

Parametric Analysis of a Steel Industrial Building Frame Considering Wind Load, Dampers and Bracings Using ETABS

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ABSTRACT

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structures are not designed to withstand lateral loads, they may collapse, resulting in the death or destruction of people or property. As a result, the structure must not only be strong enough to withstand gravity loads, but also stiff enough to withstand lateral forces. According to a review of the literature, LLRSS (Lateral load Resisting structural system) components such as base isolation and dampers are used to manage seismic vibration and lateral drift. This research compares the performance of a G+4 steel frame building with and without a damper. It is a rectangular structure with an industrial operation. The planned building's structural frame is a unique steel moment resisting frame (SMRF). ETABS is used to perform structural analysis and design. The structure's dynamic behaviour under wind and seismic loads is investigated using response spectrum analysis. Wind and earthquake vibrations are reduced by the usage of dampers. Engineers can improve the building's resilience by employing dampers. Fluid viscous dampers are investigated in depth in this research.

In addition to gravity stresses, the building's structural structure must handle

lateral loads caused by earthquakes and wind. A lateral load causes significant stresses and instability, which results in vibration and drift. If industrial steel

The parametric investigation of Dynamic analysis of 3D industrial steel structure braced with varied bracing configurations and dampers with different mass ratios utilising software (ETABS). For the structural stability of the building structure under seismic loads, X-bracing bracing configurations were adopted.

A comparison with a general steel construction was done, and the bracing structure and dampers were examined.

Keywords - Steel Frame Building, Viscous Damper, Bracing System Storey Drift, Displacement, Base Shear, ETABS

I. INTRODUCTION

Steel Worldwide different types of RC and steel structures with various floor systems are being used

for multi-storey buildings. In the past, masonry structures were widely used for building construction. Day by day technology has developed. Later, steel structural systems were started for multi-storey

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buildings. RC structural techniques for multi-story building construction started with the establishment of reinforced concrete. Non-composite RC floor systems supported on steel beams have been used in the past. It became necessary to form mechanical shear connectors to consider composite action after the invention of welding. Because many multi-story and low-rise RC and masonry buildings have failed due to earthquakes, structural engineers are seeking for alternate construction methods. The use of composite or hybrid materials is very intriguing. The fire resistance of a bare steel structure is low. Different fireproofing systems have advanced greatly in recent years. In India, masonry and RC constructions were the most common. Steel structural technologies have become increasingly popular during the previous decade. As a result, alternative structural systems are gradually gaining ground on RC structural systems. The use of stone structures is now extremely limited. In India, RC constructions predominate, with steel structures gradually making their way into multi-story building structures. As a result, a comparison analysis is required to determine the most effective structural system for a given structure.

II. Review of Literature Survey

Chao Gong et al (2022) research paper presented the seismic performance of structures subjected to earthquake mainshock-aftershock sequences. There is comparison of two types of the additional BRB elements, and also there is comparison between them and the original steel frame to show the effect of using BRB and SCBRB elements. To compare the seismic performance of BRBF and SCBRBF, the same mainshock-aftershock sequences were used in this part. Because of the flag-shaped hysteretic curve of the SCBRB elements, big amount of the energy was dissipated during the motion. Results stated that structure with SCBRB elements subjected to earthquakes have smaller responses than ones without it. Amount of the energy which was dissipated is increased. Using SCBRB and BRB elements increase frequency of the structure. Residual deformations of the SCBRBF in more than 6.6 times smaller than ones of SF, residual deformations of the BRBF more than 2.11 times smaller than ones of SF. Conclusion stated that using SCBRB elements can decrease the damage of the structure during earthquakes, and also lead to improvement of characteristics of the building such as maintainability and service life in the seismic region.

Zhe-Xi Zhang et al (2022) in the research paper, a novel type of self-centering brace, namely the selfcentering SMA-viscoelastic hybrid brace (SCVEB) was proposed. The energy dissipation was provided by the SMA cables, as well as the viscoelastic dampers (VEDs), whilst the self-centering capacity was provided by the former. The fundamental mechanical behavior of individual SMA cables and viscoelastic dampers was first investigated, followed by a more comprehensive experimental study on a proof-ofconcept SCVEB specimen.

Results stated that the SMA cable exhibits typical flag-shaped hysteretic loops with a large recovery strain. Reasonable cyclic pre-training is suggested before anchoring to SCVEB, since this process was shown to help stabilize the hysteretic response. The VED is capable of providing reliable energy dissipation. The rubber in the test did not show ratedependence property, such as typical viscoelastic material, and this may be due to the differences in their compositions. The frames using the intended SCVEB fulfilled peak inter-story drifts under the MCE and had nearly no residual interstory drifts, according to the system-level analysis. More crucially, the SCVEB can reduce the frames' peak floor acceleration even more. These positive results show that the suggested SCVEB could be a cost-effective



self-centering solution by reducing boundary frame member size while using less SMA.

III.Objectives of the research

- To study the wind performance of multi storey steel building with and without damping system.
- To compare the response of the structure under dynamic loading with dampers and bracing system.

- To Study the behaviour of Steel Structure subjected to lateral loadings.
- To understand the performance of steel structure for bracing system and damper.
- Study is carried out to observe the behaviour of Structure dynamic time history and wind loadings.

The parameters such as base shear, displacement, storey drift, are compared and discussed in detail.

IV. Methodology

Step 1 Steel structuring is complex and heavy duty structure. Numerous authors were researching seismic analysis of self centering concentrically braced frame using different analytical application.

Step 2: the first step in ETABS is model initialization where the metric units are defined besides assign steel design code as per IS 800:2007 and concrete Design code as per IS 456:2000.

itialization Options		
O Use Saved User Default Settings		0
O Use Settings from a Model File		0
Use Built-in Settings With:		
Display Units	Metric SI	~ ()
Steel Section Database	Indian	\sim
Steel Design Code	IS 800:2007	~ ()
Concrete Design Code	IS 456:2000	~ ()



Step 3 Defining Grid system data for X and Y direction, X direction is defined with variables as A, B, C, D...... and Y DIrection is defined with variables as 1, 2, 3, 4

suit r Specified Top Story Settom Story slay Grid Data as Speci subble Loc	ing	Coptions Bubble Size Grid Color	leference Points eference Planes 900	nm Quick Star	0 0 0 0	
r Specified Top Story Bottom Story Diay Grid Data as Space	ing	Cotions Bubble Size Grid Color	eference Planes	m	0 0 0 0 0 0 0 0 0 0 0 0 0 0	
Bottom Story Slay Grid Data as Spac	ing	Options Bubble Size Grid Color	900	mm Quick Star	0 0 0	
Bottom Story olay Grid Data as Space	ing	Bubble Size Grid Color	900	Ouick Star	2 1	
olay Grid Data as Spac	ing	Grid Color		Quick Star	0	
olay Grid Data as Spac	ing	Y Gód Data		Quick Stat	t New Rentarco dari	
Bubble Loc ^		Y Grid Data			- non nocial guar	ands
Bubble Loc ^						
		Grid ID	Y Ordinate (m)	Visible	Bubble Loc	
End	Add	1	0	Yes	Start	Add
End	Delete	2	4	Yes	Start	Dalata
End		3	8	Yes	Start	
End		4	12	Yes	Start	
End	Sort	5	16	Yes	Start	Sort
~						
	End End End End	End Delete End End Sot	End Delete 3 End End 4 End Sot 5	End Device 2 4 End Device 3 8 End 4 12 End Sort 5 16	Los root - <td>Los 2 4 7es 3att End Delete 3 8 Yes Satt End 4 12 Yes Satt End 5 16 Yes Satt</td>	Los 2 4 7es 3att End Delete 3 8 Yes Satt End 4 12 Yes Satt End 5 16 Yes Satt

Fig 2 Grid System Data



Step 4 Adding material properties for steel as an industrial structure in considered in the analysis

Region	India	~
Material Type	Steel	~
Standard	Indian	~
Grade	Fe345	~

Fig 3 Adding new material properties

Step 5 Defining Material properties data

Material Name	Fe345	
Material Type	Steel	~
Directional Summetry Type	leave in	
Material Display Calas	Isotropic	~
Material Notes	Modify/Show I	Notes
Material Weight and Mass		
 Specify Weight Density 	Specify Mass	Density
Weight per Unit Volume	76.9	729 kN/n
Mass per Unit Volume	7849	9.047 kg/m
Mechanical Property Data		
Modulus of Elasticity, E	2100	MPa
Poisson's Ratio, U	0.3	
Coefficient of Thermal Expansion	n, A 0.00	00117 1/C
Shear Modulus, G	8076	59.23 MPa
Design Property Data		
Modify/Sho	ow Material Property Design I	Data
Advanced Material Property Data		
Nonlinear Material Data	Material	Damping Properties
Tin	ne Dependent Properties	

Fig 4 Defining Material Property Data

Step 6 Defining Section Properties

Property Name	ISA70X70X10)		
Material	Fe345		~	
Display Color		Change		2
Notes	Modif	y/Show Notes		3
ihape				
Section Shape	Steel Angle		\sim	+*
Section Property Source				
Source: Indian	Conver	t To User Defined		
Section Dimensions				Property Modifiers
Total Depth		70	mm	Modify/Show Modifiers
Total Width		70	mm	Currentity Deradic
		10	mm	Mirror Mirror About Loopl 2 Avia
Horizontal Leg Thickness		10	mm	Mirror About Local 2-Avia
Horizontal Leg Thickness Vertical Leg				Million About Local 3-Adis
Horizontal Leg Thickness Vertical Leg Fillet Radius		0	mm	
Horizontal Leg Thickness Vertical Leg Fillet Radius		0	mm	
Horizontal Leg Thickness Vertical Leg Fillet Radius		0	mm	ОК

me Section Property Data				
eneral Data				
Property Name	ISWB500			
Material	Fe345		×	2
Display Color	Change			3
Notes	Modify/Show Notes			Č –
hape				
Section Shape	Steel I/Wide Flange		\sim	
ection Property Source				
Source: Indian	Convert To User Defined			
				Property Modifiers
ection Dimensions				
ection Dimensions Total Depth		500	mm	Modify/Show Modifiers
ection Dimensions Total Depth Top Flange Width		500 250	mm	Modify/Show Modifiers Currently Default
ection Dimensions Total Depth Top Flange Width Top Flange Thickness		500 250 14.7	mm mm mm	Modfy/Show Modifiers Currently Default
ection Dimensions Total Depth Top Flange Width Top Flange Thickness Web Thickness		500 250 14.7 9.9	mm mm mm	Modify/Show Modifiers Currently Default
ection Dimensions Total Depth Top Range Width Top Range Thickness Web Thickness Bottom Range Width		500 250 14.7 9.9 250	mm mm mm mm	Modify/Show Modifiers Currently Default
ection Dimensions Total Depth Top Range Width Top Range Thickness Web Thickness Bottom Range Width Bottom Range Thickness		500 250 14.7 9.9 250 14.7	mm mm mm mm mm mm	Modify/Show Modifiers Currently Default

Fig 5 Defining Frame Section

Fig 6 Defining Column Section

Step 7 Defining Point Spring Property data for damping system

Property Ivallie	damper	'S	
Display Color		Change	
Property Notes	N	lodify/Show Notes	
Spring Stiffness Options			
User Specified/Link Prop	erties O Ba	ased on Soil Profile and	Footing Dimensions
Simple Spring Stiffness in Globa	I Directions		
Translation X		0	kN/m
Translation Y		0	kN/m
Translation Z		200	kN/m
Rotation about X-Axis		0	kN-m/rad
Rotation about Y-Axis		0	kN-m/rad
Rotation about Z-Axis		0	kN-m/rad
ingle Joint Links at Point			
Link Property	Axial Direction	Axis 2 Angle	
Link1	+Z	45	Add
			Delete

Fig 7 Point Spring Data



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iggered Truss					
Truss Location		Structural System Properties			
Vierendeel Panel Width 2	m	Top Truss Chord Typical	ISLB200	×	
No. of Panels Before Vierendeel 3		Top Chord at Vierendeel	ISLB200	×	
No. of Panels After Vierendeel 3		Bot Truss Chord Typical	ISLB200	×	
		Bot Chord at Vierendeel	ISLB200	~	
First Bay has Truss at Top Level		Truss Diagonals	ISA70X70X10	×	
Ded. Outberry		Truss Verticals	ISA70X70X10	×	
Along X Direction		Truss Hangers	ISA70X70X10	×	
Left Edge Distance	m	Truss Posts	ISA70X70X10	×	
Right Edge Distance 0	m	Truss Knee Braces at Bot	ISA70X70X10	×	
Along Y Direction		Columns	ISWB500	×	
Top Edge Distance 0	m	Spandrels	ISWB500	×	
Bottom Edge Distance	m	Decks/Planks	Slab1	×	
Restraints at Bottom		Load			
○ None	Fixed	Dead Load Pattern	Dead	\sim	
		Dead Load (Additional)	2	kN	/m²
loor Diaphragm Rigidity		Live Load Pattern	Live	\sim	
Rigid Semi-Rigid	No Diaphragm	Live Load	3.75	kN/	/m²

Fig 8 Structural Geometry and Properties of Staggered Truss

Step 8 Defining Load cases on the considered industrial structure for live load, dead load and wind load.

Load Cases				Click to:
	Load Case Name	Load Case Type		Add New Case
Dead		Linear Static		Add Copy of Case
Live		Linear Static		Modify/Show Case
wind		Linear Static		Delete Case
			*	Show Load Case Tree
				OK Cancel

Fig 9 Defining load cases

xposure and Pressure Coefficients	Wind Coefficients	
Exposure from Extents of Diaphragms	Wind Speed, Vb (m/s)	39
Exposure from Shell Objects	Terrain Category	2 ~
	Importance Factor	1.00 ~
Vind Exposure Parameters	Risk Coefficient (k1 Factor)	1
Wind Directions and Exposure Widths Modify/Sho	Topography (k3 Factor)	1
Windward Coefficient, Cp 0.8	Exposure Height	
Leeward Coefficient, Cp 0.5	Top Story	Story4 ~
	Bottom Story	Base 🗸 🗸
	Include Parapet	
	Parapet Height	m

Fig 10 Defining properties of Wind load as per IS 875:2015

Step 9 Analyzing the model for dead load, live load and wind load in terms of deflection, displacement.



Fig 11 Analyzing the structure

Geometry of Building			
Utility of Building	Industrial Building		
No of Bays in X Direction	4 bays		
No of Bays in Y Direction	5 bays		

Table 1 Geometrical Description

Width between bays in Y Direction	2m
Width between bays in X Direction	3m, 6m
Height of Each storey	3.4m
Height of Bottom Storey	3m
Wind Speed (m/s)	39 m/s
Terrain category	II
Wind Coefficient	0.8
Soil Type	Medium
Column used	ISMB
Thickness of Slab	125mm

V. ANALYSIS RESULT

Drift:

General Steel Structure and Steel Structure with Damper



Displacement

Storey Displacement in X-Direction (in)			
Storey No.	General Steel Structure	Steel Structure with Damper	
4	2.615	2.006	



3	1.936	1.642
2	1.258	1.17
1	0.546	0.695
Base	0.4	0.305

VI.CONCLUSION

The parametric investigation of response of Nonlinear Dynamic analysis of 3D industrial steel structure braced with distinct bracing configurations and dampers with different mass ratios utilising software is the focus of this research (ETABS). For the structural stability of the building structure under seismic loads, X-bracing bracing configurations were adopted. Modals with x bracing and a damper with a mass ratio of 1.5 percent have been discovered to increase the building's performance under earthquake and wind loads. A comparison with a general steel construction was done, and the bracing structure and dampers were examined.

Storey Drift

The storey shear and storey drift graphs are useful when analysing the effect of lateral loading on a multi-story building due to seismic or wind loads. The storey drift ratio is the storey drift divided by the storey height. Storey drift is the lateral displacement of a floor relative to the floor below. The storey drift ratio is a valuable metric that can be directly compared to the code requirements because seismic loading rules often impose limits on storey drift as a percentage of the storey height. A storey drift ratio graph will reveal whether certain floors are drifting more than others, indicating that they may require stiffening. Storey Drift was measured in the X and Z directions, and it was discovered that Case I, a general structure, had 7% more storey drift than Case II, a steel structure with dampers and concentric bracing.

Storey Displacement

Story displacement is the lateral displacement of the story relative to the base. The lateral force-resisting system can limit the excessive lateral displacement of the building. The acceptance lateral displacement limit for wind load case could be taken as H/500 (some may take H/400). Store Displacement was valuated for X and Z Direction for G+5 storey steel structure considering both the cases. Variation of 3% was seen in X direction when comparing both the structures and 5% variation was seen in Z direction when compared both the structures.

Base Shear

Base shear is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity. It is calculated using the seismic zone, soil material, and building code lateral force equations. Base shear was maximum in general steel structure. Base shear was least in Z direction in both the cases. By comparing base reactions which are obtained by with and without damper, usage of dampers shows considerable effects on increase in base shear. As the base shear increase the building will be able to resist the lateral loads.

The result shown that, adding fluid viscous damper to the structure reduces not only deformation but also the storey drift and displacement. It can be concluded that wind response of steel frame is considerably reduced with added fluid viscous damper placed by bracing.

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