[Mohankar*, 5(3): March, 2016] ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

A STUDY OF PORTAL FRAME USING ANALYTICAL METHODS AND ETABS SOFTWARE

R. H. Mohankar*, Md. Imran Alam, Gopesh Gaurav, Shubham Choudhary
*Assistant Professor, Department of Civil Engineering, Priyadarshini J. L. College of Engineering, Nagpur, India-440009
Student, Department of Civil Engineering, Priyadarshini J.L. College of Engineering, Nagpur, India-440009

DOI: 10.5281/zenodo.48372

ABSTRACT

Analysis of portal frames involves lot of complications and tedious calculations by conventional methods. To carry out such analysis is a time consuming task. The Moment Distribution Method & Slope Deflection Method for analysis of portal frames can be handy in approximate and quick analysis so as to get the detailed estimates ready. In this work, these two methods have been applied only for vertical loading conditions. This paper mainly deals with the comparative analysis of the results obtained from the analysis of single bay portal frame when analyzed manually and using ETABS Software separately. The result obtained from manually is mostly matched with the results obtained from ETABS software.

KEYWORDS: Portal Frame, Moment Distribution Method, Slope Deflection Method, ETABS Software.

INTRODUCTION

Structural analysis deals with study and determination of forces in various components of a structure subjected to loads. As the structural system as a whole and the loads acting on it may be of complex nature certain simplifying assumptions with regard to the quality of material, geometry of the members, nature and distribution of loads and the extent of connectivity at the joints and the supports are always made to make the analysis simpler. For the analysis of portal frames, Moment distribution method and Slope deflection method of analysis are mainly used, which allows the engineer to analyse frames easily and design it economically. The research is concluded by evaluating a selection of portal frame, with practical dimensions in order to substantiate the conclusions as stated below.

Comparison of final end moments of a portal frame by the application of rotation contribution method and moment distribution method. The end moments calculated by these two methods are mostly matched. The percentage variation can be reduced with increase in number of iteration in both analysis methods [1]. The existing methods of approximate structural analysis described in various literatures and compare with slope deflection method, conventional approximate method and revised approximate method. [2].In this paper, the earthquake response of symmetric multistoried building is studied by manual calculation and with the help of ETABS 9.7.1 software. The responses obtained by manual analysis as well as by soft computing are compared. There is slight variation in the values of base shear in manual analysis as well as software analysis [3]. Comparison of end moments of a beam by the application of flexibility method mostly matched with slope deflection method. Slope deflection method is more preferable than flexibility method because in slope deflection method directly know unknown joints, displacement and rotation of the beam and flexibility method quite difficult as it based on matrices [4].

This paper presents the analysis of portal frame, considering mainly the case of single bay, which is the most common in practice. Portal frames are very efficient and economical when used for single-storey buildings, provided that the design details are cost effective and the design parameters and assumptions are well chosen. Portal frames consists of a horizontal beam resting on two columns are single storey with pitched or flat roof (Fig.1). The junction

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

of the beam with the column consists of rigid joints and fixed at the base. The main objective of this paper is analyse the portal frame by manually and compare their results with the help of ETABS software.

METHODS OF ANALYSIS

Moment Distribution Method: This method of analysing beams and multi-storey frames using moment distribution was introduced by Prof. Hardy Cross in 1930, and is also sometimes referred to as Hardy Cross method. It is an iterative method in which one goes in carrying on the cycle to reach to a desired degree of accuracy. To start off with this method, initially all the joints are temporarily restrained against rotation and fixed end moments for all the members are written down. Each joint is then released one by one in succession and the unbalanced moment is distributed to the ends of the members, meeting at same joint, in the ratio of their distribution factors. These distributed moments are then carried over to the far ends of the joints. Again the joint is temporarily restrained before moving on to the next joint. Same set of operations are performed at each joints till all the joints are completed and the results obtained are up to desire accuracy. The method does not involve solving a number of simultaneous equations, which may get quite complicated while applying large structures, and is therefore preferred over the slope-deflection method.

Slope Deflection Method: This method was first devised by Heinrich Manderla and Otto Mohr to study the secondary stresses in trusses and was further developed by G. A. Maney extend its application to analyze indeterminate beams and framed structures. The basic assumption of this method is to consider the deformations caused only by bending moments. It's assumed that the effects of shear force or axial force deformations are negligible in indeterminate beams or frames. By forming slope deflection equations and applying joint and shear equilibrium conditions, the rotation angles (or the slope angles) are calculated. Substituting them back in to the slope deflection equations, member end moments are readily determined.

ETABS Software: ETABS is an engineering software product that caters to multy-storey building analysis and design. Today, continuing in the same tradition, ETABS has evolved into a completely Integrated Building Analysis and Design Environment. Modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static and dynamic conditions may be evaluated using ETABS.

METHODOLOGY ADOPTED

Portal frames consists of a horizontal beam resting on two columns are single storey (Fig.1). The junction of the beam with the column consists of rigid joints and fixed at the base.
Size of Beam= 230mmX500mm, I => 2I
Size of Column= 230mmX400mm, I => I

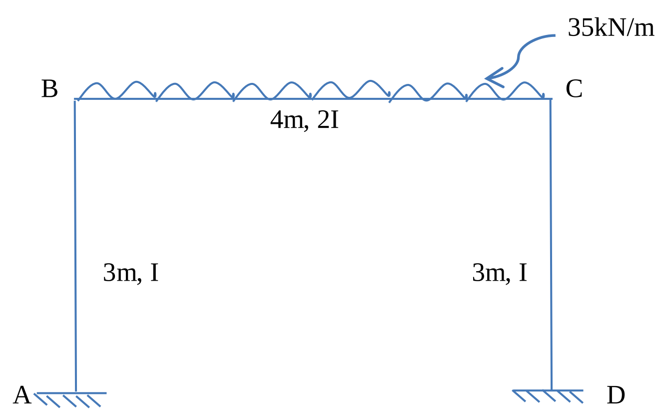

Fig.1: Portal frame considered for the analysis

3.1. Application of Moment Distribution Method (Hardy Cross Method) for the Analysis of Portal Frame:

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

3.1.1. Fixed End Moments:

The fixed end moments due to externally loads applied are,

FEM_{AB} = 0, FEM_{BA} = 0, FEM_{BC} = -46.67 kN.m, FEM_{CB} = +46.67 kN.m, FEM_{CD} = 0, FEM_{DC} = 0

3.1.2 Stiffness and Distribution Factor:

Now calculate stiffness and distribution factors,

Table.1: Stiffness and Distribution Factors

Joint	Member	Stiffness (K)	ΣK	D.F.
B	BA	0.33I	0.83I	0.40
	BC	0.5I		0.60
C	CB	0.5I	0.83I	0.60
	CD	0.33I		0.40

3.1.3 Non- Sway Moment Distribution:

Table.2: Non sway Moment Distribution

Distribution Factor		**0.4**	**0.6**	**0.6**	**0.4**	
Member	**AB**	**BA**	**BC**	**CB**	**CD**	**DC**
FEM	0	0	-46.67	46.67	0	0
		18.67	28	-28	-18.67	
	9.34		-14	14		-9.34
		5.6	8.4	-8.4	-5.6	
	2.8		-4.2	4.2		-2.8
		1.68	2.52	-2.52	-1.68	
	0.84		-1.26	1.26		-0.84
		0.50	0.76	-0.76	-0.50	
	0.25		-0.38	0.38		-0.25
		0.15	0.23	-0.23	-0.15	
	0.08		-0.12	0.12		-0.08
		0.05	0.07	-0.07	-0.05	
Final Moment	**13.31**	**26.65**	**-26.65**	**26.65**	**-26.65**	**-13.31**

3.1.4 Final End Moments:

The final end moments have been calculated as per non-sway moments,

M_{AB} = +13.31kN.m, M_{BA} = +26.65kN.m, M_{BC} = -26.65kN.m, M_{CB} = +26.65kN.m, M_{CD} = -26.65kN.m
M_{DC} = -13.31kN.m

3.2. Application of Slope Deflection Method for the Analysis of Portal Frame:

3.2.1. Fixed End Moments will be same as 2.1.1

3.2.2 Slope Deflection Equation:

In the given problem, joints B and C rotate and also translate by an amount Δ. Hence, in this problem we have three unknown displacements (two rotations and one translation) to be evaluated.

The ends A and D are fixed, hence, $\theta_A = \theta_B = 0$ and Joints B & C translate by the same amount Δ

Slope deflection equation at each ends are,

$$M_{AB} = FEM_{AB} + \frac{2EI}{l}\left(2\theta_A + \theta_B - \frac{3\Delta}{l}\right)$$
$$= 0.67EI\theta_B - 0.67EI\Delta \text{--------------------------(i)}$$

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

$M_{BA} = FEM_{BA} + \frac{2EI}{l}(2\theta_B + \theta_A - \frac{3\Delta}{l})$
$= 1.34EI\theta_B - 0.67EI\Delta$ ------------------------- (ii)

$M_{BC} = FEM_{BC} + \frac{2EI}{l}(2\theta_B + \theta_C)$
$= -46.67 + 2EI\theta_B + EI\theta_C$ ----------------------- (iii)
$M_{CB} = FEM_{CB} + \frac{2EI}{l}(2\theta_C + \theta_B)$
$= 46.67 + EI\theta_B + 2EI\theta_C$ ----------------------- (iv)

$M_{CD} = FEM_{CD} + \frac{2EI}{l}(2\theta_C + \theta_D - \frac{3\Delta}{l})$
$= 1.34EI\theta_C - 0.67EI\Delta$ ------------------------ (v)

$M_{DC} = FEM_{DC} + \frac{2EI}{l}(2\theta_D + \theta_C - \frac{3\Delta}{l})$
$= 0.67EI\theta_C - 0.67EI\Delta$ ------------------------ (vi)

3.2.3 Applying Equilibrium Condition:

Now, consider the summation of moment at joint B.

$\Sigma M_B = 0$

$M_{BA} + M_{BC} = 0$

$3.34EI\,\theta_B + EI\,\theta_C - 0.67EI\Delta = 46.67$………………………………………………. (A)

Now, consider the summation of moment at joint C.

$\Sigma M_C = 0$

$M_{CB} + M_{CD} = 0$

$EI\,\theta_B + 3.34EI\,\theta_C - 0.67EI\Delta = -46.67$…………………………………………… (B)

3.2.4 Shear Condition:

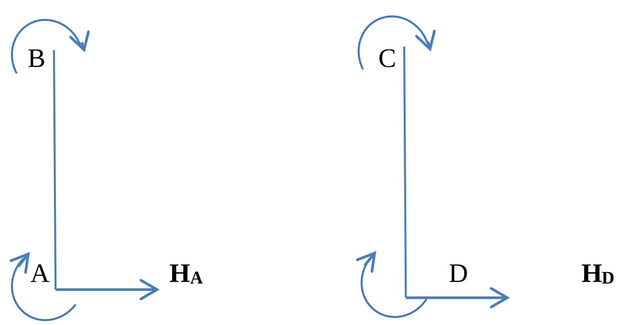

Fig.2: Shear Condition Diagram

$\Sigma M_B = 0$

$-3H_A + M_{AB} + M_{BA} = 0$ ……………………………………….(1)

$\Sigma M_C = 0$

$-3H_D + M_{CD} + M_{DC} = 0$ ……………………………………….(2)

Now consider free body diagram of the frame as shown in fig 3. The horizontal shear force acting at A and D of column member AB and CD respectively.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

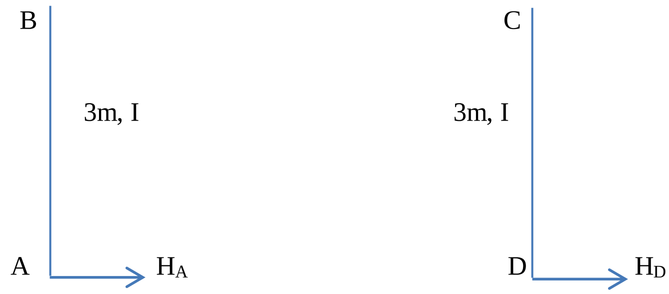

Fig.3: Free Body Diagram

Applying Equilibrium Condition, $\Sigma F_X=0$

$$H_A+H_D=0$$

$$M_{AB}+M_{BA}+M_{CD}+M_{DC}=0$$

$2.01EI\ \theta_B + 2.01EI\ \theta_C - 2.68EI\ \Delta=0$ ……………………………………(C)

Solving three equations (A), (B) & (C), we get

$\theta_B=\frac{19.94}{EI}$, $\theta_C=\frac{-19.94}{EI}$ & $\Delta = 0$

3.2.5 Final End Moments:

Substituting the values of θ_B, θ_C and Δ in the slope deflection equations we get the final end moments.

M_{AB} = +13.36 kN.m, M_{BA} = +26.73 kN.m, M_{BC} = -26.73 kN.m, M_{CB} = +26.73 kN.m, M_{CD} = -26.73 kN.m

M_{DC} = -13.36 kN.m

3.3 Application of ETABS Software:

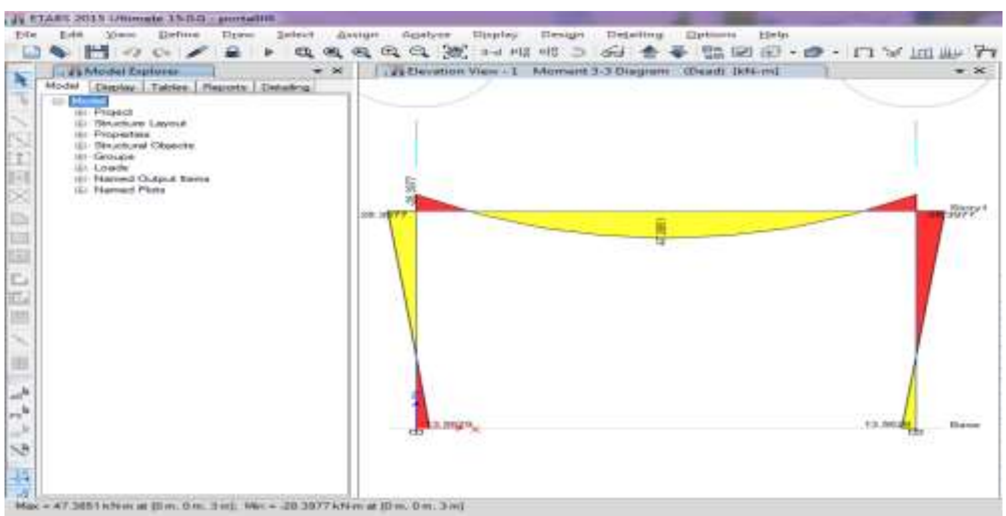

Fig.4: Final End Moments

INVESTIGATIVE ANALYSIS

After the analysis is completed, the results obtained from moment distribution method and slope deflection method has been compared with results obtained from ETABS.

Table.3: Comparison of End Moments by Manually and ETABS

Moment at	End Moments (kN.m)		
	Analytical Method		Software
	Moment Distribution Method	Slope Deflection Method	ETABS
M_{AB}	13.31	13.36	13.5629
M_{BA}	26.65	26.73	28.3977
M_{BC}	-26.65	-26.73	-28.3977
M_{CB}	26.65	26.73	28.3977
M_{CD}	-26.65	-26.73	-28.3977
M_{DC}	-13.31	-13.36	-13.5629

CONCLUSION

The End Moments of a Portal Frame calculated by the application of Moment Distribution Method and Slope Deflection Method successfully verified by using ETABS software. In this paper the results obtained from manually by two different methods are matched with the results obtained from ETABS software. There is slightly variation in the value of End Moments by manually analysis as well as software analysis. In the manually calculation the Moment Distribution Method is more preferable than Slope Deflection Methods. In Moment Distribution Method number of iterations give more accurate result and in other hand Slope Deflection Method involve solving a number of simultaneous equations which may get quite complicated, and is therefore Moment Distribution Method preferred over the Slope Deflection Method.

REFERENCES

[1]. P.R. Patil, M.D. Pidurlar, R.H. Mohankar, "Comparative Study of End Moments Regarding Application of Rotation Contribution Method (Kani's Method) & Moment Distribution Method for the Analysis of Portal Frame", IOSR Journal of Mechanical and Civil Engineering, Vol. 7, Issue 1, May- June, 2013.

[2]. Behr R.A., Goodspeed C.H. "Potential errors in structural analysis", Journal of structural engineering, Vol. 116, No11, November 1990.

[3]. Mahesh N. Patil, Yogesh N. Sonawane, "Seismic Analysis of Multistoried Building", International Journal of Engineering and Innovative Technology (IJEIT), Vol. 4, Issue 9, March 2015.

[4]. R.H. Mohankar, P.V. Thakare, Priti Bhagwat, Priyanka Dhoke, "Comparative Study of Beam by Flexibility Method & Slope Deflection Method", (IJSETR), Vol. 5, Issue 2, February 2016.

[5]. ETABS Software 2015.