Comparative Analysis of Multi-Storey Structure Into RCC And PEB

Mrs. Tabassum D. Sayyad[1], Dr. Sachin V. Admane[2]
[1]H.O.D., Dept of Civil Engineering
[2]Principal
[1, 2] Bhivrabai Sawant Polytechnic, Wagholi, Maharashtra. India

Abstract- *PEB constructions are nowadays popular owing to their advantages over conventional Concrete and Steel constructions. Concrete structures are bulky and impart more seismic weight and less deflection whereas Steel structures instruct more deflections and ductility to the structure, which is beneficial in resisting earthquake forces. PEB Construction combines the better properties of both steel and concrete along with lesser cost, speedy construction, better quality control, sustainability etc. Hence, the aim of the present study is to compare performance of a G+2 story RCC and PEB frame. Both frames are designed for same loading combinations. Beam and column sections are made of either RCC, Steel sections. STAAD PRO software is used for analysis and design and analysis results are compared. Cost effectiveness based on material cost for both building frames is determined.*

Keywords- RCC Building, Pre-engineered Building, STAAD PRO

I. INTRODUCTION

Building and houses are one of the basic needs of human beings. The construction technology has the beginning from primitive construction technology to present concept of modern house building. The present construction methodology for buildings requires the best aesthetic look, high quality and fast construction, cost effective and innovative touch. Daily new techniques are being developed for the construction of houses and buildings economically, quickly. The Pre-engineered Building concept is one of them. This concept originated in USA in the year 1990.Since then the use of pre-engineered building has spread throughout the world, now been widely used for industrial purpose.In pre-engineered building, the complete work from designing to manufacturing is carried out at the factory and then after completion of work, the building components are brought to the site for fixing. In order to build a building that is strong, durable, and is quick to construct then pre-engineered buildings are the main solution. PEB are economical and efficient method of designing and construction [P Pravin kumar Venkat rao]. Steel is the basic material that is used for Pre-engineered steel building. Steel material chooses in such way that, it offers rapid site installation and less energy consumption, to commit to the principles of sustainability, infinitely recyclable [Firoz et.al]. PEB structures are more advantageous in terms of quality control, cost effectiveness, simplicity in erection process and speed in construction [C. M. Meera]. The weight of the PEB depends on the Bay spacing, as we increased the Bay spacing at certain limit the weight reduces and further increase makes the weight heavier [Naidu et.al].The entire sectional properties of PEB will depends just upon the moments at that specific locations so there won't be any excess steel used in the thus it is economical [Kumar et.al]. PEB structures can be easily designed by simple design procedures in accordance with country standards, it is energy efficient, speedy in construction, and saves cost, sustainable and most important it's reliable as compared to conventional buildings.PEB methodology must be implemented and researched for more outputs [Bhagatkar et.al].

A. RCC Building

RCC buildings are those which are made up of cement concrete reinforced with steel bars. Steel bars are used to increase the tension capacity of the structure.Cement concrete can take compression but weak in tension whereas steel is good in tension but weak in compression.

B. Pre-engineered Building

"Pre-engineered steel buildings" are those that are totally design and manufactured in the factory and then shipped to the site for jointing /fixing. In pre -engineered building usually I shaped members also called as I beams are used. These beams are usually formed by welding together steel plates in the factory. Some manufacturers tapering the sections mean decreasing the size of web at the bottom. Engineers consider the clear span between column, bay spacing, dead loads, live loads, earthquake effect, wind loads, internal crane provision, deflection criteria, etc. for accurately design a pre-engineered building. Primary framing includes the main frame which is designed according to bending moment diagram. Thus, the BM is maximum at mid span and at fixed support. Thus, at maximum BM the depth of section is large and depth is reduced depending on BM.Purlins, girts and eave struts are the secondary framing members. For these members Cold formed Z and C-shaped members are used to fasten and support the external cladding

II. METHODOLOGY

The buildings are planned as a combination of columns and beam, slab system. After preliminary sizing of various structural members, a computer model of the structural frame of the building will be generated for carrying out computer analysis for the effects of vertical and lateral load that are likely to be imposed on the structure. The building structure will be analyzed using the STAAD PRO software. Geometrical dimensions, member properties and member-node connectivity, including eccentricities will be modeled in the analysis problem. The seismic analysis would be carried out for static loading in accordance with the relevant code of Practice. The computer analysis will evaluate individual internal member forces, reactions at foundation level and deflection pattern of the entire structures and in the individual members. This data will then be used to verify adequacy of the member sizes adopted and after further iterations arrive at the. Most appropriate design of the structural members. Some re-runs of the analysis program might be required for arriving at the optimum structural space frame characteristics that satisfy the strength and stability criteria in all respects

A. Building Details

For completion of this project, plan of existing G+2 Hospital Building is considered whose plan dimensions are 62M X 50M .This building is located at Sangli, Maharashtra. The study is carried out on both RCC and PEB construction. The load combination is same for both types of structure.

B. Structural Data for RCC Building

The plan of RCC building is shown in Figure1.Separate provisions are made for car parking, lift, staircase, operation rooms and other utilities.

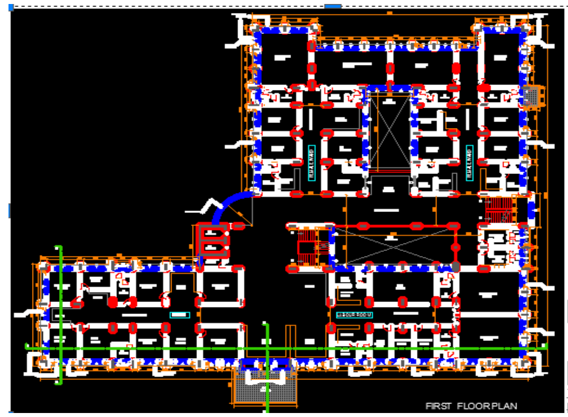

Figure 1. Plan of RCC building

Other relevant data for RCC building like total height of Building, Height of each storey, Height of parapet wall, Size of beams, Size of columns, Thickness of wall, Grade of concrete, Grade of steel, Soil condition, Bearing capacity of soil as shown in TABLE I.

TABLE I STRUCTURAL DATA FOR RCC BUILDING

Total height of Building	12 m
Height of each storey	3m
Height of parapet wall	1m
Type of Beams	Size of beams
B1	0.23m X 0.45m
B2	0.23m X 0.6m
B3	0.3m X 0.45m
B4	0.3m X 0.6 m
B5	0.3m X0.75m
Type of columns	Size of columns
C1	0.35 m X 0.68 m
C2	0.35m X 0.75m
Thickness of wall	
External wall	300 mm
Internal wall	230 mm
Seismic zone	IV
Grade of concrete	M20 –Beam & Column
	M25-Footing
Grade of steel	Fe 500
Soil condition	Hard soil
Bearing capacity of soil	120 kN-m^2

C. Structural Data for Pre-engineered Building

The plan of Pre-engineered building is shown in Figure 2.

As the bay spacing in PEB should be greater than 6m, the numbers of columns are reduced in PEB.

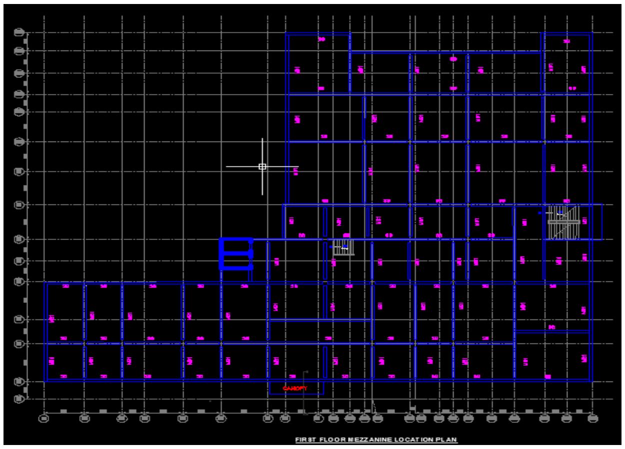

Figure 2. Plan of Pre-engineered building

Other relevant data for Pre-engineered building like total height of Building, Height of each storey, Height of parapet wall, Size of plinth beams, Size of rafters, Size of columns, Thickness of wall, Grade of concrete, Grade of steel, Soil condition, Bearing capacity of soil as shown in TABLE II.

TABLE II. STRUCTURAL DATA FOR PRE-ENGINEERED BUILDING

Total height of Building	12 m
Height of each storey	3m
Height of parapet wall	1m
Type of Plinth Beams	Size of Beams
B1	0.3 m X 0.6 m
B2	0.23m X0.45m
B3	0.3 m X0.75m
Type of Rafters	Sizes of Rafters
MB1	0.396 m X0.006 m /0.300m X 0.01m
MB2	0.292 m X0.006 m /0.250m X 0.01m
MB3	0.280 m X0.006 m /0.300m X 0.01m
MB4	0.400 m X0.006 m /0.300m X 0.01m
MB5	0.396 m X0.006 m /0.275 m X 0.01m
MB6	0.600 m X0.006 m /0.300m X 0.01m
MB7	0.34 m X0.006 m /0.300m X 0.01m
MB8	0.396 m X0.006 m /0.250 m X 0.01m
SB1	0.690 m X0.006 m /0.300m X 0.01m
SB2	0.910 m X0.006 m /0.300m X 0.01m
SB3	0.700 m X0.006 m /0.300m X 0.01m
SB4	0.700 m X0.006 m /0.300m X 0.01m
SB5	0.800 m X0.006 m /0.300m X 0.01m
SB6	0.550 m X0.006 m /0.350m X 0.01m
SB7	0.826m X0.006 m /0.300m X 0.01m
Types of columns	Size of columns
C1	0.900 m X0.006 m /0.300m X 0.016m
C2	0.900 m X0.006 m /0.300m X 0.018m
C3	0.916 m X0.006 m /0.300m X 0.010m
C4	0.940 m X0.006 m /0.300m X 0.025m
C5	0.920 m X0.006 m /0.300m X 0.010m
C6	0.940 m X0.006 m /0.370m X 0.025m
C7	0.930 m X0.015 m /0.550m X 0.016m
C8	0.920 m X0.006 m /0.350m X 0.020 m
C9	0.800 m X0.006 m /0.300m X 0.020m
Thickness of wall	
External wall	260 mm
Internal wall	180 mm
Seismic zone	IV
Grade of concrete	M20 –Plinth Beam
	M25-Footing
Grade of steel	Fe 500
Soil condition	Hard soil
Bearing capacity of soil	120 kN-m^2

III. ANALYSIS AND DESIGN

The both building frame is analyzed using Equivalent static method by STAAD pro software. Different parameters like maximum story deflection, maximum rotation, maximum moment, maximum base shear, maximum compressive stress, and maximum tensile stress studied for both models. After the completion of analysis, the code IS 456-2000 is used for RCC sections design whereas IS 800-2007 is used for PEB sections design. Seismic forces are calculated using code IS 1893-2002.The plinth beam designed for RCC frame is provided in PEB frame too.

A. Bending Moment Diagram For RCC Building

Bending moment diagram for RCC building is shown in Figure 3.

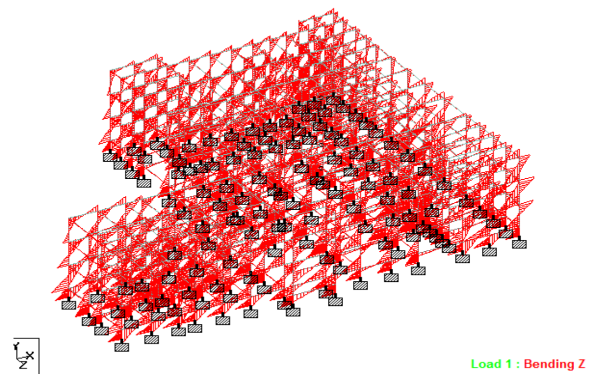

Figure 3 Bending Moment Diagram for RCC Building

B. Shear Force Diagram For RCC Building

Shear force diagram for RCC building is shown in Figure 4.

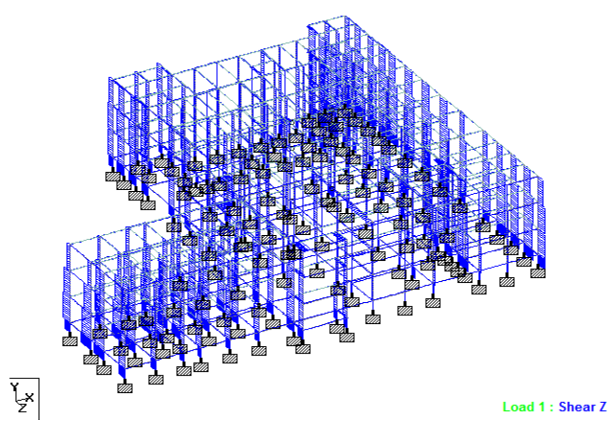

Figure 4 Shear Force Diagram for RCC Building

C. Bending Moment Diagram For PEB

Bending moment diagram for Pre-engineered building is shown in Figure 5.

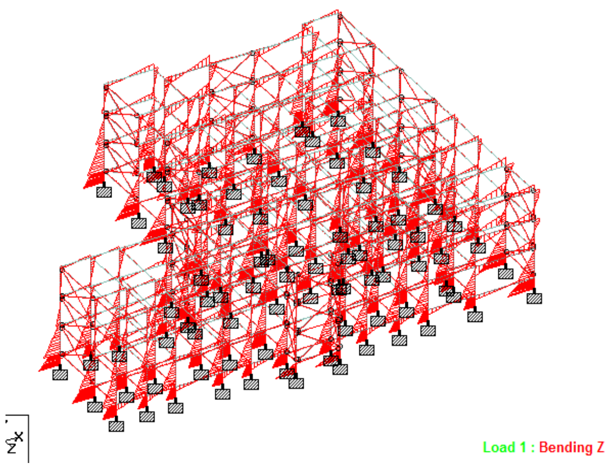

Figure 5 Bending Moment Diagram for PEB

D. Shear force Diagram For PEB

Shear force diagram for Pre-engineered is shown in Figure 6.

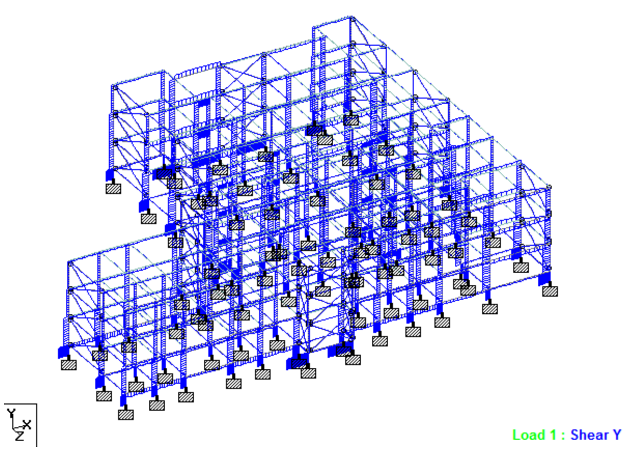

Figure 6 Shear Force Diagram for PEB

IV. RESULTS AND DISCUSSIONS

A Results from Software Analysis

The various results like maximum axial force, maximum shear force, maximum moment in column and beam are evaluated as shown in TABLE III.

TABLE III. RESULTS FROM SOFTWARE ANALYSIS

Sr.No.	Parameters	PEB Performance	RCC Performance
1	Maximum Axial Force In Column	1961.776 kN	2440.819 kN
2	Maximum Shear Forces In Column In Y Direction	139.14 kN	392.951 kN
3	Maximum Shear Forces In Column Z Direction	374.35 kN	80.38 kN
4	Maximum Moment In Column In X Direction	17.769 kN-m	1.731 kN-m
5	Maximum Moment In Column In Y Direction	327.61 kN-m	115.081kN-m
6	Maximum Moment In Column In Z Direction	252.566 kN-m	307.788 kN-m
7	Maximum Axial Force In Beam	150.699 kN	94.148 kN
8	Maximum Shear Forces In Beam Y Direction	255.259 kN	312.012 kN
9	Maximum Shear Forces In Beam Z Direction	34.909 kN	6.943 kN
10	Maximum Moment In Beam In X Direction	17.769 kN-m	74.291 kN-m
11	Maximum Moment In Beam In Y Direction	28.534 kN-m	14.983 kN-m
12	Maximum Moment In Beam In Z Direction	308.797 kN-m	455.849 kN-m

Figure 7 shows the maximum shear forces in column, from figure we can observe that, shear force in RCC column in X direction is maximum as compared to PEB column. Shear force in RCC column in Y direction is maximum as compared to PEB column and shear force in RCC column in Z direction is minimum as compared to PEB column.

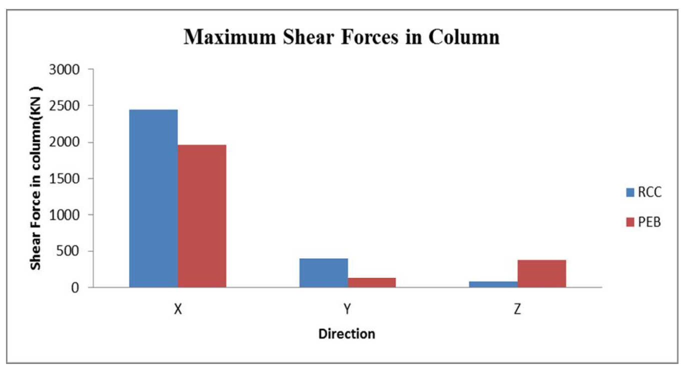

Figure 7. Maximum Shear Forces in Column

Figure 8 shows the maximum moment in column, from figure we can say that, moment in RCC column in X direction is minimum as compared to PEB column. Moment in RCC column in Y direction is minimum as compared to PEB column and moment in RCC column in Z direction is maximum as compared to PEB column.

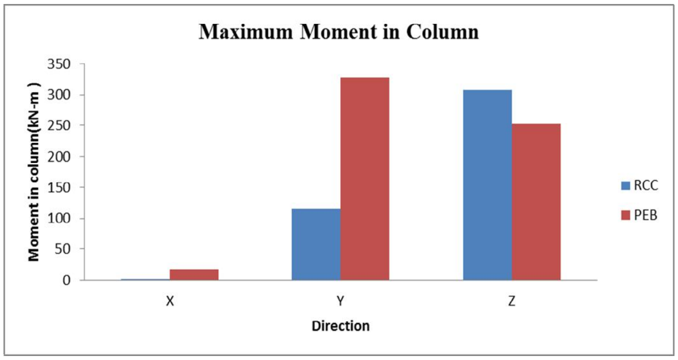

Figure 8. Maximum Moment Column

Figure 9 shows the maximum shear forces in beam, from figure we can say that, shear force in RCC beam in X direction is minimum as compared to PEB beam. Shear force in RCC beam in Y direction is maximum as compared to PEB beam and shear force in RCC beam in Z direction is maximum as compared to PEB beam.

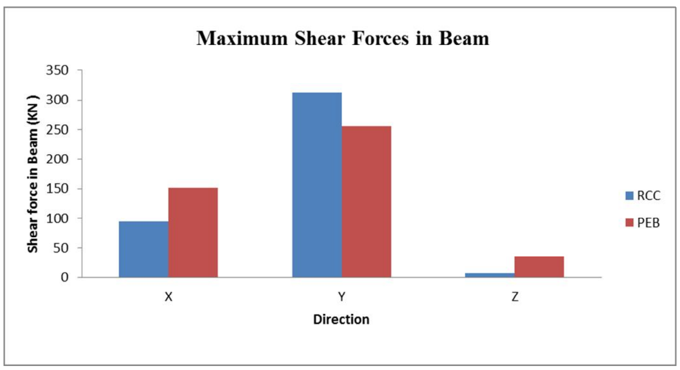

Figure 9. Maximum Shear Forces in Beam

Figure 10 shows the maximum moment in beam, from figure we can observe that, moment in RCC beam in X direction is maximum as compared to PEB beam. Moment in RCC beam in Y direction is minimum as compared to PEB beam and shear force in RCC beam in Z direction is maximum as compared to PEB beam.

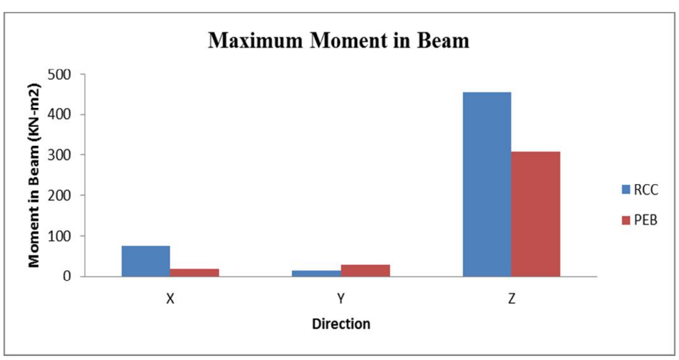

Figure 10 Maximum Moment in Beam

B Cost comparison Analysis

The total cost of project is divided into four major construction activities such as, beam, column, slab and foundation.

- RCC Frame structure

TABLE IV indicates the cost analysis for RCC Frame structure, considering the quantity of concrete only. Quantity of concrete in structural elements is calculated by manual calculation. Rate of material is taken from District schedule of rates.

TABLE IV.COST ANALYSIS RCC BUILDING (CONCRETE)

Sr.No.	Structural Element	Quantity of concrete Used(m^3)	Rate of material/ m^3	Amount
1	Beam	548.264	6978	3825786.1925
2	Column	455.348	7859	3578579.932
3	Slab	723.867	8753	6336007.851
4	Footing	385.92	5144	1985172.48
	Total			15725546

TABLE V indicates the cost analysis for RCC Frame structure, considering the quantity of Steel only. Quantity of steel in beam and column is calculated by steel take off from staad pro. Rate of material is taken as per market rate.

TABLE V.COST ANALYSIS RCC (STEEL)

Sr.No.	Structural Element	Quantity of steel Used(kg)	Rate of material/MT	Amount
1	Beam and Column	72422.31	58000	4200493.98
2	Slab	43432.02	58000	2519057.16
3	Footing	13620.564	58000	789992.712
	Total			7509543.852

Total cost in RCC Structure = Rs.15725546+Rs 7509543.852=Rs 2, 32, 35,089.85/-

- PEB Frame Structure

TABLE VI indicates the cost analysis for PEB frame structure, considering the quantity of concrete only. Quantity of concrete in structural elements is calculated by manual calculation. Rate of material is taken from District schedule of rates.

TABLE VI. COST ANALYSIS PEB (CONCRETE)

Sr.No.	Structural Element	Quantity of concrete Used(m^3)	Rate of material/m^3	Amount
1	Plinth Beam	108.67	6978	758299.26
2	Footing	196.8	5144	1012339.2
	Total			1770638.46

TABLE VII indicates the cost analysis for PEB frame structure, considering the quantity of steel only. Quantity of steel in structural elements is calculated by manual calculation. Rate of material is taken from District schedule of rates and from market rate.

TABLE VII. COST ANALYSIS PEB (STEEL)

Sr.No.	Structural Element	Quantity of steel Used(kg)	Rate of material/MT	Amount
1	Beam and Column	256229.089	48255	123643346.9
3	Plinth beam	7041.62	58000	408413.96
4	Slab	191383	40000	7655320
5	Footing	6548.848	58000	379833.184
	Total			208079018.3

Total cost in PEB structure = Rs. 1770638.46+Rs. 20807901.83 = 2, 25, 78540.29/

C Total Cost comparison Analysis

TABLE VIII indicates the Total cost comparison analysis between RCC frame structure and PEB frame structure. From it is observed that the cost of PEB frame structure is less as than RCC frame structure.

TABLE VIII.TOTAL COST COMPARISON ANALYSIS

Sr No	Total Cost of RCC Structure(Cr)	Total Cost of PEB Structure(Cr)	Difference
1	2,32,35,089.85	2,25,78540.29	656549.56

Figure 11 shows the total cost between RCC and PEB, from figure we can say that the cost of RCC frame structure is more than PEB frame structure.

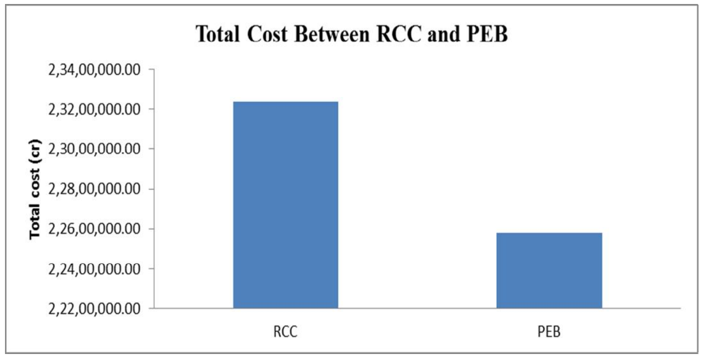

Figure 11. Total cost comparison analysis

V. CONCLUSIONS

- Base Shear for RCC frame is maximum because the weight of the RCC frame is more than the PEB frame.
- Moment in Column in X Direction and Y Direction is more in PEB Frame as compared to RCC frame.
- Moment in Column in Z Direction is more in RCC frame as compared to PEB frame.
- Moment in beam in X Direction and Z Direction is more in RCC Frame as compared to PEB frame.
- Reductions in cost of PEB frame as compared with cost of RCC frame. This involves material cost only.

REFERENCES

[1] Firoze et.al,(2012)"Design concept of pre-engineered building". International Journal of Engineering Research and Applications, Volume 2 Issue 2, pp: 267-272
[2] Meera C.M. (2013). "Pre-Engineered Building Design of an Industrial Warehouse."International Journal of Engineering Sciences and Emerging Technologies, Volume: 5, Issue: 2,pp:75-82.
[3] Lande P.S and Kucheriya V.V.(Aug.2014), "Comparative Study of an Industrial Pre-Engineered Building with Conventional Steel Building". Journal of Civil Engineering and Environmental Technology Volume 2, Number 10; April-June, 2015 pp. 77-82
[4] Naidu et.al. (Sept.2014). "Comparative Study of Analysis and Design of Pre-Engineered Buildings and Conventional Frames", International Journal of Engineering Research and Development e-ISSN: 2278-067X, p-ISSN: 2278-800X Volume 10, Issue 9.
[5] Rao K.and Vishwanath M.N. (Sept.2014). "Design Optimisation of an Industrial Structure from Steel Frame to Pre-Engineered Building", International Journal of Research in Advent Technology, Vol.2, No.9, September 2014 E-ISSN: 2321-9637.
[6] Reddy et.al.(Nov. 2014). "Design and Analysis of Pre Engineered Industrial Buildings (PEB)", International

Journal of Applied Sciences, Engineering and Management ISSN 2320 – 3439, Vol. 03, No. 06, November 2014, pp. 26 – 29.
[7] Kharta et.al. (March 2015). “A Study On Pre-Engineered Building – A Construction Technique”,Int. Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 5, Issue 3, (Part -2) March 2015, pp.05-09
[8] Shah S.A and Kumthekar M. B. (May 2015). “Guidelines for Erection process of Pre-Engineered Building”, International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869, Volume-3, Issue-5
[9] IS 456: 2000, “Code for practice of plain and reinforced concrete code of practice, Bureau of Indian Standards”, New Delhi.
[10] IS 1893: 2002, “Code for earthquake resistant design of structures- general provisions for buildings, Part I, Bureau of Indian Standards”, New Delhi.
[11] IS 800:2007, “Indian Standard Code of practice for General Construction of Steel in India,Bureau of sIndian Standards”,New Delhi