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Seismic Analysis of Braced Systems in RCC, Steel and Composite Structures

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ABSTRACT:Steel braced frame is one of the structural systems used to resist earthquake loads in multistoried buildings. Many existing reinforced concrete buildings need retrofit to overcome deficiencies to resist seismic loads. The use of steel bracing systems for strengthening or retrofitting seismically inadequate reinforced concrete frames is a viable solution for enhancing earthquake resistance. Steel bracing is economical, easy to erect, occupies less space and has flexibility to design for meeting the required strength and stiffness. In the present study, the seismic study of conventional X brace, zipper brace and SBS in RCC, steel and composite structures using ETABS software is investigated. The bracing is provided at each corner. A G+6, G+12 and G+18 story with 6 bay in X direction and 3 bay in Y direction is analyzed using ETABS.. The effectiveness of various types of steel bracing is examined. The effect of the distribution of the steel bracing along the height of the steel structure on the seismic performance of the rehabilitated building is studied. Provision of conventional X braced, zipper braced and SBS is provided in each stories. The percentage reduction in lateral displacement is found out. It is found that the zipper of steel bracing significantly contributes to the reduction in displacement and SBS contributes in the reduction of story shear compared to conventional X bracings in steel and composite structures whereas both reduction in displacement and base shear is found out for SBS braced in case of RCC structures.

KEYWORDS:x brace, zipper brace , spring back system , ETABS 2016 , time history analysis

I. INTRODUCTION

Most of the multistoried buildings using today are made up of reinforced concrete framed buildings. A reinforced concrete building should be designed to have a capacity to carry combined loads (dead, live and seismic loads) at certain safety level and at certain degree of reliability. There are several techniques to improve the strength and lateral stability of buildings. Use of steel bracing systems is one of such method which is highly efficient and economical.

A viable solution for enhancing earthquake resistance is to use steel bracing systems for strengthening and retrofitting seismically inadequate reinforced concrete frames. Through the addition of the bracing system, load could be transferred out of the frame and into the braces, bypassing the weak columns while increasing strength. Conventional steel concentrically braced frames are prone to form- ing a soft-story mechanism during strong earthquake ground shaking. This concentration of deformations in one or a few stories intensifies damage to braces at these levels, leading to greater nonstructural and structural dam- age and premature rupture of the braces at these levels compared to systems having more uniform distribution of damage over height. The concentration of damage can amplify P-Δ effects, which can in turn increase lateral displacements in the softened story. Soft stories are also likely to result in significant residual displacements, which can be costly or infeasible to repair.

As such, it is desirable to enhance the ability of concentric braced frames to avoid concentration of deformations and damage in a few stories. If a system is able to mitigate soft or weak story behavior, the peak deformation demands on individual braces and maximum residual displacements might be reduced. Several approaches have been explored by various researchers to reduce damage concentration and achieve smaller residual displacement. These systems include:

1. Zipper or vertical tie bar systems

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2. Tied-truss, masted, or strongback systems (SBS)

II. METHODOLOGY

Modeling of G+6 story structure providing ;

I. Without bracing (WB)
II. With x bracing (XB)
III. With zipper bracing(ZB)
IV. With SBS (1.Typical double-story X (DS X)

2.Intermittent chevron (IC)

3. Shifted double-story X (S DS X)

4. Tied-to-ground with single spring (SS)

5. Tied-to-ground with double spring (DS))

Modeling of G+12 story structure providing ;

1. With zipper bracing (ZB)
2. Tied-to-ground with double spring (DS)
3. With x bracing (XB)

Modeling of G+18 story structure providing ;

1. With zipper bracing (ZB)
2. Tied-to-ground with double spring (DS)
3. With x bracing (XB) Static and dynamic analysis of structures were carried out

Models of the structures are shown below in figure 1

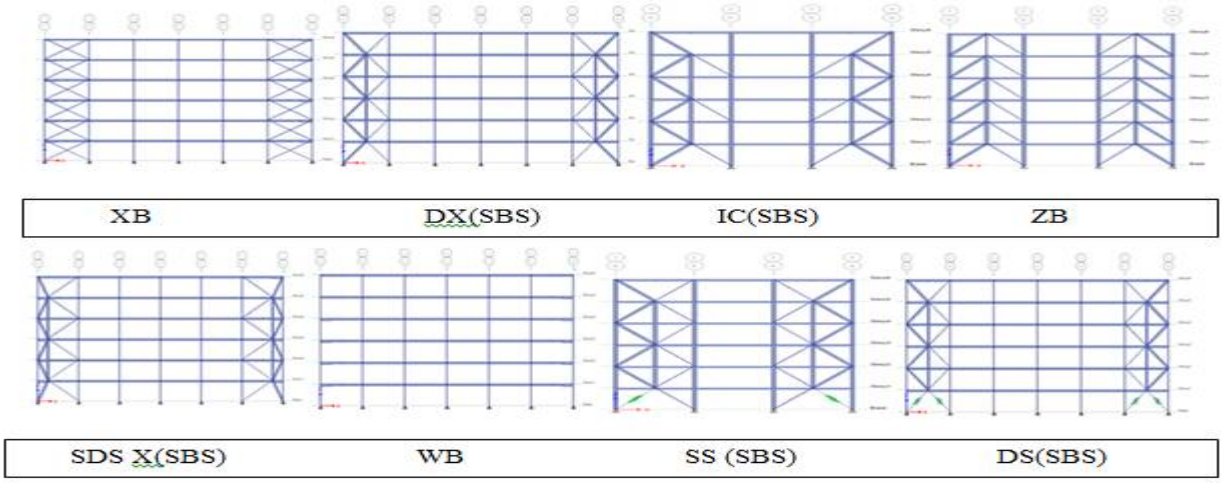

Figure 1: Eight different models of RCC, steel and composite structures for G+6 storey provided with their names are shown

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III.EXPERIMENTAL RESULT

TABLE 1: G+6 STOREY STEEL STRUCTURES

G+6 STORY STEEL STRUCTURES																	
SI NO	MODELS	MODAL ANALYSIS		STATIC EARTHQUAKE ANALYSIS				TIME HISTORY ANALYSIS(EL CENTRO EARTHQUAKE)						RESPONSE SPECTRUM ANALYSIS			
		TIME PERIOD (seconds)		BASE SHEAR (kN)		STORY DISPLACEMENT (mm)		TIME PERIOD(sec)		BASE SHEAR (kN)		STORY DISPLACEMENT(mm)		BASE SHEAR (kN)		STORY DISPLACEMENT(mm)	
		X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION
1	DS X	0.854	0.77	787.6621	873.6798	14.079	12.407	5.9	3.1	708.874	786.3	11.03	8.85	708.836	786.364	10.638	10.557
2	IC	0.958	0.842	701.6273	798.094	15.562	13.342	4.3	5.8	630.891	718.18	10.393	11.35	630.854	718.19	11.773	11.768
3	ZB	0.802	0.733	839.5854	918.7795	13.309	11.882	2.4	3.1	680.04	744.25	5.69	7.31	755.6	826.925	10.08	9.7593
4	SDS X	0.918	0.819	733.3349	822.2089	14.86	12.878	4.3	5.7	594.022	665.95	8.77	7.81	660.035	739.98	11.137	11.18
5	X B	0.92	0.822	731.3587	818.4036	15.148	13.185	4.3	5.8	592.42	662.91	8.83	10.13	658.233	736.59	11.31	11.39
6	W B	7.392	2.292	166.7547	291.0419	154.221	28.017	2.6	6.5	138.67	235.71	116.11	17.73	150.107	261.939	119.726	120.054
7	SS	0.904	0.828	744.3568	812.4062	14.312	12.689	4.3	6.6	669.89	731.16	8.58	9.1	669.939	731.18	10.655	10.652
8	DS	1.148	1.03	586.0873	653.0626	15.634	13.8	5.9	4.4	527.39	587.77	11.72	10.03	527.426	525.58	11.717	11.67

Table 1: G+6 storey RCC structures

G+6 STOREY RCC STRUCTURES					
SNO	MODELS	DISPLACEMENT(mm)		BASE SHEAR (kN)	
		X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION
1	D X	10.508	10.55	1114.65	1113.29
2	IC	9.38	9.26	1005.79	998.46
3	ZB	9.51	9.538	1156.19	1154.15
4	SDS X	9.50	9.414	1017.44	1014.99
5	XB	10.408	10.44	1047.501	1046.99
6	WB	16.208	17.27	409.980	399.700
7	SS	8.96	8.45	1014.88	1007.87
8	DS	7.64	7.65	792.715	789.92

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Table 1: G+6 storey composite structures

G+6 STOREY COMPOSITE STRUCTURES							
SNO	MODELS	DISPLACEMENT(mm)		BASE SHEAR (kN)		TIME PERIOD(seconds)	
		X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION
1	D X	6.63	6.69	1331.76	1025.74	0.637	0.626
2	IC	8.95	11.08	687.75	797.422	0.771	0.761
3	ZB	7.71	8.11	1286.39	1350.36	0.601	0.599
4	SDS X	11.46	9.29	689.51	739.911	0.918	0.819
5	XB	9.74	9.73	875.89	875.68	0.715	0.715
6	WB	26.06	29.08	269.16	263.07	2.361	2.308
7	SS	9.039	11.205	916.60	874.49	0.732	0.698
8	DS	8.792	8.73	670.83	673.88	0.952	0.948

Table 4: comparison of results with X bracings

Comparison of structures with X braced frames		
structures	Average % variation in deformation	Average % variation in deformation
RCC	15	20
Steel	36	21
composite	45	32

IV. CONCLUSION

1. Implementation of static and dynamic analysis to study the best pattern and location analytically using ETABS software was done successfully, thereby achieving the objective of the study.
2. G+6, G+12, and G+18 story structures was considered for the study with different models of arrangement of SBS and zipper systems.
3. When G+6 story is considered, providing 8 different models and static and dynamic analysis is carried out and their results were obtained. The best out of 8 models are selected and provided to G+12 and G+18 structures.
4. The result extracted from G+6 story shows that the model with zipper bracings and SBS tied to double springs have less story displacement and base shear respectively compared to structure without bracings for steel and composite structures.

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5. The result extracted from G+6 story shows that the model with SBS tied to double springs have less story displacement and base shear respectively compared to structure without bracings for RCC structures.
6. As the height is increased from lower rise to medium and high rise, it is observed that structures reducing displacement values.
7. While comparing deformation, around 45% variation is observed for composite structure when compared to X bracing.
8. While comparing base shear, around 32% variation is observed for composite structure when compared to X bracing.Deformation value without bracing is found to be 154.22mm in X direction. When the implementation of SBS (DS), deformation is reduced to 6.022mm in X direction. This shows that there is 96.095% reduction in X direction.
9. Maximum value of storey drift for SBS (DS) was found to be 0.001443 which is within the limit as per IS : 1893:2002.
10. As a whole, we can conclude that providing zipper and SBS is more effective in comparison to X bracings to these structures to resist lateral loads.

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