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Comparative Structural Analysis of Pre-Engineered Building

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Abstract: *A healthy trend in the form of growing demand for construction work in the residential, commercial, institutional, industrial and infrastructure sectors has been observed over the last decade. Modern structures are much more complex and complex compared to the previous period. One of the main changes that everyone is experiencing is that the current structures are higher and thinner. The current requirement of structures is that they should be lighter, but not jeopardize functionality. Civil engineering is under constant economic competition between steel, concrete and other building materials.*

Keywords: Pre-engineered building, steel, building, pitch and analysis.

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 to use its metal building systems.

II. LITERATURE REVIEW

Pratik R. Atwal et al. (2017) analyzed and designed building G + 3 using IS 800-2007 and international standards, which are AISC-10, BS5950-2000 and Euro-03 Results show, that for the American reduction of the steel weight code is up to 24% compared to IS 800-2007. American codes generally prefer the design of steel buildings, although the weight of the structure is reduced to 28% by Euro-03 and up to 10% by BS5950-2000.

Subod S. Patil et al. (2017) conducted a comparative study and design of pre-engineered buildings (PEB) and conventional steel frames using software for full-time programs. Steel structures are designed for wind analysis, and manual analysis is performed in accordance with IS 875 (Part III) – 1987. They considered three examples. Frame 80 m long, 30 m wide and 6 m distance between the bay designed for both PEB and conventional, and comparisons were made in terms of steel weight. They found that PEB designs are lighter and the design is fast and efficient compared to the CSB design. PEB support reactions are much less than CSB, so a lightweight foundation has been adopted, and this has also reduced construction costs.

K. Prabin Kumar and D. Sunny Prakash (2018) presented a document on a complete analysis of the planning and design of an industrial barn using STAAD Pro software. They considered a hanger 50 m, a width of 15 m, an ear height of 10 m, and a slope of 10 degrees on the roof. The main goal is to achieve a plastic and stiffer hanger for this purpose, they provide fastening at different intervals, and the distance between the bays also ranges from 7.5 m and 7 m for the first and last bays and the other 5 bays, respectively. The calculation of the various loads acting on the structure was carried out by means of code provisions and the construction of the foundation was made. From the results, they concluded that the deviations receive less than the calculated allowable deflection.

III. METHODOLOGY

Based on the literature review and the gaps found in the research, the combinations of model for different pre-engineered building are obtained. The different model combinations are as follows:

- **Bay spacing of 5m**: This model is analyzed for the spacing of 5m with varying ridge angle of 1 in 10, 1 in 15 and 1 in 20 for the proper comparison.
- **Bay spacing of 6m**: This model is analyzed for the spacing of 6m with varying ridge angle of 1 in 10, 1 in 15 and 1 in 20 for the proper comparison.
- **Bay spacing of 7m**: This model is analyzed for the spacing of 7m with varying ridge angle of 1 in 10, 1 in 15 and 1 in 20 for the proper comparison.

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 software of STAAD-PRO was used for the purpose of the analysis and design of the pre-engineered buildings.

3.1 Preliminary Data

Building Type =
Length , l = 98.00 m
Width , w = 30.00 m
Purlin Spacing = 1.50 m
Bay spacing for centre = 7.0 m
Bay spacing for gable end = 7.000 m
Clear eave height , h = 10.00 m
Max. eave height = 11.50 m
Roof slope (θ) = 1in 10

3.2 Load Calculations

DEAD LOAD (DL)
Wt. of sheeting = 5 Kg/m²
Wt of purlin = 5 Kg/m²
Wt of fixing = 4.5 Kg/m²
Collateral load = 5.5 Kg/m²
Wt of sag rods = 5 Kg/m²
Total Dead Load = 25 Kg/m²
Total Dead load = 0.25 kN/m2
Dead Load (DL) FOR 7 M centre span = 1.75 KN/m
Dead Load (DL) FOR 7 M span(Gable End Span) = 0.875 KN/m

LIVE LOAD (LL) IS: 875 (Part-2) 1987
Live load/unit area, roof = 75.00 Kg/m²
Live load/unit area, roof = 0.75 kN/m2
LL for 7m centre span = 5.25 KN/m
LL for 7 m span(Gable End Span) = 2.63 KN/m

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The models are modelled and analysed using STAAD-PRO software, the models are as follows

- Model-1: PEB structure with 5m bay spacing and slope of 1 in 10
- Model-2: PEB structure with 5m bay spacing and slope of 1 in 15
- Model-3: PEB structure with 5m bay spacing and slope of 1 in 20
- Model-4: PEB structure with 6m bay spacing and slope of 1 in 10
- Model-5: PEB structure with 6m bay spacing and slope of 1 in 15
- Model-6: PEB structure with 6m bay spacing and slope of 1 in 20
- Model-7: PEB structure with 7m bay spacing and slope of 1 in 10
- Model-8: PEB structure with 7m bay spacing and slope of 1 in 15
- Model-9: PEB structure with 7m bay spacing and slope of 1 in 20

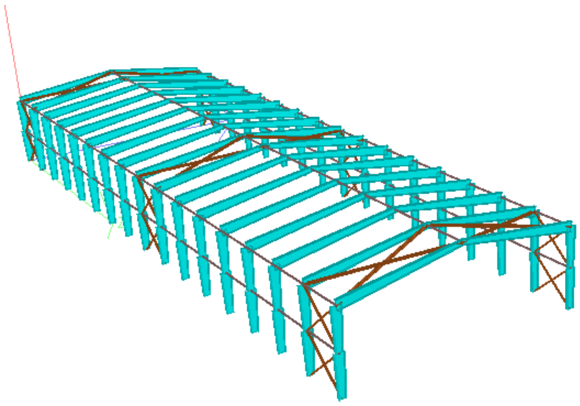

Figure 1: 3-D Details of the model

The above diagram gives the 3-D view of the model, the tapered section as shown in the figure.

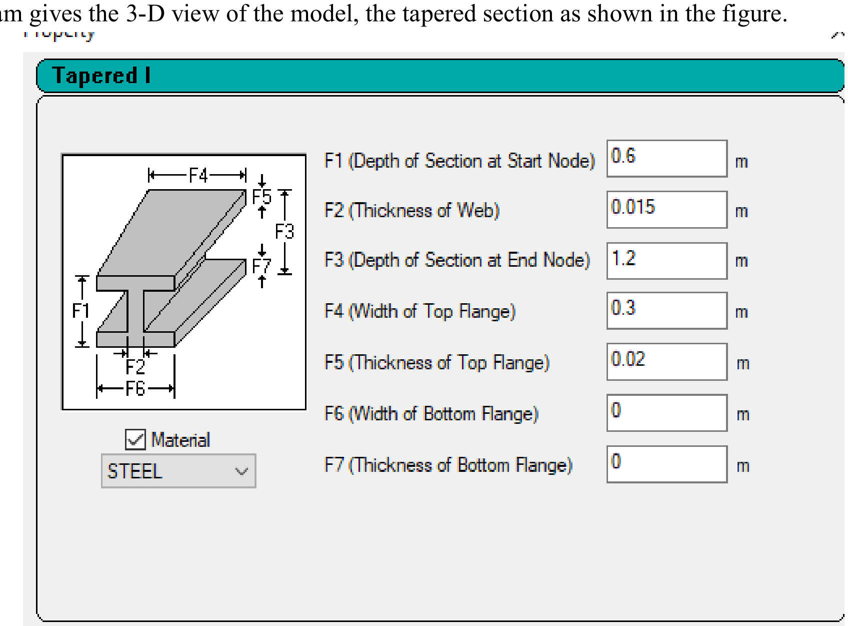

Figure 2: Property details of the member used for Column design

IV. RESULTS AND DISCUSSIONS

In this study a comparative analysis and design of Pre-Engineered building for different ridge angle and bay spacing is done by using STAAD Pro. The result of this analysis will include bending moment at support, at beam rafter, at ridge of rafter, steel takeoff, deflection and support reaction. Software used is STAAD Pro.

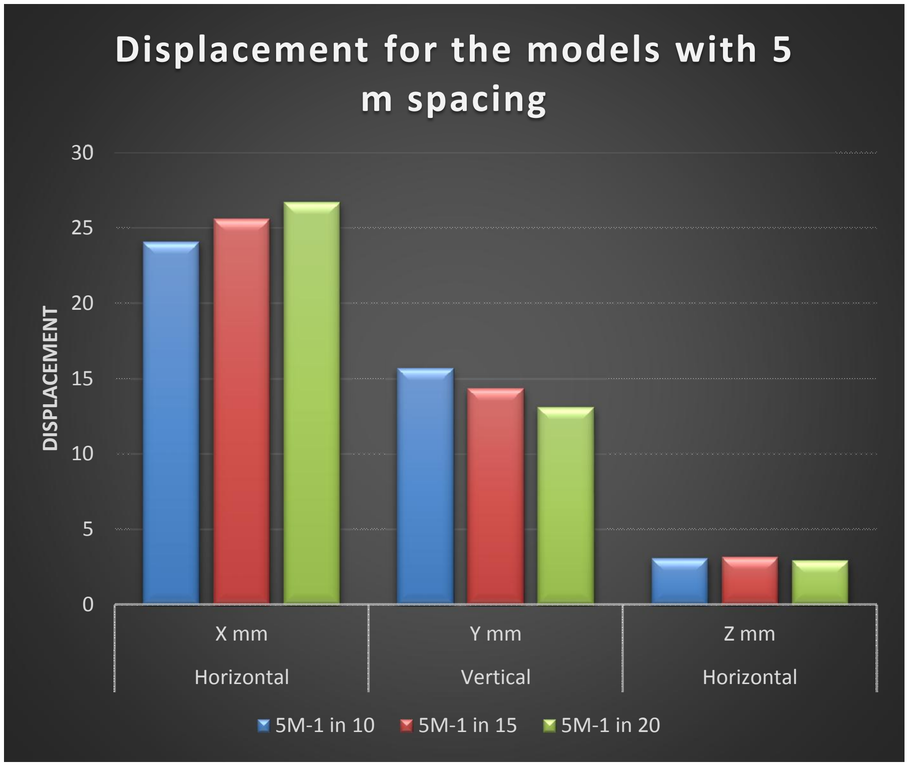

Figure 3: Displacement for models with 5m spacings

The above figure 3 shows the displacement for models with 5 m spacing and the maximum value is obtained for the model having angle of 1 in 20.

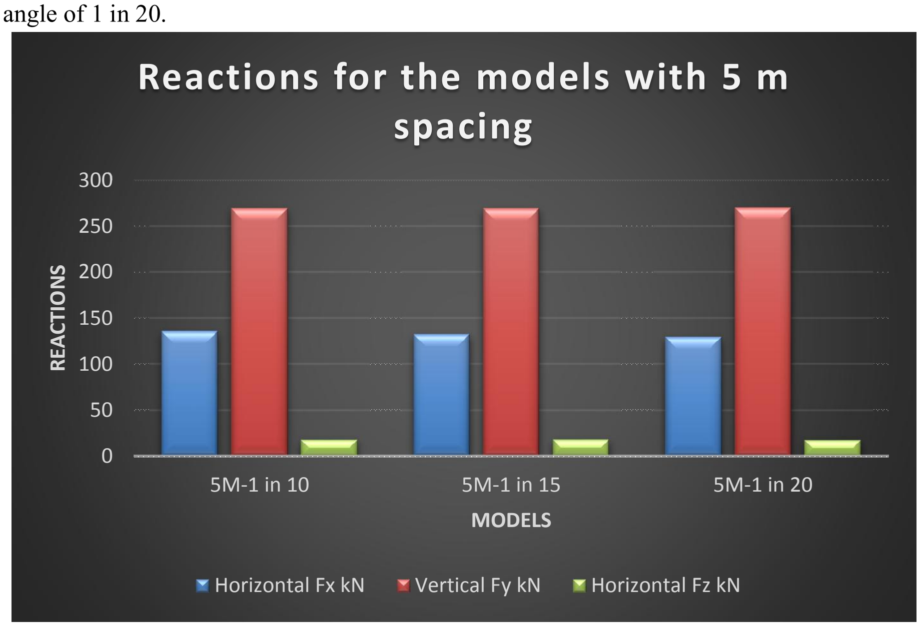

Figure 4: Reactions for models with 5m spacings

The above figure 4 shows the Reactions for models with 5 m spacing and almost similar value is obtained for the all model.

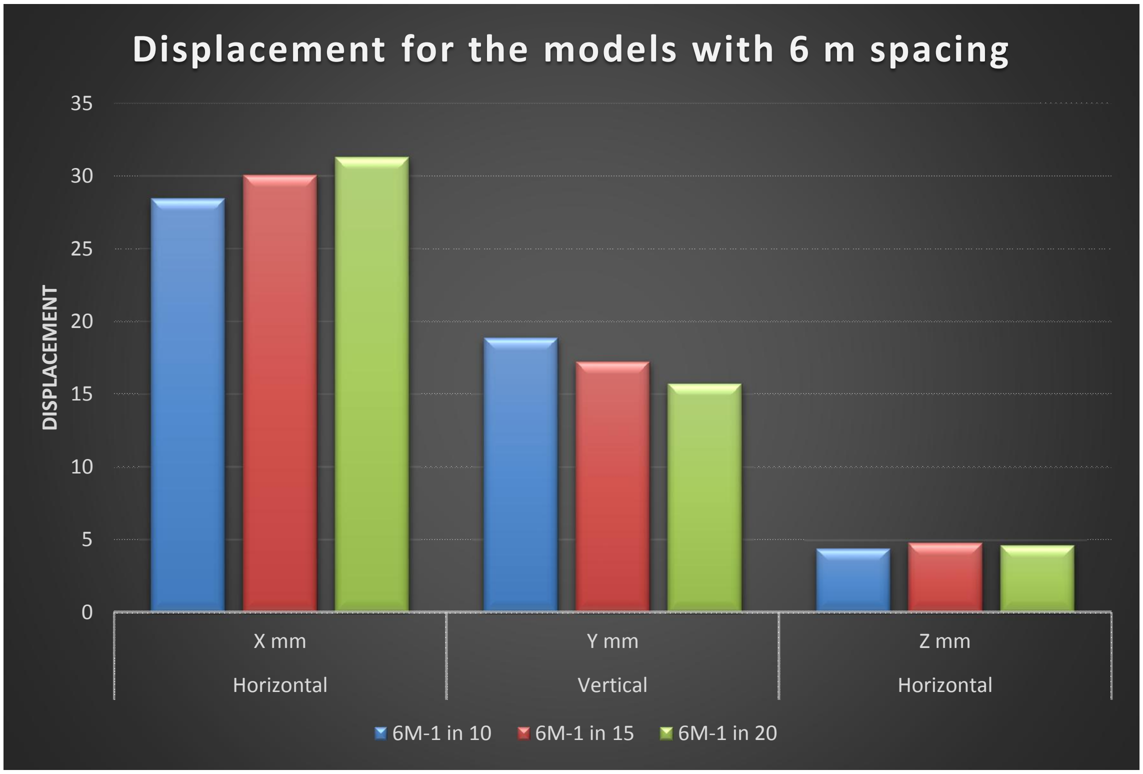

Figure 5: Displacement for models with 6m spacings

The above figure 5 shows the Displacement for models with 6m spacings and the maximum value is obtained for the model having angle of 1 in 20.

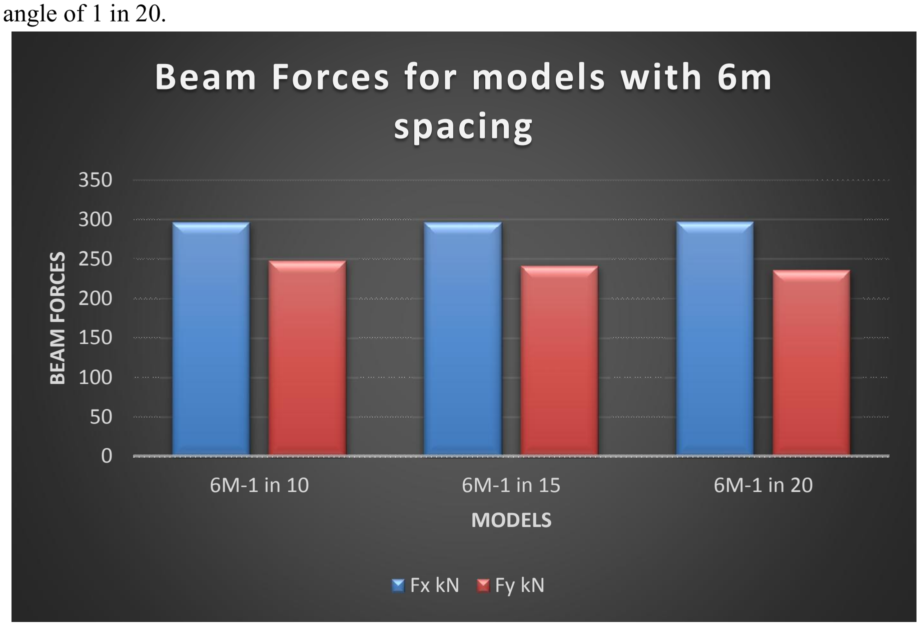

Figure 6: Beam Forces for models with 6m spacings

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

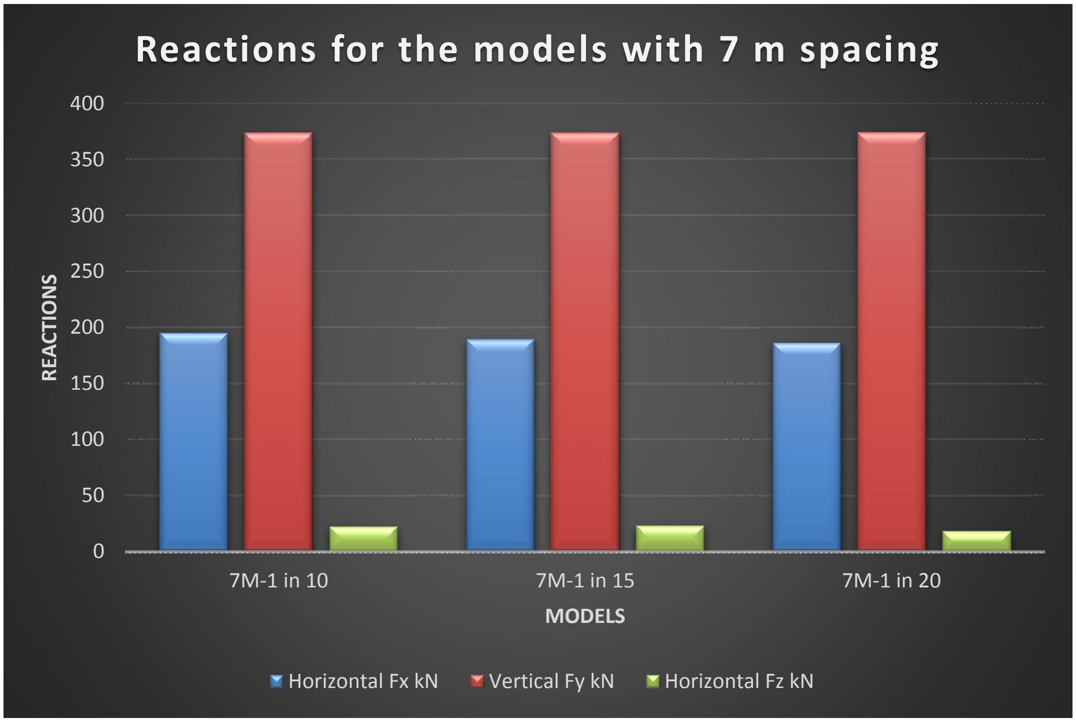

Figure 7: Reactions for models with 7m spacings

The above figure 7 shows the Reactions for models with 7 m spacing and almost similar value is obtained for the all model.

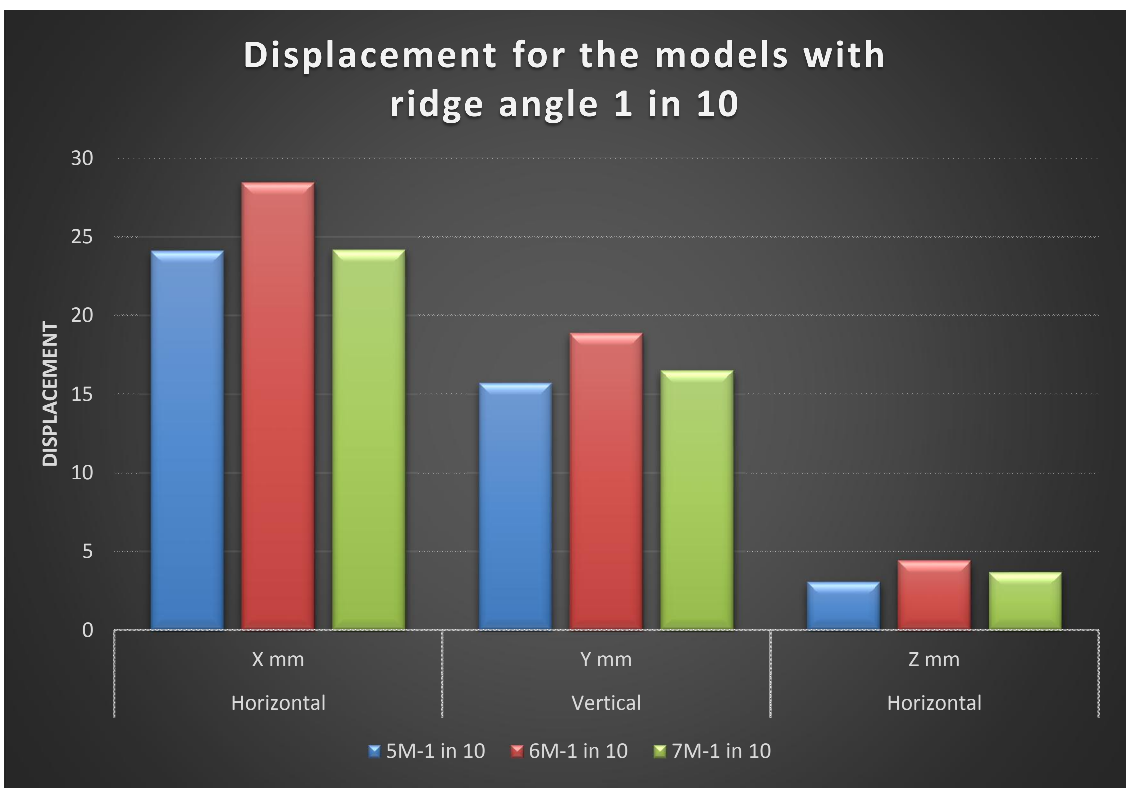

Figure 8: Displacement for models with Ridge Angle of 1 in 10

The above figure 8 shows the Displacement for models with Ridge Angle of 1 in 10 and the maximum value is obtained for the model having spacing of 6m.

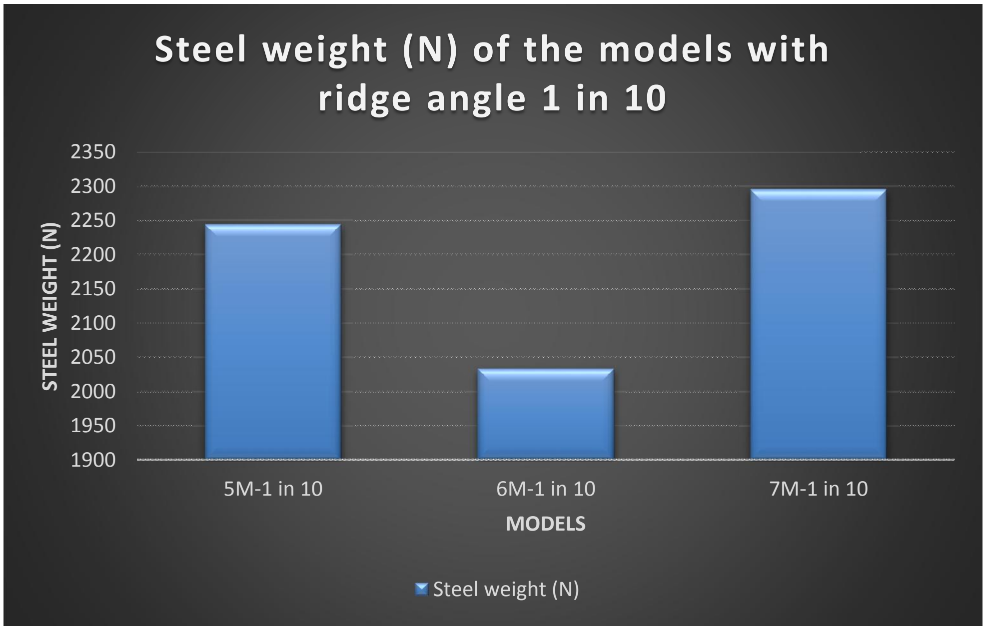

Figure 9: Steel Take-Off for models with Ridge Angle of 1 in 10

The above figure 9 shows the Steel Take-Off for models with Ridge Angle of 1 in 10 and minimum value is obtained for the case of model having bay spacing of 6m.

V. CONCLUSION

The following conclusions are drawn from the models which are modelled using STAAD-PRO software.

1. The displacement is maximum for the ridge angle with 1 in 20 while it is minimum in the case of ridge angle with 1 in 10.
2. Steel weight is also considered to be the maximum in the case of 7 m spacing while the minimum steel weight is in the case of 6m spacing.
3. The displacement is found to be maximum in the case of the model having the spacing of 6m while it is minimum in the case of spacing with 5m.
4. The reactions are found to be minimum in the case of the spacing with 5m while it is maximum in the case of model with 7m spacings.
5. The beam forces are also maximum in the case of the model with 7m spacing and minimum in the case of spacing of 5m.

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