Parametric Evaluation of Pre –Engineered Building (PEB) and Conventional Steel Sheds

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Abstract -*Pre-engineered buildings are mostly prepared using predesigning and prefabrication process. The advancement in the pre-engineered building construction approach involves time limitation, cost-effectiveness, improved structural behaviour and advanced architectural view. Pre-engineered buildings are becoming an effective replacement of conventional steel buildings in every aspect. It shows more advanced results in case of cost comparison, construction time, quality parameters and architectural point of view. The main objective of the current study is to compare pre-engineered steel buildings and conventional steel building in every aspect. A pre-engineered building was designed and then comparative analysis was done concerning a conventional building with the same configuration. The software which was mainly used for the entire designing and analysis part was Bentley STAAD PRO and it was found that the Pre-engineered building gives more sustainable results as compared to conventional steel buildings. It was also found that, if the construction process was according to conventional methods it will be more time consuming and more budget consuming at every aspect, so pre-engineered buildings usage should be implemented as the construction as well as the maintenance cost of pre-engineered buildings is very less as that of conventional steel buildings...In this project work we have compare parametric evaluation of pre –engineered building (PEB) and conventional industrial sheds of length 120m and width 60m under the influence of moving crane loads for both pinned support and fixed support using STAAD Pro.*

Key Words: **Max. Displacement, Time period ,Base shear, STAAD Pro .etc.**

1.INTRODUCTION

India being a developed country massive house building construction is taking place in various parts of the country. Since 30% of Indian population lives in towns and cities; hence construction is more in the urban places. The requirement of housing is tremendous but there will always be a shortage of house availability as the present masonry construction technology cannot meet the rising demand every year. Hence one has to think for alternative construction system for steel or timber buildings, but timber is anyway not suitable to tropical countries like India.In structural engineering, a pre-engineered building (PEB) is designed by a manufacturer to be fabricated using a pre-determined inventory of raw materials and manufacturing methods that can efficiently satisfy a wide range of structural and aesthetic design requirements. Within some geographic industry sectors these buildings are also called Pre-Engineered Metal Buildings. Historically, the primary framing structure of a pre-engineered building is an assembly of I- shaped members, often referred as I beam. In PEB, I section beams used are usually formed by welding together steel plates to form of I section. I section beams are then field-assembled (e.g. bolted connections) to form the entire frame of the pre-engineered building. Cold formed Z and C-shaped members may be used as secondary structural elements to fasten and support the external cladding. Roll-formed profiled steel sheet, wood, tensioned fabric, precast concrete, masonry block, glass curtain wall or other materials may be used for the external cladding of the building.In order to accurately design a pre-engineered building, engineers consider the clear span between bearing points, bay spacing, roof slope, live loads, dead loads, collateral loads, wind uplift, deflection criteria, internal crane system and maximum practical size and weight of fabricated members. Historically, pre-engineered building manufacturers have developed pre-calculated tables for different structural elements in order to allow designers to select the most efficient beams size for their project. In pre-engineered building concept the complete designing is done at the factory and the building components are brought to the site in CKD (Completely knock down condition). These components are then fixed / jointed at the site and raised with the help of cranes. The pre- engineered building calls for very fast construction of buildings and with good aesthetic looks and quality construction. Pre-engineered Buildings can be used extensively for construction of industrial and residential buildings. The buildings can be multi storied (4-6 floors). These buildings are suitable to various environmental hazards. Pre-engineered buildings can be adapted to suit a wide variety of structural applications; the greatest economy will be realized when utilizing standard details. An efficiently designed pre-engineered building can be lighter than the conventional steel buildings by up to 30%. Lighter weight equates to less steel and a potential price savings in structural framework.

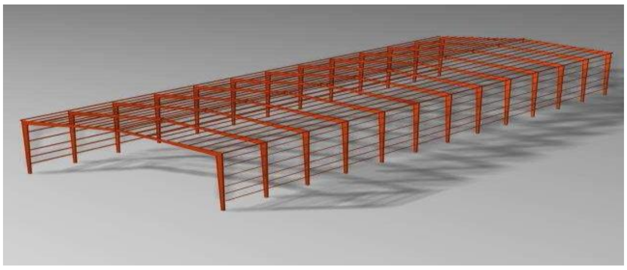


Figure No.1 – Pre Engineered Building (PEB) shed

1.1 Need of pre-engineered buildings

In almost all parts of the world, the steel industry is growing rapidly. The use of steel structures at a time when there is a risk of global warming is not only economical but also environmentally friendly. If we go for standard steel structures, the time frame will be longer, and the price will be higher as well, and both together, i.e. time and cost, will make it inexpensive. Therefore, the complete construction is performed in the factory in pre-engineered structures, and according to the design, members are prefabricated and then transported to the site where they are erected in less than 6 to 8 weeks.

1.2History of PEB

The use of pre-engineered buildings has been limited to North America and the Middle East for the most period until 1990. The use of pre-engineered buildings has since spread throughout Asia and Africa, where the concept of PEB architecture has now been widely accepted and lauded. The principle of pre-engineered steel buildings is known as the most flexible and economical building. In the construction industry, the economy and the speed of delivery and installation of these buildings are unparalleled. No other building system matches the pre-engineered building system in terms of speed and cost from excavation to occupancy.

1.3 Components of PEB

Primary members

Primary members in a PEB are the primary load bearing membranes and usually consists of the main rigid frame. Vertical members are called as columns and horizontals members are called as rafters. These are generally built up members made with hot rolled plates.

Secondary members

Cold-formed members such as roof purlins, wall girts, eave strut, etc are the secondary members in the PEB process.

1.4 Stages in Structural Design

Every structure follows a specific path from its initiation to ultimate design as follows:

1. Structural planning of the pre-engineered building (PEB)and conventional steel sheds .
2. Calculation of applied loads.
3. Structural analysis of the building.
4. Design of the building as per analysis.
5. Drawing and detailing of the structural members.
6. Preparation of tables and graphs.

It is the responsibility of the structural engineer to construct the building structurally good, considering all the loads acting on the building. There are so many methods of conducting these design we use STAAD Pro.software.

1.5 Introduction to STAAD Pro.

STAAD or (STAAD.Pro) is a structural analysis and design software application originally developed by Research Engineers International in 1997. STAAD.Pro is one of the most widely used structural analysis and design software products worldwide. It supports over 90 international steel, concrete, timber & aluminium design codes.It can make use of various forms of analysis from the traditional static analysis to more recent analysis methods like p-delta analysis, geometric non-linear analysis, Pushover analysis (Static-Non Linear Analysis) or a buckling analysis. It can also make use of various forms of dynamic analysis methods from time history analysis to response spectrum analysis. The response spectrum analysis feature is supported for both user defined spectra as well as a number of international code specified spectra. STAAD Pro stands for Structural Analysis And Designing Program. STAAD Pro software is widely used in analyzing and designing structures – buildings, bridges, towers, transportation, industrial and utility structures. Designs can involve building structures including culverts, petrochemical plants, tunnels, bridges, piles; and building materials like steel, concrete, timber, aluminium, and cold-formed steel.Basically, STAAD helps structural engineers automate their tasks by removing the tedious and long procedures of the manual methods.STAAD allows structural engineers to analyze and design virtually any type of structure. Structural engineering firms, structural consultants, departments in construction companies, and government agencies use this software extensively.

1.6 Features

STAAD Pro is capable of analysing and designing civil engineering structures such as buildings, bridges, and plane and space trusses.

1. This software can generate loads (wind and earthquake) as per building codes of selected countries.
2. Design of steel and reinforced concrete buildings as per the codes of selected countries can also be carried out with STAAD Pro.

3. It can carry out linear elastic (static and dynamic) and nonlinear dynamic analysis (although I am not sure how good the nonlinear analysis algorithms are, not having used those features).

4. The user interface is simple and easy to learn. This software is currently developed by Bentley Systems Inc. It was originally developed by Research Engineers Inc. in California.

1.7Getting Started

This paper includes detailed information on the methodology to analyze and design a pre engineered building and conventional steel sheds under anction of moving crane load for both pinned base and fixed base using STAAD Pro. Step by step procedure has been explained with the help of diagrams. Next to that, load calculations have been explained in depth and effect of seismic and wind calculations have been undertaken.

2. LITERATURE REVIEW

Shaik kalesha ,B.S.S.Ratnamala Reddy ,Durga Chaitanya Kumar Jagarapu (2020) (1)In this paper they studied an analytical study on pre engineered buildings using staad pro.the main objectives of this paper is to understand the concept of PEB and to minimize the usage of cost and time.

Lovneesh Sharma,neleshwar taak,pankaj kumar mishra (2021)(2) In this paper they work on comparative study on pre-engineered building with conventional steel structures using STAADPro.The main objective of the current study is to compare pre-engineered steel buildings and conventional steel building in every aspect. A pre-engineered building was designed and then comparative analysis was done concerning a conventional building with the same configuration.

Subodh s.patil, raviraj V.jadhav , Pritam A.Mali (2020)(3) in this paper they study analysis and design of pre –engineered building of an industrial warehouse.main objectives of this paper is to compare pre-engineered building (PEB) with conventional steel structure and separate analysis and design of pre engineered building with increased bay space is taken for study .

Aijaz ahmad zende, Prof.A.V.Kulkarni ,Aslam Hutagia (2019)(4)in this paper they work on comparative study of analysis and design of pre-engineered building and conventional frames .for doing this work they have considered three models.

C.M.Meera (2013)(5) in this paper a comparative study of PEB concept and CSB concept .the study is achieved by designing a typical frame of a proposed industrial warehouse building using both the concepts and analyzing the designed frames using the structural analysis and design software Staad pro.

David Milner, James Wesevich, Lisa Nikodym, Vincent Nasri, Darell Lawver, John Mould (2018)(6)In this paper they study on Improved blast capacity of pre-engineered metal buildings using coupled CFD and FEA modeling. In this study, a typical PEMB is selected and assessed for selected loads using a variety of approaches of increasing analytical sophistication. The extent of building damage is determined by each method and the results are compared to demonstrate the benefit of each analytical method. The use of refined analytical methods is shown to estimate significantly less damage in the PEMB for the loads considered.

2.1 OBJECTIVES

The main objective of this paper is to undergo analysis and design of pre-engineered building (PEB) and conventional steel sheds and study parametric evaluation of both PEB and conventional steel sheds under action of moving crane load for pinned base and fixed base.The objectives have been specified as follows:

1. Generation of Pre engineered building and conventional steel shed model on STAAD Pro..
2. Comparison of severity of forces acting on the structure.
3. Finding out effects on various parameters of Pre-engineered building (PEB) And conventional steel sheds building under moving crane load.
4. To Find Support Reaction ,Deflection ,Time period ,base shear ,Etc.
5. Analysis & design of Pre Engineered Building (PEB) and conventional steel sheds for moving crane load for both pinned base and fixed base on STAAD Pro.
6. Study of the behavior of structural member of both PEB and conventional steel sheds under the action of moving crane loads for pinned base and fixed base .

3. Methodology To Undertake Analysis And Design On Staad Pro.

3.1. Design coded and standards

In general pre-engineered buildings are designed based on American or Indian codes of practice based on customer requirements.

3.1.1. Types of loads

3.1.2. Dead load(IS 875 –PartI)

It includes primary member's self-weight i.e. frames and sec-ondary structural component weight such as purlin, girts, Flange Braces, roof, and wall braces and wallboard.

3.1.3 Live load(IS 875 –PartII)

Live loads are temporary usually short-lived and may be fixedor moving. Live loads on the roof and floor are provided by Workers ' repairs, owing to equipment and materials. Movable artifacts during the lifespan of the system but do not include water, snow, seismic or dead load.

3.1.4. Seismic load(IS 1893-2016)

Earthquake forces trigger seismic load and it is applied horizon-tally at the center of the main structure's weight. The structure was designed and constructed under the following formula to with stand the minimum-maximum lateral seismic force:

$$Vb = AhW$$

3.1.5.Wind load(IS 875 –PartIII)

Wind load is governed by the building's wind speed, roof slope,eave height, and enclosure conditions. Based on enclosure conditions internal pressure coefficient is taken as following

1. Enclosed ±0.2

2. Partially enclosed ±0.5

3. Open ±0.7

3.1.6 Crane

A crane is a type of machine, typically fitted with a hoist, wire ropes or chains, and sheaves that can be used both for raising and lowering materials and for horizontal movement.

Types of cranes normally available in PEB buildings are:

Top Running EOT Crane

Underhung Crane

Semi-gantry Crane

Jib Crane

Monorail Crane

3.2 Project Statement

A structure considered here is a Pre-engineered building (PEB) and conventional steel sheds with plan dimension 60m X 120 m. For wind load IS 875(1987) part-3 is used and IS:1893 (part -1) 2002 is used for seismic loading.

Table no 1: Specification of building model

Location	Aurangabad
Length	120 m
Width	60 m
Eave Height	12 m
Seismic Zone	II
Wind Speed	39 m/s
Wind Terrain Category	2
Wind Class	C
Life Span	50 Years
Slope Of Roof	1 in 10
Bay spacing	6m

3.3 Modelling

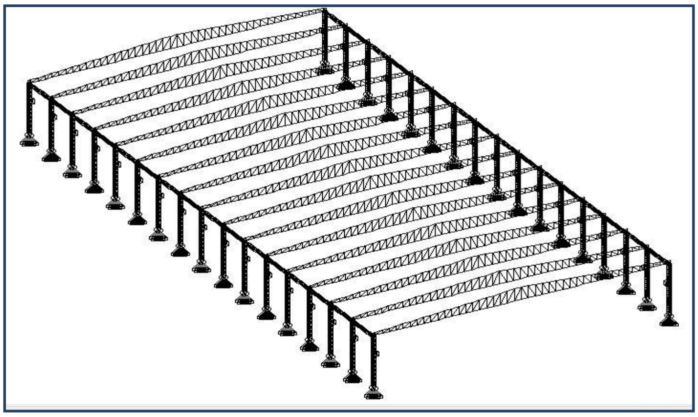


Figure No. 2 -3D View Of Pinned Based Conventional Steel Shed

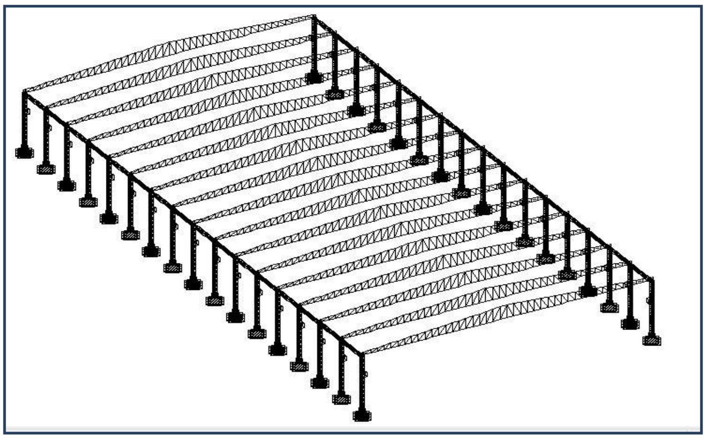


Figure No.3 -3D View Of Fixed Based Conventional Steel Shed

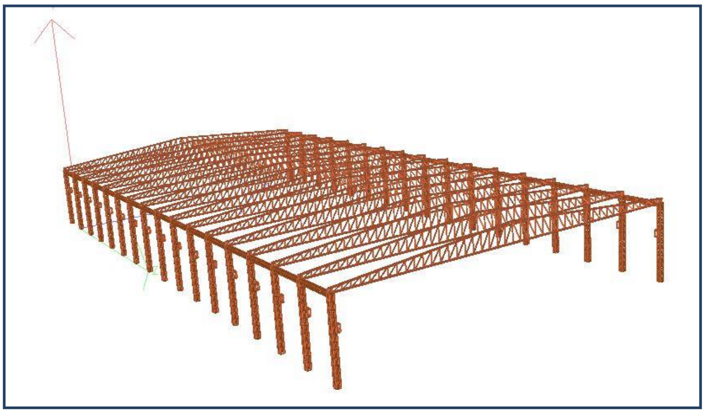


Figure No.4 -3D Model View Of Fixed Base Conventional Steel Shed

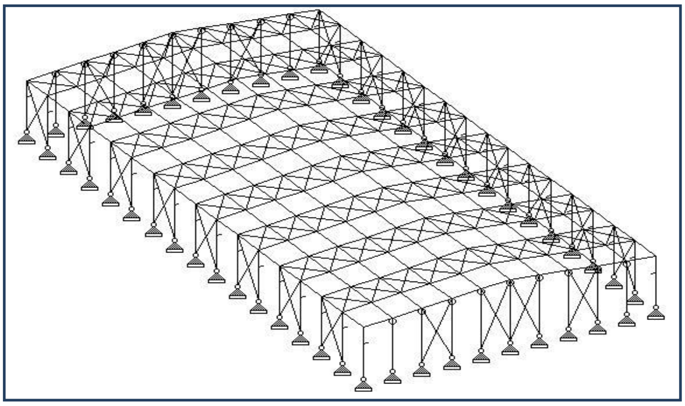


Figure No.5 -3D View Of Pinned Based PEB

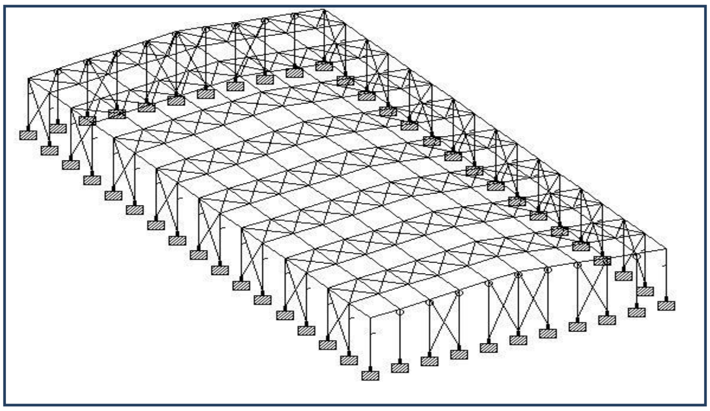


Figure No.6 -3D View Of Fixed Based PEB

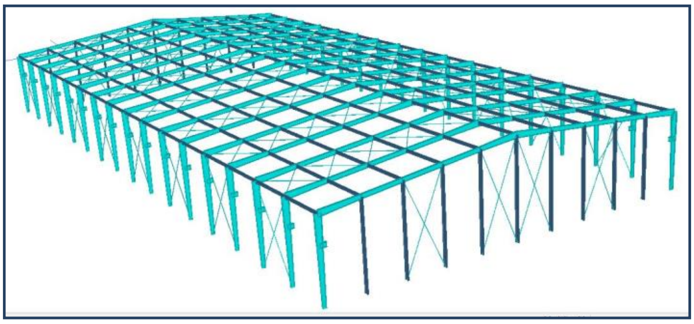


Figure No.7 -3D View Of PEB

4. Methodology To Undertake Analysis Pre-Engineered

Building(PEB) And Conventional Steel Sheds under moving crane load .

4.1 Load combination

The load combination is taken into account according to codes. Different load combinations are used according to different codes used for PEB layout. It can be divided into three different

Categories:

1. Load Combinations as per AISC
2. Load Combinations as per IS875/IS800-19
3. Load Combinations as per IS800-2007

Load combination for PEB and Conventional steel sheds

LOAD COMB 1 DL+LL
LOAD COMB 2 1.5(DL+LL)
LOAD COMB 3 1.5(DL+EQX)
LOAD COMB 4 1.5(DL-EQX)
LOAD COMB 5 1.5(DL+EQZ)
LOAD COMB 6 1.5(DL-EQZ)
LOAD COMB 7 1.2(DL+LL+EQX)
LOAD COMB 8 1.2(DL+LL-EQX)
LOAD COMB 9 1.2(DL+LL+EQZ)
LOAD COMB 10 1.2(DL+LL-EQZ)
LOAD COMB 11 1.2(DL+LL+WL)

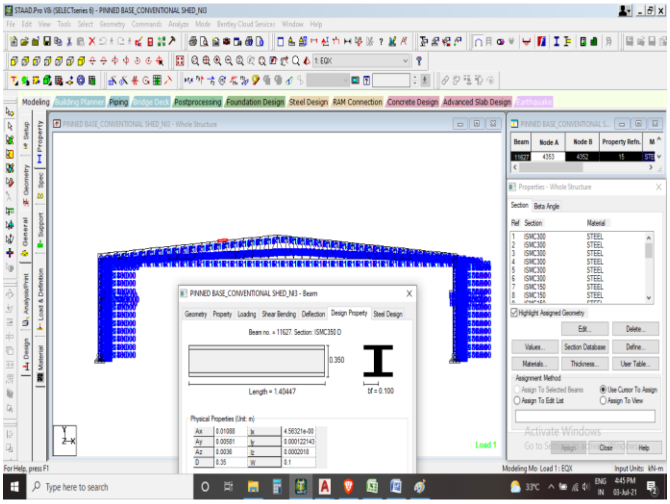


Figure No.8 –Load defined for Pinned based conventional steel sheds

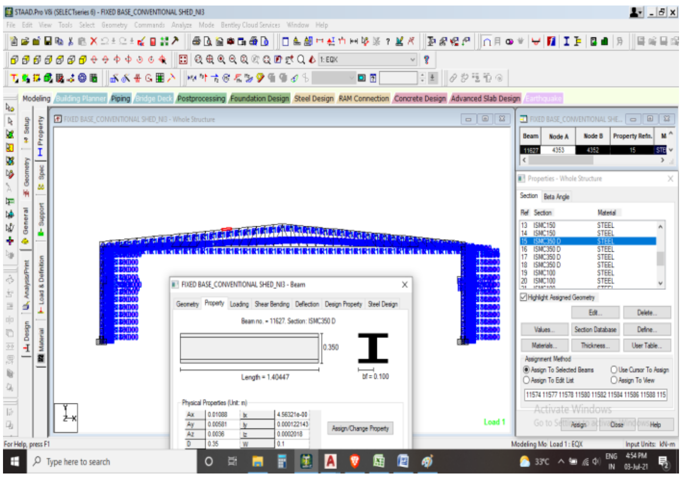
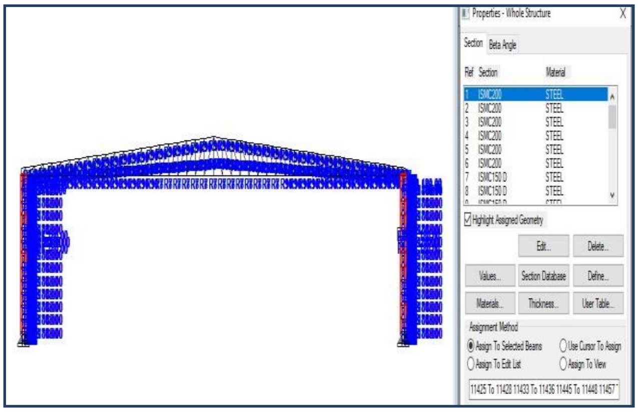


Figure No.9 –Load defined for Fixed based conventional steel sheds



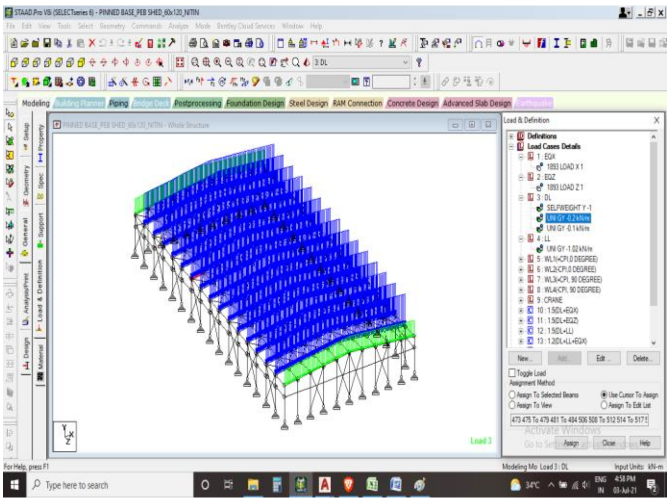


Figure No.10 –Load defined for Pinned based PEB

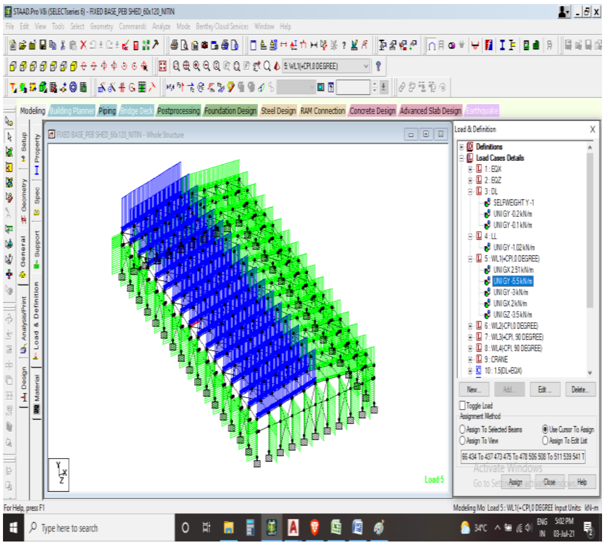


Figure No.11 –Load defined for Fixed based PEB

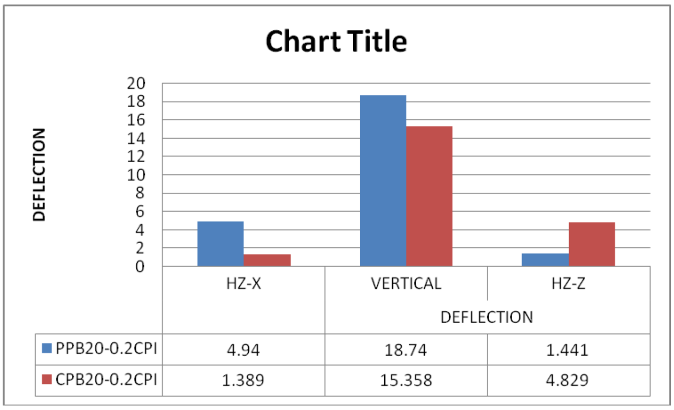
5. Result and Discussion

5.1 Deflection : Following table shows deflection values In pre engineered building (PEB) and conventional steel sheds :

Table no.2 : Deflection values for pinned base PEB and conventional steel sheds

MODEL NAME	DEFLECTION		
	HZ-X	VERTICAL	HZ-Z
PPB20-0.2CPI	4.94	18.74	1.441
CPB20-0.2CPI	1.389	15.358	4.829

PPB –PEB with Pinned base
CPB –Conventional Steel Shed with Pinned base

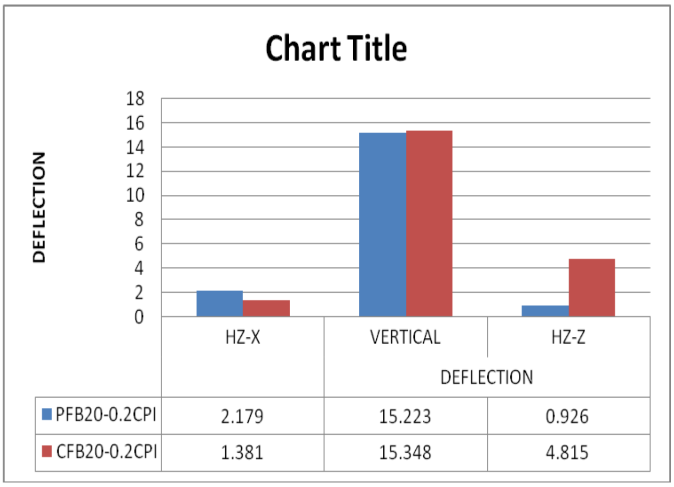


Graph No.1 –Deflection Values In Pinned Based PEB and Conventional Steel Sheds

Table no.3 : Deflection values for Fixed base PEB and conventional steel sheds

MODEL NAME	DEFLECTION		
	HZ-X	VERTICAL	HZ-Z
PFB20-0.2CPI	2.179	15.223	0.926
CFB20-0.2CPI	1.381	15.348	4.815

PFB –PEB with Fixed based
CFB –Conventional Steel Shed with Fixed based

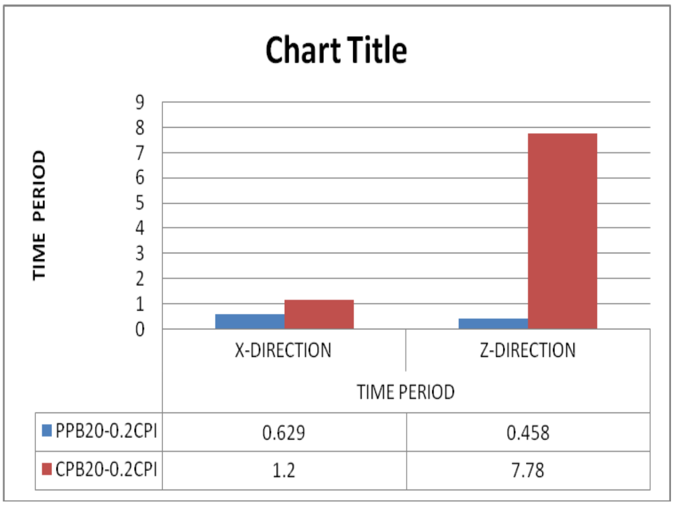


Graph No.2 –Deflection Values In Fixed Based PEB and Conventional Steel Sheds

5.2 Time period in seismic analysis

Table no.4 : Time period values for Pinned based PEB and Conventional Steel Sheds

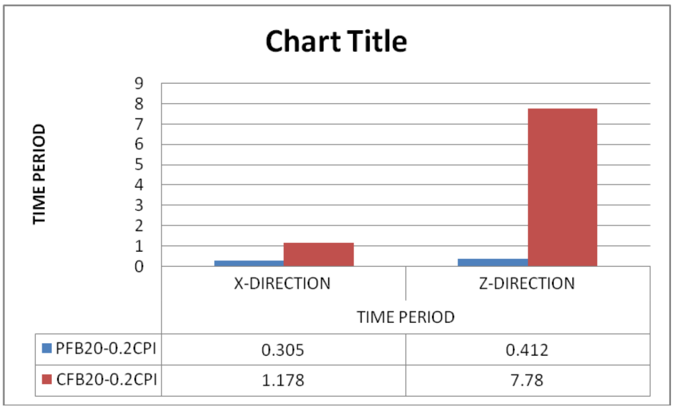
MODEL NAME	TIME PERIOD	
	X-DIRECTION	**Z-DIRECTION**
PPB20-0.2CPI	0.629	0.458
CPB20-0.2CPI	1.2	7.78



Graph No.3 –Time Period Values In Pinned Based PEB and Conventional Steel Sheds

Table no.5 : Time period values for Fixed based PEB and Conventional Steel Sheds

MODEL NAME	TIME PERIOD	
	X-DIRECTION	**Z-DIRECTION**
PFB20-0.2CPI	0.305	0.412
CFB20-0.2CPI	1.178	7.78

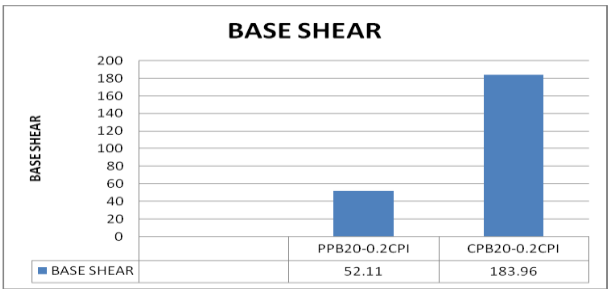


Graph No.4 –Time Period Values In Fixed Based PEB and Conventional Steel Sheds

5.3 Base Shear

Table no.6 : Base Shear values for Pinned base PEB and Conventional Steel Sheds

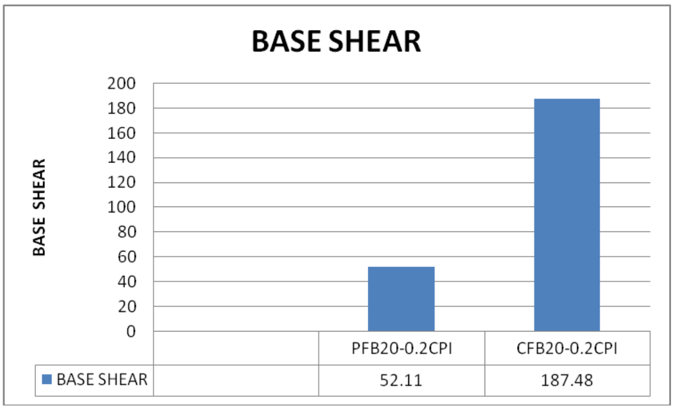
MODEL NAME	BASE SHEAR
PPB20-0.2CPI	52.11
CPB20-0.2CPI	183.96



Graph No.5 –Base shear Values In Pinned Based PEB and Conventional Steel Sheds

Table no.7 : Base Shear values for Fixed base PEB and **Conventional Steel Sheds**

MODEL NAME	BASE SHEAR
PFB20-0.2CPI	52.11
CFB20-0.2CPI	187.48



Graph No.6 –Base shear Values In Fixed Based PEB and Conventional Steel Sheds

6. CONCLUSIONS

1. While analyzing Pre-Engineered Building(PEB) and conventional steel sheds of same size it was observed that deflection values are less in Pre Engineered Building as compared to conventional steel sheds.
2. From table number two and graph number one it was observed that deflection values in Pinned based PEB are greater than Pinned based conventional steel sheds.
3. Also from table number three and graph number two it was observed that deflection values in fixed based PEB are less as compared to fixed based conventional steel shades.
4. From table number four and graph number three it was observed that time period for PEB in pinned based is less as compared to Pinned based conventional steel sheds.
5. From table number five and graph number four it was observed that time period for PEB in Fixed based is less as compared to fixed based conventional steel sheds .
6. While analyzing it was observed that base shear values for both pinned base and fixed based in PEB are less as compared to conventional steel sheds as shown in table number six and seven and graph numbers five and six .

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