PERFORMANCE EVALUTION OF PEB LARGE SPAN INDUSTRIAL SHEDS BY NON LINEAR STATIC APPORACH STRENGTHEN BY BRACINGS

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Abstract— *Steel structures are mostly preferred for industrial buildings due to it higher strength to Weight ratio as compare to RCC structures; therefore, the increasing demand of the industrial sheds and warehouses, pre-engineered building concept is getting famous rapidly not only in India but also all over the world that requires a long clear span of a column free space which can provide easy access and mobility within the building. The current study involve the comparative study of Pre Engineered Steel Buildings (PEB) and Conventional steel building without bracing system are the two examples, and other third, fourth and fifth example is Pre Engineered steel Building with a different bracing system is taken for the Study. Analysis of the structure is being done by sap2000 software. To evaluate the nonlinear seismic response, pushover analysis approach has been adopted; plastic hinges have been assigned to every frame element at each nodal point, based on FEMA 356 and ATC-40. Following parameters have been considered for evaluating the response such as Mode shapes and their time period, Hinge status, ADRS (Acceleration demand response spectrum) curves for evaluating performance points.*

Keywords— **PEB frames, CSB frames, Tapered sections, Steel tube, IS Standard, SAP2ooo.**

1. INTRODUCTION

Steel industry is growing quickly in almost all the parts of the world. The utilization of steel structures is not just economical but also Eco-friendly at the time when there is a hazard of global warming. Here, “economical” word is considering time and cost Time is most significant viewpoint, steel structures (Pre-manufactured) is worked in exceptionally brief period and one such model is Pre Engineered Buildings (PEB). Pre-designed structures are only steel structures in which abundance steel is kept away from by tightening the areas according to the twisting second's necessity `One may consider its chance, yet it's a reality numerous individuals don't know about Pre Engineered Buildings. Conventional steel structures, time period will be more, and steel cost will be more, and both together for example time and cost, makes it uneconomical.

Fig .1: Example of PEB structure

2. OBJECTIVES OF THE STUDY

- To study the behaviors of PEB and conventional steel building with varied bracing configuration.
- To record the inelastic response of each different structural configuration by having different Bracings like Cross bracing, K-bracing, and diagonal bracing.
- To developed the acceleration demand response spectrum (ADRS) of each different CSB and PEB model
- To work the performance level of CSB and PEB models by establishing performance points.

3. DESCRIPTION OF THE STUDY

Model 1 (CSB) – conventional steel building is consist of I-section frame element having hinge support to the column without bracings

Model 2 (PEB) – pre engineering steel building is consist of tapering I-section frame element having hinge support to the column without bracings

Model 3 (PEB) with single bracing – pre engineering steel building is consist of tapering I-section frame element having hinge support to the column with single bracings system

Model 4 (PEB) with X- bracing – pre engineering steel building is consist of tapering I-section frame element having hinge support to the column with X- bracings system

Model 5 (PEB) with K- bracing – pre engineering steel building is consist of tapering I-section frame element having hinge support to the column with K-bracings system

4. METHODS OF ANALYSIS

In this paper all the results are extracted from SAP2000, the parameters for non-linear response of structure are as follows.

1. Modal analysis, 2.Non-linear hinges, 3.Acceleration demand response spectrum (ADRS) and performance point

5. DESIGN DATA:

Length of building	:	72m
Width of building	:	36m
Eave height of building	:	12m (clear height)
Bay spacing	:	8m
Slope	:	1:10
Purlins	:	50mm
Rafter	:	300x5x200x8
Rafter 1 (RF1)	:	250-400x5x200x8
Rafter 2 (RF2)	:	400-250x5x200x8
Rafter 3 (RF3)	:	250-300x5x200x8
Hot rolled I-section	:	400X6X200X8
End Column (EC)	:	350X6X250X8
Bracing	:	50mm
Roof panels	:	2mm thick
LOAD ON ROOF PANEL		
Dead load	:	0.15 KN/m^2
Live load	:	0.75 kN/m^2

6. RESULTS AND DISCUSSIONS

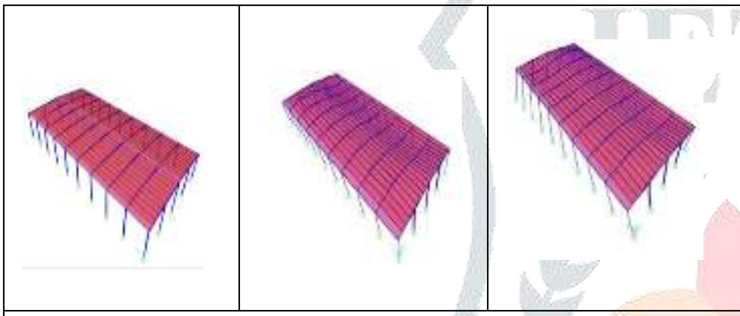
The results of Modal analysis, Non-linear hinges, Acceleration demand response spectrum (ADRS) and overall performance for the different tower models are presented and compared.

MODAL ANALYSIS

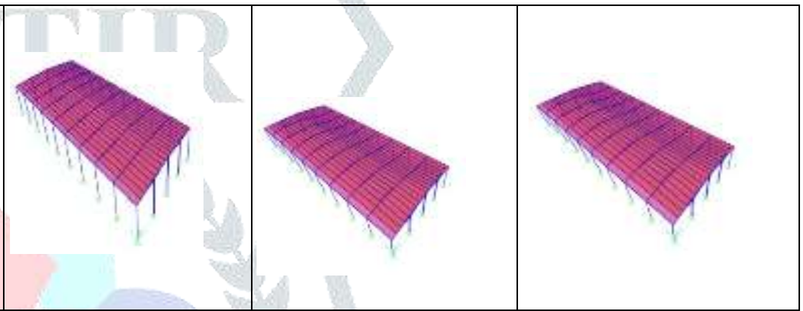
This parameter is extremely essential to evaluate the dynamic or free vibration responses of any type of structural systems, there to understand the modal nature of the above mentioned towers, 12 modes of vibrations have been considered, and for each mode modal mass participation has been evaluated to understand the nature of mode of vibrations of every single mode. And an attempt is made to understand the natural and circular frequencies of the structures with Eigen values for each single mode. Due to space restriction only 3 fundamental modes of vibrations are only added here

MODEL 1										
mode number	Time period in sec	frequency cycle/sec	Circ Freq red/sec	Eigen value rad^2/sec^2	Modal mass participation in UX	MMP in UY	MMP in UZ	MMP in RX	MMP in RY	MMP in RZ
1	3.075	0.559	1.368	4.135	0.000	1.000	0.000	0.001	0.000	0.000
2	2.400	0.417	2.618	6.851	0.976	0.000	0.000	0.000	0.004	0.000
3	1.978	0.506	3.177	10.091	0.000	0.000	0.000	0.000	0.000	0.985

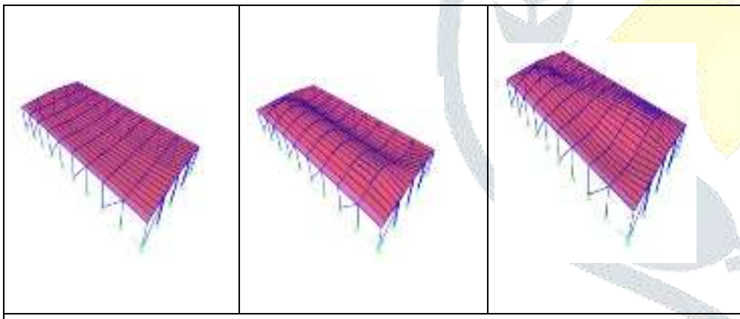
MODEL 2										
1	2.873	0.054	0.340	0.116	0.000	1.000	0.000	0.001	0.000	0.000
2	2.528	0.396	2.485	6.176	0.968	0.000	0.000	0.000	0.006	0.000
3	2.047	0.488	3.069	9.421	0.000	0.000	0.000	0.000	0.000	0.979
MODEL 3										
1	1.065	0.939	5.899	34.795	0.000	0.000	0.552	0.000	0.000	0.000
2	0.717	1.394	8.759	76.717	0.407	0.000	0.000	0.000	0.193	0.000
3	0.651	1.536	9.654	93.194	0.000	0.000	0.000	0.000	0.000	0.014
MODEL 4										
1	1.062	0.941	5.914	34.975	0.000	0.000	0.551	0.000	0.000	0.000
2	0.665	1.504	9.449	89.290	0.069	0.000	0.000	0.000	0.324	0.000
3	0.648	1.543	9.694	93.968	0.000	0.000	0.000	0.000	0.000	0.005
MODEL 5										
1	0.787	1.271	7.986	63.770	0.000	0.000	0.513	0.000	0.000	0.000
2	0.507	1.971	12.385	153.390	0.763	0.000	0.000	0.000	0.054	0.000
3	0.456	2.195	13.794	190.267	0.000	0.003	0.000	0.379	0.000	0.000



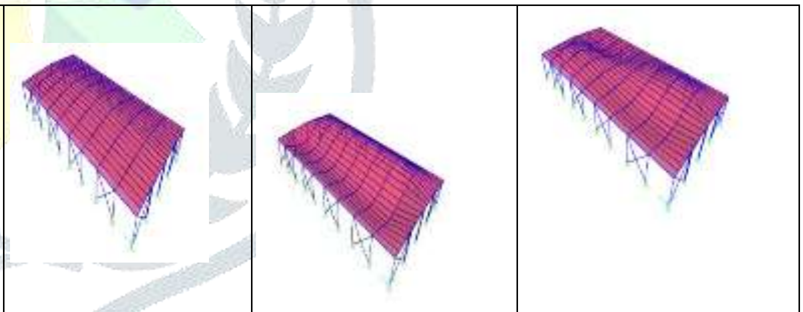
Model 1, Mode 1, 2 & 3



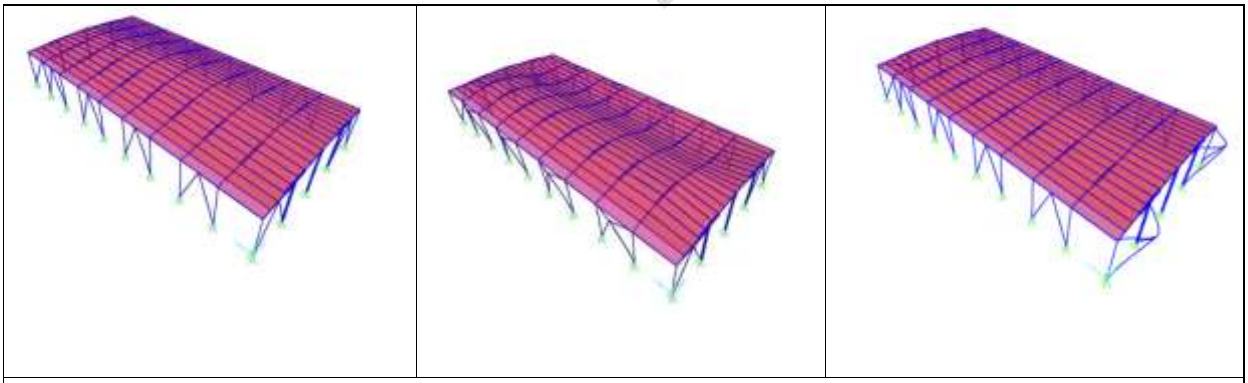
Model 2, Mode 1, 2 & 3



Model 3, Mode 1, 2 & 3



Model 4, Mode 1, 2 & 3



Model 5, Mode 1, 2 & 3

Model 1: This model has particular records the highest amount of natural time periods among all other models. this model have Therefore got huge modal mass participation ratio's along x direction and torsion is exhibit in mode 3 and maximum torsion is in third mode, And rapidly increases in Eigen value of 4^{th} and once in 10th mode and in 11th mode only in x direction respectively. This pattern is not enough against seismic threatening. Model 2 are seems to be equivalent to each other.

Model 2: This model also has records second highest amount of time periods of all other models. this model have got huge modal mass participation ratio's are in both direction of starting modes torsion is exhibit in mode 3 and maximum torsion is in third mode, And rapidly increases in Eigen value of 4th and 5th less when compare with 1st models. Circular frequency is slightly increasing first 4 modes. Therefore this configuration is not enough against seismic force.

Model 3: This model have got only 40% amount of modal mass participation in the 2nd mode and 59% in 11th mode in X direction respectively and in y direction there is no modal mass participation. These models have got 50% amount of modal mass participation in the 1st mode and 60% in 12th mode in Z direction, torsion is exhibit in mode 3 and maximum torsion is in third mode, Circular frequencies appeared to be significantly increased in nature mode of vibrations.

Model 4: This model have got only 69% amount of modal mass participation in the 2nd mode in X direction respectively. In Y direction there is no modal mass participation. These models have got 55% amount of modal mass participation in the 1st mode and 53% in 11th mode in Z direction , torsion is Exhibit very less in mode 3 and maximum torsion is in third mode, Circular frequencies appeared to be significantly increased in nature mode of vibrations.

Model 5: This model have got only 79% amount of modal mass participation in the 2nd mode in X direction respectively. In Y-direction there is no modal mass participation. These models have got 55% amount of modal mass participation in the 1st mode in Z direction, torsion is exhibit very less in mode, Circular frequencies appeared to be significantly increased in free vibration. It has got highest Eigen value and lowest natural time period as compare with other models.

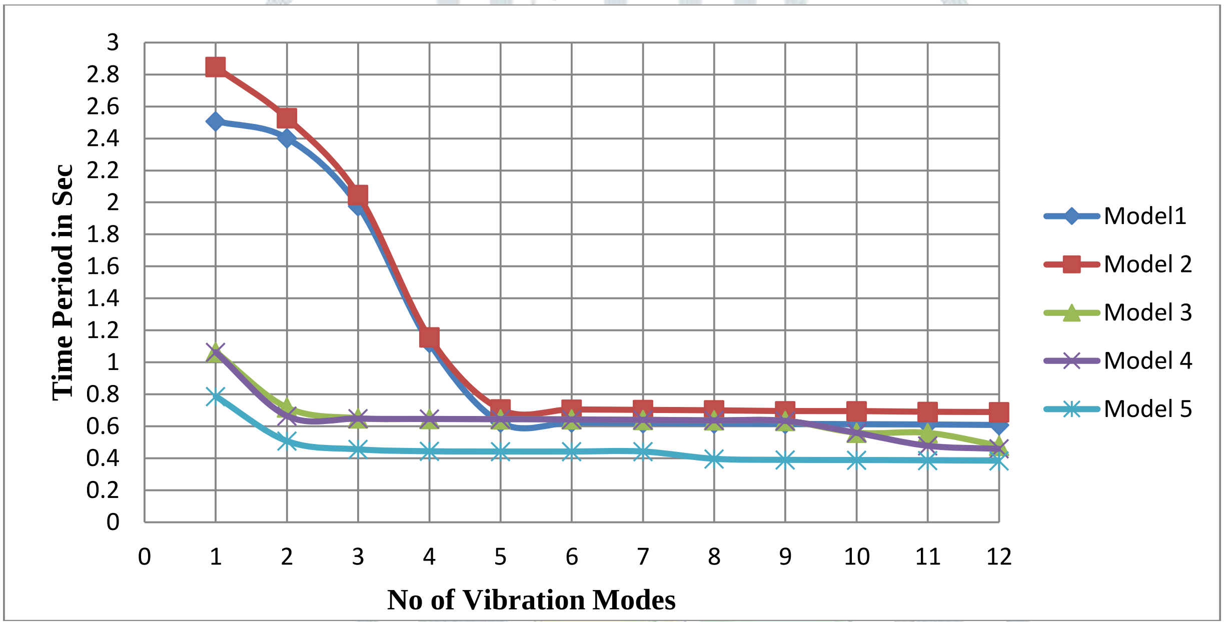
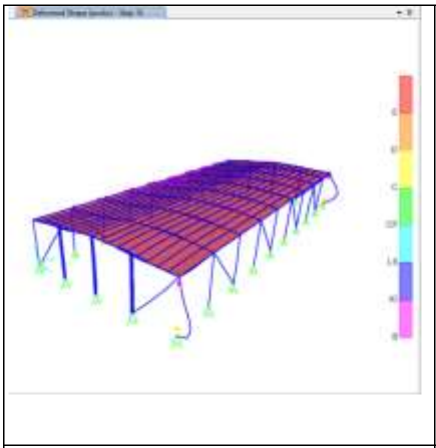


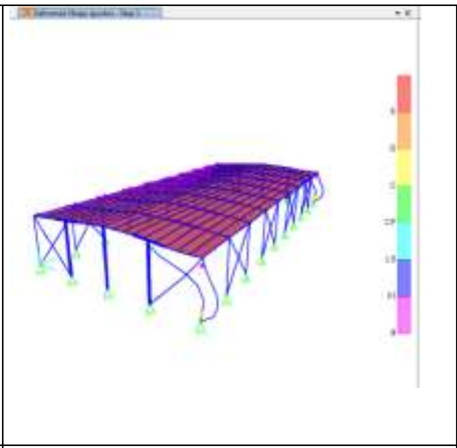
Chart: Shows the Fundamental natural time periods of different models

Non-linear Hinges

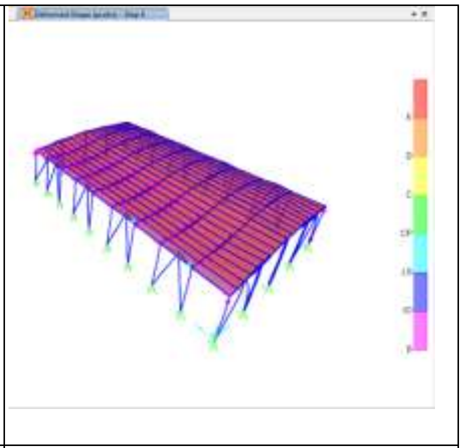
This is one of the important parameter, for recognizing the non-linear damages in the structure after any earthquake, in this particular study P-hinge or the hinges for only axial load have been considered, because all the structural members in pin-jointed space frames are either in tension length of 0.2m. Pushover analysis has been done SAP2000, in both the longitudinal and transverse direction. An automated acceleration load pattern in SAP2000 has been considered, pushover or non-linear static analysis is iterative procedure (SAP2000 has used Newton Rapson method). The no of hinges generation with their acceptance criteria for each different tower model is given as fallows or compression. The axial hinges are assigned at the ends of every structural element for a hinge



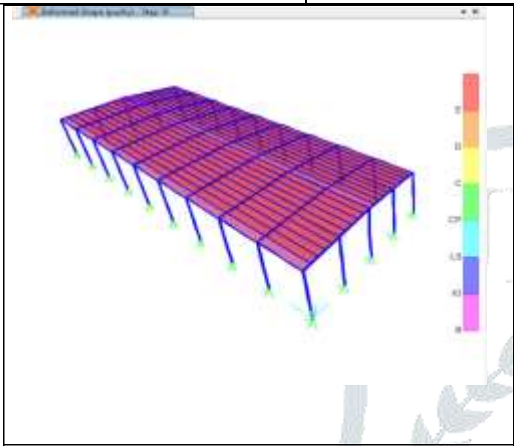
Model 3 Push x



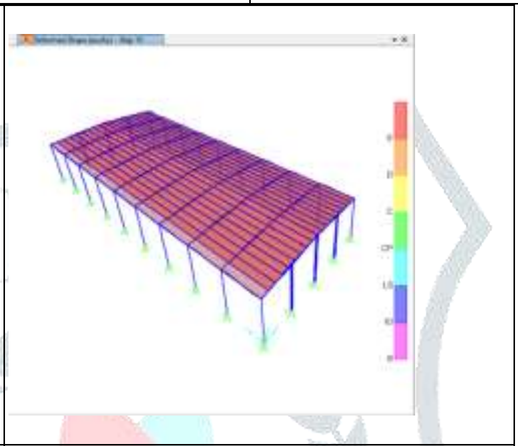
Model 4 Push x



Model 5 Push x



Mode1 1 Push x



Mode1 2 Push x

Here some of hinge data has been collected, because of space confinements the entire hinges have not be includes here.

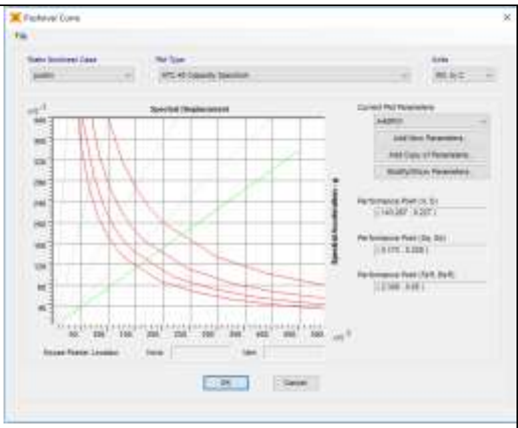
Model 1: Non linear analysis has been carry out along both directions, and it also showing non-linear behavior against seismic force along in y direction.

Model 2: This model has showing same hinge status as same model 1.but it shown plastic deformation.

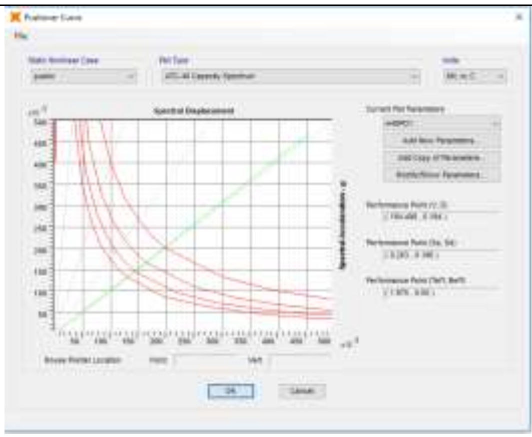
Model 3: Results are shown for Hinge178H1 along both direction, its shows the hinges status of immediate occupancy to collapse prevention. This model shows good performance by adding single diagonal bracing system to this structure.

Model 4: Results are shown for Hinge142H2 same as model 1 and model 2.but it shows over stiff as compare to all model, due to placing of cross bracing system to structure.

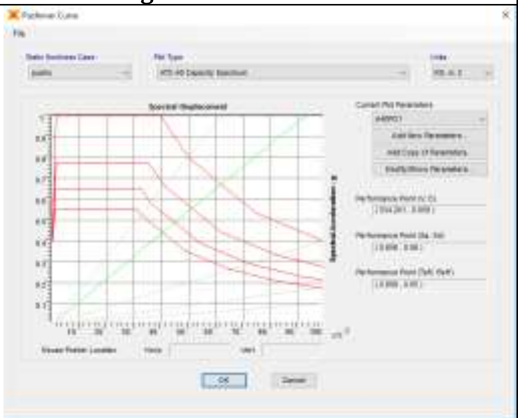
Model 5: For Hinge514H1 shows plastic rotations, reaching beyond CP (collapse prevention) as compare to all models, and it also showing non-linear behavior against seismic force along in y direction, due to in bracing system.



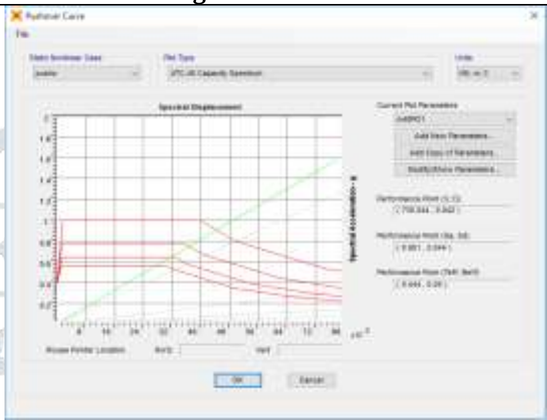
ADRS in longitudinal direction for Model 1



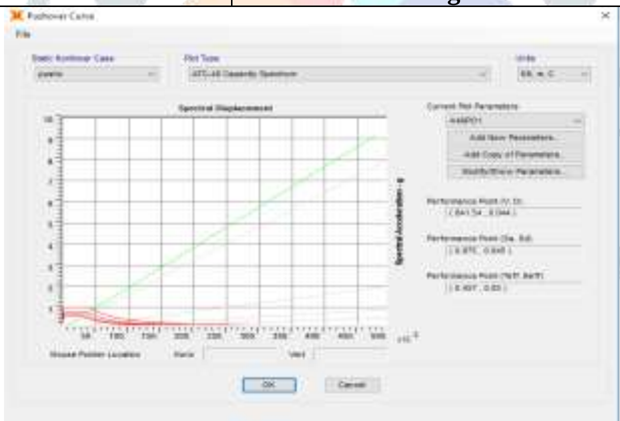
ADRS in longitudinal direction for Model 2



ADRS in longitudinal direction for Model 3



ADRS in longitudinal direction for Model 4



ADRS in longitudinal direction for Model 5

Model 1: The performance point formed only PUSH X, the base shear and the displacement at performance point are V = 143.269KN, D = 0.227M FOR PUSHX AND PUSHY there is no performance point formed. Overall performance of this steel building is not well enough as far as nonlinear performance is concern.

Model 2: The performance point formed only PUSH X, the performance point are V = 143.269KN, D = 0.227M FOR PUSHX, AND PUSHY there is no performance point formed. The performance of this steel building is not well enough as far as nonlinear performance is concern. Not provided bracing for lateral support to the vertical column.

Model 3: The performance point formed for both PUSHX are V = 534.269KN, D = 0.059M FOR PUSHX AND V =718.27 KN, D =0.0452 M FOR PUSHY. Non linear performance is good as compare to model 1 and model 2.

Model 4: The performance point formed for both PUSHX AND PUSHY .V = 735.0269KN, D = 0.042M FOR PUSHX AND V =816.27 KN, D =0.026 M FOR PUSHY, has good seismic performance as compare with model 3.

Model 5: the performance point formed for both the load cases, performance point are V = 841.0269KN, D = 0.044M FOR PUSHX AND V =933.27 KN, D =0.033M FOR PUSHY, the overall performance of this building is good enough as far as nonlinear performance is concern. This model has got highest base shear compare with all other models.

7. CONCLUSIONS

1. Model 1 has particular records the highest amount of natural time periods among all other models, as it indicates conventional steel building is not suitable for large span.
2. The PEB model with X- braced system will have least lateral displacement and it suitable for large span building in seismic prone zones.
3. The PEB with X-braced and PEB with K-braced system will have least time period and highest Eigen value in compare to other model 1, 2 and model 3.
4. The stiffness of the building increase as the natural time period decreases.
5. Model 1 and model 2 has indicates the range of immediate occupancy level, and this configuration are not good for performance level in seismic zones.
6. Model 4 indicates over stiffness behavior as compare to all model PEB with X-braced configuration is suitable for 3 to 6 m bay and K-braced configuration is suitable for more than 6 m bay.
7. Model 1, 2 and 3 configuration is showing non linear performance against seismic loading in Y-direction

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