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PUSHOVER ANALYSIS OF STEEL FRAME

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Abstract – Steel is by far most useful material for building construction in the world and in last decades steel structure has played an important role in construction industry. Providing strength, stability and ductility are major purposes of seismic design. It is necessary to design a structure to perform well under seismic loads. In this Paper nonlinear push over analysis is carried out for high rise building steel frame with different pattern of bracing system. The shear capacity of the structure can be increased by introducing steel bracing in structural system. There is n number of possibilities to arrange steel bracing for Ex. Diagonal, X, K, V Inverted V. A typica12th- story regular steel frame having V zone building is designed for various types of concentric bracings like Diagonal, V, X, and Exterior X and Performance of each frame is carried out through nonlinear static analysis. Using different types of material sections i.e. ISMB and ISA or any tubular or hollow sections are used to compare for same patterns of bracing.

Keywords- Steel Frame, Analysis

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INTRODUCTION

Earthquake is a natural phenomenon, which is generated in earth's crust. Duration of earthquake is usually rather short, lasting from few seconds to more than a minute or so. But thousands of people lose their lives due to earthquakes in different parts of the world. Building collapse or damages are the major loss due to earthquake ground motion. In an earthquake, the building base experiences high-frequency movements, which results in inertial forces on the building and its components. The force is created by the building's tendency to remain at rest, and in its original position, even though the ground beneath it is moving. The use of the nonlinear static analysis (pushover analysis) came in to practice in 1970‟s but the potential of the pushover analysis has been recognized for last two decades years. This procedure is mainly used to estimate the strength and drift capacity of existing structure and the seismic demand for this structure subjected to selected earthquake. This procedure can be used for checking the adequacy of new structural design as well.

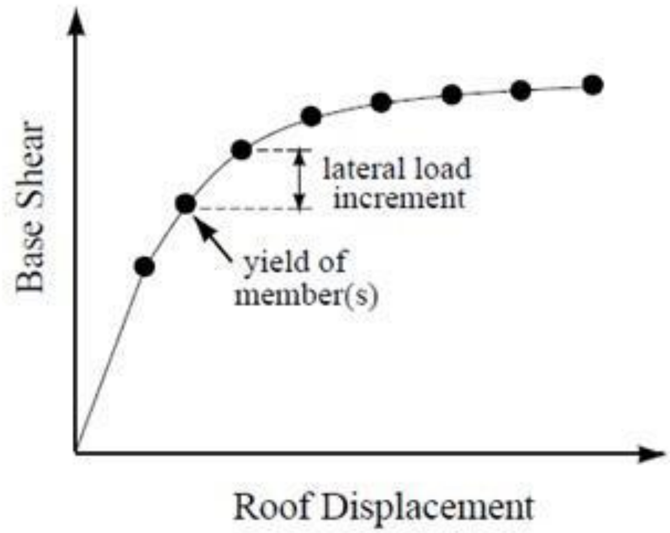
The effectiveness of pushover analysis and its computational simplicity brought this procedure in to several seismic guidelines (ATC 40 and FEMA 356) and design codes (Euro code 8 and PCM 3274) in last few years.

Pushover analysis is a static, nonlinear procedure in which the magnitude of the structural loading is incrementally increased in accordance with a certain predefined pattern. With the increase in the magnitude of the loading, weak links and failure modes of the structure are found. The loading is monotonic with the effects of the cyclic behavior and load reversals being estimated by using a modified monotonic force-deformation criteria and with damping approximations. Static pushover analysis is an attempt by the structural engineering profession to evaluate the real strength of the structure and it promises to be a useful and effective tool for performance based design.

Many methods were presented to apply the nonlinear static pushover (NSP) to structures. These methods can be listed as:

(1) Capacity Spectrum Method (CSM) (ATC)

(2) Displacement Coefficient Method (DCM) (FEMA 356)



Typical Capacity (Pushover) Curve of Structure

1.2. Objectives: - To obtain most feasible and economical structural system for a high rise steel frame building through pushover analysis and its correspondents design.

Following are the main objectives of the present study:

1) To study the behavior of building after application of seismic force.
2) To investigate the seismic performance of a multi-story steel frame building with different bracing arrangements using Nonlinear Static Pushover analysis method.

3) Estimates of force and displacement capacities of the structure. Sequence of the member yielding and the progress of the overall capacity curve.

4) Sequences of the failure of elements and the consequent effect on the overall structural stability.

5) To evaluate the performance factors for steel frames with various bracing arrangements designed according to Indian Code.

STRUCTURAL MODELING

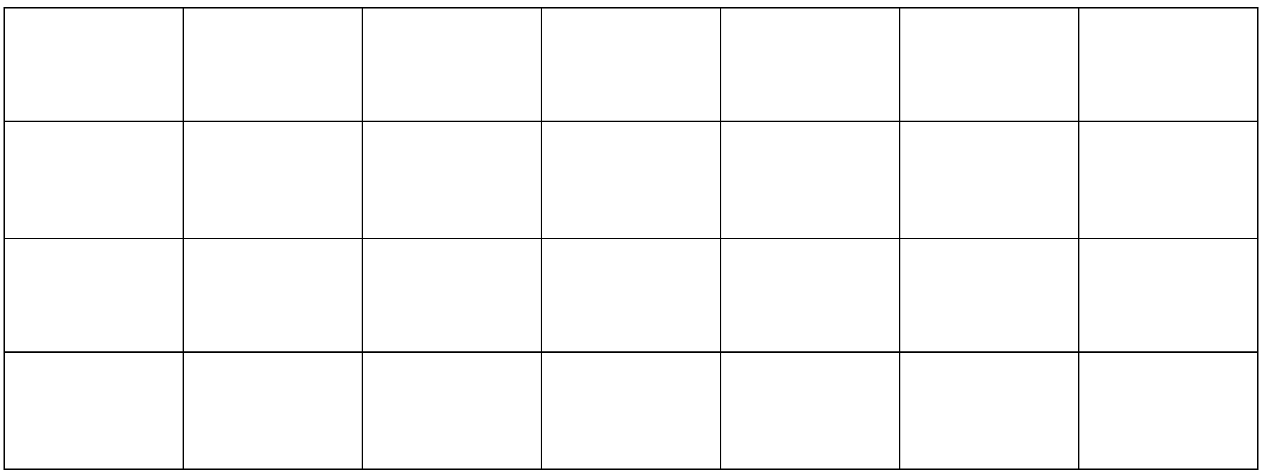
For the analysis work, Use high rise steel frame building (12) floors are made to know the realistic behavior of building during earthquake. The length of the building is 21m and width is 16m with each 3.65m floor height. The columns are assumed to be fixed at the ground level. Non Linear static analysis i.e. pushes over analysis is used. Use of bracing with different section and different material. The Steel Framed structure without bracing and Steel Framed structure with different bracing patterns.

2.1 Building Description:-

1) Size of Building = 21m X 16m
2) Each Floor Height = 3.65m

3) Total Height of Building = 43.8m
4) Slab Thickness = 125mm
5) Zone of Building = V
6) Steel Section (ISMB450) Beam and Column (ISMB500) or (ISMB600)
7) Steel (ISA) or Tubular Pipe (Hollow Section) Bracing Used
8) Grade of Steel = Fe250
9) Live Load = 3KN/m
10) Floor Finish Load = 1KN/m

2.2 Plan of Building



Bay @ 3m in X-direction and 4m in Z-direction (21m X 16m)

2.3 Static Load Calculation

Static Load for without bracing of steel frame having 12th floor steel building. Calculate the total gravity and lateral load acting at each nodal point on the building structure. The total load can be calculated are as follows.

Total Load Due to Dead Load = 4713 KN
Total Load Due to Live load = 8388 KN
Total Load on structure = 13101 KN
Load on each floor = 1091.71KN

Building Properties:-

1) The Building can design V zone class Z=0.36
2) The Response Reduction Factor R = 5
3) The importance factor I = 1

4) Medium soil Type II

The time period in X direction & Z direction can be calculated as

$$T = 0.09\,h/\sqrt{d}$$

For X direction T = 0.09*43.8 /4.582 =0.86 so Sa/g = 1.582

For Z direction T = 0.09*43.8/ 4 = 0.985 so Sa/g = 1.38

For X direction Ah = Z*I*Sa / 2Rg

= 0.36*1*1.582 / 2*5

= 0.0712

For Z direction Ah = 0.0621

Lateral Load = Ah*Wi

Lateral load on X direction = 0.0712*13101 = 932.7912KN

Lateral Load in Z direction = 0.0621*13101 = 813.572 KN

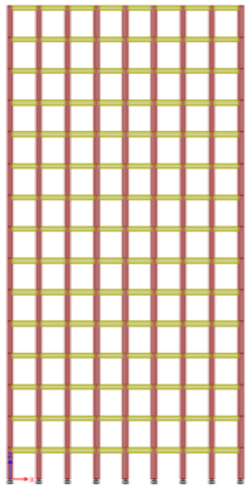
RESULT

Lateral Load Distribution with height by the static Method

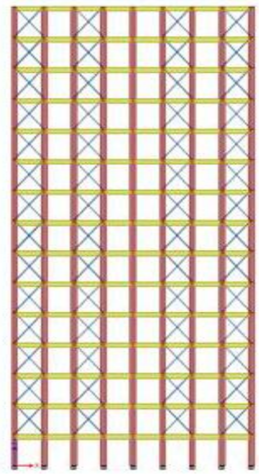
				Earthquake in X & Z direction			
Sr. No.	No. of Storied	Load on each floor Wi	Height (m)	Wi*H2/1000	Wi*hi2/∑Wihi2	X (KN)	Z(KN)
1	12	1091.750	43.8	2094.456	0.505	471.305	411.068
2	11	1091.750	40.15	1759.925	0.425	396.027	345.411
3	10	1091.750	36.5	1454.483	0.351	327.295	285.464
4	9	1091.750	32.85	1178.131	0.284	265.109	231.226
5	8	1091.750	29.2	930.869	0.225	209.469	182.697
6	7	1091.750	25.55	712.697	0.172	160.375	139.877
7	6	1091.750	21.9	523.614	0.126	117.826	102.767
8	5	1091.750	18.25	363.620	0.088	81.824	71.366
9	4	1091.750	14.6	232.717	0.056	52.367	45.674
10	3	1091.750	10.95	130.903	0.032	29.457	25.692
11	2	1091.750	7.3	58.179	0.014	13.092	11.419
12	1	1091.750	3.65	14.544	0.004	3.273	2.855
					1.000	932.79	813.572

3.1 Lateral Load Distribution without Bracing

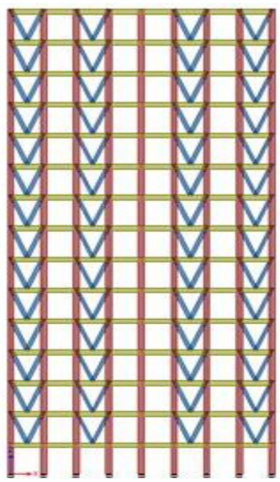
3.2 Different Types of Bracing (Steel Bare Frame)



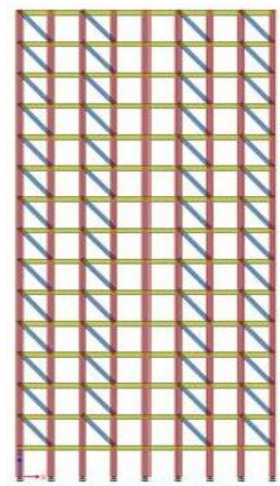
Steel Frame Building without Bracing



Steel Frame Building with X Bracing



Steel Frame Building with V Bracing



Steel Frame Building with Diagonal Bracing

3.3 RESULT ANALYSIS

Analyzing the “n” number of Diagonal, X, K, V Inverted V bracing, maximum base shear capacity is X Types of bracing so only result of X bracing is given.

Base Shear Using X Bracing

Base Shear (KN) X direction = 932.79KN

Types of Bracing	Without Bracing	With Bracing	% Increment
ISMB 200	**932.79**	**1132.152**	**17.72**
Tube(Hollow Section) 130x130x4.85	**932.79**	**1125.458**	**17.12**
ISA (200X200X18)	**932.79**	**1107**	**15.73**

Base Shear (KN) Z direction = 813.572KN

Types of Bracing	Without Bracing	With Bracing	% Increment
ISMB 300	**813.572**	**867.723**	**4.82**
Tube(Hollow Section) 150x150x6.0	**813.572**	**854.31**	**4.76**
ISA (150X150X18)	**813.572**	**871.138**	**6.6**

CONCLUSION

The selected frame models are analysed using different types of bracing. The seismic performance of a multi-story steel frame building is designed according to the provisions of the Indian code. Shear capacity of the structure can be increased by introducing Steel bracings in the structural system. Bracings can be used as retrofit as well. There are "n" numbers of possibilities to arrange Steel bracings. A typical G+11-story steel frame building is designed for various types of eccentric bracings as per the Indian Code. Performance of each frame is studied through nonlinear static analysis. Out of this bracing "X" bracing gives maximum base shear. The result of "X" bracing increases more than 30% than of diagonal or K bracing. also using ISMB section the capacity of base shear increases very well.

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