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Comparative Analysis of PEB Structure with Varying Bay Spacing

Anushri A. Isal[1], N. G. Gore[2]
[1]*ME Student,* [2]*Assistant Professor, Department of Civil Engineering, MGM College of Engineering and Technology, Kamothe, Navi*

Abstract: ***Pre-designed buildings are nothing more than steel buildings in which excess steel is avoided by narrowing sections according to the requirements of the moment of bending. The PEB concept is widely used in many industrialized countries. It consists of a complete steel frame building system with components pre-designed to combine into a variety of combinations to meet the unique requirements of specific end goals. If we go for conventional steel structures, the time frame will be longer and the cost will be higher, and both together, ie time and cost, make it uneconomical. This study analyzes the structure of PEB using STAAD-PRO software when the distance between bays changes.***
Keywords: Ridge angle, PEB, beam forces, moment and steel

I. INTRODUCTION

Technological improvements over the year have greatly contributed to improving the quality of life through various new products and services. One such revolution was pre-designed buildings. The scientific and sound term pre-engineering buildings appeared in the 1960s. The buildings were pre-designed because, like their ancestors, they relied on standard engineering designs for a limited number of non-shelf configurations. Several factors made this period important for the history of metal buildings. First, advanced technology has constantly expanded the maximum possibilities for clear flight of metal buildings. The first rigid frame buildings, introduced in the late 1940s, could cover only 40 feet. In a few years, buildings at 50, 60 and 70 feet became possible. By the end of the 1950s, rigid frames with spans of 100 feet became available, allowing buildings to look different from the old tired corrugated view. Third, the collided panels were presented by Strand-Steel Corp. in the early 1960s, which allowed a certain individuality of design. Around the same time, continuous flying cold formed Z purlins were invented, the first factory-insulated panels were designed by Butler, and the market was the first UL-approved metal roof. And last but not least, but no less important, the first computer-designed metal buildings also debuted in the early 1960s. With the advent of computerization, design capabilities have become almost limitless. All of these factors combined to create a new metal boom in the late 1950s and early 1960s. As long as the buyer can be limited by standard designs, the buildings could be correctly called pre-designed. After the industry started offering custom metal buildings to meet the specific needs of each customer, the name of the pre-designed building became somewhat erroneous. In addition, the term was inconveniently close and easily confused with untidy prefabricated buildings, with which the new industry did not want to be associated. Although the term pre-engineering buildings is still widely used and can often be found even in this book, the industry now prefers a metal building.

II. LITERATURE REVIEW

Syed Firoz et al. (2012) studied the technique of building pre-engineered buildings. They found that the system of pre-engineering steel construction has great advantages for single-storey buildings, and it is a practical effective alternative to the conventional system of steel buildings. Pre-engineered buildings are built and serviced at a minimum time. Pre-engineering is designed using STAAD pro. They also discussed different types of staff, advantages and disadvantages and STAAD Pro. procedure for pre-engineering building.

Mrs. Darshana P. Zoad (2012) conducted a detailed investigation into the evaluation of a building previously being developed in India. In this study, she considered the building to be 25.8 m wide and 56 m long. Detailed design and analysis is performed according to the Indian code (IS 875 (Part I To V) and IS 1893) and the American code (AISC, MBMA-96) using structural analysis and software for STAAD Pro design.

It was observed that the real-time load is 0.75 KN/sq.m according to the IS code, while it is 0.57 KN / sq.m. M according to MBMA. Thus, it was concluded that downloads by Indian codes are greater than MBMA codes. This is due to the difference in the cross-sectional classification of steel elements.

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Aijaz Ahmad Zende et al. (2013) conducted a comparative study of the analysis and design of PEB and a conventional steel building using STAAD Pro.software software. The dormitory building measures 14.37 m X 52.14 m, the row spacing is 8.4 m, the height of the cornice is accepted as 6 m with a roof slope of 1 per 10, is developed and analyzed for dynamic forces, including wind forces and seismic forces. They concluded that the weight of steel is reduced to 27% for the dormitory building, which leads to increased resistance to seismic forces.

S. M. Meera (2013) analyzed and designed the structure of the industrial warehouse using both concepts using STAAD Pro. They considered a building with 4 spans 30 m wide, 192 m long, and a distance between the bays of 12 m. Height 12 m. The building is symmetrical, so they consider the frame to be a span of 30 m, and the design of the analysis is carried out taking into account the wind load. The result shows that the roof structure of PEB is almost 30% lighter than the structure of CSB. The maximum deviation for CSB is 8.61 mm, and for PEB 1.86 mm - much less than CSB.

III. PROBLEM FORMULATION

In this study a comparative analysis and design of Pre-Engineered building of span width 30m and length 96m for different ridge angle and bay spacing is done by using STAAD Pro. The modeling is done to examine bending moment, beam forces, steel take-off, deflection and support reaction. Software used is STAAD Pro.

For the present study,

1) The models are considered having the pre-engineered building with different span, bay spacing and ridge angle.
2) The span varied in range of 95 m, 96 m and 98m.
3) The spacing of the bay varied from 5m, 6m & 7m.
4) The ridge angle varied from 1 in 10, 1in 15 and 1 in 20.
5) The structure is analyzed for the region of Bangalore with basic wind speed of 33 m/s as per IS:875 (Part-3):2015.

Modelling in Software

The present study deal with the pre-engineered building having rectangular shape in the plan. Total nine models are modes with the change in the bay spacing and the ridge angle is carried out in the STAAD-PRO software. The building is modeled for the wind region of Bangalore with the basic wind speed of 33 m/s as per IS 875-2015. The span slightly varied for the different models with different bay spacing. STAAD-PRO software was used for the modeling of the pre-engineered building which have the activities that includes

a) To create the geometry
b) To give the material property, support and load
c) Analysis of the model
d) Extraction & interpretation of results

A. Calculation of WIND LOAD (WL) –IS 875 (PART-III)-1987

Basic wind speed (Vb) - Ba	=	33	m/s
Design wind speed (Vz)	=	Vbxk1xk2xk3Xk4	
where,			
k1	=	probability factor (risk coefficient)	
	=	1	
k2	=	terrain, height and structure size factor	
	=	1	
k3	=	topography factor	

	=	1		
k4	=	Cyclonic Factor		
	=	1		
Vz	=	33	m/s	

Design wind pressure (pz) = $0.6xVz^2$

Pz	=	0.653	KN/m^2

Design Wind Pressure , Pd	=	Pz X Kd X Ka X Kc		
Wind Directionality Factor , Kd	=	0.900		or Clause IS 875 - 1
Area Averaging Factor, Ka	=	0.800		or Clause IS 875 - 1
Combination Factor , Kc	=	0.900		or Clause of IS 875
Kd X Ka X Kc	=	0.648		
Design Wind Pressure , Pd	=	0.457	KN/m2	

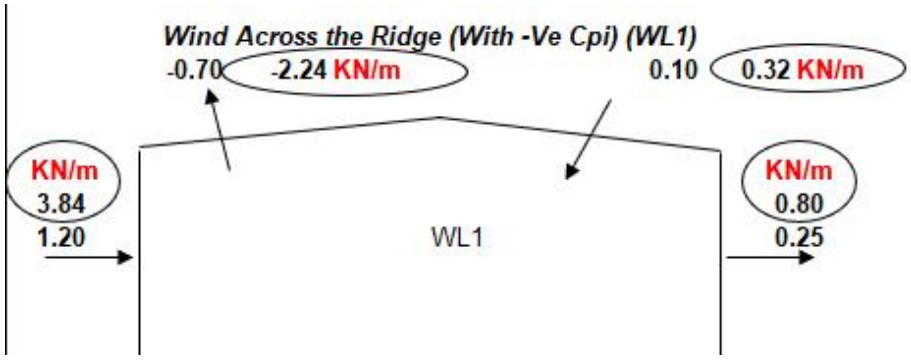
PRESURE COEFFICIENTS:~

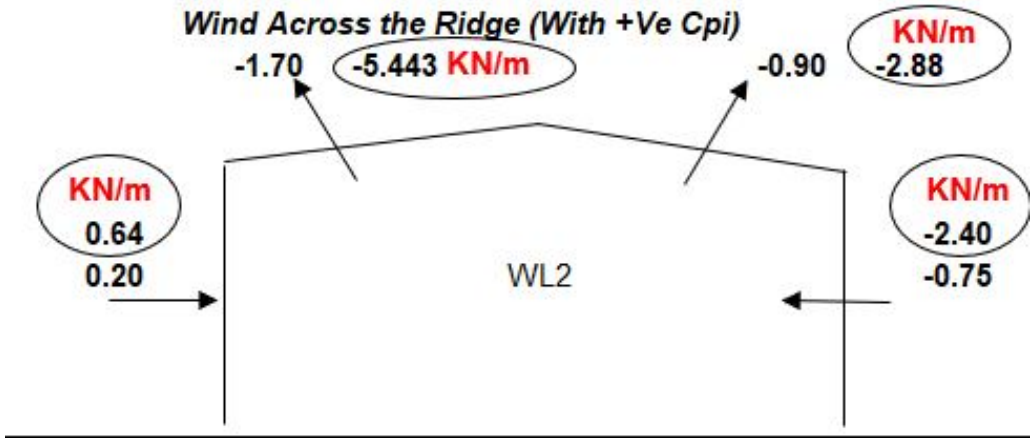
Area of the face	=	980	m2	
Area of the opening	=	20	+	
	=	44	m2	
Percentage Area of the Opening	=	4.49	%	

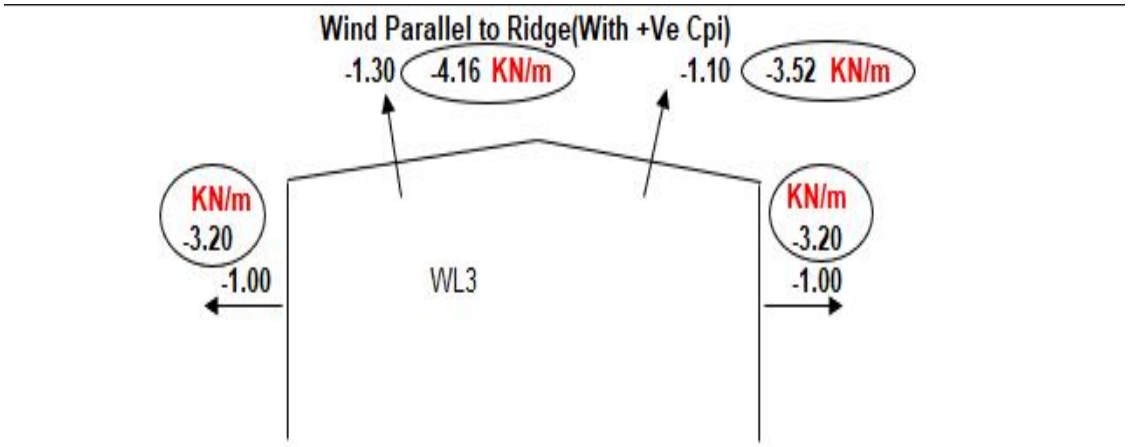
Encloser condition of the building	=	Partially Enclosed ±		Enclosed 0.
Internal pressure coeff.(Cpi)	=	0.50		Partially Enclo 0. Open 0.
h/w	=	0.333		
l/w	=	3.27		
	=	3/2<=l/w<4		

B. External Pressure coeff.(Cpe)

Wind Angle (ɵ)	Table 4 Coeff. For Wall		Table 5 Coeff. For Roof		Table 6 Coeff. For Wall	
	Left	Right	Left	Right	GABLE 1	GABLE 2
0 degree	0.70	-0.25	-1.2000	-0.40	-0.60	-0.60
90 degree	-0.50	-0.50	-0.80	-0.60	0.70	-0.10







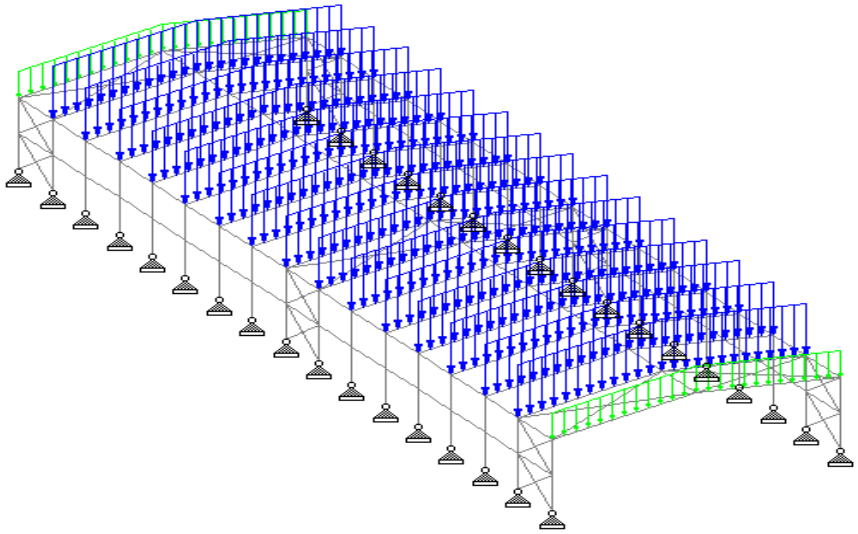


Figure 1: Loads applied on the structure

The above figure gives the Loads applied on the structure for the different models in terms of the dead load, live load, wind load and the combination of the loads.

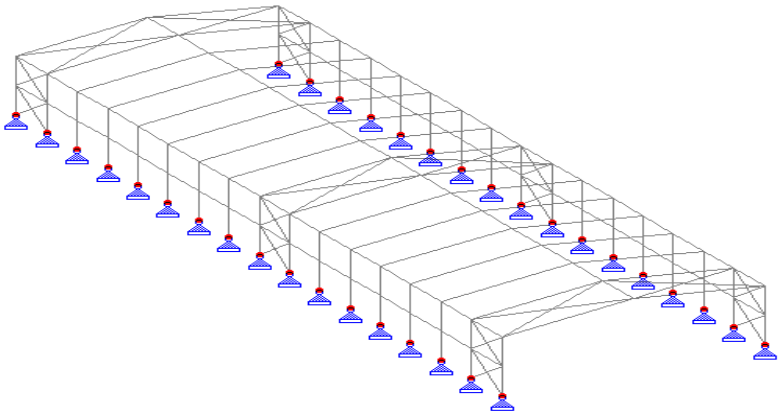


Figure 2: Supports given to the column of structure

The above figure gives Supports given to the column of structure for all the models, the support considered as pinned support.

IV. RESULTS

The following results are obtained.

TABLE 1: DISPLACEMENT FOR MODELS WITH 5M SPACING

Parameters		5m-1 in 10	5m-1 in 15	5m-1 in 20
Horizontal	X-direction	24.081	25.589	26.719
Vertical	Y-direction	15.709	14.359	13.098
Horizontal	Z-direction	3.066	3.153	2.924

TABLE 2:REACTION FOR MODELS WITH 5M SPACING

Parameters		5m-1 in 10	5m-1 in 15	5m-1 in 20
Horizontal	Fx KN	135.495	132.301	129.197
Vertical	Fy KN	268.984	268.981	269.468
Horizontal	Fz KN	17.741	17.851	17.338

The above table 2 shows the Reactions for models with 5m spacing and almost similar value is obtained for the all model.

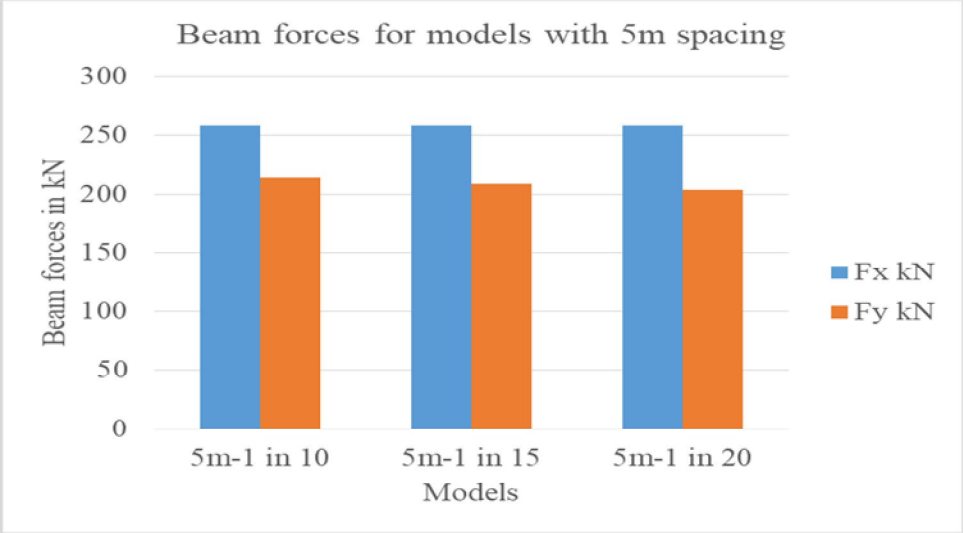


Figure 3: Beam Forces for models with 5m spacing

The above figure 3 shows the Beam Forces for models with 5m spacing and the value of Fx is comparatively maximum and Fy is minimum.

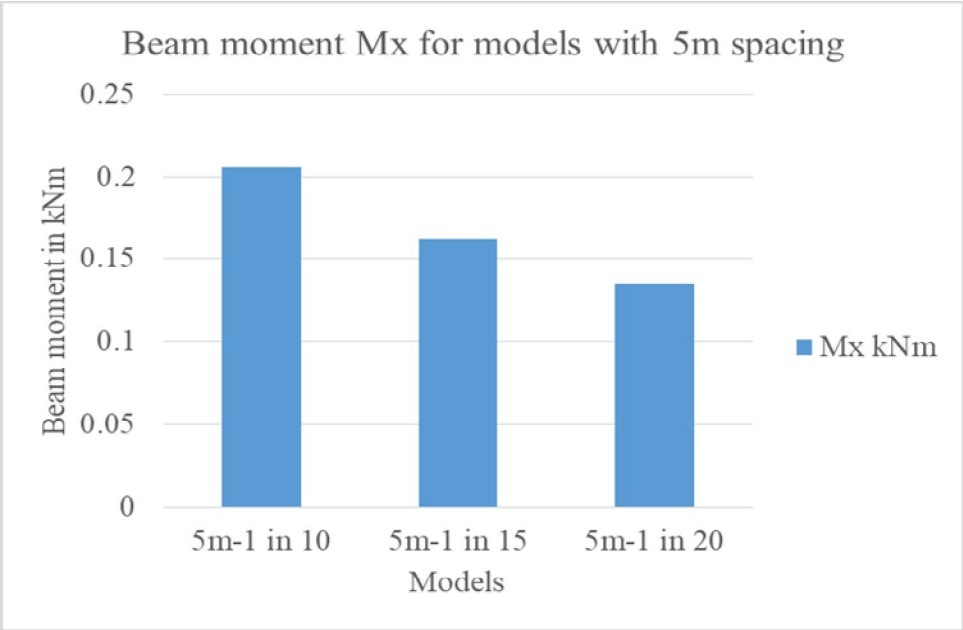


Figure 4: Beam Moment Mx for models with 5m spacing

The above figure 4 shows the Beam Moment Mx for models with 5m spacing and the maximum value is obtained for the model having angle of 1 in 10.

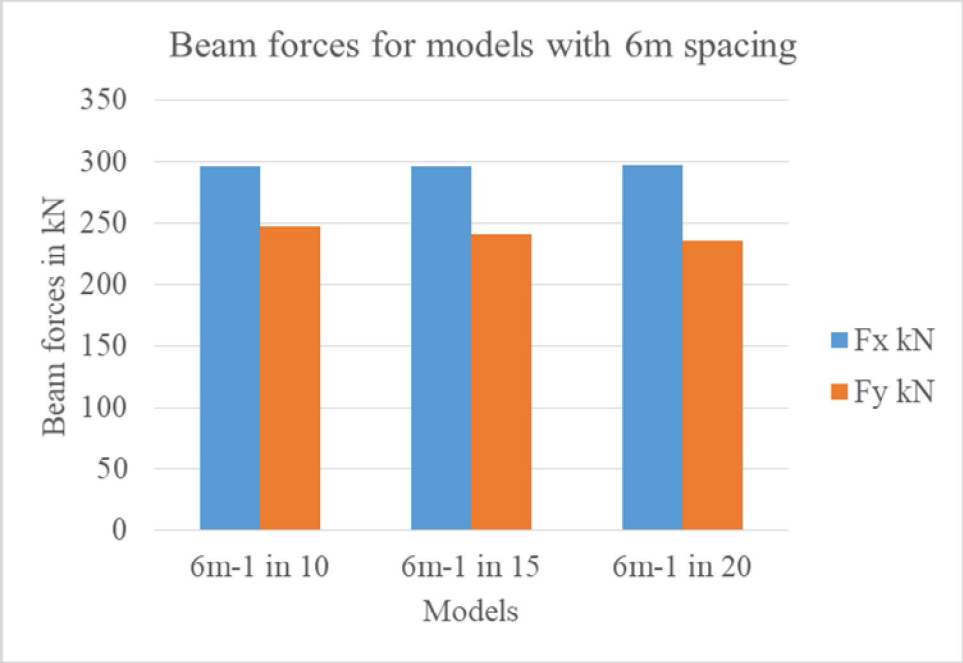


Figure 5: Beam Forces for models with 6m spacing

The above figure 5 shows the Beam Forces for models with 6 m spacing and comparatively higher values obtained for Fx and minimum for Fy.

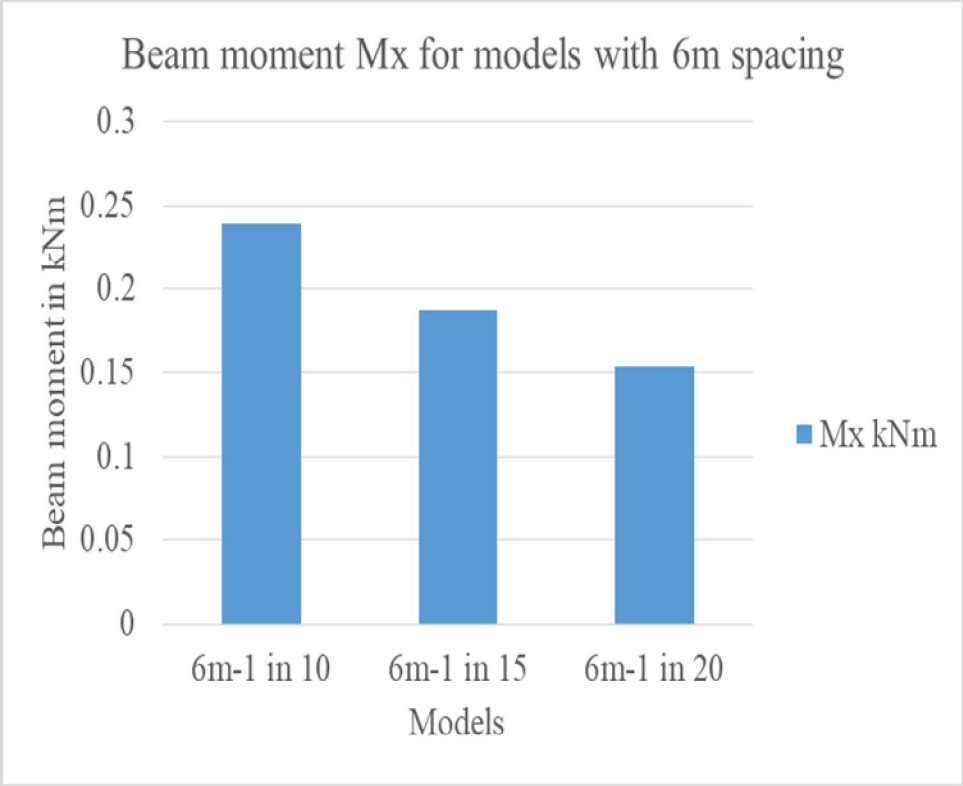


Figure 6: Beam Moment Mx for models with 6m spacing

The above figure 6 shows the Beam Moment Mx for models with 6m spacing and the maximum value is obtained for the model having angle of 1 in 10.

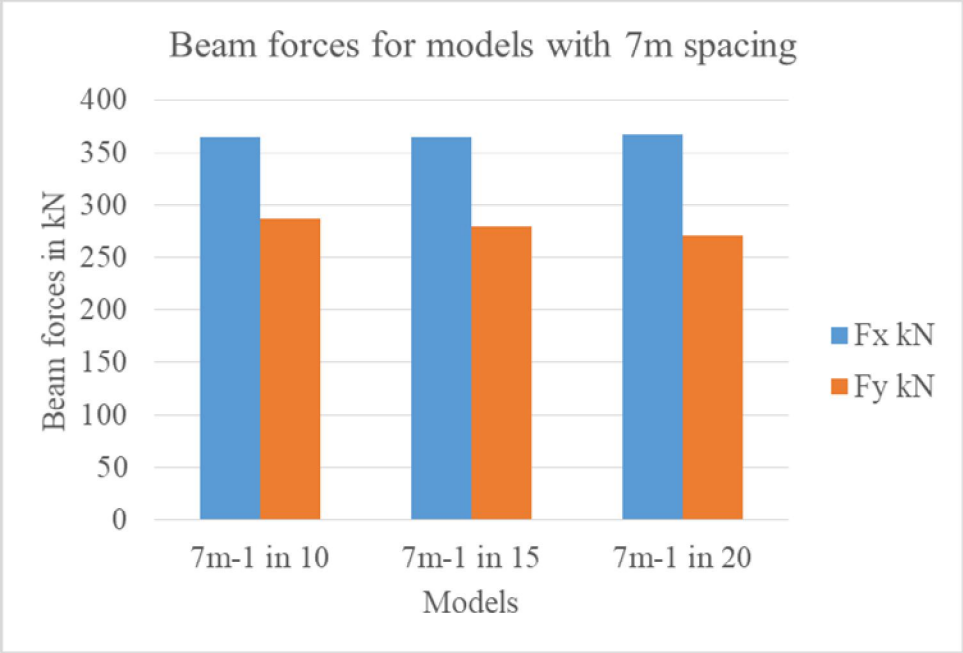


Figure 7: Beam Forces for models with 7m spacing

The above figure 7 shows the Beam Forces for models with 7 m spacing and comparatively higher values obtained for Fx and minimum for Fy.

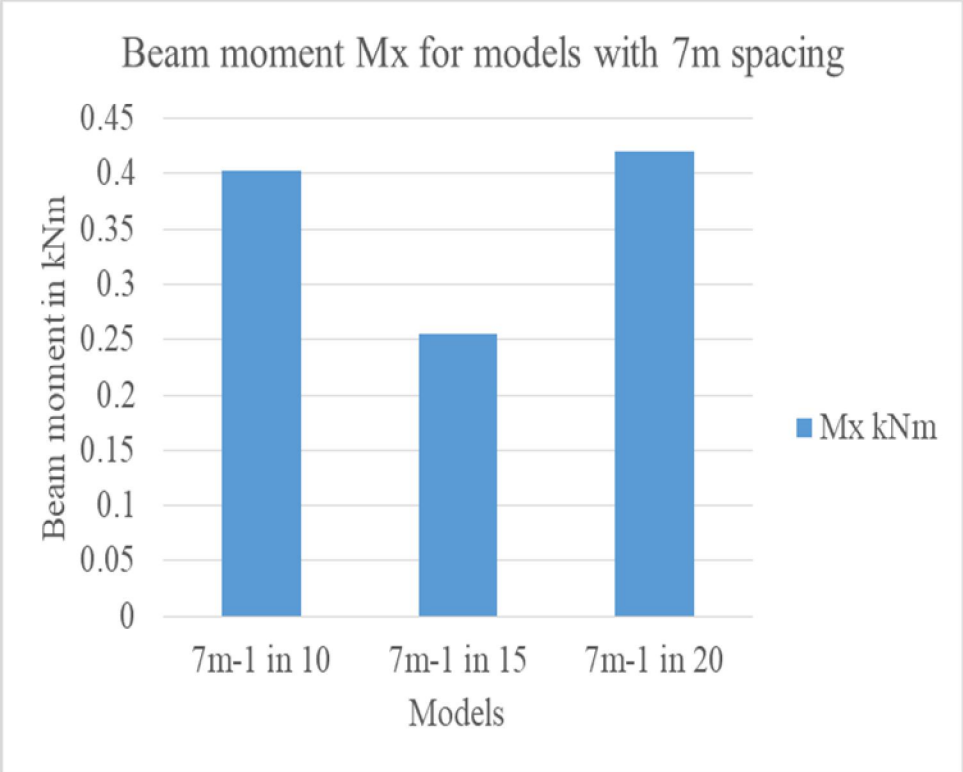


Figure 8: Beam Moment Mx for models with 7m spacing

The above figure 8 shows the Beam Moment Mx for models with 7m spacings and the maximum value is obtained for the model having angle of 1 in 20.

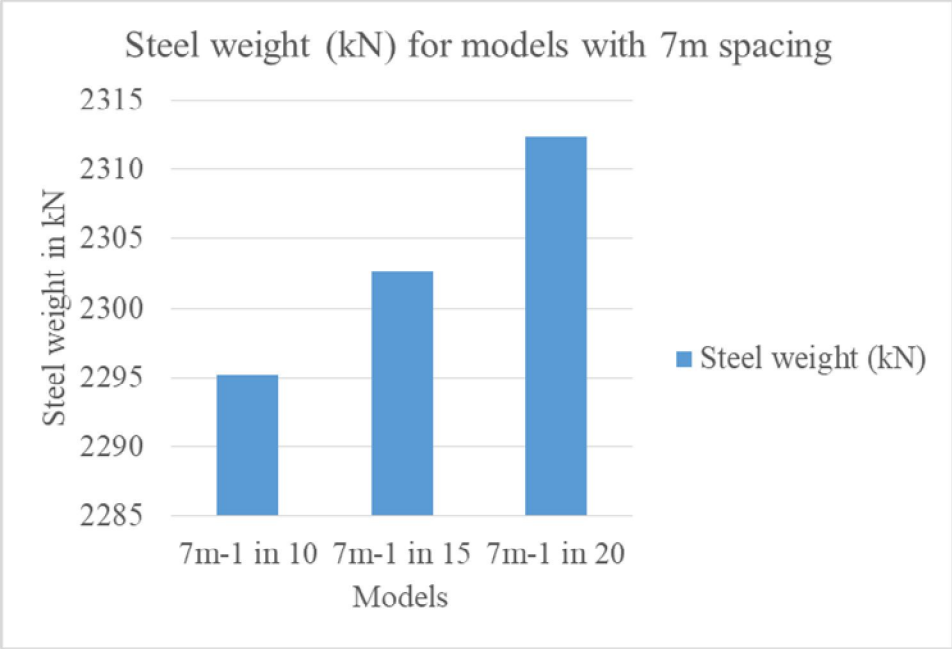


Figure 9: Steel Take-Off for models with 7m spacing

The above figure 9 shows the Steel Take-Off for models with 7m spacing and the maximum value is obtained for the model having angle of 1 in 20.

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V. CONCLUSIONS

The following conclusions are obtained.

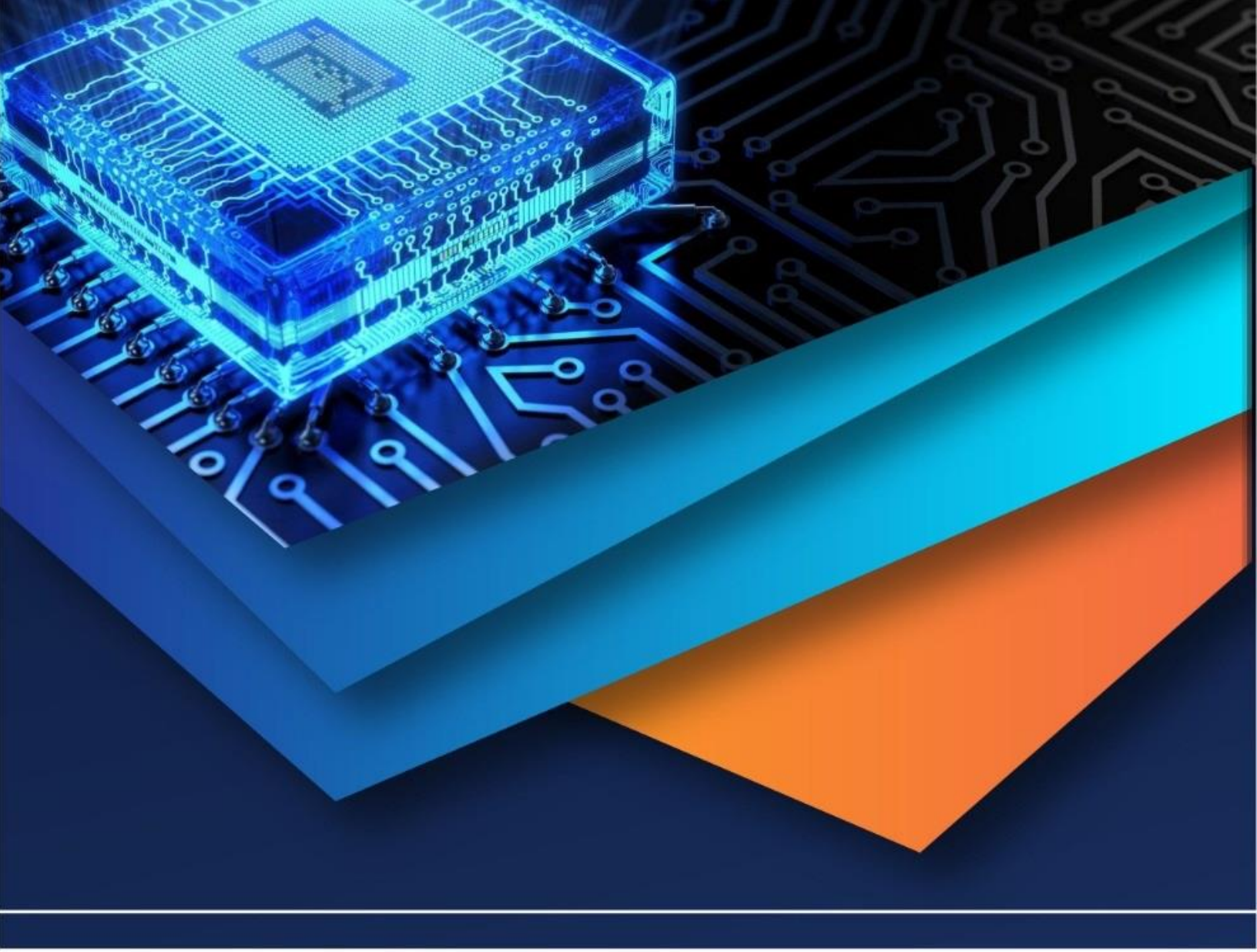
1) The Beam Forces for models with 5m spacing and the value of Fx is comparatively maximum and Fy is minimum.
2) The Beam Moment Mx for models with 5m spacing and the maximum value is obtained for the model having angle of 1 in 10.
3) The Beam Forces for models with 6 m spacing and comparatively higher values obtained for Fx and minimum for Fy.
4) The Beam Moment Mx for models with 6m spacing and the maximum value is obtained for the model having angle of 1 in 10.
5) The Beam Forces for models with 7 m spacing and comparatively higher values obtained for Fx and minimum for Fy.

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