

Analysis of a High-Rise Building Considering Hybrid Shear Wall Under Seismic Load

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ABSTRACT

Article Info	Shear walls are structural elements that protect structures from lateral loads such							
July-August-2022	as wind and earthquakes. When the external walls of a building are							
	insufficiently strong and stiff, shear walls are added to the interior to provide							
Publication Issue :	greater strength and stiffness. When the permissible span width ratio for the							
Volume 6, Issue 4	floor or roof diaphragm is exceeded, these shear walls are required. Shear walls							
	are flexural members that are commonly used in high- and low-rise buildings to							
Page Number : 108-116	prevent total collapse due to seismic stresses.							
	Here hybrid shear wall means a combination of shear wall and X bracing. This							
Article History	research is focused towards presenting the behavior of structure considering							
Accepted : 05 Aug 2022	three different cases namely, structure with X bracing at corner, structure with							
Published : 20 Aug 2022	shear wall at corner and structure with hybrid shear wall at corner.							
	The structure was modelled and analyzed using analytical application ETABS v							
	2016. The parameters of comparison were Storey displacement, storey shear.							
	Storey drift, storey stiffness and base shear.							
	Keywords: Hybrid Shear Wall, Response Spectrum Analysis, Shear wall, Seismic							
	Forces.							

I. INTRODUCTION

To securely carry gravity and lateral loads, tall building design entails a conceptual design, approximation analysis, preliminary design, and optimization. The basic goal of all structural systems employed in the construction of structures is to effectively transfer gravitational loads. Dead load, active load, and snow load are the three most frequent loads caused by gravity. Buildings are also vulnerable to lateral loads induced by wind and seismic forces, in addition to these vertical loads. High stresses, sway movement, and vibration can all be caused by lateral loads.

The structural design of high-rise buildings incorporates wind and earthquake dynamic calculations. Computer performance has improved dramatically in recent years, and practically all structural designers now utilise computer software for high-rise building structural design. In high-rise



buildings susceptible to lateral wind and seismic stresses, shear walls are extremely critical.

II. Literature Survey

In this study we are preparing review of literatures, journals related to advancesin construction industry mainly in concrete technology. Following research has been reviewd as follows:

Alshawabkeh Shorouq and Wu Li (2019) A "hybrid" concrete shear wall system was investigated in this study, which included mild steel reinforcement as well as posttensioned steel for flexural strength and inelastic energy dissipation. In order to examine the expected seismic behaviour of the concrete wall subjected to seismic loading in a series of prototype or model hybrid walls of post tensioned steel in precast concrete shear walls and cast-in-place concrete shear walls, a logical parametric study was conducted.

The use of mild steel in addition to post-tensioned steel in reinforcing the concrete shear wall improved the characteristics of the concrete shear wall in terms • of resisting seismic forces, particularly in terms of reducing lateral displacement (i.e., dislocation) caused • by an earthquake loading, according to the findings.

Satya Narayan Reddy et al (2019) In this study, a residential building (modeled as conventional Frame, • Shear wall and hybrid structure) is evaluated for its Dynamic performance under different seismic zones • using ETABS (2016). The load considerations and Design conform to IS 1893: 2016 PART I. The Storey Stiffness, Storey shear, Maximum Storey Drift and Maximum Story Displacement of the three different models under different seismic zones was compared. Structure The analysis incorporates the response spectrum method conforming to IS 1893-2016 part 1 and the load considerations conforming to IS 456 and ductile designing incorporated as per IS 13920-2016.

Conclusion stated that the shear wall structure performs effectively at severe seismic zone. The

conventional RC frames are prone to high storey drifts and displacement at higher seismic zones. The Storey drift and the Storey displacements were well within the limits as per the IS codes. Storey drift and Storey displacements was only 25% and 40% respectively in the shear wall structure when compared to the Conventional RC frame structure. The variation of the stiffness was the lowest in the Shear wall structure and the highest in the conventional RC structures. But stiffness variation is slightly varying in case of shear wall structure due to a high percentage of openings in stilt and parking floor. The stiffness variation in the conventional frame structure was found most. Storey shear in shear wall structure is 40 % lesser compared to conventional and 25% in hybrid structure.

III.OBJECTIVES OF THE STUDY

- Behaviour study of 10 storey high rise RCC structure with X bracing, shear walls and hybrid shear wall for seismic & wind loads.
- The variation of storey drifts of the models to be investigated.
- The variation of displacement has to be investigated considering response spectrum analysis.
- It is necessary to perform both similar static analysis and response spectrum analysis.
- The response of three structural system are to be investigated.

IV. METHODS AND MATERIAL

Steps of Modelling

Step 1 Reviewing research papers published by different authors in order to identify the scope of the research.

Step 2 Defining grid system data for x and y coordinates. In ETABS, X coordinates are defined on



grid ID as A, B, C etc and Y coordinates as 1, 2, 3 etc. The Z direction defined the storey height.

G1	e]	Story	Range Option Default		Click to Mode	fy/Show: Reference Points		0.0	0000
System Origin			User Specified			Reference Planes		6	
Global X	0 m		Top Story		Options			ē-	
Global Y	0 m		Bottom Story		Bubble Si	te 1000	mm	0	
Rotation	0 de	9			Grid Color			0	
В	5	Yes	End	Add	2	5	Yes	Start	Add
C	10	Yes	End	0.11	3	10	Yes	Start	0.11
	15	Yes	End	Delete	4	15	Yes	Start	Delete
D		Yes	End		5	20	Yes	Start	
D	20						24	A	Cont
D E F	20 25	Yes	End	Sort	6	25	Tes	Start	JUIL
D E F	20 25	Yes	End	Sort	6	25	Tes	Start	Juit

Fig 1 Grid System Data

Step 3 Defining structure object and applying simple storey data, here number of storey is G+10 with typical storey and bottom height is 3.2 m.

and Dimensions (Plan)				Story Dimens	lions		
O Uniform Grid Spacing				Simple	e Story Data		
Number of Grid Lines	in X Direction			Numb	er of Stories	10	
Number of Grid Lines	in Y Direction			Typic	al Story Height	3.2	:
Spacing of Grids in X	Direction			Botto	m Story Height	3.2	
Spacing of Grids in Y	Direction						
Specify Grid Labeling	Options		Grid Labels				
Custom Grid Spacing				O Custo	m Story Data		
Specify Data for Grid	Lines		Edit Grid Data	Spec	fy Custom Story Data	E	dit Story Data
Add Structural Objects	Grid Only	I н I I I I Steel Deck	Staggered Truss	Flat Slab	Fiat Slab with Perimeter Beams	Waffle Slab	Two Way or Ribbed Slab

Fig 2 Model Template

Step 3 This step defines the properties of material as here RCC structure is considered with X bracing, shear wall and hybrid shear wall.

General Data				
Material Name	M30			
Material Type	Concrete		\sim	
Directional Symmetry Type	Isotropic		\sim	
Material Display Color				
Material Notes	dify/Show Notes			
Material Weight and Mass				
Specify Weight Density	O Spe	cify Mass Density		
Weight per Unit Volume		24.9926	kN/m³	
Mass per Unit Volume		2548.538	kg/m³	
Mechanical Property Data				
Modulus of Elasticity, E		27386.13	MPa	
Poisson's Ratio, U		0.2		
Coefficient of Thermal Expansion,	A	0.0000055	1/C	
Shear Modulus, G		11410.89	MPa	
Design Property Data				
Modify/Show	Material Property	Design Data		
Advanced Material Property Data				
Nonlinear Material Data		Material Damping P	roperties	
Time	Dependent Prop	erties		

General Data			
Material Name	Fe345		
Material Type	Steel		\sim
Directional Symmetry Type	Isotropie		\sim
Material Display Color		Change	
Material Notes Modify/Show Notes.		y/Show Notes	
Material Weight and Mass			
Specify Weight Density	O Spe	oify Mass Density	
Weight per Unit Volume		76.9729	kN/m³
Mass per Unit Volume		7849.047	kg/m³
Mechanical Property Data			
Modulus of Elasticity, E		210000	MPa
Poisson's Ratio, U		0.3	
Coefficient of Thermal Expansion,	A	0.0000117	1/C
Shear Modulus, G		80769.23	MPa
Design Property Data			
Modify/Shov	v Material Property	Design Data]
Advanced Material Property Data			
Nonlinear Material Data		Material Damping P	roperties
Time	Dependent Prop	arties	

Fig 3.Defining property of concrete (M30)

Fig 3 Defining properties of steel

Step 4 Defining section data for beam, column, slab, X bracing system and shear wall



Fig 3 Defining section properties for beam







Frame Section Property Data General Data Property Name bracing X type ~ ... Material Fe345 Change... Display Color Notes Modify/Show Notes... Shape Section Shape Steel I/Wide Flange \sim Section Property Source Source: User Defined roperty Modifien Section Dimensions Modify/Show Modifiers... Currently Default Total Depth 450 Top Flange Width 250 mm Top Flange Thickness 25 Web Thickness 13 mm Bottom Flange Width mm 250 Bottom Flange Thicknes 25 mm Fillet Radius 0 ОК mm Cancel Show Section Properties...

Fig 9 Defining section properties for X bracing system

esign Type	Rebar Material					
P-M2-M3 Design (Column)	Longitudina	l Bars	HYSD41	5		~
 M3 Design Only (Beam) 	Confinemer	nt Bars (Ties)	HYSD41	5		~
einforcement Configuration	Confinement Bars		Check/	Desig	n	
 Rectangular 	Ties		 Reinforcement to be Checked 			Checked
Circular	 Spirals 		Reinforcement to be Designed		Designed	
ongitudinal Bars						
Clear Cover for Confinement Bars					40	mm
Number of Longitudinal Bars Along 3	3-dir Face				3	
Number of Longitudinal Bars Along	2-dir Face				5	
Longitudinal Bar Size and Area		20	\sim		314	mm²
Comer Bar Size and Area		20	\sim		314	mm ²
onfinement Bars						
Continientent bar Size and Area		10	~		[79	
Longitudinal Spacing of Confinemen	t Bars (Along 1-Axis)				150	mm
Number of Confinement Bars in 3-dir					3	
Number of Confinement Bars in 2-dir					3	

Fig 10 Frame section property reinforcement data fro design type and rebar material

Property Name	shear wall
Property Type	Specified V
Wall Material	M30 ~
Notional Size Data	Modify/Show Notional Size
Modeling Type	Shell-Thin 🗸
Modifiers (Currently Default)	Modify/Show
Display Color	Change
Property Notes	Modify/Show
Property Data	
Thickness	200 mn
ОК	Cancel



OK Cancel

Top Bars at J-End

Bottom Bars at I-End

Bottom Bars at J-End

Bottom Bars

60

mm

Fig 11 Defining properties of shear wall Step 5 Defining load pattern for dead, live and seismic

0

0

0

mm²

mm²

mm²





Fig 12 Defining seismic load pattern as per IS 1893 part I 2016



Fig 13 Defining response spectrum function

Lodu Case Name		EQ		Design
Load Case Type Exclude Objects in this Group Mass Source		Response Spect	um	V Notes
		Not Applicable		_
		Previous (MsSrc	Previous (MsSrc1)	
ads Applied				
Load Type	Load Name	Function	Scale Factor	70
Acceleration	U1	Default Uniform	9806.65	Add
Acceleration	U2	Default Uniform	9806.65	Delete
Acceleration	112	V Default Uniform	0000.05	-
ner Parameters Modal Load Case		Modal	3806.60	
her Parameters Modal Load Case Modal Combination Meth	od Nesponse	Modal CQC Rigid Frequency, f1		Advanced
ner Parameters Modal Load Case Modal Combination Meth	od kesponse	Modal CQC Rigid Frequency, f1 Rigid Frequency, f2		Advanced
her Parameters Modal Load Case Modal Combination Meth Include Rigid F	od kesponse	Modal CQC Rigid Frequency, f1 Rigid Frequency, f2 Periodic + Rigid Type	3806.63	Advancec
her Parameters Modal Load Case Modal Combination Meth Include Rigid F Earthquake Durati	od Response	Modal CQC Rigid Frequency, f1 Rigid Frequency, f2 Periodic + Rigid Type	3806.65	Advances
her Parameters Modal Load Case Modal Combination Meth Include Rigid F Earthquake Durati Directional Combination	od kesponse an, td type	Modal CQC Rigid Frequency, f1 Rigid Frequency, f2 Periodic + Rigid Type CQC3	3806.65	Advancer
her Parameters Modal Load Case Modal Combination Meth Include Rigid F Earthquake Durati Directional Combination 1 Absolute Direction	od od on. td Type al Combination Scale	Modal COC Rigid Frequency, f1 Rigid Frequency, f2 Periodic + Rigid Type COC3 Factor	3806.65	Advances
her Parameters Modal Load Case Modal Combination Meth Include Rigid F Earthquake Durati Directional Combination 1 Absolute Direction Modal Damping	od Response on. td Type al Combination Scale [Constant at 0.05	Modal QQC Rigid Frequency, f1 Rigid Frequency, f2 Periodic + Rigid Type QQC3 Factor	Jourson	Advances

Fig 14 Defining Load case data for Response Spectrum

Step 6 analyzing the structure for displacement, drift and shear force



Fig 15 Analyzing stress





Fig 16 Storey Drift



Fig 17 Stress on Shear Wall





Geometrical Description of Symmetrical Building						
Length in X-direction	25m					
Length in Y-direction	25m					
Floor to Floor Height	3m					
Total Height of Building	30m					

Slab Thickness	200mm
Wall Thickness	230mm
Shear wall Thickness	200mm
Column Size	450X450mm
Beam Size	450X250mm

Table 2 Geometrical Description of Bracing System

Geometrical Description of X I	Bracing System
Total Depth	450 mm
Total Flange Width	250 mm
Total Fhange Thickness	25 mm
Web Thickness	13 mm
Bottom Flange Width	250 mm
Bottom Flange Thickness	25 mm
Fillet Radium	0
Section Shape	Steel I/ Wide Flange

V. ANALYSIS RESULT









VI.CONCLUSION

This research is focused towards presenting the behaviour of structure considering three different cases namely, structure with X bracing at corner, structure with shear wall at corner and structure with hybrid shear wall at corner. The structure was modelled and analyzed using analytical application ETABS v 2016. The parameters of comparison were Storey displacement, storey shear, storey drift, storey stiffness and base shear.

- ✓ Storey displacement is the lateral displacement of the storey relative to the base. It is the total displacement of the 10th storey with respect to the ground. Compared to X bracing and shear wall, the hybrid shear wall structure has lower displacement values.
- ✓ Storey Drift is defined as the ratio of displacement of two consecutive floor to height of that floor. Compared to X bracing and shear structure, the hybrid Shear wall structure has lower Drift ratios. Storey drift of building is within the limit as clause no 7.11.1 of IS-1893 (Part-1):2002.
- ✓ Storey shear factor is the ratio of the story shear force when story collapse occurs to the story shear force when total collapse occurs. Here the storey shear was minimum for structure with X bracing in comparison to other two cases.
- ✓ Storey stiffness is estimated as the lateral force producing unit translational lateral deformation in that storey, with the bottom of the storey restrained from moving laterally, i.e., only translational motion of the bottom of the storey is restrained while it is free to rotate. Maximum storey stiffness was analyzed in structure with shear wall as compared to structure with x bracing and structure with hybrid shear wall.
- ✓ 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. Here the base shear was found maximum in structure with hybrid shear wall at corner in comparison to structure with shear wall and structure with x bracing.

VII. Future Scope

- Parameters of material consumption in terms of weight of steel, volume of concrete, time of construction and cost should be evaluated to outline and compare the economic efficiency of the structures.
- 2. In this study hybrid shear wall is considered as a combination of X bracing and shear wall, whereas hybrid shear wall may be prepared using different materials such as using polymers for future study.
- 3. This research is limited to seismic analysis and in future wind load can be further considered.

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