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Study of Behaviour of Steel Structure by Push Over Analysis

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Abstract: In last decades Steel structure has played an important role in construction Industry. It is necessary to design a structure to perform well under seismic loads. The seismic performance of a multi-story steel frame building is designed according to the provisions of the current Indian code (IS 800 -2007). The shear capacity of the structure can be increased by introducing Steel bracings in the structural system. Bracings can be used as retrofit as well. There are „n" numbers of possibilities to arrange Steel bracings such as D, K, and V type eccentric bracings. A typical eight-story steel frame building is designed for various types of eccentric bracings as per the IS 800- 2007. D, K, and V are the different types of eccentric bracings considered for the present study. Performance of each frame is studied through nonlinear static analysis.

Keywords: Pushover analysis, Steel frames, Bracings.

I. INTRODUCTION

In last decades Steel structure plays an important role in the construction industry. It is necessary to design a structure to perform well under seismic loads. Shear capacity of the structure can be increased by introducing Steel bracings in the structural system. Bracings can be used as retrofit as well. There are „n" numbers of possibilities are there to arrange Steel bracings. Such as D, K, and V type eccentric bracings. Design of such structure should have good ductility property to perform well under seismic loads. To estimate ductility and other properties for each eccentric bracing Push over analysis is performed. A simple computer-based push-over analysis is a technique for performance-based design of building frameworks subject to earthquake loading. Push over analysis attains much importance in the past decades due to its simplicity and the effectiveness of the results. The present study develops a push-over analysis for different eccentric steel frames designed according to IS-800 (2007) and ductility behaviour of each frame. Pushover analysis is a static, nonlinear procedure using simplified nonlinear technique to estimate seismic structural deformations. It is an incremental static analysis used to determine the force-displacement relationship, or the capacity curve, for a structure or structural element. The analysis involves applying horizontal loads, in a prescribed pattern, to the structure incrementally, i.e. pushing the structure and plotting the total applied shear force and associated lateral displacement at each increment, until the structure or collapse condition.

II. LITERATURE REVIEW

Dinesh J.Sabu and Pajgade (2012) concentrated on seismic evaluation of existing reinforced concrete building. Seismic analysis was carried out for existing reinforced concrete building. The reinforcement provided in building was compared with all the three formats of modeling i. e. bare frame modeling, brick infill frame modeling and infill + soil effect interaction model. After all the study, the following conclusions were drawn.The strength of the existing structure could be enhanced to the required level and it would definitely improve the seismic resistance capacity of the building required for zone III. The concrete jacketing method was easy, effective and economical method for improving the seismic resistance capacity of the member and building as well. About 30% to 40% less reinforcement required in building with brick infill + soil interaction effect as compared to bare frame in ground storey. And relatively less difference in reinforcement in other upper storey.

Ramaraju et al. (2012) carried out the nonlinear analysis (pushover analysis) for a typical six storey office building designed for four load cases, considered three revisionsof Indian (IS: 1893 and IS: 456) codes. In that study, nonlinear stress–strain curves for confined concrete and user-defined hinge properties as per Eurocode 8 were used. A significant variation was observed in base shear capacities and hinge formation mechanisms for four design cases with default and user-defined hinges at yield and ultimate. This may be due to the fact that, the orientation and the axial load level of the columns cannot be taken into account properly by the default-hinge properties. Based on the observations in the hinging patterns, it was apparent that the user-defined hinge model was more successful in capturing the hinging mechanism compared to the model with the default hinge.

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Shahrin Hossain (2011) followed the procedures of ATC 40 in evaluating the seismic performance of residential buildings in Dhaka. The present study investigated as well as compared the performances of bare frame, full infilled and soft ground storey buildings. For different loading conditions resembling the practical situations of Dhaka city, the performances of these structures were analysed with the help of capacity curve, capacity spectrum, deflection, drift and seismic performance level. The performance of an in filled frame was found to be much better than a bare frame structure. It is found that, consideration of effect of the infill leads to significant change in the capacity. Investigation of buildings with soft storey showed that soft storey mechanism reduced the performance of the structure significantly and makes them most vulnerable type of construction in earthquake prone areas.

Mehanny and El Howary (2010) evaluated the seismic assessment of ductile versions of low to mid-rise moment frames located in moderate seismic zones was carried out through comparative trial designs of two (4 and 8-story) buildings adopting both space and perimeter framed approaches. Code-compliant designs, as well as a proposed modified code design relaxing design drift demands for the investigated buildings, were examined to test their effectiveness and reliability. Vulnerability curves for the frames were generated corresponding to various code-specified performance levels. However, the study suggested that more consistentreliability for designed structures would be achieved by disaggregating the force reduction factor into its static and dynamic parts and that code default values of this factor for some building types would be better reduced for a more reliable performance.

III.METHODOLOGY

For analysis work, models of building (G+8) floors are made to know behavior of building during earthquake. Typical bay width is taken 4m in both X and Z direction. Number of bays in both directions are 4. Storey height (Floor to Floor) 3.1m were considered. All the joints of beam, column and bracing are rigid.The models were analyzed as per Indian standard Code. All the columns are fixed from base for foundation.

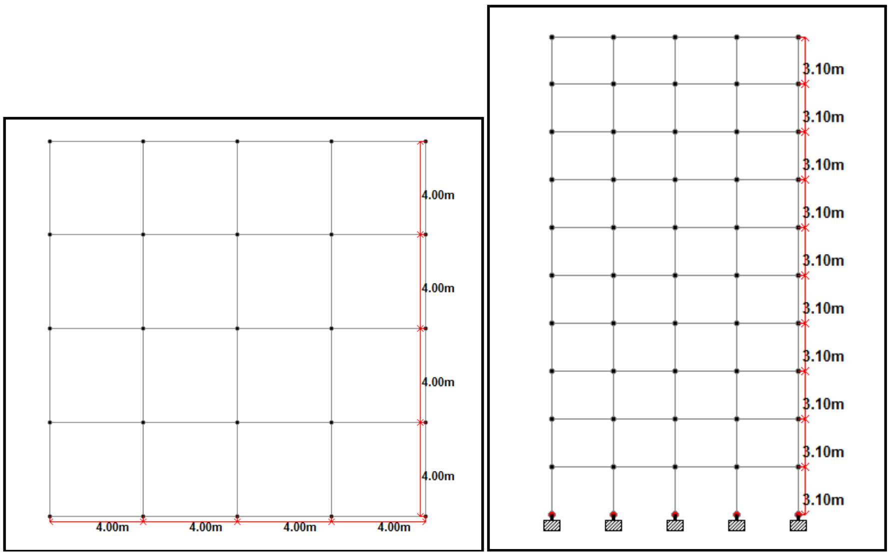


Fig. 3.1 Common Plan and Elevation for All Building Model

IV. MATERIAL PROPERTIES

Table3.1 Building Parameter For Study

Sr.No.	Particular	Details
1	Live Load	3 KN/m^2 at typical floor, 1.5KN/m^2 on terrace
2	Slab Thickness	150 mm
3	Wind Load	As per IS 875 – Not designed for wind load, since earthquake loads exceed the wind loads
4	Earthquake Load	As per IS-1893 (Part 1) - 2002
5	Depth of foundation below ground	3.1
6	Type of soil	Type II, Medium as per IS:1893
7	Storey height	3.2
8	Plan size	16 m X 16 m

9	No. of bays in X direction	4
10	No. of bays in Y direction	4
11	Grade of concrete	M-20
12	Grade of steel	Fe 410 Structural Steel
13	Column size	ISMB 550
14	Beam size	ISWB 500
15	Bracing size	ISMB 400
16	Building importance factor	1
17	Response reduction factor for concentric and eccentric respectively	4,5
18	Height of building	31.9

V. PUSH OVER ANALYSIS IN STAAD PRO

Three types of frames namely V, D and K were analysed in Staad Pro as per the steps described below

STEP 1: Modelling of structure as per geometry.

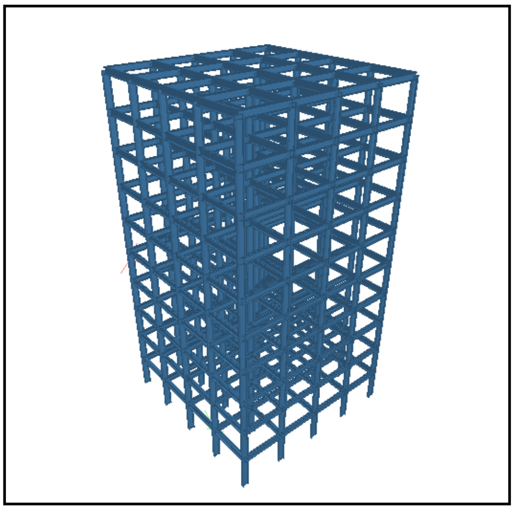
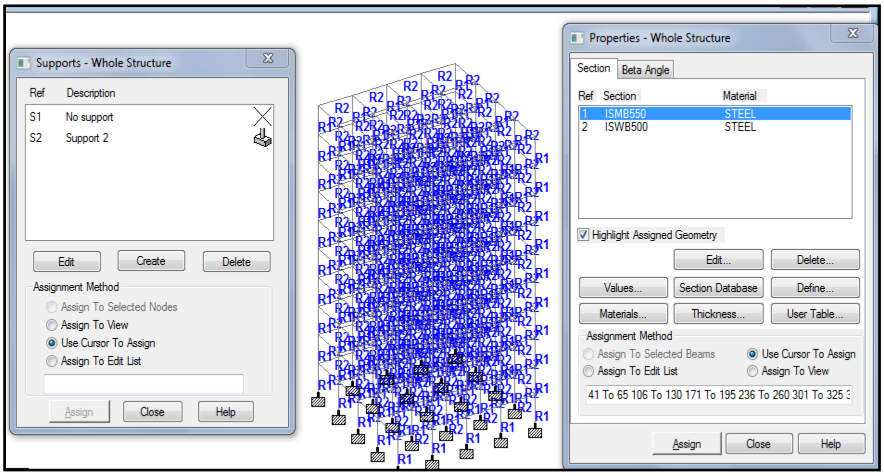


Fig. 5.1 3D model of Structure

STEP 2: Assigning supports and member properties to beams and columns.



Supports - Whole Structure

Ref	Description
S1	No support
S2	Support 2

Assignment Method
○ Assign To Selected Nodes
○ Assign To View
● Use Cursor To Assign
○ Assign To Edit List

Properties - Whole Structure

Ref	Section	Material
1	ISMB550	STEEL
2	ISWB500	STEEL

☑ Highlight Assigned Geometry

Assignment Method
○ Assign To Selected Beams
● Use Cursor To Assign
○ Assign To Edit List
○ Assign To View

41 To 65 106 To 130 171 To 195 236 To 260 301 To 325 3

Fig. 5.2 Structure with fixed support and assigned member properties

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STEP 3: Pushover definition

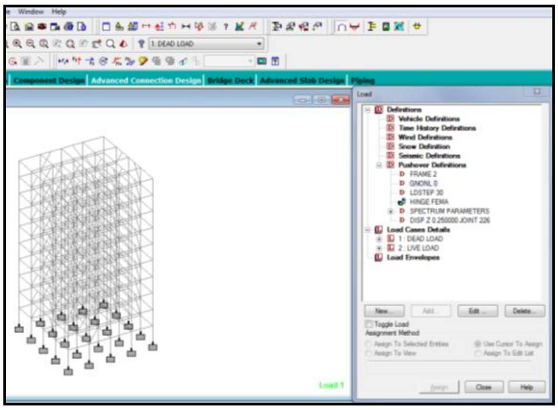

Fig. 5.3 Pushover Definition in Staad Pro

Staad Pro Program For Push Over Analysis

```
STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 16-Mar-18
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0; 2 4 0 0; 3 8 0 0; 4 12 0 0; 5 16 0 0; 6 0 0 4; 7 4 0 4; 8 8 0 4;
……275 16 -3.1 16;
MEMBER INCIDENCES
1 1 2; 2 2 3; 3 3 4; 4 4 5; 5 1 6; 6 2 7; 7 3 8; 8 4 9; 9 5 10; 10 6 7; 11 7 8;……..642 17 267; 643 18 268; 644 19 269;
DEFINE MATERIAL START
ISOTROPIC STEEL
E 2.05e+008
POISSON 0.3
DENSITY 76.8195
ALPHA 1.2e-005
DAMP 0.03
END DEFINE MATERIAL
MEMBER PROPERTY INDIAN
TO 300 326 TO 560 586 TO 625 TABLE ST ISWB500
CONSTANTS
MATERIAL STEEL ALL
SUPPORTS
251 TO 275 FIXED
DEFINE PUSHOVER DATA
FRAME 2
GNONL 0
LDSTEP 30
HINGE FEMA ALL
SPECTRUM PARAMETERS
DAMPING 5.0000 0.0000 0.0000 0.0000
SC 4
SS 0.1
S1 0.25
DISP Z 0.25 JOINT 226
END PUSHOVER DATA
LOAD 1 LOADTYPE Gravity  TITLE DEAD LOAD
SELFWEIGHT Y -1
MEMBER LOAD
1 TO 40 66 TO 105 131
UNI GY -14.5
PERFORM PUSHOVER ANALYSIS
FINISH
```

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VI. RESULT

Result of deflection ontained from Staad Pro Analysis was presented in below and profile for deflected shape for the structure presented graphically.

Table 6.1Centre Column Deflection for V Frame (Pushover Analysis)

Node	L/C	Horizontal	Vertical	Horizontal	Resultant
		X mm	Y mm	Z mm	mm
3	1 DEAD LOAD	0	-0.962	-0.004	0.962
	2 LIVE LOAD	0	-0.304	-0.002	0.304
28	1 DEAD LOAD	0	-1.747	-0.123	1.751
	2 LIVE LOAD	0	-0.555	-0.055	0.558
53	1 DEAD LOAD	0	-2.396	-0.069	2.397
	2 LIVE LOAD	0	-0.768	-0.03	0.768
78	1 DEAD LOAD	0	-2.932	-0.039	2.932
	2 LIVE LOAD	0	-0.947	-0.016	0.947
103	1 DEAD LOAD	0	-3.367	-0.02	3.367
	2 LIVE LOAD	0	-1.096	-0.007	1.096
		0	-3.708	-0.008	3.708
	2 LIVE LOAD	0	-1.219	-0.001	1.219
153	1 DEAD LOAD	0	-3.961	0.001	3.961
	2 LIVE LOAD	0	-1.315	0.003	1.315
178	1 DEAD LOAD	0	-4.131	0.01	4.131
	2 LIVE LOAD	0	-1.387	0.007	1.387
203	1 DEAD LOAD	0	-4.226	0.02	4.226
	2 LIVE LOAD	0	-1.438	0.011	1.438
228	1 DEAD LOAD	0	-4.25	0.04	4.25
	2 LIVE LOAD	0	-1.466	0.024	1.466

Table 6.2 Centre Column Deflection for K Frame (Pushover Analysis)

Node	L/C	Horizontal	Vertical	Horizontal	Resultant
		X mm	Y mm	Z mm	mm
3	1 DEAD LOAD	0	-0.689	-0.065	0.692
	2 LIVE LOAD	0	-0.223	-0.032	0.225
28	1 DEAD LOAD	0	-1.28	-0.02	1.28
	2 LIVE LOAD	0	-0.417	-0.01	0.417
53	1 DEAD LOAD	0	-1.844	-0.016	1.844
	2 LIVE LOAD	0	-0.605	-0.009	0.605
78	1 DEAD LOAD	0	-2.361	-0.013	2.361
	2 LIVE LOAD	0	-0.78	-0.008	0.78
103	1 DEAD LOAD	0	-2.817	-0.01	2.817
	2 LIVE LOAD	0	-0.937	-0.007	0.937
128	1 DEAD LOAD	0	-3.202	-0.008	3.202
		0	-1.073	-0.006	1.073
153	1 DEAD LOAD	0	-3.509	-0.005	3.509
	2 LIVE LOAD	0	-1.185	-0.005	1.185
178	1 DEAD LOAD	0	-3.733	-0.001	3.733
	2 LIVE LOAD	0	-1.271	-0.003	1.271
203	1 DEAD LOAD	0	-3.868	0.013	3.868
	2 LIVE LOAD	0	-1.33	-0.001	1.33
228	1 DEAD LOAD	0	-3.911	0.003	3.911
	2 LIVE LOAD	0	-1.361	0.009	1.361

Table 6.3 Centre Column Deflection for D Frame (Pushover Analysis)

Node	L/C	Horizontal	Vertical	Horizontal	Resultant
		X mm	Y mm	Z mm	mm
3	1 DEAD LOAD	0	-0.689	-0.065	0.692
	2 LIVE LOAD	0	-0.223	-0.032	0.225
28	1 DEAD LOAD	0	-1.28	-0.02	1.28

	2 LIVE LOAD	0	-0.417	-0.01	0.417
53	1 DEAD LOAD	0	-1.844	-0.016	1.844
	2 LIVE LOAD	0	-0.605	-0.009	0.605
78	1 DEAD LOAD	0	-2.361	-0.013	2.361
	2 LIVE LOAD	0	-0.78	-0.008	0.78
103	1 DEAD LOAD	0	-2.817	-0.01	2.817
	2 LIVE LOAD	0	-0.937	-0.007	0.937
128	1 DEAD LOAD	0	-3.202	-0.008	3.202
	2 LIVE LOAD	0	-1.073	-0.006	1.073
153	1 DEAD LOAD	0	-3.509	-0.005	3.509
	2 LIVE LOAD	0	-1.185	-0.005	1.185
178	1 DEAD LOAD	0	-3.733	-0.001	3.733
	2 LIVE LOAD	0	-1.271	-0.003	1.271
203	1 DEAD LOAD	0	-3.868	0.013	3.868
	2 LIVE LOAD	0	-1.33	-0.001	1.33
228	1 DEAD LOAD	0	-3.911	0.003	3.911
	2 LIVE LOAD	0	-1.361	0.009	1.361

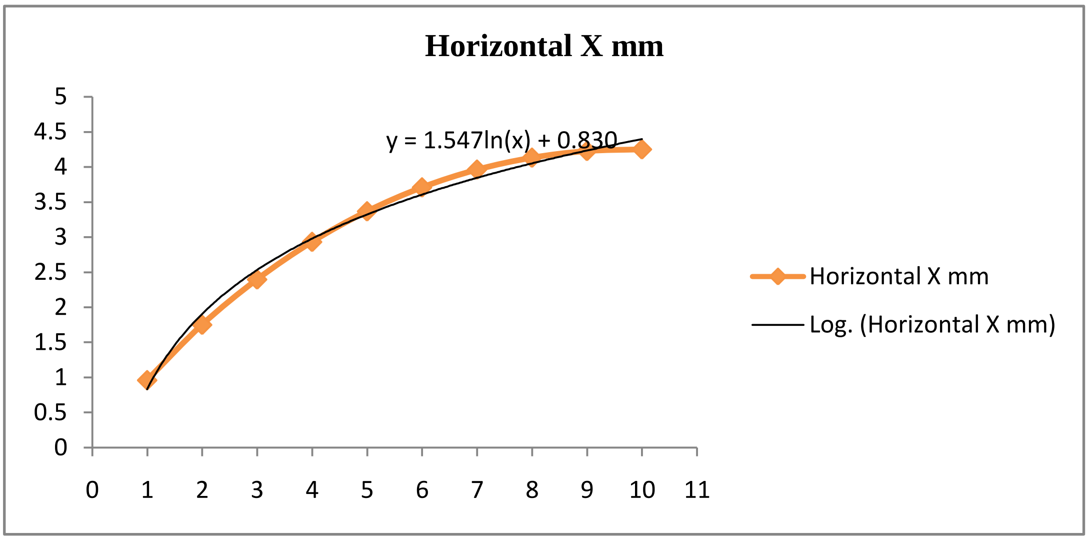

Fig. 6.1 Deflected Shape of V Frame

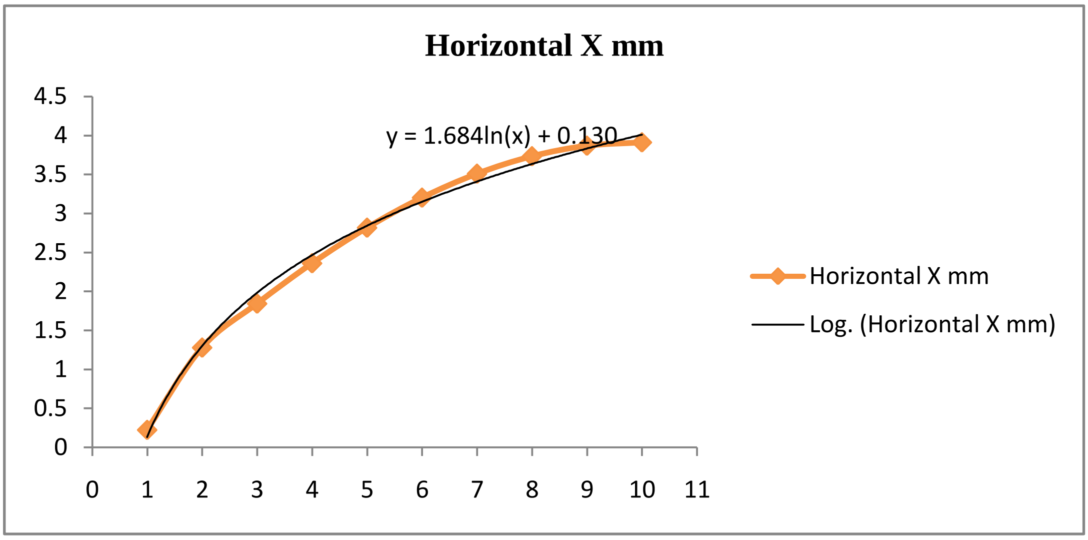

Fig. 6.2Deflected Shape of K Frame

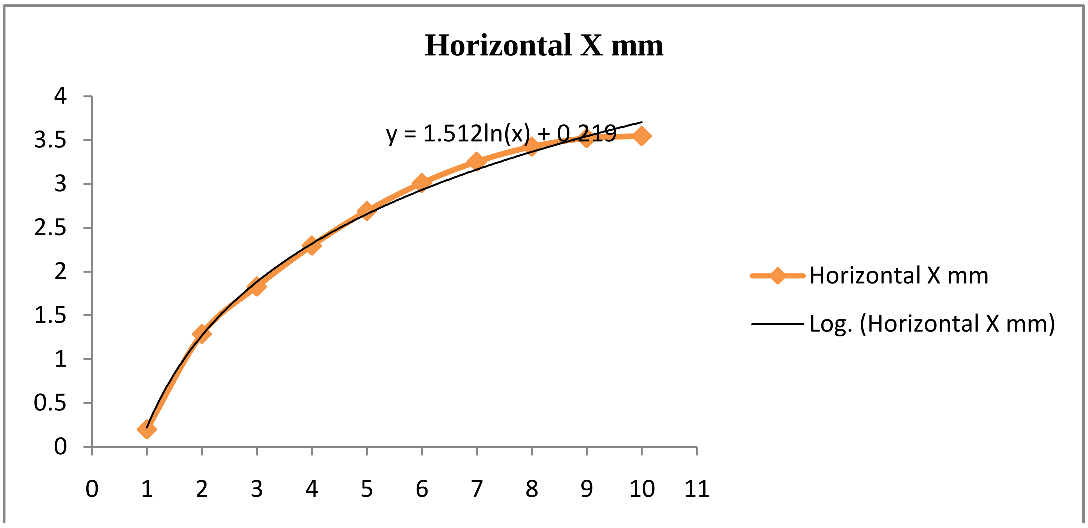

Fig. 6.3 Deflected Shape of D Frame

VII. CONCLUSION

The selected frame models are analyzed using pushover analysis. The seismic performance of a multi-story steel frame building is designed according to the provisions of the current Indian code (IS 800 -2007). Shear capacity of the structure can be increased by introducing Steel bracings in the structural system. Bracings can be used as retrofit as well. There are „n" numbers of possibilities to arrange Steel bracings such as D, K, and V type eccentric bracings. D, K, and V are the different types of eccentric bracings considered for the present study. Performance of each frame is studied through nonlinear static analysis.

From above graphical representation equation for finding out deflection for V,K and D frame by pushover analysis is obtained and presented below

Table 7.1 Equation for Deflection of Frame

Sr.No.	Type of Frame	Equation
1	V Frame	y = 1.5479ln(x) + 0.8305
2	K Frame	y = 1.6849ln(x) + 0.1301
3	D Frame	y = 1.512ln(x) + 0.2199

REFERENCES

[1] 1. Dinesh J.Sabu and Pajgade"Seismic Evaluation of Existing Reinforced Concrete Building"Engineering Structures, 28, 1494–1502, 2012

[2] 2. Ramaraju, Dabeer Anwer Danish "Pushover Analysis of Multistorey Reinforced Concrete Building"International Journal of Advance Research, Ideas and Innovations in Technology Volume3, Issue4, pp 527 -533

[3] 3. R. Shahrin & T.R. Hossain "Seismic performance evaluation of residential buildings in Dhaka city by using pushover analysis" 4th Annual Paper Meet and 1st Civil Engineering Congress, December 22-24, 20 11, Dhaka, Bangladesh

[4] 4. Mehanny and El Howary "Seismic vulnerability evaluation of RC moment frame buildings in moderate seismic zones" Earthquake Engineering & Structural Dynamics February 2010 Volume 40 , Issue 2, pp 215-235

[5] 5. Mehdi Poursha "A consecutive modal pushover procedure for nonlinear static analysis of one-way unsymmetric-plan tall building structures" Engineering Structures , Volume 33, Issue 9, September 2009, pp 2417-2434

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