapered faces) all three values are coming minimum such as for case-I Drag coefficient is 0.89239417, drag force is 10789.438 and bending moment is 1618.41
- The effect of increase in length on the frequency is reciprocal in nature as the length increases the value Tall buildings cause accelerated wind at ground level, which may influence the comfort and safety of the pedestrians.
- From the wind engineer's point of view, 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.
- The overall massing of the building and its orientation towards the prevailing wind are critical factors that dictate how much the impact will be.
- Architectural modifications to corner geometry, such as chamfered corners, rounded corners, tapered corner can also significantly reduce wind induced response of buildings.

- From the analysis carried out in the aerodynamic modification of building with rectangular C.S with rounded corners edges have the least drag.
- The study carried out in this paper will be helpful for finding more efficient use of the techniques in Optimization of tall structures for wind loading. of natural frequency decreases in hyperbolic fashion.

IX. SCOPE FOR FUTURE WORK

- In this study four cases has been taken, but there is many more scope to check the study and for more accuracy such as helical, opening etc.
- This study is carried out only for major modification of structure. But, it can also apply for combination of major and minor modification of structures

REFERENCES

1 1. Sanyal, P. and S. K. Dalui (2020). "Comparison of aerodynamic coefficients of various types of Y-plan-shaped tall buildings." Asian Journal of Civil Engineering 21(7): 1109-1127.

2. Nikose, T. J. and R. S. Sonparote (2019). "Dynamic wind response of tall buildings using artificial neural network." The Structural Design of Tall and Special Buildings 28(13): e1657.

3. Baghaei Daemei, A., et al. (2019). "Study on wind aerodynamic and flow characteristics of triangular-shaped tall buildings and CFD simulation in order to assess drag coefficient." Ain Shams Engineering Journal 10(3): 541-548.

4. Hui, Y., et al. (2019). "Characteristics of aerodynamic forces on high-rise buildings with various façade appurtenances." Journal of Wind Engineering and Industrial Aerodynamics 191: 76-90.

5. Kim, B. and K. T. Tse (2018). "POD analysis of aerodynamic correlations and wind-induced responses of two tall linked buildings." Engineering Structures 176: 369-384.

6. Bairagi, A. K. and S. K. Dalui (2018). "Comparison of aerodynamic coefficients of setback tall buildings due to wind load." Asian Journal of Civil Engineering 19(2): 205-221.

7. Li, Y., et al. (2018). "Aerodynamic treatments for reduction of wind loads on high-rise buildings." Journal of Wind Engineering and Industrial Aerodynamics 172: 107-115.

8. Sharma, A., et al. (2018). "Mitigation of wind load on tall buildings through aerodynamic modifications: Review." Journal of Building Engineering 18: 180-194.

9. Lo, Y.-L., et al. (2017). "Effects of aerodynamic modification mechanisms on interference from neighboring buildings." Journal of Wind Engineering and Industrial Aerodynamics 168: 271-287.

10. Dongmei, H., et al. (2017). "Aeroelastic and aerodynamic interference effects on a high-rise building." Journal of Fluids and Structures 69: 355-381.

11. Song, J., et al. (2016). "Aerodynamics of closely spaced buildings: With application to linked buildings." Journal of Wind Engineering and Industrial Aerodynamics 149: 1-16.
12. latively small. It may even be overshadowed by the effects of link-induced structural coupling.

13. Aly, A.-M. and J. Bresowar (2016). "Aerodynamic mitigation of wind-induced uplift forces on low-rise buildings: A comparative study." Journal of Building Engineering 5: 267-276.

14. Kim, W., et al. (2015). "Interference effects on aerodynamic wind forces between two buildings." Journal of Wind Engineering and Industrial Aerodynamics 147: 186-201.

15. Xie, J. (2014). "Aerodynamic optimization of super-tall buildings and its effectiveness assessment." Journal of Wind Engineering and Industrial Aerodynamics 130: 88-98.

16. Bandi, E. K., et al. (2013). "Experimental investigation on aerodynamic characteristics of various triangular-section high-rise buildings." Journal of Wind Engineering and Industrial Aerodynamics 122: 60-68.

17. Tanaka, H., et al. (2012). "Experimental investigation of aerodynamic forces and wind pressures acting on tall buildings with various unconventional configurations." Journal of Wind Engineering and Industrial Aerodynamics 107-108: 179-191.

18. Amin, J. A. and A. K. Ahuja (2010). "AERODYNAMIC MODIFICATIONS TO THE SHAPE OF THE BUILDINGS:A REVIEW OFTHE STATE-OF-THE-ART." ASIAN JOURNAL OF CIVIL ENGINEERING (BUILDING AND HOUSING) 11(4): 433-450.

19. Kim, Y. and J. Kanda (2010). "Characteristics of aerodynamic forces and pressures on square plan buildings with height variations." Journal of Wind Engineering and Industrial Aerodynamics 98(8): 449-465.

20. Tamura, Y., et al. (2010). Aerodynamic Characteristics of Tall Building Models with Various Unconventional Configurations. Structures Congress 2010: 3104-3113.

21. Kim, Y.-M., et al. (2008). "Across-wind responses of an aeroelastic tapered tall building." Journal of Wind Engineering and Industrial Aerodynamics 96(8): 1307-1319.

22. Gu, M. and Y. Quan (2004). "Across-wind loads of typical tall buildings." Journal of Wind Engineering and Industrial Aerodynamics 92(13): 1147-1165.

23. Cheng, C. M., et al. (2002). "Acrosswind aerodynamic damping of isolated square-shaped buildings." Journal of Wind Engineering and Industrial Aerodynamics 90(12): 1743-1756.

24. Kim, Y.-M. and K.-P. You (2002). "Dynamic responses of a tapered tall building to wind loads." Journal of Wind Engineering and Industrial Aerodynamics 90(12): 1771-1782.

25. Hayashida, H. and Y. Iwasa (1990). "Aerodynamic shape effects of tall building for vortex induced vibration." Journal of Wind Engineering and Industrial Aerodynamics 33(1): 237-242.