SEISMIC EVALUATION OF FRAMED STRUCTURES

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Abstract :-

Building damage by earthquake action is a serious problem. In this paper seismically deficient structures are studied by carrying out the Pushover analysis of frame structures using SAP Software. Building get deformed because of the lateral and seismic forces acting on the structure. Forces increased as per the height of structure : low rise structures have higher resonant frequency and hence lower frequency high rise structures are studied. In this paper, the following activities are taken up to draw the results. Study of various earthquake and pushover forces acting ,formation of hinges and their implementation available in the literature evaluating the real strength of the structure and damage assessment of the multistoried building structures.

Keywords :- Frame structure, Pushover Curve, SAP2000, Target Displacement, Performance point.

I. Introduction

Earthquake perhaps the most disastrous calamity has been threatening the mankind since the day of its inception. Suitable amount of research have been reported towards the mitigation of seismic hazard, proposing careful detailing of structural systems and Improvising many new materials and external device conducive to dissipation energy imparted to the structure during seismic excitation. With the advent of each catastrophic earthquake,Failure of these structures attributes almost irrecoverable damage to the body society, there is a consequence of past earthquakes
The 1989 Loma Prieta Earthquake in San Francisco, The 1994 Northridge Earthquake in California causes significant loses. The damage included column and beam failures, shear cracking in shear walls, beam slab connection and beam column joint failures.The seismic risk may be reduced by taking special measures based on scientific knowledge about the behavior of the building and earthquake action ., so it is always advisable to strengthen the building,by determining the weakening points of building. To achieve the increased seismic resistance engineers need information regarding the seismic demand and seismic capacity of the building elements during the design earthquake. Inelastic procedures are necessary to identify the modes of damage and evaluate the possibility of progressive collapse. Most of the human injuries and economic losses are caused by the failure of the engineered structures, particularly building recent earthquakes, in which large economic losses have been suffered, confirm this noticeably the building structure may be damaged significantly without its collapse. Thus seismic design balances reduced cost and the acceptable damage. To improve their seismic performance the Damage assessment , and rehabilitation of the existing building structures have been proposed in the following literature.

II. Literature Review

In this section an attempt has been made for a literature review for pushover analysis of frame structures :-

A. Krawinkler and Seneviratna (1995)

On this paper Target Displacement Estimation of MDOF Structure through equivalent SDOF domain are carried out. The comparison of pushover and nonlinear dynamic Analysis provides good estimation of seismic demands for Low rise structures.

B. Mwafy and Elnashai (2001)

This paper performed a series of pushover analysis using Uniform,triangular and multimodal load patterns then pushover curves were obtained. It was noted that this analysis is more appropriate for low rise and short period structures and TriangularLoading is adequate to predict the response of structures.

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C. Inel, Tjhin and Aschheim
A study conducted to evaluate the accuracy of various lateral load patterns such as first mode, inverted triangular, rectangular & code. Peak values of peak roof drifts were compared to those obtained from nonlinear dynamic analysis. It provides good estimates of peak displacement Response for both regular & weak story buildings

III A]. Various Modifications Levels

Isolation.
Dampers.
Slosh Tanks. .
Reinforcement.
Connections between building and their expansion additions.
Exterior concrete columns.

III B]. Seismic performance levels

The three structural performance Levels and Two Structural Performance Ranges Consist of:

- S-1 : Immediate Occupancy performance Level
- S-2 : damage control performance range
  (Between Life Safety and Immediate Occupancy Performance Level)
- S-5 : Collapse Prevention performance Level
  In addition, there is the designation of S-6, Structural performance not considered, conversing the situation where only nonstructural improvements are made.
  The four Nonstructural performance Levels are: N- A : Operational performance Level
- N-B : Immediate Occupancy Performance Level
- N-C : Life Safety Performance Level
- N-D : Hazards Reduced Performance Level
  In addition, there is the designation of N-E Nonstructural Performance Not Considered, to cover the situation where only structural improvements are made [FEMA]

- IO : Immediate Occupancy Performance Level
- LS : Life Safety Performance Level
- CP : Collapse Prevention Performance Level

IV. Proposed work

Figure 1. RCC Frame Structures

Figure 2. Infill Frame Structure

Details of Structure

Type :- Multistorey RCC Frame
Zone :- III
Number Of Storey :- G+III
Floor to floor Height :- 3.1 M
Depth of Foundation :- 1.2m
External walls :- 230 mm thick
Internal walls :- 150 mm thick
Live Load :- 3 KN/Sqm on roof
:-1.5KN/Sqmonroof
Exposure Conditions :- Mild Environment
Density of Concrete :- 25 KN/Cum
Density of Brick :- 20KN/Cum
Materials :- M20 Concrete
Materials : - Fe 415 Main
Design Philosophy :- Limit Statet Method conforming to IS 456-2000
Seismic Analysis :- IS 1893 Part I 2002
Size of Columns :- 300X450
Size of Beams :- 300 X350
Depth of Slab :- 150 mm

Materials :-

Concrete
Characteristic compressive strength (fck)=20 Mpa
Poissons Ratio = 0.3
Density =25 KN/Cum
Modulis of Elasticity E= 5000√fck = 22360.68 MPa

Steel :-

Fe 415 grade of steel = 415 MPa
Modulus of Elasticity E = $2x10^5$ MPa

Infill :-

Characteristic compressive strength (fck)=4 Mpa
Poissons Ratio = 0.15
Density =16 KN/Cum
Modulis of Elasticity E= 550fm = 2200 MPa

Loads :-

Dead Slab = 3.75 KN/M
Dead FF = 1.0 KN/M
Dead RT = 1.5 KN/M
Live = 3.0 KN/M
Live Roof 1.5 KN/M

Design Seismic Base Shear :-

Dead Slab = 3.75X1.5 = 5.625 KN/M
Dead FF = 1.0X1.5 = 1.50 KN/M
Dead RT = 1.5X1.5 = 2.25 KN/M
Live = 3.0 X 1.5 =4.5 KN/M
Live Roof 1.5 X1.5 = 2.25 KN/M
Wt. of 230mm ext. wall=0.23x1x(3.1-0.45)x20=12.19Kn/m
Wt. of 150mm ext. wall=0.15x1x(3.1-0.45)x20=7.95Kn/m
Wt. of 230mm partition wall=0.23x1x1.5x20=6.9Kn/m

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Calculation of width of Brace (w) :-

$W = 0.175(\lambda h_{col})^{-0.4} D$ ------- Eq. (1)

Where,

$\lambda = [E_m t_{inf} \sin\theta \;/\; 4E_{fe} I_c hi_{nf}]$

$t\ inf$ = thickness of infill

$h\ inf$ = height of infill

$l\ inf$ = length of infill

$\theta = \tan^{-1}(h_{inf} / l_{nf})$

$h_{col\,=}$ height of column, between the cnetrelines of beams

E_{me} & E_f = Youngs Modulus of material and infill

$I_{c\,=}$ Moment of inertia of column

$D_{infl\,=}$ Diagonal length of infill

$f_{m\,=}$ Compressive strength of infill wall

λ_{-} Relative stiffness of infill

Table 1. Brace Width

Parameter	Brace 1	Brace 2	Brace 3	Brace 4
Width W in (m)	0.641	0.442	0.373	0.629

Table 2. Various Performance Levels

Type	Collapse prevention S-5	Life Safety S-3	Immediate Occupancy S-1
Primary	Extensive cracking and hinge formation in ductile elements. Limited cracking and/ or splice failure in some nonductile columns. Severe damage in short columns.	Extensive damage to beams. Spalling of cover and shear cracking (1/8” width) for ductile columns. Minor spalling in nonductile columns. Joint cracks <1/8” wide.	Minor hairline cracking. Limited yielding possible at a few locations. No crushing (strains below 0.003)

Secondary	Extensive spelling in columns (limited shortening) and beams Severe joint damage. Some reinforcing buckled.	Extensive cracking and hinge formation in ductile elements. Limited cracking in some nonductile columns. Severe damage in short columns.	Minor spalling in a few places in ductile columns and beams. Flexural cracking in beams and columns. Shear cracking in joints <1/16" width.
Drift	4% transient or permanent	2% transient ; 1% permanent	1% transient ; negligible permanent

Case I (Bare Frame)

Table 3. Force VS Displacement

STEP	DISP N	FORCE KN
1	0.016248	756.763
2	0.032224	1246.078
3	0.088394	2181.338
4	0.15271	3119.376
5	0.152715	3026.786

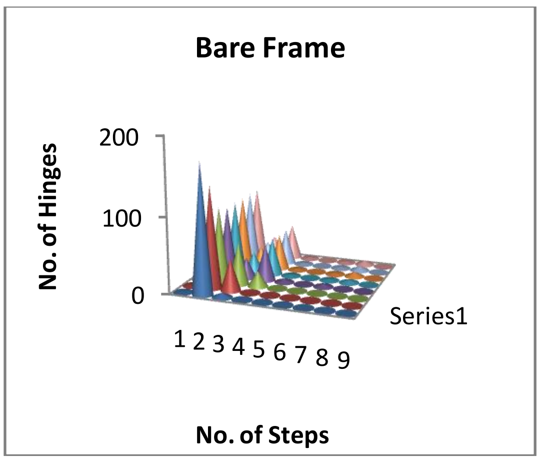

Figure 3. Hinge Levels

Case II (RCC Frame with Diagonal bracing)

Table 4. Force VS Displaceement.

STEP	DISP N	FORCE KN

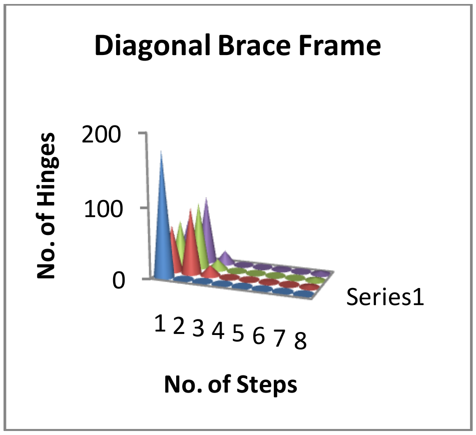

Figure 4. Hinge Levels

1	0.016248	756.763
2	0.032224	1246.078
3	0.088394	2181.338
4	0.15271	3119.376

Case III (RCC frame with Cross bracing)

Table 5. Force VS Displacement

STEP	DISP N	FORCE KN
1	0.016248	756.763
2	0.032224	1246.078
3	0.088394	2181.338
4	0.15271	3119.376

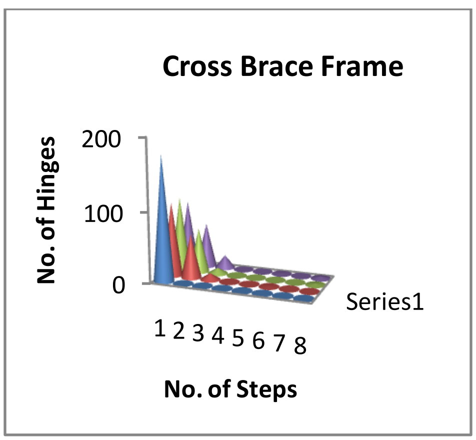

Figure 5. Hinge Levels

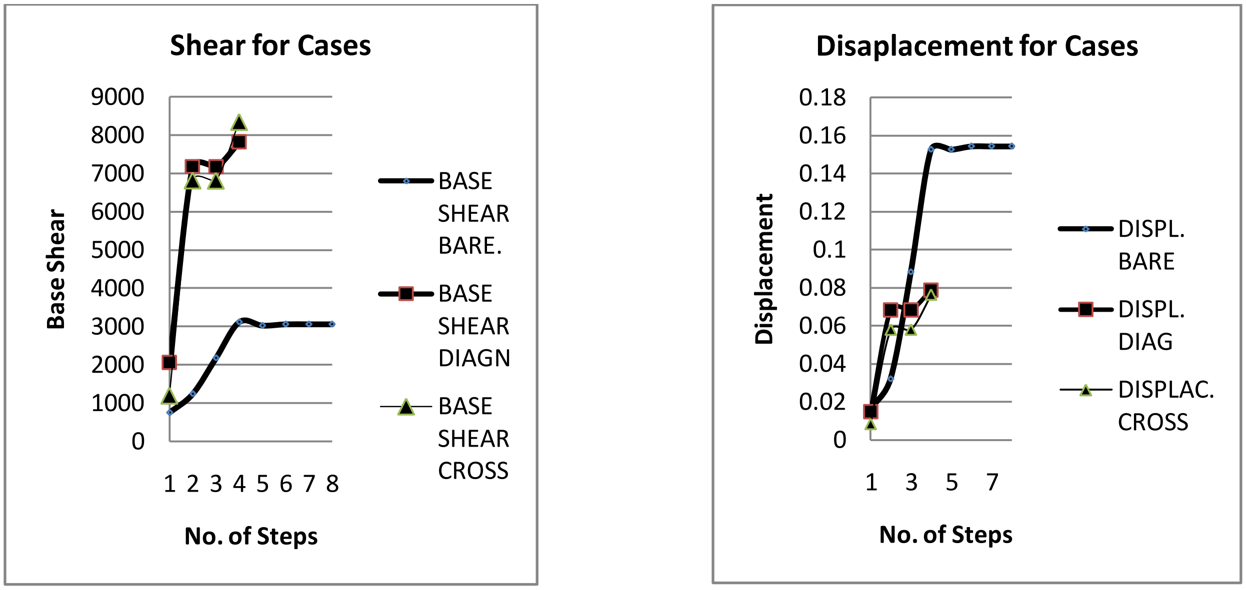

Figure 6. Base Shear And Displacement Diagram for three Cases.

V.Conclusion

- Floor Displacement is maximum for bare frame as compared to strut frame.
- Deflection is reduced in infilled frame as compared with bare frame.
- Since the performance point is achieved hence the displacement of the structure is within range. (Demand is not more than the capacity of building).
- Since the natural period of the performance is reduced, that building strength is increased.
- Static pushover analysis is an attempt by the structural engineering profession to evaluate the real strength of the structure and it promises to be a useful and effective tool for performance based design.

VI. References

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