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# Impact of Various Parameters on Buildings Which are Pre- Engineered

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**ABSTRACT**

The experimental study is conducted to analyze the effect of different parameters on pre-engineered buildings and comparison of pre-engineered building with conventional building. In first stage effect on structure for different roof angles and bay spacing is checked and the optimum structure is selected. Further effect of column height on structure are studied. Comparison made based on steel consumption, displacement, base reaction and moment values. From the models most optimized is selected and compared with conventional roof truss model. From pre-engineered buildings model with height 5.45m, roof angle 5.71° and bay spacing 7m is selected and compared with conventional structure of same properties but deigned using truss members. Finally results shows that pre engineered buildings are optimum and reduces steel consumption by approximately 25-30%.

## 1. INTRODUCTION

The utilization of steel structures in an industrial building is developing quickly in all regions of the world. It isn't just financially beneficial yet additionally eco-friendly. For the most part, there are two kinds of steel structures, Conventional Buildings, and Pre-Engineered Buildings. The present study is formulated to accomplish the staggered plan-based enhancement of pre-engineered steel structures. To accomplish it, a wide range of PEB structures are considered for the study and will be planned under specific parameters to make the structure increasingly effective. The upsides of steel as a development material are generally acknowledged, and the idea of the pre-designing structure is a moderately new idea when contrasted with conventional steel building (CSB). The upside of pre-designed structures over conventional steel structures is in banter right now. Pre-engineered buildings (PEB) allude to those steel structures which are pre-fabricated before being moved to the task site. As the name shows, it incorporates the pre-designing of every single basic part of the structure considering the engineering and architectural prerequisites. The structural concept of PEB is to utilize just the necessary profundity of the part that is required at that specific spot contingent on the bending moment. These outcomes in the tapered sections all through the range of the structure. The decreased shape is gotten by the built-up members. The utilization of tapered sections brings about diminishing the expense of the structure by cutting off superfluous steel [1-5].

## 2. LITERATURE REVIEW

Muhammad Umair Saleem (2018) was conceived in his present study to implement layered optimization based on the design of pre-engineered steel truss industrial buildings. To this end, a wide range of industrial steel buildings were selected for the analysis and design of traditional industrial buildings integrated with truss systems. The analysis showed that truss height plays an important role in the structural efficiency and cost of steel truss buildings. Hollow steel sections performed better than hot rolled steel sections.

Bala murali krishnan R. and Ibrahim Shabbir Mohammedali (2019) in their study of the analysis and design of a two-story (G + 1) PEB showroom using STAAD Pro in accordance with British standards (BS 5950-1: 2000) and Euro codes (EC3) EN-1993 -1) with the analysis of wind and earthquakes. As part of the project, two showroom models were created, namely the British Standard (BS) model and the Eurocode (EC) model using the STAAD Pro.BS model, which proved to be an economical model compared to the Euro symbol [6-10].

Sai Chowdeswara Rao Korlapati1 at al. (2018) in his paper 16 different 2D Frames were selected for each pre-engineered building and conventional steel building. By varying the tributary width and wind speed, the frames were analyzed by a software of structural analysis i.e., STAAD pro (V8i). A comparison was conducted depending upon base reactions, moments at eave, horizontal defection at eave, vertical deflection at ridge and steel take off. Concluded that, the performance and cost effectiveness of pre-Engineered building was much improved under heavy loading as compared to the conventional ones.

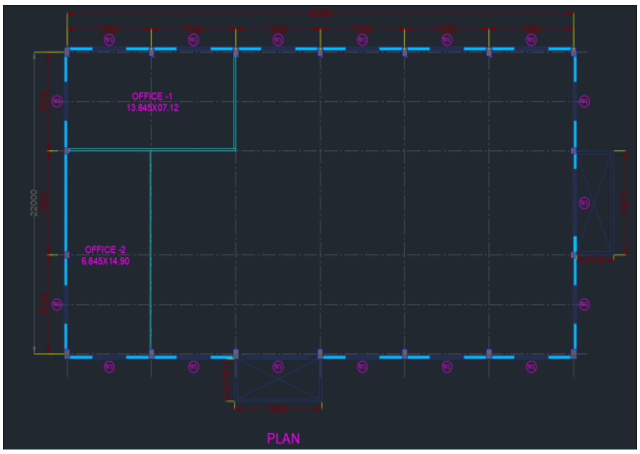
Nitin Vishwakarma (2018) incorporates in his research paper a traditional and pre-engineered steel building concept for the design of 18m industrial buildings located in Palwal near New Delhi, India. The rigid structure of a pre-engineered building with elements of varying thickness, a conventional building with conventional steel elements, and a conventional building with various hollow and composite sections in paper is discussed. A total of five cases were studied. The aim is to achieve the most economical project for this purpose, a comparison of the designed structures is made and finally the most suitable and economical structure for construction is selected [11].

## 3. OBJECTIVE

The main objective of this paper is to study of the concept of pre-engineered buildings with its applications and advantages over conventional structure. Creation of pre-engineered building model using a commercial software and validation of model result by comparing it with analytical solution. To study effect of parameters such as bay spacing, roof angle, column height on pre-engineered buildings. To compare conventional steel building with pre-engineered building [12-14].

## 4. SALIENT FEATURES AND IMPORTANT DIMENSIONS

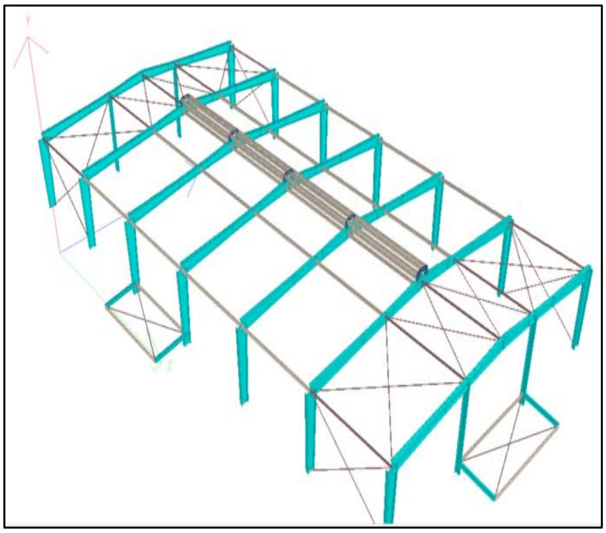
| | | |
|---|---|---|
| Building Dimension | - | 42m x 22m |
| Clear eave height | - | 5.45m |
| Maximum eave height | - | 6.55m |
| Roof slope | - | 2.86°, 5.71°, 10° |
| weight of sheet and purlins | - | 0.84KN/m |
| Live load of roof | - | 5.25 KN/m |
| Basic wind speed | - | 39 m/sec (Pune) |
| Seismic zone (Z) | - | Zone III- Pune |

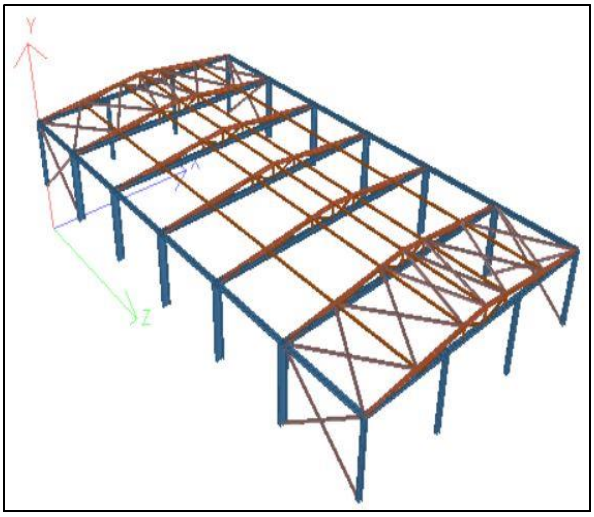


Plan for Industrial Structure

## 5. MODELING

The analysis is performed using STAAD PRO V8i. In accordance with IS 875, load combinations are considered, which consist of static, temporary, wind and earthquakes. Static methods are used for wind and earthquakes. The parameters above are roof slope (θ), span (B) and column height (h). Also, a traditional truss model has been prepared for comparison.


Pre-engineered Building Model


Conventional Roof Truss Model

## 6. RESULTS AND DISCUSSION

**Comparison for Bay Spacing Vs. Roof Angle-**

Table 1
Max Reaction at Base of Column (Kn)

| Θ/B | 4m | 7m | 10m |
|---|---|---|---|
| 2.86 | 216.32 | 217.47 | 228.973 |
| 5.71 | 218.568 | 220.136 | 232.729 |
| 10 | 222.7 | 224.59 | 238.112 |

In table- 1, the primary response does not strongly depend on the angle of the roof, but increases slightly with the span. The largest base reaction is 238.112 at θ = 10 ° for a distance between compartments of 10 m.

Table 2
Steel Consumption ($Kg/m^2$)

| Θ/B | 4m | 7m | 10m |
|---|---|---|---|
| 2.86 | 44.827 | 28.912 | 29.109 |

| | | | |
|---|---|---|---|
| 5.71 | 45.436 | 28.716 | 29.356 |
| 10 | 46.654 | 29.597 | 29.011 |

Table 7 shows that for a frame span 42m as the angle (θ) increases consumption of steel increases while along bay spacing consumption of steel quantity decreases as the bay spacing increases. The minimum consumption of steel from table 7 is 28.716kg/m2when θ = 5.71° and bay spacing is 7m.

Table 3
Max Moment at Beam Column Junction (Kn.M)

| Θ/B | 4m | 7m | 10m |
|---|---|---|---|
| 2.86 | 584.609 | 643.2 | 671.381 |
| 5.71 | 596.073 | 647.099 | 661.746 |
| 10 | 598.643 | 651.302 | 655.786 |

In table- 3 The maximum value moments are tabulated for various inclinations of roof angle (θ) and bay spacing (B). It can be similarly observed that the max moments at the beam column junction increases with the bay spacing. The largest moment is 671.381 KN.m when θ = 2.86° for a bay spacing 10m.

Table 4
Max Shear Force at Beam Column Junction (Kn)

| Θ/B | 4m | 7m | 10m |
|---|---|---|---|
| 2.86 | 166.931 | 173.551 | 179.416 |
| 5.71 | 169.51 | 177.558 | 180.208 |
| 10 | 172.68 | 181.9 | 186.223 |

In table- 4 The maximum value of shear force is tabulated for various inclinations of roof angle (θ) and bay spacing (B). It can be similarly observed that the max shear force at the beam column junction increases with the bay spacing. The largest shear force is 186.223 KN when θ = 10° for a bay spacing 10m.

Table 5
Max. Horizontal Displacement-X Direction (mm)

| Ɵ/B | 4m | 7m | 10m |
|---|---|---|---|
| 2.86 | 16.19 | 13.227 | 13.427 |
| 5.71 | 11.29 | 11.275 | 10.172 |
| 10 | 13.31 | 12.76 | 9.645 |

In table 5- Maximum horizontal displacement along X-Direction are tabulated for various inclinations of angle (θ) and bay spacing (B). It can be similarly observed that as the bay spacing increases the displacement decreases while it does not have a variation in a definite pattern as roof angle increases. The largest displacement is 16.19mm when θ = 2 °.86 for a bay spacing 4m.

Table 6
Maximum Horizontal Displacement-Z Direction (Mm)

| Ɵ/B | 4M | 7M | 10M |
|---|---|---|---|
| 2.86 | 36.897 | 17.381 | 9.679 |
| 5.71 | 31.473 | 14.395 | 6.068 |
| 10 | 30.201 | 13.86 | 5.131 |

In table 6- Maximum horizontal displacement along z-Direction are tabulated for various inclinations of angle (θ) and bay spacing (B). It can be similarly observed that as the bay spacing increases the displacement decreases while it does not have a variation in a definite pattern as roof angle increases. The largest displacement is 36.897mm when θ = 2 °.86 for a bay spacing 4m.

**Comparison for Different Column Heights-**

Table 7 θ = 5.71 °
Max Vertical Reaction at Base of Column (KN.)

| 2M | 5.45M | 10M |
|---|---|---|
| 215.742 | 220.136 | 225.675 |

In table- 7, The vertical reaction at base does not seem to vary much with the column height, it increases marginally with the column height. The largest base reaction is 225.675kN when H= 10m.

Table 8 θ = 5.71 °
Max Horizontal Reaction at Base of Column (Kn)

| 2M | 5.45M | 10M |
|---|---|---|
| 298.038 | 121.179 | 59.991 |

In table- 8, The horizontal reaction along X-Direction shows huge difference in values. For H=2m maximum reaction is observed as shown in table.

Table 9 θ = 5.71 °
STEEL CONSUMPTION $(Kg/m^2)$

| 2M | 5.45M | 10M |
|---|---|---|
| 23.041 | 28.716 | 35.566 |

In table- 9, The consumption of steel increases as height of columns increases. For column height of 2m minimum value is observed.

Table 10 θ = 5.71 °
Max Moment at Beam Column Junction (Kn.M)

| 2M | 5.45M | 10M |
|---|---|---|
| 590.023 | 647.099 | 587.43 |

In table- 10, The maximum moment is observed at column height of 5.45m and value is 647.099KN.m.

Table 11 θ = 5.71 °
Max Shear Force at Beam Column Junction (Kn)

| 4M | 5.45M | 10M |
|---|---|---|
| 161.368 | 177.558 | 183.827 |

In table- 11, The maximum shear force observed in beam column junction increases as column height increases. The maximum value of shear force is 183.827KN when column height is 10m.

Table 12 θ = 5.71 °
Max. Horizontal Displacement- Z Direction (mm)

| 2M | 5.45M | 10M |
|---|---|---|
| 6.569 | 13.308 | 42.768 |

Table 12 shows values of horizontal displacement along Z direction for different column heights. Table shows that value of displacement increases as height increases. Maximum displacement observed at 10m height and its value is 42.768mm.

| Table 13 | | θ = 5.71 ° |
|---|---|---|
| Max. Horizontal Displacement- X Direction (mm) | | |
| 2M | 5.45M | 10M |
| 2.794 | 11.298 | 82.606 |

Table 13 shows values of horizontal displacement along X direction for different column heights. Table shows that value of displacement increases as height increases. Maximum displacement observed at 10m height and its value is 82.606mm

**Comparison Between Conventional Steel Building Vs. Pre-Engineered Building-**

| Table 14 | |
|---|---|
| Max. Vertical Reaction at Base of Column (Kn) | |
| Conventional | 276.065 |
| Pre-Engineered | 220.136 |

In table- 14, Maximum vertical reaction is seen in conventional structures i.e. 279.065KN and pre-engineered structures shows reduction in vertical reaction.

| Table 15 | |
|---|---|
| Max. Horizontal Displacement Z Direction (mm) | |
| Conventional | 25.554 |
| Pre-Engineered | 14.395 |

In table- 15, conventional building shows more deflection as compared to pre-engineered building. Hence Pre-engineered building is more suitable.

| Table 16 | |
|---|---|
| Max Horizontal Displacement X Direction (mm) | |
| Conventional | 24.07 |
| Pre-Engineered | 11.275 |

In table- 16, Deflection more in conventional structures and shows considerable reduction in pre-engineered buildings.

| Table 17 | |
|---|---|
| Steel Consumption ($Kg/m^2$) | |
| Conventional | 38.917 |
| Pre-Engineered | 28.7165 |

In table- 17, conventional structures more steel consumption as compared to pre-engineered buildings. From results pre-engineered buildings shows 26.211% decrease in steel consumption.

## 7. CONCLUSION

1. From results it shows that with change of roof angle there is not much variation in steel consumption and other parameters as it is when they bay spacing is changed.
2. When models are compared for different roof angle and bay spacing, it shows that model with 7m bay spacing and roof angle of 5.71 is optimum for every parameter and shows optimum steel consumption i.e. 28.716$Kg/m^2$.
3. When models are compared for different column height it shows that column with 2m height shows less consumption of steel, but in practical column with height of 5-6m are more and more used.
4. When compared with conventional steel building, conventional building shows more vertical reaction at base. Also, when compared for displacement, values for conventional buildings are on higher sides.
5. When steel consumption is compared, conventional buildings shows around 35.524% more steel consumption than pre-engineered building i.e. 10.201 $Kg/m^2$ which is not economical and makes structure heavy.

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