Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 7, Issue 2; April-June 2020, pp. 134-140

http://www.krishisanskriti.org/Publication.html

STUDY OF WIND LOADS ON STEEL BUILDING WITH AND WITHOUT DIFFERENT BRACED SYSTEM

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Abstract—*This study examines the structural performance of a steel building with different systems. In this study are used different braced systems. Wind loads and Seismic forces characteristics of buildings are usually improved by Braced systems. Most efficiently obtained from these structures. It is very possible to build a structure that will perform well in the event of wind loads. A G+44 story residential steel building was designed and analysed for this study under wind loads conditions. The structural characteristics of the steel building have been studied by various type of Bracing systems, such as K-Bracing, Chevron Bracing and V-Bracing and analysis of structure using ETABS 17 software are done. This study consider wind speed zone 50m/sec, Thus, the dominating factor in this study is wind load parameters such as time period, story drift and story displacement for a steel building with a different combination of braced system, and without braced system. Wind loads analysis according to Indian standards code IS875:2015(part III) by Diaphragm analysis method. Finally, the Chevron Bracing design is arguably the best structural performance of any kind of design considered here in such conditions.*

Keywords: *Steel Building, ETAB'S 17 Software, V-Bracing, K-Bracing, Chevron Bracing (Inverted V-Bracing), Natural Time Period, Story Drift, Story Displacement*.

I INTRODUCTION

India is currently a fast-growing country that needs more infrastructure as its population grows. Due to population growth, the demand value of housing is growing day by day. The only option to meet the need for other residential and commercial land is vertical construction, which is a multi-story building. This type of treatment requires safety, as these apartment buildings are very sensitive to additional lateral loads from earthquakes and winds. In other countries, as the height of a building increases, its responds to lateral loads. Multi-story buildings are prone to excessive deformation, which requires special measures to reduce this deformation. Braced frames are a common type of construction, easy to analyze and construct economically. There are basically categorized into two brace Frames.

1. **Concentric Braced Frames (CBF's):** A class of structures that withstand lateral loads through a system of vertical concentrating worms, the members of which focus on the joints. CBF's are generally effective in withstanding lateral forces because they can offer high strength and stiffness. These properties can also lead to less favorable seismic properties, such as lower cloud strength and higher acceleration. CBF's are a general structure system or composite system for any seismicity.

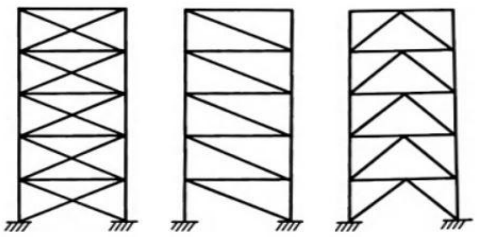


Fig. 1: Concentric Bracing

2. **Eccentric Brace Frames (EBF's):**An eccentric bracing is more flexible than a concentric bracing. Consequently, the ability to absorb and dissipate energy during a wind loads in the eccentric bracing system is increased. The flexibility of these braced is due to the beam falling between the two braces or the beams between the bracelet post. This part of beam are called link beam. These beams are felt due to very large displacements, due to the non-linear behavior of the communication beam, they violate the applied load of the diagonal bracing. Most difference CBF's & EBF's are, EBF's increases flexibility, but

CBF's increases lateral strength.

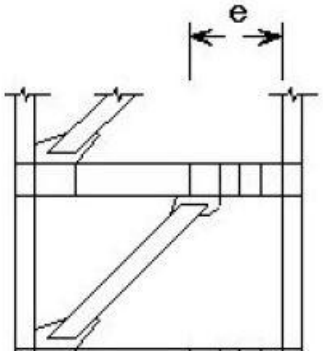


Fig. 2: Eccentric Bracing

II OBJECTIVE OFSTUDIES

The purpose of this study is analyze of steel structure with different braced systems under gravity loads& wind loads.

1. To study the performance of steel building with different types of braced and without bracedsystems.
2. The compare some mainly parameters such as Natural Time Period, Story Displacements, & Story Drift on the performance of multi-story buildings with different types of bracings i. e. (V- Bracing, K-Bracing and chevron Bracing).
3. To find optimized braced system under given loads.

III STRUCTURAL BUILDINGDETAIL

The building length & width are 27m & 27m. The height of story is 3m. The building shape is symmetrical to X and Y axis. The columns are assumed to be fixed at ground level. In this study, A G+44 story steel building of 7 bays in X-direction &7 bay in Y- direction have been considered for the investigation the effect of the different types of bracing system. Below table shows details of the building that is used for the analysis of the building.

Table 1: Description of theBuilding

S. No.	Structural Parts	Dimensions
1.	Location	Vishakhapatnam(A. P)
2.	Type of Building	Residential Building(G+44)
3.	Plan Dimension	27m*27m=729sq. m
4.	Type of Structure	Steel Structure
5.	Length In X-Direction	27m
6.	Length in Y-Direction	27
7.	No. of Bays in X-Direction	7No@4. 5m
8.	No. of Bays in Y-Direction	7No@4. 5m
9.	Total Height of Building	132m
10.	Floor to Floor Height	3m
11.	Slab Thickness	125mm
12.	Beam Size	ISMB600
13.	Column Size	ISWB600-1
14.	Secondary Beam For Slab	ISMB300
15.	K-Bracing	ISMB600
16.	Chevron Bracing	ISMB600
17.	V-Bracing	ISMB600

Table 2: MaterialProperties

S. No.	Material	Grade
1.	Steel Grade	Fe345
2.	Density of Steel	7850Kg/m^3
3.	Rebar	HYSD500
4.	Young's Modulus(E)	2. 1*10^5N/mm^2
5.	Shear Modulus	80000N/mm^2
6.	Poisson's Ratio	0. 3
7.	Concrete Grade	M30

Table 3: WIND LOADS DATA as per IS 875:2015 (part 3)

S. No.	Factors	Details
1.	Basic Wind Speed	50m/sec
2.	Risk Co-Efficient(K_1)	1(clause 6. 3. 1)
3.	Terrain Category(K_2)	Category-2(clause 6. 3. 2)
4.	Topography Factor(K_3)	1(clause 6. 3. 3)
5.	Class of Building	Class-b
6.	Windward Co-efficient($C_{p)}$	0. 8
7.	Leeward Co-efficient(C_v)	0. 5

LOADINGS:

a) Dead load (Self weight of building) as per IS 875-Part (I).
b) Live load= 4KN/m^2 as per IS 875-Part (II).
c) Seismic loads as per IS 1893:2016(Part-I).
d) Wind loads as per IS 875:2015 Part (III).

IV PROBLEMFORMULATION

This study is focused on wind load response of multistory **steel(G+44) building** with different types of bracing system. Building are located on seismic zone II and basic wind speed zone 50m/sec as per IS code guidelines using ETAB's-17 software.

(a). Model 1- steel building (G+44) without Bracing.

(b). Model 2- steel building (G+44) with Chevron-Bracing (Inverted V-Bracing).

(c). Model 3- steel building (G+44) with K-Bracing.

(d). Model 4- steel building (G+44) with V-Bracing.

Model 1: Steel Building (G+44) with Without Bracing system

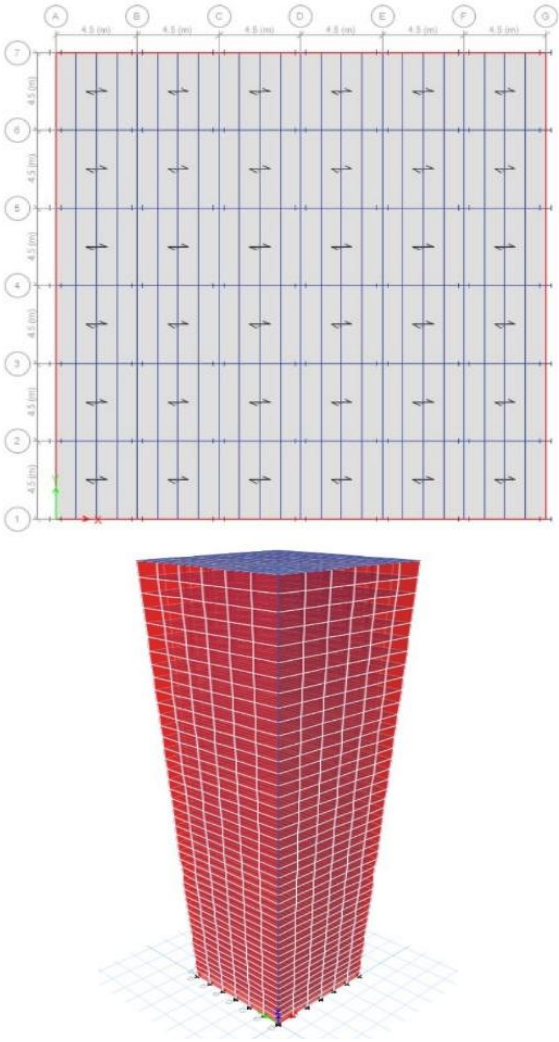
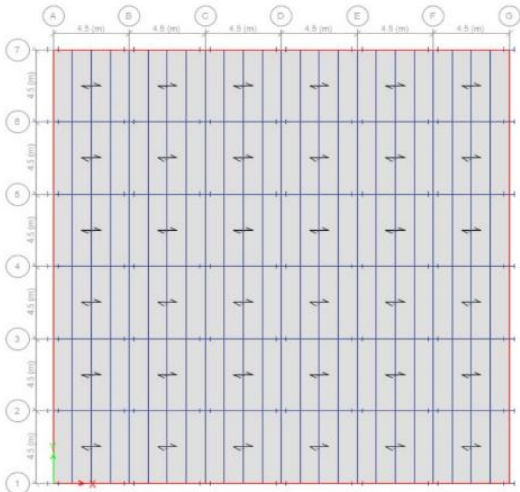


Fig. 5: Plan & 3D view

Model 2: Steel Building (G+44) with Chevron Bracing system



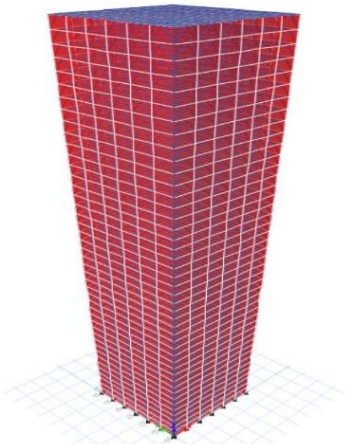
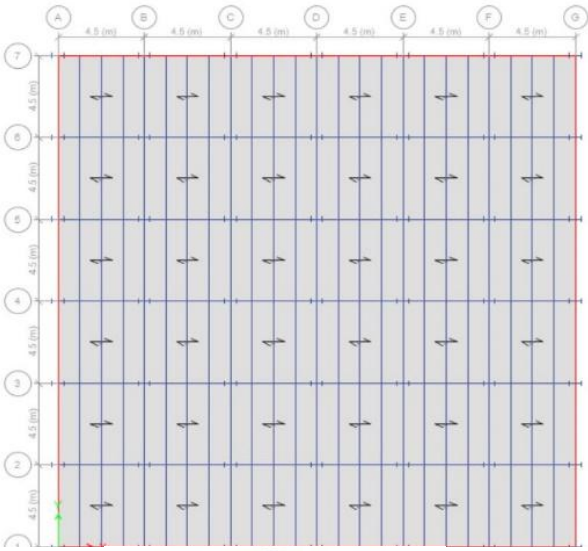


Fig. 6: Plan & 3D view

Model 3: Steel Building (G+44) with K-Bracing system



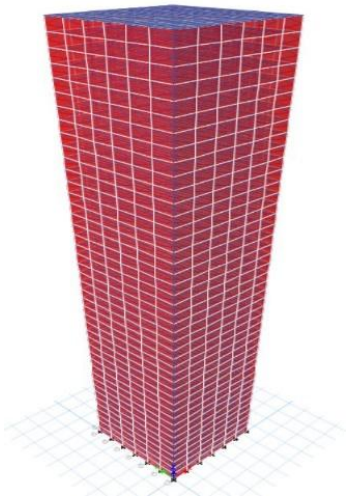


Fig. 7: Plan & 3D view

Model 4: Steel Building (G+44) with V-Bracingsystem

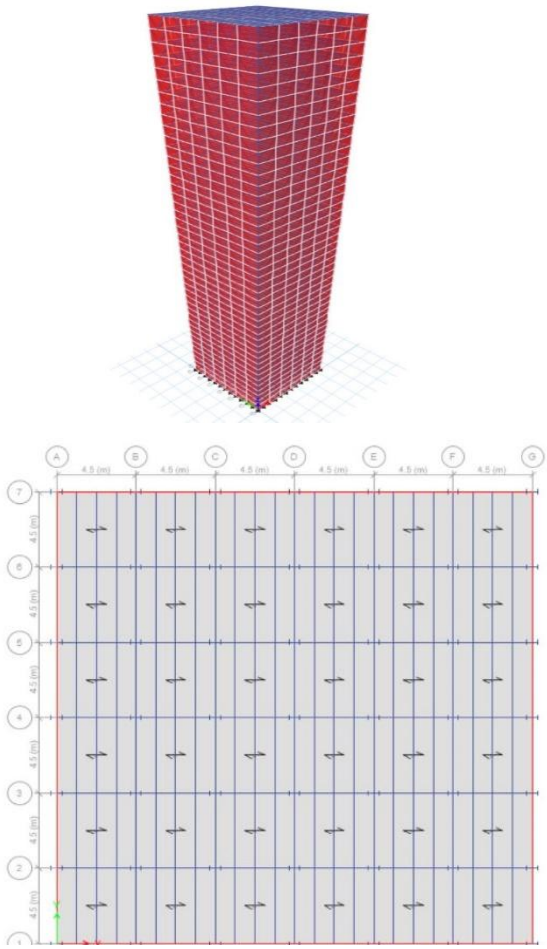


Fig. 8: Plan and 3-D view

V RESULT & DISCUSSION

There are various parameters defined in this study such as Natural time period, story drift and story displacement. It can be defined as:

a) Natural Time Period

The natural period (T_n) of construction is the period of a building that covers one complete cycle of fluctuations. It is determined by two main factors: the mass (m) of the building and stiffness (k). The ratio of natural period, stiffness and mass is given as:,

$T_n = 2\Pi\sqrt{}$ (m/k) It's units are second (sec)

Table 4: Natural Time Period

Mode	WithoutBracing (sec)	Chevron Bracing (sec)	K-Bracing (sec)	V-Bracing (sec)
Mode 1	4. 83	3	3. 67	3. 115
Mode 2	3. 973	2. 985	3. 465	3. 007
Mode 3	2. 064	0. 769	1. 048	0. 833
Mode 4	1. 485	0. 706	0. 918	0. 734
Mode 5	1. 118	0. 682	0. 812	0. 704
Mode 6	0. 789	0. 333	0. 447	0. 349
Mode 7	0. 687	0. 319	0. 383	0. 33
Mode 8	0. 566	0. 257	0. 345	0. 274
Mode 9	0. 549	0. 218	0. 295	0. 227
Mode 10	0. 419	0. 207	0. 275	0. 215
Mode 11	0. 41	0. 162	0. 275	0. 167
Mode 12	0. 387	0. 154	0. 274	0. 162

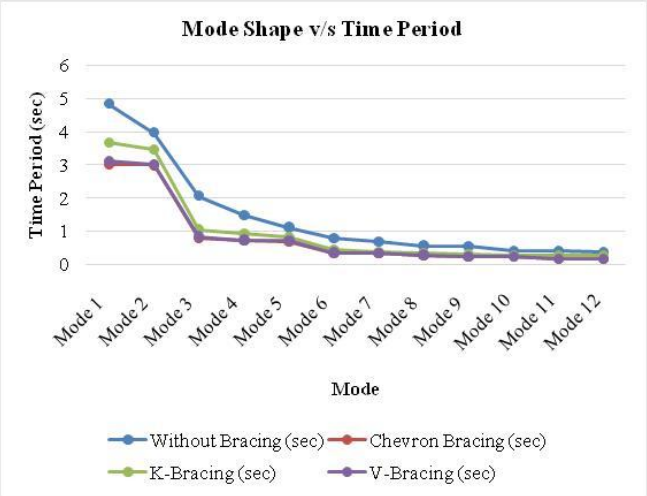


Fig. 9: Comparison of Time period

This study are classified as the above Natural time period graph and table find as the Chevron bracing are most efficient bracing as compared to K-bracing, V-bracing system and without bracing.

b) Story Displacement

Lateral displacement means the complete displacement of the floor relative to the ground due to lateral forces acting on the building. The displacement as per **IS 1893 (Part I):2016** is limited to **H/250**.

Story	Without Bracing (mm)	Chevron Bracing (mm)	K-Bracing (mm)	V-Bracing (mm)	Permissible Limit
44	709. 528	281. 316	421. 679	320. 778	528
43	699. 544	274. 23	412. 018	312. 667	516
42	689. 154	267. 094	402. 261	304. 507	504
41	678. 35	259. 906	392. 401	296. 296	492
40	667. 13	252. 665	382. 436	288. 031	480
39	655. 49	245. 372	372. 361	279. 714	468
38	643. 433	238. 029	362. 178	271. 345	456
37	630. 96	230. 637	351. 888	262. 926	444

36	618. 074	223. 201	341. 492	254. 46	432
35	604. 78	215. 722	330. 995	245. 951	420
34	591. 082	208. 207	320. 233	237. 403	408
33	576. 989	200. 659	309. 593	228. 822	396
32	562. 507	193. 084	298. 869	220. 214	384
31	547. 647	185. 488	288. 169	211. 585	372
30	532. 419	177. 878	277. 199	202. 942	360
29	516. 835	170. 262	266. 369	191. 465	348
28	500. 908	162. 647	255. 566	185. 65	336
27	484. 65	155. 041	244. 581	177. 017	324
26	468. 075	147. 454	233. 635	168. 407	312
25	451. 2	139. 895	222. 834	159. 338	300
24	434. 04	132. 374	211. 891	151. 294	288
23	416. 611	124. 901	200. 955	142. 815	276
22	398. 932	117. 488	190. 041	134. 402	264
21	381. 021	110. 146	179. 165	126. 069	252
20	362. 898	102. 888	168. 342	117. 83	240
19	344. 583	95. 726	157. 591	109. 697	228
18	326. 509	88. 673	146. 929	101. 686	216
17	307. 464	81. 743	136. 376	93. 812	204
16	288. 706	74. 95	125. 952	86. 091	192
15	269. 851	68. 311	115. 678	78. 54	180
14	250. 925	61. 839	105. 577	71. 175	168
13	231. 958	55. 553	95. 672	64. 016	156
12	212. 981	49. 468	85. 988	57. 081	144
11	194. 026	43. 602	76. 551	50. 39	132
10	175. 128	37. 974	67. 391	43. 965	120
9	156. 323	32. 604	58. 536	37. 827	108
8	137. 654	27. 511	50. 021	31. 999	96
7	119. 165	22. 719	41. 881	26. 508	84
6	100. 907	18. 249	34. 158	21. 378	72
5	82. 931	14. 128	26. 898	16. 639	60
4	65. 295	10. 383	20. 154	12. 321	48
3	48. 068	7. 048	13. 843	8. 457	36
2	31. 324	4. 163	8. 491	5. 086	24
1	15. 123	1. 782	3. 761	2. 252	12

Table 5: Story Displacement

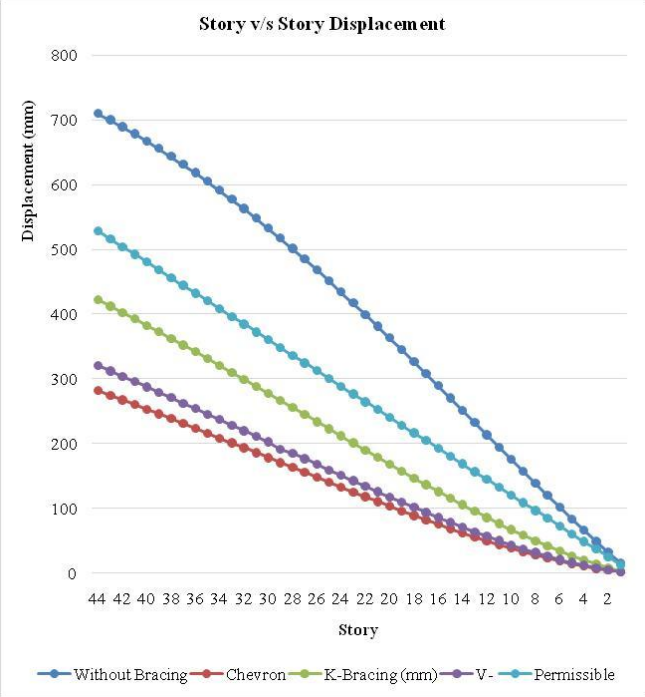


Fig. 10: Comparison of Story Displacement

From above graph and table of Story displacement, it is concluded that Chevron bracing (Inverted bracing) is more efficient bracing system as compared to without and X-bracing systems.

c) Story Drift

Story drift is the lateral displacement of one level relative to the upper or lower level. According to **IS 1893(part I):2016**(clause 7. 11. 1. 1), the level of demolition of the floor is the level of demolition divided by the height of the story. The floor drift in any case should not exceed **0. 004 times** so the limited story drift value is **0. 004 x 3 = 12 mm**.

Table 6: Story Drift

Story	Without Bracing (mm)	Chevron Bracing (mm)	K-Bracing (mm)	V-Bracing (mm)	Permissible Limit
44	9. 985	7. 085	9. 662	8. 111	12
43	10. 389	7. 136	9. 757	8. 16	12
42	10. 804	7. 188	9. 859	8. 211	12
41	11. 221	7. 241	9. 966	8. 264	12
40	11. 639	7. 293	10. 074	8. 317	12
39	12. 057	7. 343	10. 183	8. 369	12
38	12. 473	7. 392	10. 291	8. 419	12
37	12. 886	7. 437	10. 396	8. 466	12
36	13. 294	7. 478	10. 497	8. 509	12
35	13. 697	7. 516	10. 593	8. 548	12
34	14. 093	7. 548	10. 683	8. 581	12

33	14. 482	7. 575	10. 767	8. 608	12
32	14. 86	7. 596	10. 843	8. 629	12
31	15. 228	7. 61	10. 91	8. 642	12
30	15. 584	7. 616	10. 967	8. 648	12
29	15. 928	7. 615	11. 014	8. 645	12
28	16. 258	7. 606	11. 049	8. 632	12
27	16. 574	7. 587	11. 073	8. 61	12
26	16. 875	7. 559	11. 083	8. 578	12
25	17. 16	7. 521	11. 08	8. 535	12
24	17. 429	7. 473	11. 063	8. 48	12
23	17. 679	7. 413	11. 03	8. 413	12
22	17. 911	7. 342	10. 982	8. 333	12
21	18. 123	7. 258	10. 916	8. 24	12
20	18. 315	7. 162	10. 833	8. 133	12
19	18. 486	7. 053	10. 731	8. 011	12
18	18. 633	6. 93	10. 609	7. 874	12
17	18. 758	6. 792	10. 467	7. 721	12
16	18. 856	6. 64	10. 304	7. 552	12
15	18. 926	6. 471	10. 117	7. 365	12
14	18. 967	6. 287	9. 906	7. 159	12
13	18. 977	6. 085	9. 684	6. 935	12
12	18. 955	5. 866	9. 436	6. 691	12
11	18. 898	5. 628	9. 161	6. 425	12
10	18. 805	5. 37	8. 855	6. 138	12
9	18. 669	5. 093	8. 515	5. 827	12
8	18. 488	4. 793	8. 139	5. 492	12
7	18. 258	4. 47	7. 723	5. 13	12
6	17. 976	4. 121	7. 26	4. 739	12
5	17. 636	3. 745	6. 744	4. 138	12
4	17. 227	3. 335	6. 163	3. 863	12
3	16. 744	2. 884	5. 5	3. 371	12
2	16. 201	2. 381	4. 73	2. 835	12
1	15. 123	1. 782	3. 761	2. 252	12

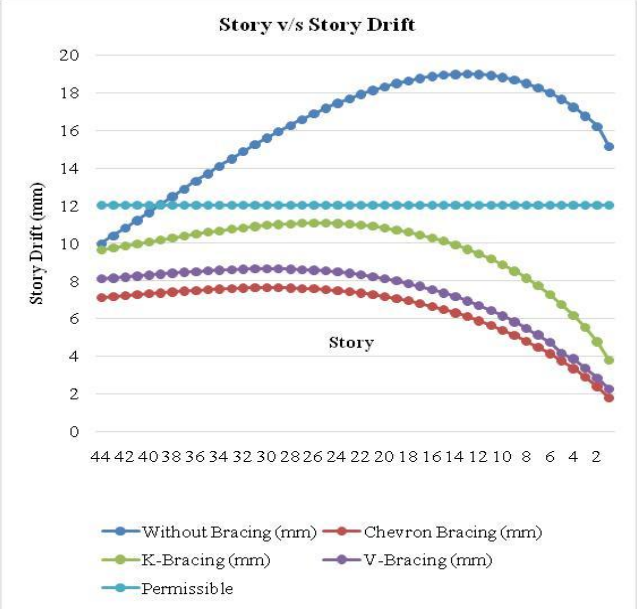


Fig. 11: Comparison of Story Drift

From above graph and table of Story drift, it is concluded that Chevron bracing (Inverted bracing) is more efficient bracing system as compared to without, K-bracing and V-bracing systems.

VI CONCLUSIONS

The following conclusions can be drawn from the above-mentioned research.

- Among all the analysed models with links, the factors taken into account are within acceptable limits.
- Based on the natural period (sec), it is evaluated that the chevron model has the lowest natural period value (sec), which is a more efficient model than other models.
- Time taken in first mode is minimum in Chevron braced structure and in other all with respect to braced structure, 61. 00% more in without braced, 22. 33% more in K-braced and 3. 83% and more in V-braced structure.
- Based on the Story Displacement (mm), it is evaluated that the chevron model has the lowest Story Displacement value (mm), which is a more efficient model than other models.
- Displacement is minimum in Chevron braced structure and in other all with respect to braced structure, 152. 21% more in without braced, 49. 89% more in K-braced and 14. 02% more in V-braced structure.
- Based on the Story Drift (mm), it is evaluated that the chevron model has the lowest Story Drift value (mm), which is a more efficient model than other models.
- Drift is minimum in Chevron braced structure overall comparisons shows with respect to braced structure, 149.

17% more in without braced, 45. 52% more in K-braced and 13. 55% more in V-braced structure.

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