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IMPACT OF WIND EXPOSURE ON CONSTRUCTION COSTS IN BANGLADESH: A COMPARATIVE STUDY OF BNBC 2020 PROVISIONS

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Abstract

Bangladesh frequently faces devastating tropical cyclones due to its geographical location. The Bangladesh National Building Code (BNBC) 2020 introduces specific wind exposure provisions to ensure structural safety and resilience against high winds. These provisions define critical design parameters, including wind speeds, topographic factors, and importance levels, based on geographical conditions. This study investigates the impact of BNBC 2020 wind exposure provisions on the construction costs of high-rise buildings. Using ETABS 2016, three 15-story dual-system RCC buildings were analyzed under varying wind exposure categories, with uniform earthquake provisions. Results revealed significant cost variations, with material requirements increasing by up to 22% in higher wind exposure categories. This research contributes valuable insights into the relationship between wind exposure provisions and construction costs, aiding stakeholders in optimizing structural designs and budgets for cyclone-prone regions like Bangladesh.

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Introduction:-

Urbanization and population growth in Bangladesh have created a growing demand for high-rise buildings, particularly in densely populated and land-constrained areas like Chittagong. These structures efficiently utilize limited land but also face significant challenges from lateral wind loads and wind-induced forces. As building height increases, so does the sensitivity to wind loads, requiring meticulous analysis to ensure cost-effectiveness and safety. Structural engineers are tasked with selecting appropriate components to resist lateral forces while adhering to reliability, serviceability, and occupant comfort standards.

High-rise structures in Bangladesh must also withstand natural disasters, such as cyclones, which are frequent due to the country's geographical location. The Bangladesh National Building Code (BNBC) 2020 introduces wind speed categorizations and exposure classifications based on zones, terrain types, and local conditions. These provisions account for factors such as gust impacts, internal pressures, and topographic influences to calculate design wind pressures. Using ETABS 2016, this study analyzes multiple wind exposure scenarios within the same seismic zone near Chittagong.

While many civil engineers are trained in linear analysis, designing wind-resistant buildings demands specialized expertise to understand complex structural behavior under varying lateral and axial loads. Previous research has compared building codes and evaluated high-rise performance under diverse wind speeds, but limited studies have addressed the specific impacts of BNBC 2020's wind exposure classifications on structural components and associated costs.

The primary objective of this study is to identify variations in structural component sizes, reinforcement requirements, and construction costs resulting from different wind exposure categories as defined by BNBC 2020. By bridging this knowledge gap, the study aims to provide valuable insights and recommendations for engineers and stakeholders to design cost-effective, resilient high-rise buildings tailored to Bangladesh's unique wind exposure conditions.

Literature Review:-

While numerous studies have examined various aspects of wind loads, there is a notable lack of research focused on the cost estimation of building materials influenced by wind loads in Bangladesh.

Faysal (2014) conducted a comparative study of BNBC 1993, BNBC 2010, NBC-India-2005, IBC 2009, and ASCE 7-05, evaluating wind loads using factored general wind pressure. The findings revealed that BNBC 2010's wind load provisions for urban areas (Exposure A) are marginally higher than those of BNBC 1993. Conversely, in obstructed and unobstructed open terrain areas (Exposures B and C), BNBC 2010's wind load values are significantly lower than BNBC 1993. Moreover, BNBC 2010's provisions are comparable to ASCE 7-05 and slightly less conservative than IBC 2009. For urban and obstructed terrains, NBC-India-2005 emerged as the most conservative, whereas BNBC 1993 exhibited the highest conservatism for unobstructed open terrains.

Masum, Akter, Hossen, and colleagues (2018) evaluated the wind load provisions in BNBC 1993 and the proposed BNBC 2015. Their study assessed parameters such as basic wind speed, height and exposure coefficients, gust factors, sustained wind stresses, external stress coefficients, and design wind stresses. The results highlighted that BNBC 2015's wind load provisions for urban areas are significantly higher compared to BNBC 1993, whereas, for obstructed and unobstructed terrains, the wind loads are considerably lower.

Verma (2016) conducted a comparative analysis of building responses to wind loads using wind loading codes from four countries: Japan (AIJ-RLB-2004), India (IS 875-3), Hong Kong (CP-2004), and New Zealand (AS/NZS1170.2:2002). The study focused on a 200-meter tall square building subjected to static wind loads and compared parameters such as design wind stresses at varying heights, gust factors, base shear, and base bending moments. The findings underscored significant differences in outcomes among these codes, with Indian standards exhibiting unique design requirements.

Sarothi, Akter, Amanat, and colleagues (2019) explored the variations in the design and analysis of RC frame structures in high seismic and wind zones, specifically in Chattogram, Bangladesh. Utilizing finite element analysis (FEA) with both older and newer building codes, the study revealed that newer codes typically resulted in less economically efficient designs due to higher safety margins. However, these designs offered enhanced resilience compared to those adhering to older codes.

The BNBC 2020 divides Bangladesh into three wind exposure categories—A, B, and C—based on ground surface roughness, which is determined by natural topography, vegetation, and constructed facilities. As illustrated in **Figure 1: Basic Wind Speed Map**, the country is categorized into zones with varying wind speeds and exposures. For each wind direction considered, the upwind exposure category is evaluated for two upwind sectors extending 45 degrees on either side of the selected wind direction.

Ground surface roughness is further categorized to define exposure conditions. Surface Roughness A includes urban and suburban areas, wooded regions, or terrains with closely spaced obstructions, such as single-family dwellings or larger structures. Surface Roughness B covers open terrains with scattered obstructions of heights generally less than 9.1 meters, including flat open country, grasslands, and water surfaces in cyclone-prone regions. Surface Roughness C represents flat, unobstructed areas and water surfaces outside cyclone-prone zones, such as smooth mudflats and salt flats.

Based on these surface roughness categories, the three exposure classifications are defined. Exposure A applies where Surface Roughness A conditions prevail for a distance of at least 792 meters or 20 times the building's height, whichever is greater. For buildings with a mean roof height of 9.1 meters or less, the upwind distance can be reduced to 457 meters. Exposure B serves as the default classification when neither Exposure A nor Exposure C applies. Exposure C is applicable where Surface Roughness C conditions prevail for a distance greater than 1,524 meters or 20 times the building height, whichever is greater. Exposure C also extends into downwind areas of Surface Roughness A or B for 200 meters or 20 times the building height, whichever is greater. In transitional zones, the category resulting in the largest wind forces is used, although intermediate exposures may be determined through a rational analysis based on recognized literature.

The classification of exposure categories is crucial for designing the Main Wind-Force Resisting System (MWFRS). For buildings and other structures, wind loads for the MWFRS are determined according to the relevant exposure category for each wind direction. For low-rise buildings, wind loads are calculated using velocity pressure coefficients corresponding to the exposure category that produces the highest wind forces at the site.

The Building Frame System, which provides resistance to both gravity and lateral loads, plays a central role in structural integrity. These systems can include shear walls, braced frames, moment-resisting frames, dual systems, and special structural systems. Each system is designed to ensure the stability of buildings under the influence of wind forces, contributing to both safety and serviceability.

Methodology:-

The study aims to assess the impact of wind load on the analysis results and required construction materials for a 150-foot-tall structure in three different exposures in Bangladesh. It considers key design criteria, including structural dimensions, material properties, and loads, such as dead loads, live loads, floor finish loads, partition wall loads, and wind loads, based on a clayey sand (SC) soil profile, concrete compressive strength of 4000 psi, and steel yield stress of 60,000 psi. Load combinations are applied following BNBC-2020 standards to analyze variations in member sizes and reinforcements. Moment-resisting frames are adopted as the structural system for their efficiency in resisting lateral loads. Horizontal deflection due to wind loading is evaluated using the load combination D + 0.5L + 0.7W to ensure serviceability. Stability checks are conducted to verify equilibrium, component sizes, and reinforcements, ensuring the structure's safety under varying wind conditions. The models, developed for 150-foot-tall moment-resisting frame structures with uniform dimensions, are analyzed using ETABS software, which is employed for detailed structural analysis and design. Supporting figures generated in ETABS 2016, such as the plan, column layout, front elevation, and 3D visualization, illustrate the results effectively.

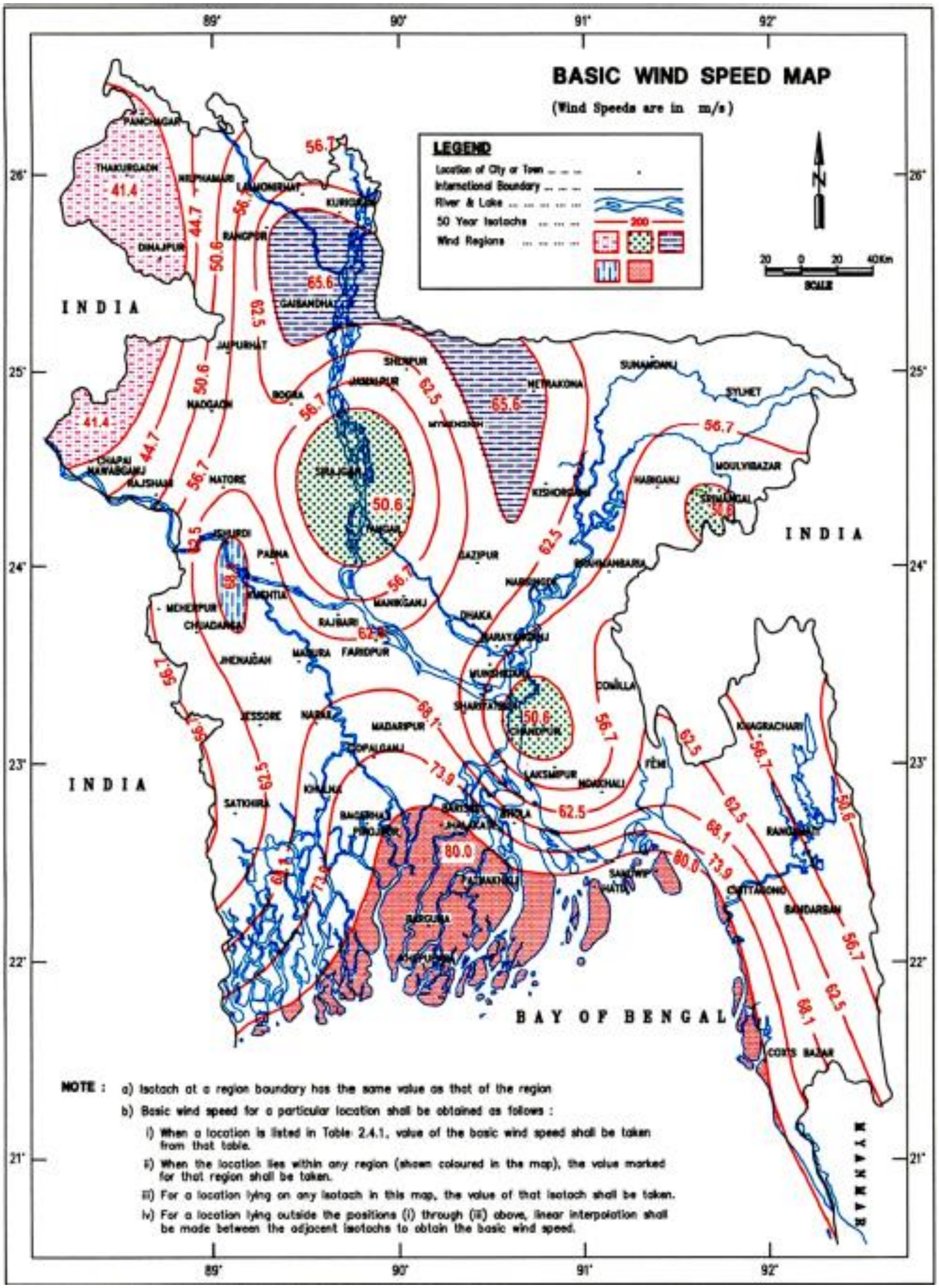


Fig. 1:- Basic wind speed map (BNBC, 2020).

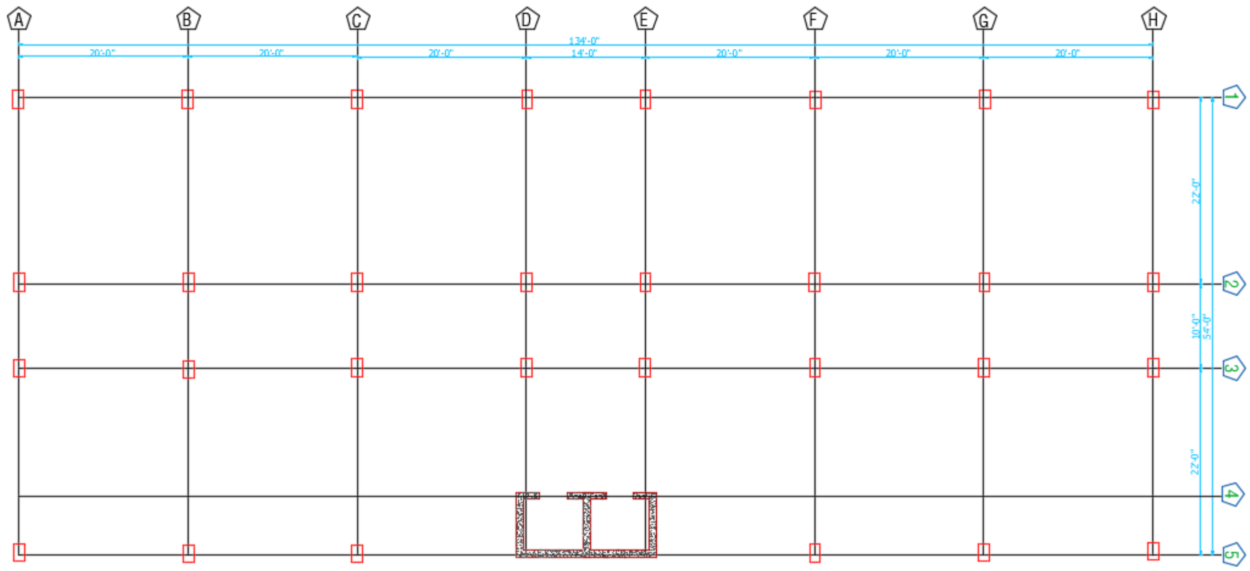


Fig. 2:- Plan of selected structure. (ETABS 2016).

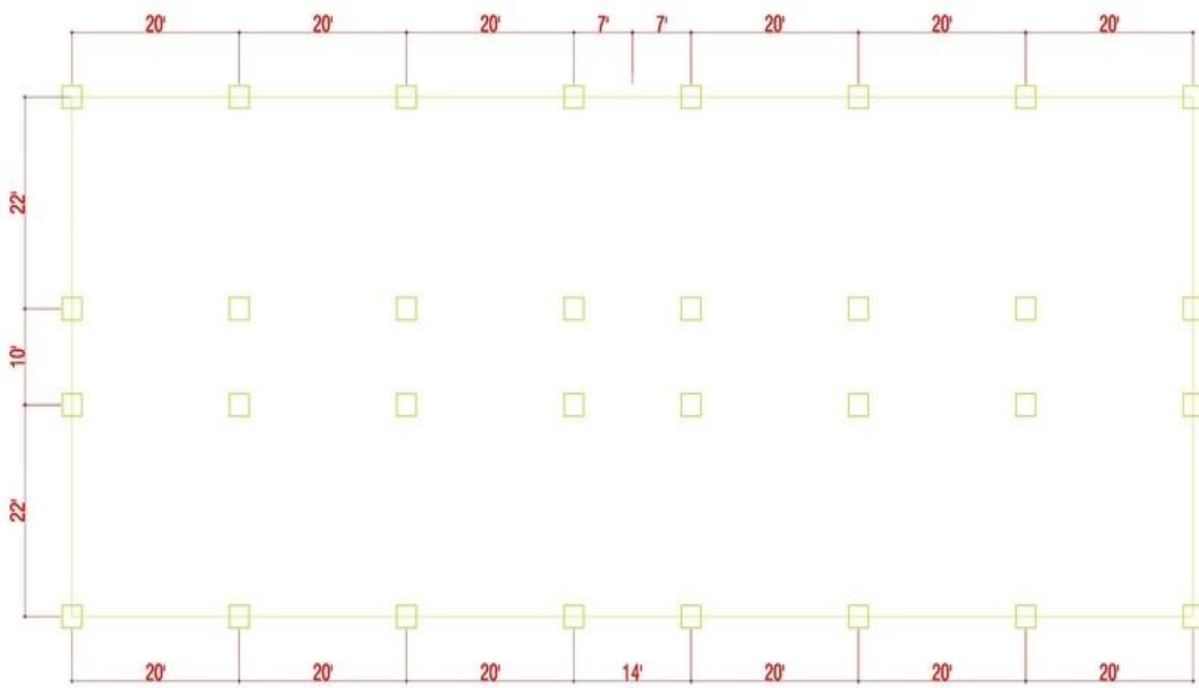


Fig. 3:- Column layout of selected structure. (ETABS 2016).

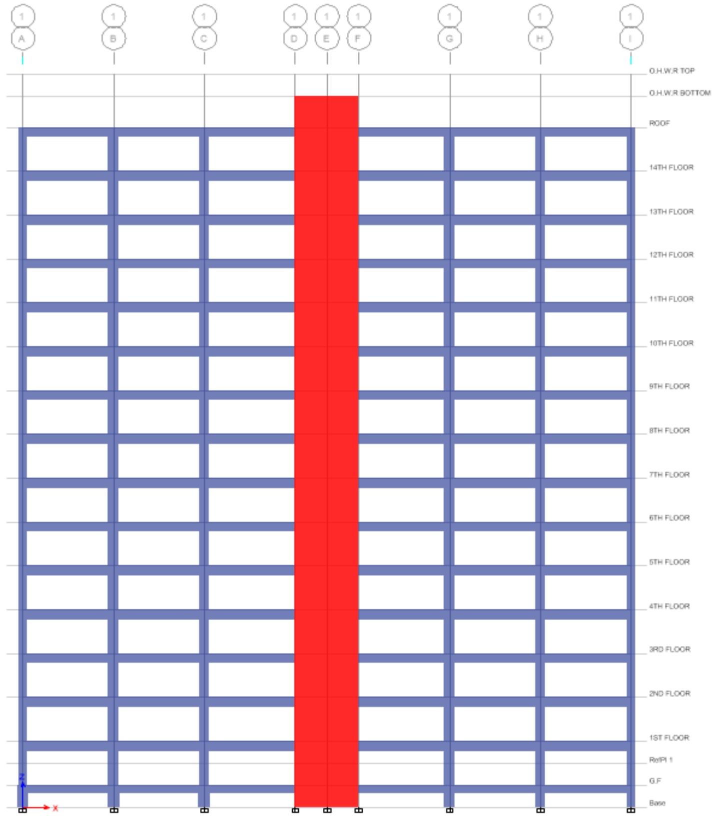


Fig. 4:- Front elevation of selected (150ft. height) structure (ETABS 2016).

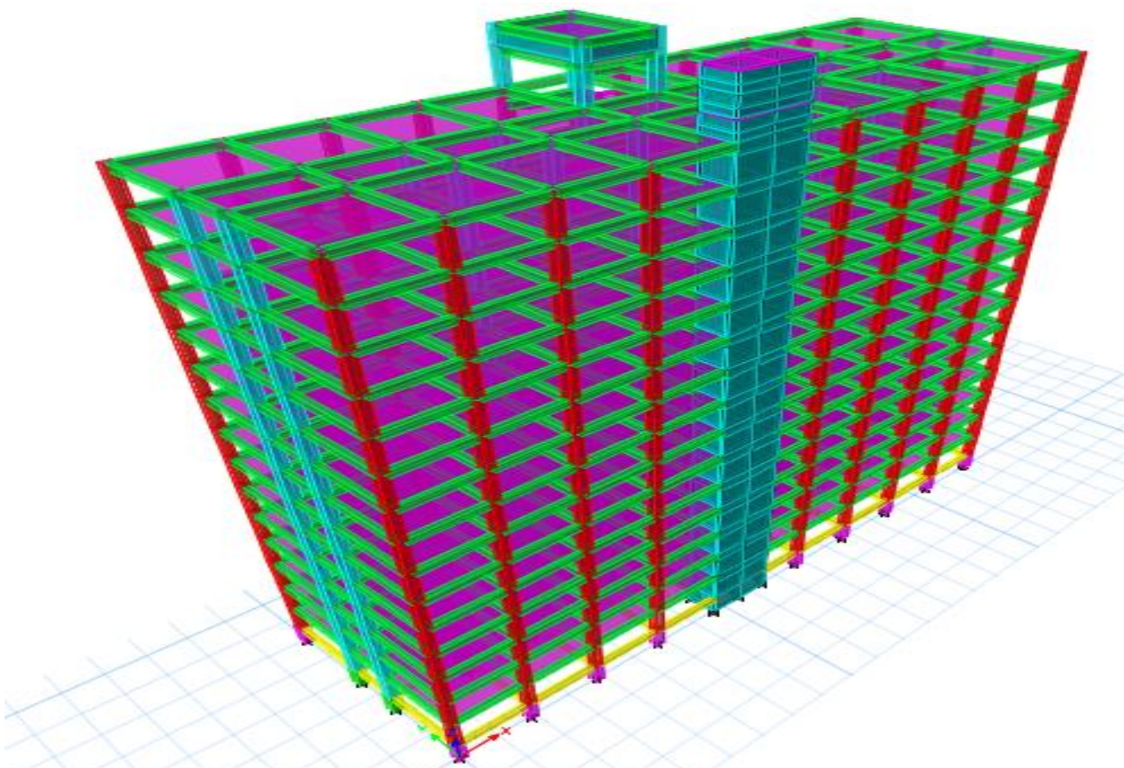


Fig. 5:- 3D of selected (150ft. height) structure (ETABS 2016).

Result and Discussion:-

Three 150-foot-tall buildings in varied Bangladeshi exposures were examined and developed as part of the study. The needed reinforcement, component size, and tale displacement were compared. Seismic loads in accordance with BNBC 2020 were taken into account. The cost differences between exposures, the storied deflection, component size, and the number of reinforcements needed per square inch of the structure were also compared in the results. The maximum base shares in the X and Y directions are as follows: A - 521kip (X) and 1580kip (Y), B - 668kip (X) and 1886kip (Y), and C - 754kip (X) and 2283kip (Y). Figure 6 shows the total base share for lateral loads in exposures A, B, and C.

Total reaction of a corner column in three different exposures A, B & C are 7.15kip, 12.4kip & 14.3kip in X direction and 2.24kip, 3.4kip and 4.3kip in Y direction respectively. (Shown in the figure 7) On the other hand moment also sharply increase with respect to exposure A, B & C are 20 kip/ft, 35.7kip/ft & 37.9 kip/ft.

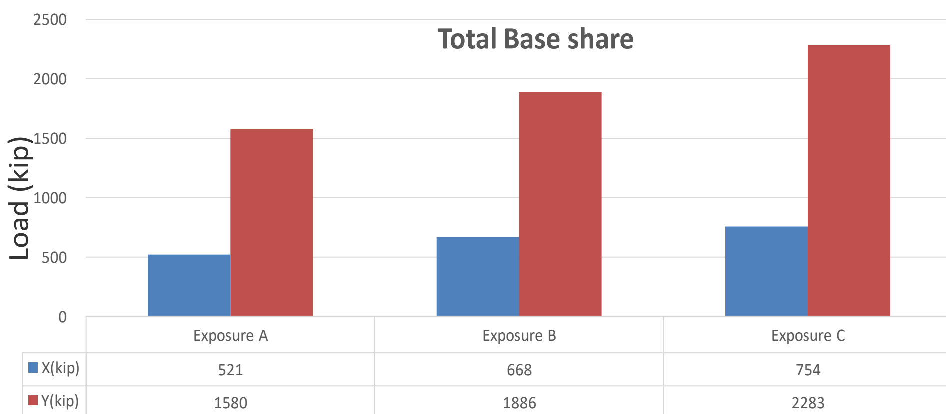


Fig. 6:- Total base share for three different exposures.

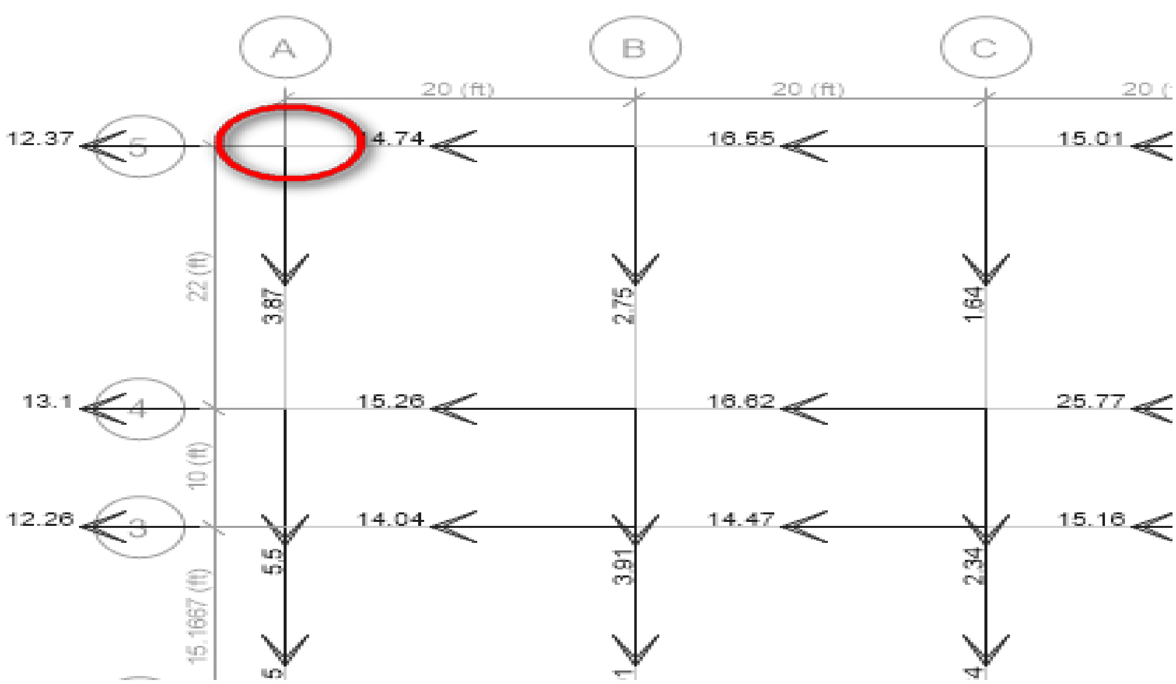
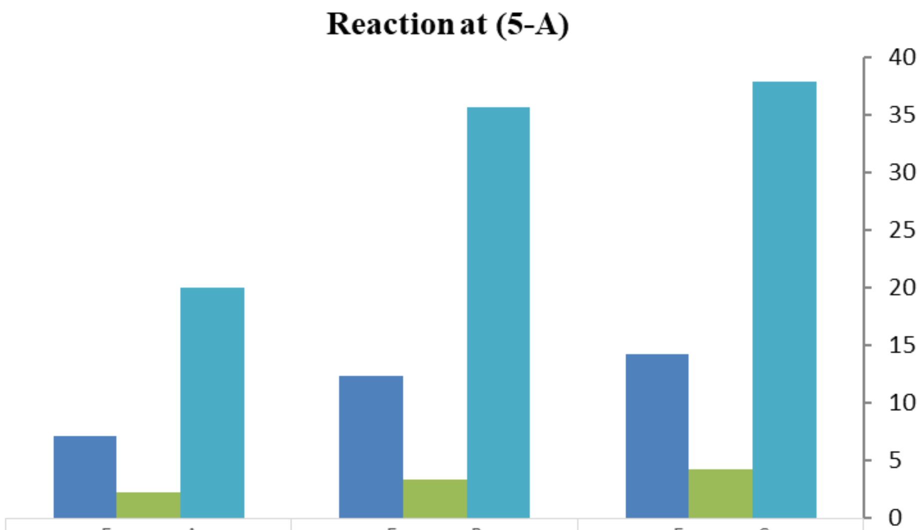


Fig. 7:- Reaction at (5-A).



	Exposure A	Exposure B	Exposure C
X(kip)	7.15	12.4	14.3
Y(kip)	2.24	3.4	4.3
Moment (k/ft)	20	35.7	37.9

Fig. 8:- Reaction (Corner column) for three different exposures.

Total reaction of a centre column in three different exposures A, B & C are 11.60 kip, 14.5 kip &16.8 kip in X direction and 2.07 kip, 2.3 kip and 2.5 kip in Y direction respectively. (Shown in figure 9) On the other hand moment also sharply increase with respect to exposure A, B & C are 19 kip/ft., 20.3 kip/ft. & 21.5 kip/ft.

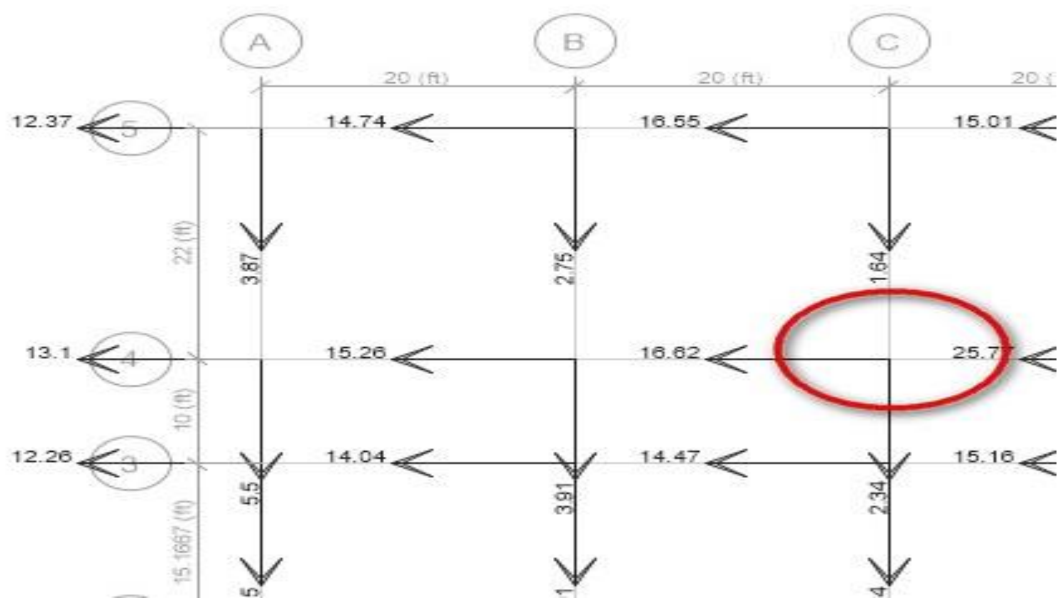


Fig. 9:- Reaction at (4-C).

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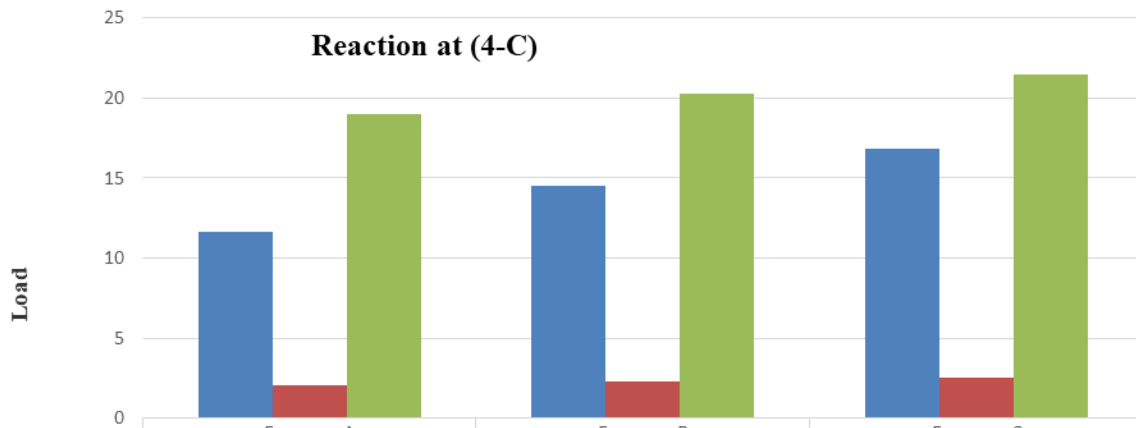

	Exposure A	Exposure B	Exposure C
X(kip)	11.6	14.5	16.8
Y(kip)	2.07	2.3	2.5
Moment (k/ft)	19	20.3	21.5

Fig. 10:- Reaction (Centre column) for three different exposures.

Storied Deflection

Storied deflection for lateral loads in three exposures is shown in Figure 11 for A, B & C exposure. Allowable displacement (L/500) due to lateral loads is also too compared with actual displacements in three different exposures. The maximum story displacements of this building in different exposure A, B&C are 2.37 inch, 2.32 inch and 2.30 inch respectively. It's found that the story deflection of this building due to wind load are 2.1%, 0.86%, more than exposure A in exposure B and exposure C respectively in three wind exposure of Bangladesh. It is found that the deflection at different exposure due to lateral loads is less than its allowable limits for three wind exposure.

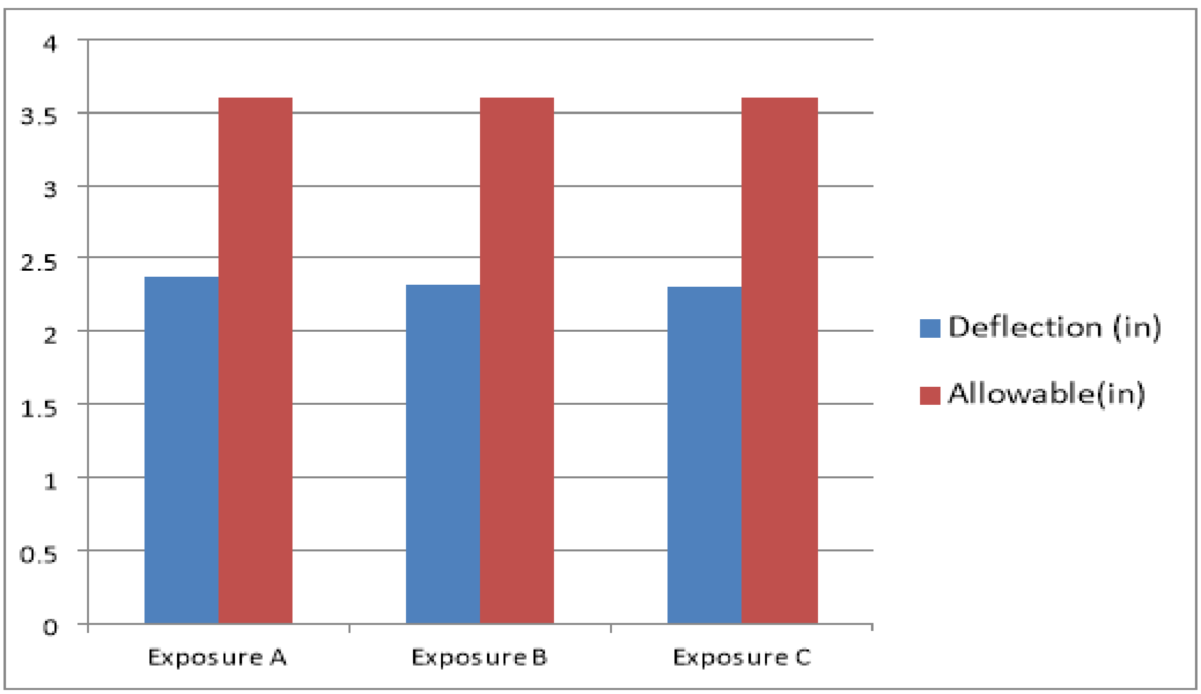

Fig. 11:- Stories deflection for three exposures.

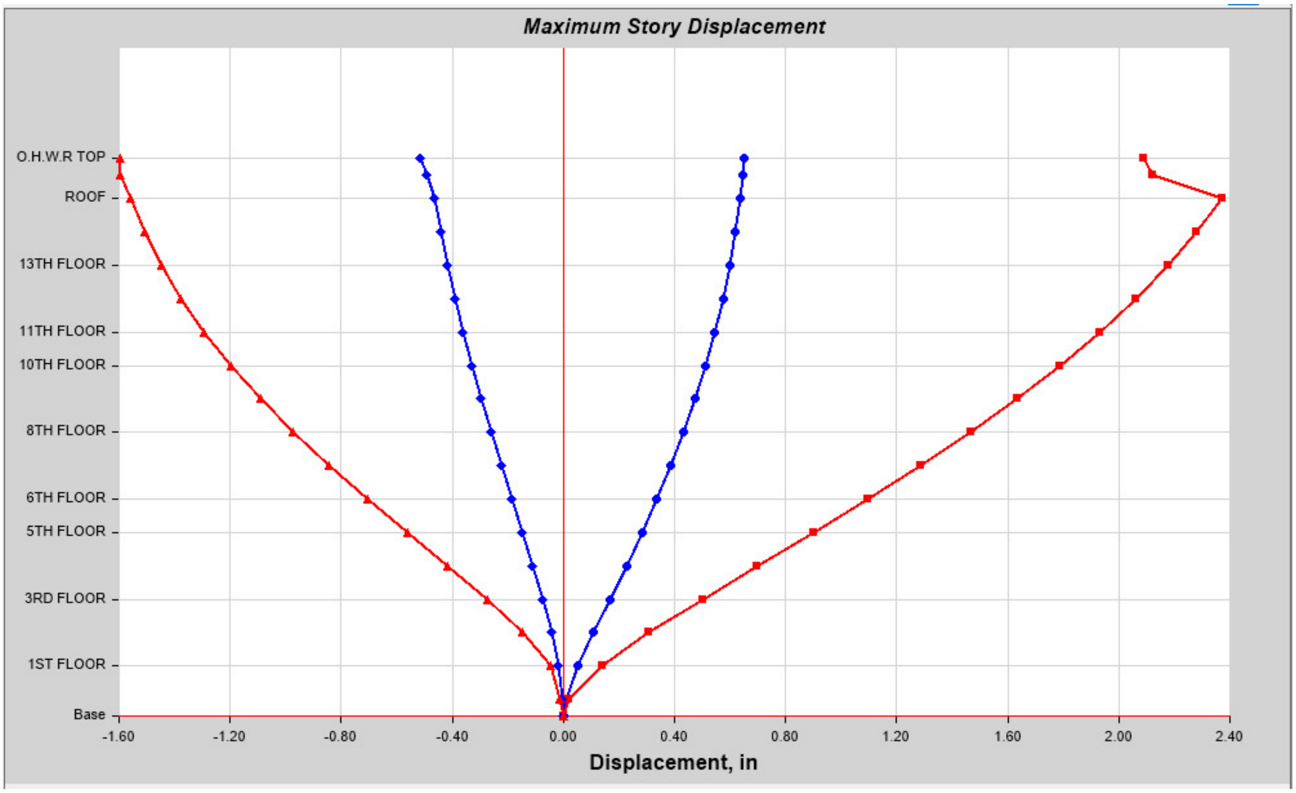

Fig. 12:- Maximum story displacement.

Column Size

Different size of column shows bellow the table,where total number of column in different three exposure is same but same size not applicable in different exposure.Table 1 shows 24''x24'' column size needed 04 numbers in exposure A,but that size not applicable in others two exposure,on the other hand 30''x 30'' column size needed 10 numbers in exposure A,but the same size column 14 numbers needed for other two exposures.

Table 1:- Different column size and number for three exposures.

Column size	Exposure A	Exposure B	Exposure C
	Number of columns	Number of columns	Number of columns
24''x 24''	4 No's	Not Applicable	Not Applicable
28''x 28''	14 No's	14 No's	14 No's
30''x 30''	10 No's	14 No's	14 No's
33''x 33''	2 No's	2 No's	2 No's

Column Reinforcement (Corner Column)

Table 2 shows the reinforcement area (in2) of a corner column (5-A) is 7.29 squre inch,12.69 squre inch, & 14.99 squre inch in three different exposure respectively and reinforcement increase 42.55% and 51.36% more then exposure A in exposure B and exposure C respectively.

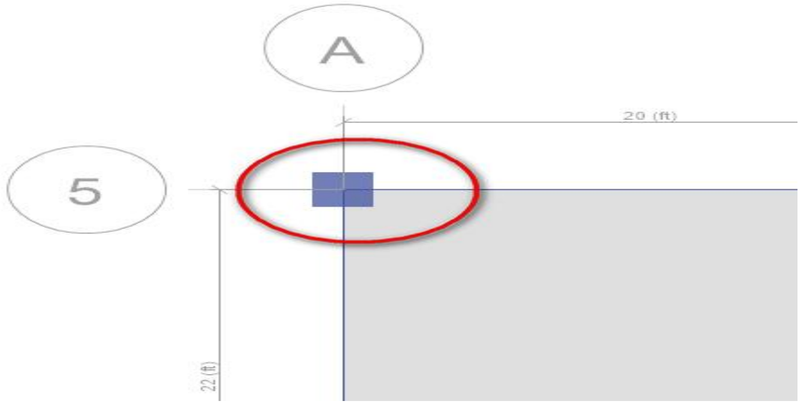

Fig.13:- Corner column (5-A).

Table 2:- Different column reinforcement for three exposures.

Location	Exposure	Exposure A	Exposure B	Exposure C
Corner (5-A)	Column Size(inch)	24x24	28x28	28x28
	Reinforcement (in2)	7.29	12.69	14.99
	Reinforcement Increase (%)	---	42.55	51.36

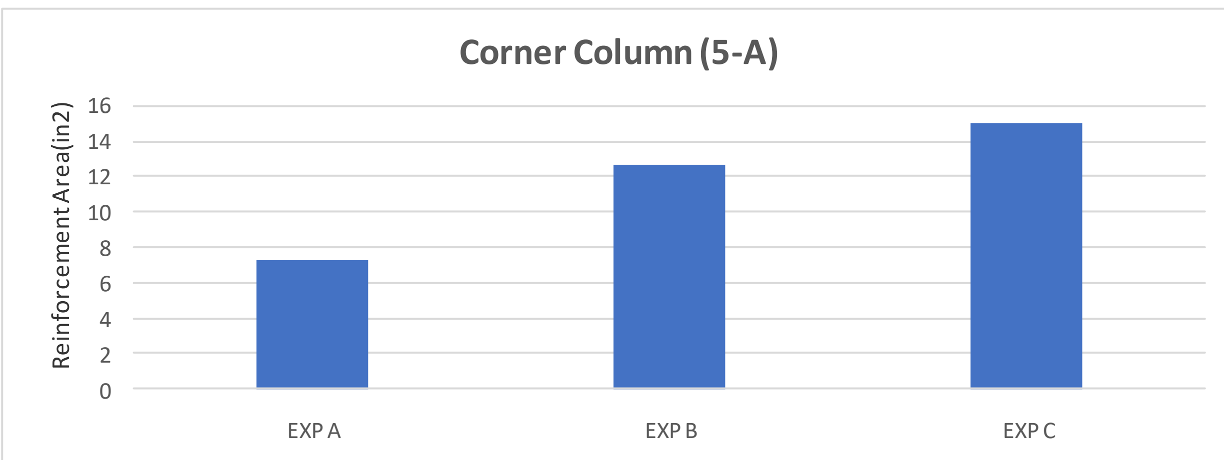

Fig. 14:- Different column reinforcement area for three exposures.

Column Force (Corner Column)

Figure 15 shows different force (kip) for a corner column (5-A) is 651.35 kip,727.96 kip and 746 kip in three different exposure respectively and the force increase 10.52% and 12.68% more then exposure A in exposure B and exposure C respectively.

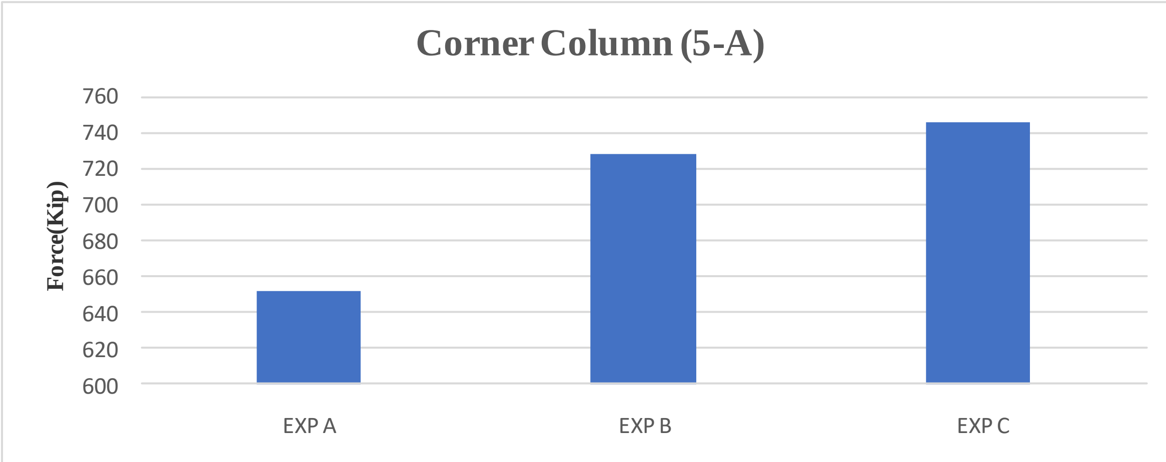

Fig. 15:- Different column force for three exposures.

Column Reinforcement (Center Column)

Table 3 shows the reinforcement area (in2) of a center column (4-C) is 10.89 squre inch,17.31 squre inch, & 22.38 squre inch in three different exposure respectively and reinforcement increase 37.09% and 51.34% more then exposure A in exposure B and exposure C respectively

Table 3:- Different column reinforcement for three exposures

Location	Exposure	Exposure A	Exposure B	Exposure C
Center (4-C)	Column Size	30X30	30X30	30X30
	Reinforcement (in2)	10.89	17.31	22.38
	Reinforcement Increase (%)	-	37.09	51.34

Table 3 Different column reinforcement for three exposures

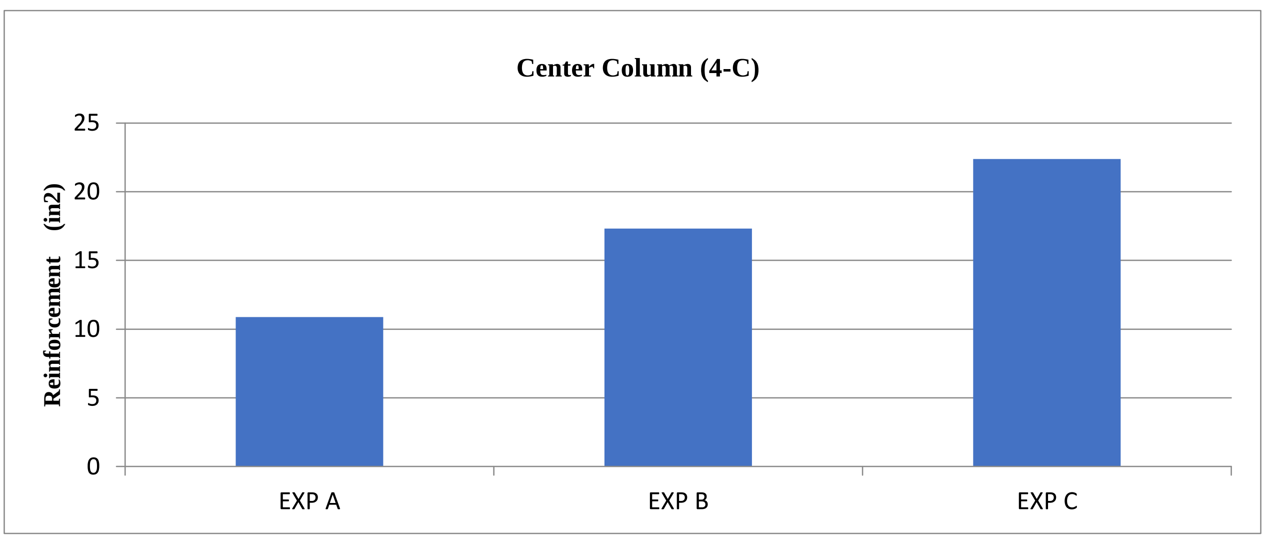

Fig.16:- Different column reinforcement area for three exposures.

Column Force (Center Column)

Figure 17 shows different force (kip) for a center column (4-C) is 1504.82 kip,1533.54 kip and 1546.46 kip in three different exposure respectively and the force increase 1.87% and 2.70% more then exposure A in exposure B and exposure C respectively.

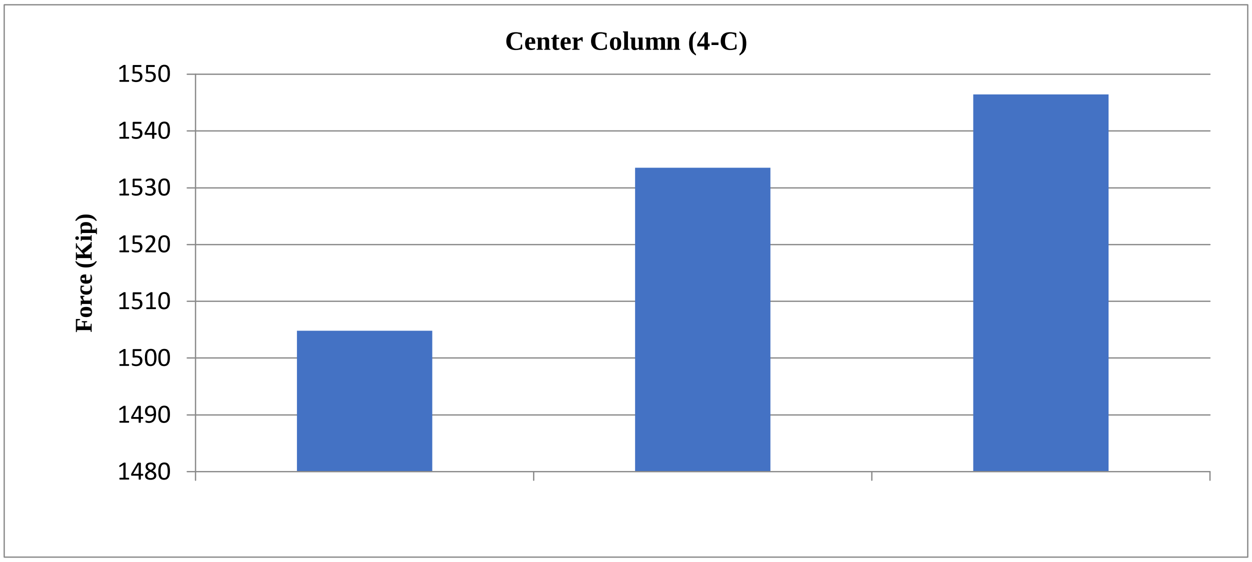

Fig. 17:- Different column force for three exposures.

Beam Size

Different size of floor beam shows bellow the table 4,where same size not applicable in different exposure.Table shows Grid (3-4) beam size is 18’’X28’’ in exposure A,24’’X36’’ in exposure B and 25’’X 40’’ in exposure C .

Floor Beam size	Exposure A	Exposure B	Exposure C
Grade Beam	15" x 24"	15" x 24"	15" x 24"
Grid 3-4	18" x 28"	24" x 36"	25" x 40"
Other	15" x 28"	15" x 30"	15" x 32"

Table 4:- Different beam size for three exposures.

Beam Reinforcements(Grid-3)

Table 5shows the variation of reinforcement on Grid-3 in different three exposures. Maximum positive reinforcement is 1.29 squre inch, 1.4 squre inch, & 1.41 squre inch in three different exposure respectively and reinforcement increase 7.85% and 8.5% more then exposure A in exposure B and exposure C respectively.

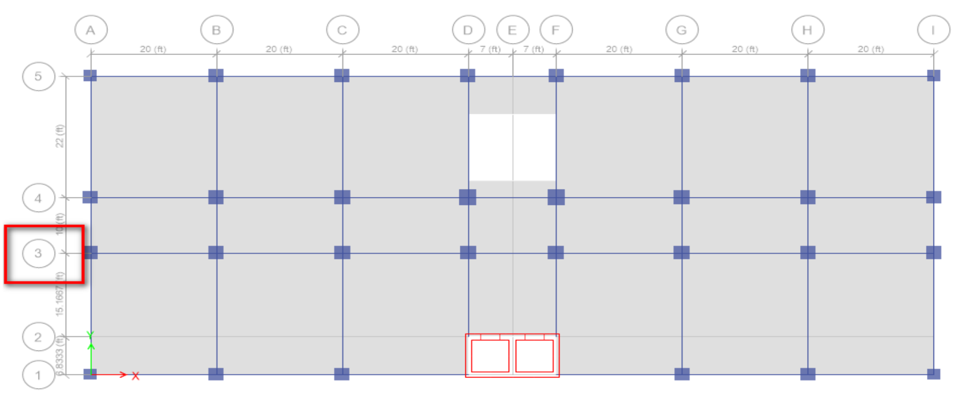

Fig. 18:- Beam reinforcement at Grid-3.

On the other hand, maximum negative reinforcement is 2.01 squre inch, 2.04 squre inch, & 2.03 squre inch in three different exposure respectively and reinforcement increase 1.5% and 0.98% more then exposure A in exposure B and exposure C respectively.

Table 5:- Different reinforcement for three exposures.

Location		**Exposure**	**Exposure A**	**Exposure B**	**Exposure C**
Grid 3	Flexure	Max "+" Reinforcement	1.29	1.4	1.41
		Max "-" Reinforcement	2.01	2.04	2.03
	Stirrup		2 leg 10 mm @ 4"	2 leg 10 mm @ 4"	2 leg 10 mm @ 4"

Beam Reinforcements(Grid-C)

Table 6 shows the variation of reinforcement on Grid-C in different three exposures. Maximum positive reinforcement is 3.9 square inch, 4.10 square inch, & 4.61 square inch in three different exposures respectively and reinforcement increase 4.87% and 15.4% more than exposure A in exposure B and exposure C respectively.

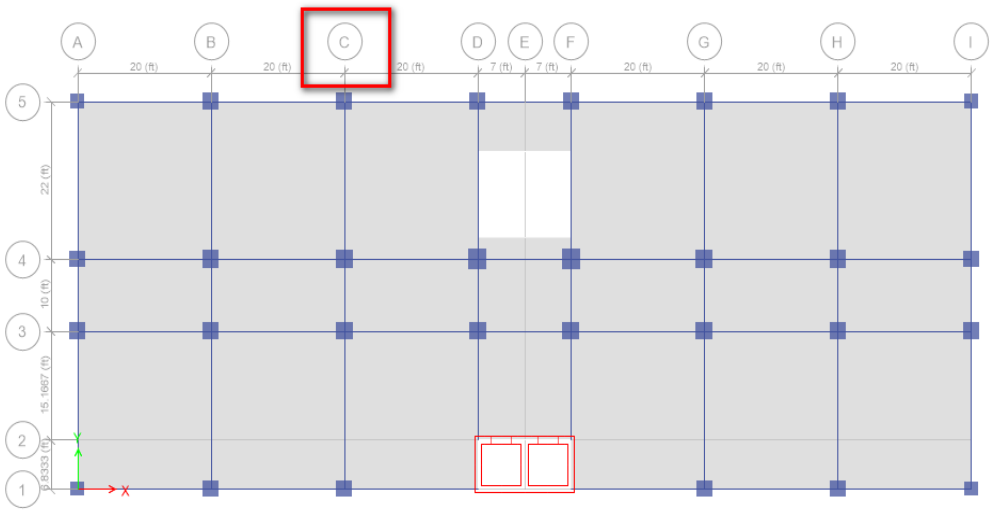

Fig. 19:- Beam reinforcement at Grid-C.

On the other hand, maximum negative reinforcement is 4.15 squre inch, 4.45 squre inch, & 4.97 squre inch in three different exposure respectively and reinforcement increase 6.74% and 16.5% more then exposure A in exposure B and exposure C respectively.

Location		Exposure	Exposure A	Exposure B	Exposure C
Grid C	Flexure	Max "+" Reinforcement	3.9	4.1	4.61
		Max "-" Reinforcement	4.15	4.45	4.97
	Stirrup	Grid 1-3, 4-5	3 leg 10 mm @ 4"	3 leg 10 mm @ 4"	2 leg 12 mm @ 4"

Table 6:- Different reinforcement for three exposures.

Shear wall Reinforcements

Same size is considered for shear wall in all exposures. Reinforcement is nearly same for higher exposure because of increased framing system.

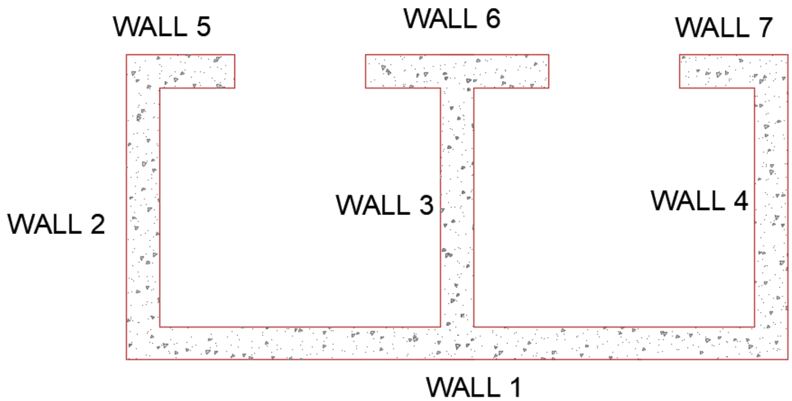

Fig. 20:- Shear Wall.

Cost Variation (Considering LGED 2018-19 rate schedule for the cost variation)

Location	**Exposure**	**Exposure A**	**Exposure B**	**Exposure C**
Center (4-C)	Column Size	30X30	30X30	30X30
	Reinforcement (Ton)	3.02	5.62	6.67
	Reinforcement Increase (%)	-	46.21	54.32
	Cost(tk)	3.06 Lac	5.69 Lac	6.75 Lac
	Cost Increase (%)	-	46.26	54.72

Table 7:- Different weight of reinforcement for three exposures.

Total required weight of reinforcement for center column (4-C) at exposure B and C is 2.60 ton and 3.65 ton more than exposure A.

Location	Exposure	Exposure A	Exposure B	Exposure C
Corner (5-A)	Column Size	24X24	28X28	28X28
	Reinforcement (Ton)	1.7	2.3	2.9
	Reinforcement Increase (%)	-	26.28	42.67
	Cost(tk)	1.72 Lac	2.33 Lac	2.94 Lac
	Cost Increase (%)	-	26.07	41.37

Table 8:- Different weight of reinforcement for three exposures.

Total required weight of reinforcement for corner column (5-A) at exposure B and C is 0.60 ton and 1.20 ton more than exposure A

Location	Exposure	Exposure A	Exposure B	Exposure C
Side A(1-5)	Beam Size	15x28	15X30	15X32
	Reinforcement (Ton)	0.36	0.51	0.55
	Reinforcement Increase (%)	-	29	34
	Cost(tk)	0.36 Lac	0.51 Lac	0.55 Lac
	Cost Increase (%)	-	29.41	34.55

Table 9:- Different weight of reinforcement for three exposures.

Total required weight of reinforcement for side beam A (1-5) at exposure B and C is 0.15 ton and 0.19 ton more than exposure A

Conclusion:-

The design of buildings, particularly high-rise structures, requires civil engineers to integrate wind resistance into their analysis and design processes. While linear analysis remains the foundation of their education, engineers must evaluate wind forces to understand the behavior of structures under lateral and axial stresses, especially as buildings become taller and more exposed. Ensuring occupant comfort at higher levels necessitates careful selection of load-bearing components and strict adherence to reliability and serviceability standards under challenging wind conditions.

Buildings in Bangladesh must also withstand natural disasters such as cyclones. The 2020 Bangladesh National Building Code (BNBC) provides guidelines for determining fundamental wind speeds based on geographic zones by considering factors such as structural importance, exposure, topography, directionality, and wind speed. Design wind pressures are established by incorporating gust effects, external and internal pressure coefficients, and adjustments for roof slope, vegetation, and the built environment.

This study utilizes the finite element software ETABS 16.2 to model and analyze the response of a 15-story Main Wind-Force Resisting System (MWFRS) structure under three distinct wind exposure conditions within the same seismic zone in Chittagong. Wind loads prescribed in BNBC 2020 were applied, and materials for beams, columns, and deflection were evaluated using Microsoft Excel. The analysis produced the following key findings:

1. **Base Shear:** Total base shear at the X-direction is 521 kips, 668 kips, and 754 kips for Exposures A, B, and C, respectively. Similarly, in the Y-direction, it is 1,580 kips, 1,888 kips, and 2,283 kips for Exposures A, B, and C, respectively.
2. **Column Reactions:** The reaction at the central column (4-C) in the X-direction for Exposures B and C is 20% and 31% higher, respectively, than Exposure A. Similarly, in the Y-direction, the increase is 10% and 17%, respectively.
3. **Column Sizes:** The required column sizes increase by approximately 26.53% in Exposures B and C compared to Exposure A due to higher wind loads.

4. **Corner Column Reinforcement:** The required reinforcement for the corner column (5-A) increases by 42.52% and 51.36% for Exposures B and C, respectively, compared to Exposure A.
5. **Corner Column Weight:** The additional reinforcement weight for the corner column (5-A) is 0.60 tons for Exposure B and 1.20 tons for Exposure C compared to Exposure A.
6. **Beam Sizes:** Beam sizes need to increase by 6.67% and 12.5% for Exposures B and C, respectively, compared to Exposure A.
7. **Beam Reinforcement:** Positive reinforcement requirements for beams increase by 7.85% and 8.49% for Exposures B and C, respectively, compared to Exposure A.
8. **Overall Column Reinforcement:** Total column reinforcement required for the 15-story building increases by 17.53% for Exposure B and 22.18% for Exposure C compared to Exposure A.

These findings highlight the significant impact of wind exposure on the structural design of high-rise buildings in Bangladesh. As wind exposure levels increase, larger column and beam dimensions, as well as higher reinforcement quantities, are necessary to ensure structural safety and serviceability. The study underscores the critical role of wind considerations in the design process, particularly in regions prone to high wind pressures and extreme weather conditions.

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References:-

1. Bangladesh National Building Code (BNBC 2020). Government of Bangladesh, Ministry of Housing and Public Works, Dhaka, Bangladesh, 2021, pp. 2464.
2. Rabbi, S. S. M. (2020). A comparative study on lateral load analysis by using ETABS considering two different versions of BNBC. In 5th International Conference on Civil Engineering for Sustainable Development (ICCESD), KUET, Khulna, Bangladesh.

3. Mann, G. (2015). Design of Diagrid Structural System for Tall Buildings. M. Tech. Thesis, National Institute of Technology, Kurukshetra, India, pp. 198.
4. Taranath, B. S. (1988). Structural Analysis & Design of Tall Building. 2 Pennsylvania Plazas, New York City: McGraw Hill Book Company.
5. American Society of Civil Engineers (ASCE-7-05). (2005). Minimum Design Loads for Buildings and Other Structures. American Society of Civil Engineers, USA.
6. Faysal, R. M. (2004). Studied and compared BNBC 1993 & BNBC 2010. M. Thesis, BUET, Bangladesh.
7. Masum, M. M. H., Akter, A., Akter, S., & Hossen, M. J. (2018). Evaluation of provisions of wind load evaluation given in present BNBC 1993 compared to proposed BNBC 2015. KUET, Bangladesh.
8. Verma, A., & Goliya, R. K. (2016). Comparison of static wind load on high-rise buildings according to different wind loading codes and standards. International Journal of Engineering Research, 5(05), 885-890.
9. Abdullah, F., Islam, Z., Asif, M. A. T., & Ali, S. (2021). A comparative study of lateral load analysis considering two BNBC codes using ETABS software. American Journal of Civil Engineering, 9(4), 118-126.
10. Robert, C. I. (1998). Cost estimating principles. ASCE Journal of Construction Engineering and Management.
11. Smith, B., & Coul, J. (1991). Tall Building Structures: Analysis and Design. John Wiley & Sons, Inc., USA.
12. Nilson, A. H., David, C., & Dolan, C. W. (2003). Design of Concrete Structures. 13th Edition. McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020.
13. Varela, J., Tanner, D., & Klingner, R. (2004). Development of response modification coefficient and deflection implication factor for design of AAC structural systems. 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada.
14. American Society of Civil Engineers (ASCE). (2003). Commentary on structural design criteria. Chapter 4, pp. 36-58.
15. Hasan, M. Y., Monir, M. U., Ahmed, M. T., Abd Aziz, A., Shovon, S. M., Akash, F. A., & Ali, S. (2022). Sustainable energy sources in Bangladesh: A review on present and future prospects. Renewable and Sustainable Energy Reviews, 155, 111870.