Analysis Of A Steel Structure Considering Braced And Unbraced Eccentric Condition Using ETABS

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Abstract- In modern seismic design, damping devices are used to increase the capacity of structures to dissipate energy. This Project evaluates the efficiency of using a passive friction damper system in a structure compared with typical structures and the influence of the damper's capacity on the structural response. The analysis concludes that dampers with lower capacity slip more times during earthquake than dampers with bigger capacity but the acceleration result increases.

The main objective of this research is to assess the seismic performance of Eccentrically Braced Frames of different configurations. Modelled Eccentrically Braced Frames subjected to both linear and nonlinear analysis in ETABS. The linear analysis gives an insight to mode shapes and mass participation ratios.

Keywords: Seismic Analysis, Storey Drift, Base Shear, Storey Displacement, ETABS

I. INTRODUCTION

Earthquake is a wavering which is produced by powers underneath the lithosphere, traveling through the asthenosphere. It very well may be expressed as the vibration which happens due to energy delivered in the asthenosphere. The arrival of the energy is the consequence of the quick interruption or the definite eruption of a piece of the outside layer, or even because of the human mediations brought about by blasts. This issue has been a critical subject of thought for specialists. At last numerous analysts and researchers recommended the utilization of supporting frameworks for the viable opposition of the seismic burdens.

Brace System

A Fundamental concept in engineering – bracing – involves added additional elements to a frame in order to increase its ability to withstand lateral loads. There are two main varieties of braced frames – concentric and eccentric.

Concentric Bracing

Concentric propping comprises of slanting supports situated in the plane of the edge. The two finishes of the support join

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toward the end points of other outlining individuals to shape a bracket, making a firm edge.



Fig 1: Common types of concentric bracing

Eccentric Bracing

Eccentric bracing comprises of corner to corner supports situated in the plane of the edge where one or the two closures of the support don't join toward the end points of other outlining individuals. The framework basically joins the elements of a second casing and a concentrically propped outline, while limiting the disservices of every framework.



Fig 2: Common types of eccentric braced framing

Damping System

Damper systems are planned and fabricated to safeguard underlying honest characters, control primary harms, and to forestall wounds to the occupants by engrossing seismic energy and lessening distortions in the construction. Seismic dampers grant the design to oppose serious information energy and diminish hurtful diversions, powers and speed increases to designs and inhabitants. There are a few kinds of seismic dampers to be specific gooey damper, erosion damper, yielding damper, attractive damper, and tuned mass damper.

ETABS

ETABS is the shortening of "Expanded 3D Investigation of building Framework". ETABS is a result of PCs and Designs, Inc. which is perceived worldwide as the spearheading pioneer in primary designing examination and plan programming for underlying and tremor designing. They have presented ETABS with the accompanying section.

II. LITERATURE REVIEW

Srushti Bagal et.al (2020) in the exploration paper, a multistoried exposed and supported steel outlines was examined by Execution Based Seismic Plan (PBSD) technique in STAAD Expert High level following nonlinear static examination. Outline parts (bar, sections, and so forth.) was continuously changed in accordance with represent nonlinear versatile plastic conduct under consistent gravity loads and gradually expanding sidelong loads. The outcomes were dissected as far as uprooting, shear powers, plastic pivots and limit bend.

Results presumed that propped steel outline at ideal position expands the shear limit of construction and performs well, most extreme in LS level. No breakdown of part is seen here after gradual parallel burdens. Weakling investigation is effectively executed to concentrate on non direct way of behaving of design under seismic tremor stacking.

Shaik Mohammad et.al (2019) creator examined the exhibition of a 6 celebrated steel outline working with knee supporting framework and contrasted and exposed outline. Weakling examination, comparable static investigation, Reaction Range investigation, Time history examination is acted in ETABS in light of IS 1893:2002 (section 1) rules. The manual computation was finished based on Identical static examination and Reaction range investigation to figure out base shear for establishment and parallel power for every story deck section and contrasted the qualities and exposed outline. Results expressed that the knee propped outline framework is vital for decrease the impact on parallel relocation by unearthly speed increase (Sa). The inside story float in Y-

unearthly speed increase (Sa). The inside story float in Yheading is far contrasted with admissible float proportion according to IS 1893:2002 (section 1). Subsequently, the knee supporting edge underlying inside story float is adequate by IS 1893:2002 (section 1).

III. METHODOLOGY

Step 1 New model quick template is defined on the first step, as here in this case, G+9 storey structure was

considered, with number of storey as 10, typical storey height of 3.2m and the bottom storey was locked at 3m.

		Story Dimensions		
O Uniform Grid Spacing		Simple Story Data		
Number of Grid Lines in X Direction		Number of Stories	10]
Number of Grid Lines in Y Direction		Typical Story Height	3.2]=
Spacing of Grids in X Direction		Bottom Story Height	3].
Spacing of Gride in Y Direction				
Specify Grid Labeling Options	Grid Grinels			
Custom Grid Spacing		O Custom Story Data		
Specify Data for Grid Lines	Edit Grid Data	Specify Custom Story Data	Ent Day Date	
Add Structural Objects				
E-				1
				-
				4.
		First State First State with	Waffle Slab Two Way	~
	David Placement Trans	a list to be a list to be a list of the li	TYNTING CHEN INVO TENY	

Fig 3 : New Model Quick Template

Step 2 Defining Grid System, this leverage is available in ETABS where the structure can be predefined on parameters of grid system defining them in X and Y direction by naming grid ID in x direction as A,B, C,..... and 1, 2, 3, 4....in y direction.

		Story	Pange Option			Click to Mode	y/Show:				
G1			Default				Reference Points		(C)	0.0	0000
System Origin			Over Specified Top Story				Reference Planes		()- ()-		
Gobal X	0	m.				Options			0-		
Global Y.	ō	m.	Bottom Story			Bubble Sta	æ 800	mm	0-		
Rotation	0	deg				Grid Color			64		
Rectangular G	da										
Display	Grid Data as Ordinates	C	Display Grid Dat	a as Sc	pacing			Quick	Start New Rectan	gular G	inds
X Grid Data						Y Grid Data					
Grid I	X Ordinate (m)	Vable	Bubble Loc	^		Grid ID	Y Ordinate (m)	Visible	Bubble Loc	~	
В	4	Yes	End		Add	2	4	Yes	Start		Add
C	8	Yes	End		Dulate	8	8	Yes	Start		Outer
D	12	Yes	End		Celete	4	12	Yes	Start		Delete
E	16	Yes	End			5	16	Yes	Start		
E.	20	Yes	End		Sort	6	20	Yes	Start		Sort
				¥						¥	

Fig 4 Defining Grid System Data for X and Y Direction.

Step 3 Defining Material Properties as M30 grade of concrete and HYSD500 grade of steel is considered for beam, column shear wall and slab.

General Data			
Material Name	MBO		
Material Type	Concrete		\sim
Directional Symmetry Type	Isotropio		~
Material Display Color		Change	
Material Notes	Mode	fy/Show Notes	
Material Weight and Mass			
Specify Weight Density		cify Mass Density	
Weight per Unit Volume		24.9926	kN/m ³
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 Propert	y Design Data]
Advanced Material Property Data			
Nonlinear Material Data		Material Damping P	roperties
Time	Dependent Prop	erties	
Modulus of Rupture for Cracked Defle	ections		
Program Default (Based on Co	oncrete Slab Des	ign Code)	
O User Specified			

Fig 5: Defining Property of concrete for M30.

Material Name	HYSD500		
Material Type	Rebar		~
Directional Symmetry Type	Uniaxial		
Material Display Color		Change	
Material Notes	Mo	dify/Show Notes	
Material Weight and Mass			
Specify Weight Density	() S	pecify Mass Density	
Weight per Unit Volume		76.9729	kN/m³
Mass per Unit Volume		7849.047	
Mechanical Property Data			
Modulus of Elasticity, E		200000	MPa
Coefficient of Thermal Expansion,	A	0.0000117	1/C
Design Property Data			
Modify/Show	w Material Prope	rty Design Data]
Advanced Material Property Data			
Nonlinear Material Data		Material Damping P	roperties
Tarse	e Dependent Pro	spientierm	

Fig 6: Defining Properties of Rebar Step 4 Defining Section properties for beam as 450x300mm, column 500x500mm, properties of wall 200mm.

Property Name	beam		
Material	M30	~	2
Notional Size Data	Modify/Show Notiona	I Size	
Display Color	Chan	ge	••• •••
Notes	Modify/Show Note	es	• •
Shape			
Section Shape	Concrete Rectangular	~	
Section Property Source			
Source: User Defined			Property Modifiers
Section Dimensions			Modify/Show Modifiers
Depth	450	mm	Currently Default
Width	300	mm	Reinforcement
			Modry/ show Hebar
			ок
			Canad

Fig 7: Defining Section Properties of Beam

Property Name	column			-
Material	M30	~	2	
Notional Size Data	Modify/Show Notiona	Size	3	
Display Color	Chan	ge	• • +	•
Notes	Modify/Show Note	55	•	•
Shape				•
Section Shape	Concrete Rectangular	~		
Section Property Source				
Source: User Defined			Property Modifiers	
Section Dimensions			Modify/Show Modifier	8
Death	600		Currently Default	
Uepin	1000		Reinforcement	
width	500	I mm	Modify/Show Rebar	

Fig 8: Defining Section Property for column

Step 5 Assigning Fixed Support at the bottom of the structure in X, Y and Z direction.

Translation X Rotation about X Translation Y Rotation about Y Translation Z Rotation about Z ast Restraints	Restraints in Globa	al Direct	ions
Translation Y Rotation about Y Translation Z Rotation about Z ast Restraints	Translation	×	Rotation about X
Translation Z Rotation about Z ast Restraints	Translation	Y	Rotation about Y
ast Restraints	Translation	z	Rotation about Z
	ast Restraints		

Fig 9: Assigning Fixed Support

Step 6 Defining Properties for friction dampers

Link Prop	erty Name	e dam	per	P-Delta Pa	rameters		Modify/Show	N
Link Type	2	Dam	oper - Friction Spring V	Acceptanc	e Criteria		Modify/Show	N22
Link Prop	erty Note	8	Modify/Show Notes			None	specified	
fotal Mass a	nd Weigh	ne -						
Mass		100	kg	Rotati	Rotational Inertia 1 Rotational Inertia 2		0	ton-m ²
Weight		100	kN	Rotati			0	ton-m ²
				Rotati	onal Inert	ia 3	0	ton-m ²
actors for L	ine and A	vea Springs						
Link/Sup	net Prop	entry in Defined	for This Length When Llend in	a Line Spring Prope	rty		1	m
- o orde	prost Prope	eny a Denned	for this beinger when oaco in					
Link/Sup	port Prop	erty is Defined	for This Area When Used in an	Area Spring Proper	ty		1	m²
Link/Sup Directional P	port Prop	erty is Defined	for This Area When Used in an	Area Spring Proper	ty		1	m²
Link/Sup Directional P Direction	port Properties Fixed	NonLinear	for This Area When Used in an Properties	Area Spring Proper	ty Fixed	NonLinear	1 Prop	m ²
Unk/Sup Directional P Direction	Properties Fixed	NonLinear	Froperties	Area Spring Proper Direction	fy Fixed	NonLinear	1 Prop Modify/Sh	m ² erties
Unk/Sup Directional P Direction U1 U1 U2	roperties Fixed	NonLinear	For This Area When Used in an Properties Nodly/Show for U1	Area Spring Proper Direction P R1 R2	ty Fixed	NonLinear	1 Prop Modify/Sh Modify/Sh	erties one for R1 ow for R2
Unk/Sup Directional P Direction U1 U1 U2 U2 U2 U3	roperties Fixed	NonLinear	Properties Boothy/Stow for U2 Modify/Show for U2	Area Spring Proper Direction P R1 R2 R3	Fixed	NonLinear	1 Prop Modify/Sh Modify/Sh	erties ow for R1 ow for R2 ow for R3
Unk/Sup Directional P Direction U1 U1 U2 U2 U2 U3	Fixed	NonLinear	for This Zength Milet Oald of The for This Zength Milet Oald of The Properties Modify/Show for U1 Modify/Show for U3 Fix All	Area Spring Proper Direction R1 R2 R3 Clear Al	Fixed	NonLinear	1 Prop Modify/Sh Modify/Sh	m ² entities ow for R1 ow for R2
Unk/Sup Directional P Direction U1 U2 U2 U2 U3	roperties Fixed	NonLinear	From the Congress of the Congr	Area Spring Proper Direction R1 R2 R3 Clear All	Fixed	NonLinear	1 Prop Modify/Sh Modify/Sh	m ² erties ow for R1 ow for R2 ow for R3
Unk/Sup Directional P Direction U1 U1 U2 U2 U2 U3	roperties Fixed V V ions Used for 1	NonLinear	For This Area being in their loads in an Properties Modify/Show for U2 Modify/Show for U3 Fix All fal Load Cases	Area Spring Proper Direction R1 R2 R3 Clear All	Fixed	NonLinear	1 Prop Modify/Sh Modify/Sh	m ² erties ow for R1 ow for R2 ow for R3
Unk/Sup Directional P Direction U1 U1 U2 U2 U3	Fixed Fixed Sons Used for I Used for I	NonLinear	From the Cargor When Used in an Propertise Modify/Show for U2 Modify/Show for U3 Fix All fail Load Cases tional Viscous Damping	Area Spring Proper Direction P R1 R2 R3 Clear All	Fixed	NonLinear	1 Prop Modify/Sh Modify/Sh	m ² over for R1 ow for R2 ow for R3

Fig 10: Defining Link Property Data for damping system

Step 7 Defining Loading conditions for dead load, live load and earthquake load.

Load	Туре	Self Weight Multiplier	Auto Lateral Load		Add New Load
Qy	Seismic	~ 0	IS 1893:2016	\sim	Modify Load
lead ive Gx Gy	Dead Live Seismic Seismic	1 0 0	IS 1893:2016 IS 1893:2016		Modify Lateral Load Delete Load
					OK Cased

Fig 11: Defining Load Pattern

Step 8 Defining Seismic load data for different seismic zones.

Direction and Eccentricity		Seismic Coefficients		
X Dir	Y Dir	Seismic Zone Factor, Z		
X Dir + Eccentricity	Y Dir + Eccentricity	Per Code	0.36	1
X Dir - Eccentricity	Y Dir - Eccentricity	O Her Defined		
Ecc. Batio (All Dianh.)		O user Denned		-
		Site Type		1
Overwrite Eccentricities	Overwrite	Importance Factor, I	1.5	
Story Range		Time Period		
Top Story	Story10 🗸	O Approximate Ot (m) =		
Bottom Story	Base ~	Program Calculated		
		O Liese Defined		sec

Fig 12 : Seismic Zone Data for Zone V

Step 9 Shell Assignment floor meshing option

Default		
O For Defining Rigid Diap	hragm and Mass Only (No Stiff	ness - No Vertical Load Transfer - Applies to Horizontal Floors Only)
O No Auto Meshing (Use	Object as Structural Element)	
 Mesh Object Into 	by	Elements (Applies for 3 or 4 noded objects only with no curved edges)
O Auto Cookie Cut Objec	t into Structural Elements	
Further Mesh When	e Needed to Maximum Element	Size of mm
Add Restraints on Edg	e if Comers have Restraints	

Fig 13: Shell Assignment for Meshing

IV. PROBLEM IDENTIFICATION

Building configu	uration for structure
Building configuration	G+9
Structure Type	Steel Structure
Plan Dimension	25mx25m
Number of Bay in X-direction	5
Distance between bays in X-direction	4m
Distance between bays in Y-direction	4m
Number of Bay in Y-direction	5
Height of the structure	31.8m
Bearing capacity of soil	200 KN/m2
Slab Thickness	150mm
Storey Height	3.2m
Bottom Storey Height	3m
Wall Thickness	150mm
Parapet Wall	150mm
Section of Beam	450mmx300mm
Section of Column	500mmx500mm
Table 1: Building o	configuration

Table 1:	Building	configuratio
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Grade of Concrete	M30
Weight per unit Volume	24.9926 kN/m3
Mass per Unit Volume	2548.538 kg/m3
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

Table 2: Properties of Concrete

Material Name	HYSD500
Material Type	Rebar
Weight per unit Volume	76.9729 kN/m3
Mass per Unit Volume	7849.047 kg
Modulus of Elasticity, E	200000MPa
Coefficient of Thermal Expansion, A	0.0000117 1/C

Table 3: Properties of Rebar

Material Name	Fe345
Weight per unit Volume	76.9729 kN/m3
Mass per Unit Volume	7849.047 kg
Modulus of Elasticity, E	21000MPa
Poisson's Ratio, U	0.3
Coefficient of Thermal Expansion, A	0.0000117 1/C
Shear Modulus, G	80769.23 MPa

Table 4: Properties of Steel

Loading Condition

The gravity loads and earthquake loads will be taken for analysis. As per IS 1893 (Part1): 2016 Clause no: 6.3.1.2, the following load cases have to be considered for seismic analysis:

- 1. 1.5 DL
- 2. 1.5(DL+IL)
- 3. 1.2(DL+IL + EL along X direction)
- 4. 1.2(DL+IL + EL along Y direction)
- 5. 1.2(DL+IL - EL along X direction)
- 6. 1.2(DL+IL - EL along Y direction)
- 7. 1.5(DL + EL along X direction)
- 8. 1.5(DL + EL along Y direction)
- 9. 1.5(DL - EL along X direction)
- 10. 1.5(DL - EL along Y direction
- 11. 0.9DL + 1.5EL along X direction
- 12. 0.9DL + 1.5EL along Y direction
- 13. 0.9DL - 1.5EL along X direction
- 14. 0.9DL - 1.5EL along Y direction

Following loadings are adopted for analysis:-

1. Self weight: Dead load of materials 2. Dead Load: Calculated by software using density and sectional data of the structural members.

A. 25.K.N/m³ X 0.20 m

B. 5.0 K.N/ m²

Floor finishing = 1.625KN/ m^2

Total Weight of slab = 5.0 KN/ m^2 + 1.625KN/ m^2 = 6.625 KN/ m^2

3. Live Load: It is calculated as per IS-875 (Part II): 1987Live load on floors = $4KN/m^2$

4. Earthquake Load: It is calculated as per IS-1893 (Part I): 2016.

Vb = Ah x Weight of the building Ah = (Z/2) x (Sa/g) x (I/R). Calculation for Sa/g

$$Ta = 0.075 h^{0.75}$$
 [IS 1893 (Part 1):2016, Clause 7.6.1]

 $= 0.075 \text{ x} (15)^{0.75} = 0.571 \text{ sec.}$

Zone factor, Z = 0.36 for Zone V, IS: 1893 (Part 1):2016, Table 2 Significance factor, I = 1.5 (building) Delicate soil site and 5% damping Sa/g = 1.36/0.571 = 2.381According to I.S.: 1893 (Part 1): 2016.

Case Study

Case I- A Conventional G+9 storey structure.



Fig 14: G+9 Conventional Structure



Fig 15: G+9 Centric Brace Structure



Case II- Centric brace structure



Fig 16: Eccentric brace structure

Case IV- Frictionally damped



Fig 17 : G+9 Structure with Friction Dampers

V. RESULTS AND DISCUSSION

Lateral Displacement



Fig 18: Lateral Displacement in X-direction.

Storey Drift





Time Period





Base Shear





VI. CONCLUSION AND FUTURE SCOPE

The lateral displacement was maximum for unbraced structure which was on the higher side by 37% in comparison to frictionally damped structure.

The structure was found stable in all the four cases and favourable results were visible for both eccentric braced structure and frictionally damped structure.

Time period was evaluated with mode 12 where the stable results were visible for frictionally damped structure.

The base shear formula is: V = 0.2 (W) V represents the shear force that will be generated at the base of a building. 0.2 represents earthquake force. W represents the weight of the building. The base shear was least for contric brace structure and maximum for unbraced structure.

FUTURE SCOPE

- The research on the accuracy of fast nonlinear analysis as an alternative to direct integration analysis should be further studied.
- As the modal time-history analysis is especially suitable for structures equipped with energy dissipating devices, this was also performed in this study with friction dampers as a third LFRS.
- Further investigate the behaviour of frictional dampers with soft storey structure.

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