INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING AND TECHNOLOGY (IRJET) E-ISSN: 2395-0056
VOLUME: 07, SPECIAL ISSUE | JUNE 2020 WWW.IRJET.NET P-ISSN: 2395-0072
International Conference on Recent Trends in Science & Technology-2020 (ICRTST - 2020)
Organised by: ATME College of Engineering, Mysuru, INDIA

Comparison between Analysis of a Portal Frame by E-TABS and Moment Distribution Method

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***Abstract*—**Portal frames are widely used in many civil engineering structures. Analysing these portal frames is a necessary but tedious and time-consuming task. Among the conventional methods, the moment distribution method is one of the simplest and easiest methods. ETABS, which is a modern method, on the other hand is much faster and less tedious. In the present study, a comparative analysis of the moment distribution method and ETABS is carried out. The results obtained from both these methods are matched to tally their similarities and differences. In the present study, results obtained from ETABS and moment distribution method are compared. The maximum value obtained by Moment distribution method is 4.46kN-m and from ETABS is 4.4156kN-m.

Keywords-Structural Analysis, portal frame, Moment distribution method, ETABS

1. INTRODUCTION

Structural Analysis is the analysing of the effects of forces and loads in different parts of a structure. Since the structural system and the loads acting on it are complex in nature, certain assumptions are made and some properties with this regard like 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 made to analyse in simpler way.

It is usually seen that the analysis could be done by various method and is done accordingly after collecting the data but it is also observed that if there is a change in the requirements of the new system then it would mean doing the system analysis again making it difficult to compute. Also, it is very time consuming to analyse a system by structural analysis and is not always dependable as the results could be wrong.

There are various manual methods for structural analysis, like Slope deflection method, Rotation Contribution method, Stiffness method and many more. Of all, Moment Distribution is considered mostly because it is the Simplest and Easiest. Therefore, in this paper, we are using Moment Distribution Method to represent the conventional methods.

There are certain software's, like ETABS and STAAD Pro that are implemented for the analysis of structures against the applied loads as per the IS codes. ETABS (Extended Three-Dimensional Analysis of Building Systems) is a highly efficient analysis and design program developed especially for building systems. It is loaded with an integrated system with an ability to handle the largest and most complex building models and configurations. Hence making it better result oriented, easier and also faster.

2. LITERATURE SURVEY

A. R.H. Mohankar et.al

In their paper entitled, "A Study Portal Frame Using Analytical Methods and ETABS Software", describes the comparison in analysing a portal frame done manually and with the use of ETABS Software in separate ways.

B. P. Mendis et.al

This paper entitled, " Blast Loading and Blast Effects on Structures – An Overview " provides us an insight on the effect of explosions caused by bombs on structures with the details of the nature of explosions and the mechanism of blast waves in free air and also tells about the various methods roughly get to know the loads by blasts and hence the response of the structure.

C. P.V. Thakare et.al

This journal paper entitled, "Comparative Study of Beam by Flexibility Method & Slope Deflection Method", they have outlined the basic concepts, similarities and difference in the two kinds of methods which are Flexibility method and Slope deflection method. The paper concludes with an explanation that slope deflection is an easier method.

D. Dr. P.D Hiwase et.al

In this paper entitled, "Comparison between Manual and Software Approach towards Design of Structural Elements", they have compared the analysis and design of a multi-storey building by manual and software calculations. IS 456 has been used for column analysis and design. The manual results were compared with the results from both ETABS and STAAD PRO to better understand their accuracy and need.

3. OBJECTIVE

The study is mainly focused on analysing a portal frame using two different methods and comparing their results. This paper is a comparative analysis of Moment distribution method and ETABS. The fundamental objectives can be summarised as follows:

- To briefly understand the conventional and modern methods of analysis, Moment Distribution method and ETABS.
- Perform analysis of a portal frame using the Moment Distribution method as well as ETABS.
- Conduct an investigative analysis to compare the results obtained from both the methods and thus determines their benefits and drawbacks.

4. SCOPE

In the present study, a Portal frame is analysed and designed by manual and software methods to understand the benefits of each and compare their accuracy. Moment Distribution method is considered to be the easiest and most accurate method among all the manual methods and hence has been chosen to represent the manual methods. ETABS has a growing popularity among the software method.

5. METHOD OF ANALYSIS

A. Using Manual Method- Moment Distribution Table:

This method is also known as Hardy- Cross method as it was introduced by Prof. Hardy Cross, in the year 1930. It includes many iterative processes. This method had made the analysis of beams and multi-story frames easier.

The distribution factors for the frame are calculated according to the joints of the frames. Fixed end moments are calculated using the external loads applied on the frames. The values obtained are substituted I the moment distribution table. The joints are temporarily restrained against rotation, initially. Each joint is released one after the other, and unbalanced moment is distributed to end of the members in the ratio of their distribution factor. These distributed moments are carried to far end of the joints. Again, the joints are temporarily restrained and the same sets of operations are carried out until the desired accuracy is obtained. This may prove to provide better results of final moments for a frame in the manual calculation process.

B. Using Software-ETABS

Building frameworks is analyzed and designed using ETABS. It involves complex process, yet made the tedious work of analyzing the frames simpler. ETABS is considered as the most famous investigation and outline programming software. In this method, if the plans prepared using AUTOCAD is extracted into the ETABS software. Further, the materials and the loads are defined for each member. The base of the frame is fixed and the joints are considered to be rigid. The final frame structure is subjected to analysis and the results obtained are generated based on the requirement.

6. METHODOLOGY ADOPTED

C. Moment Distribution Method

The portal frame considered in the analysis comprises of the following details:

Members AC=BD=4m. CD=2m as shown in the figure.

Support conditions: fixed

Loading:

1. Member CD is loaded at rate of 20kN/m throughout the member.
2. A point load is applied at the member AC at a distance of 3m from the support which is acting towards the right side and is considered as positive.
3. A point load is applied at the member BD at a distance of 3m from the support which is acting towards the left side and is considered as negative.

Assuming the moment of inertia for the members as:

M_{AC}=I, M_{CD}=2I, M_{DB}=I

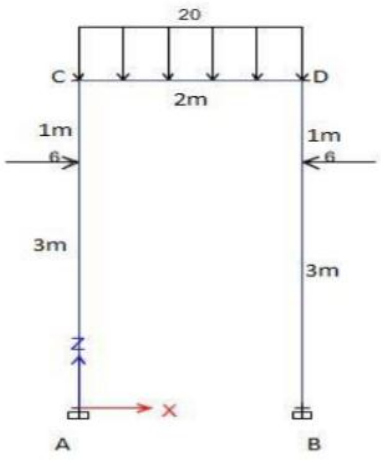

FIG: PORTAL FRAME

D. Calculation of distribution factor

Distribution factors are calculated using the table below:

TABLE I. DISTRIBUTION FACTOR

Joint	Member	Relative Stiffness(K)	Total Relative Stiffness ($\sum K$)	Distribution Factor
C	*CA*	$I/4$		$1/5$

	CD	$2I/_2 = I$	$5I/_4$	$4/_5$
D	***DC***	$2I/_2 = I$	$5I/_4$	$4/_5$
	DB	$I/_4$		$1/_5$

Fixed End Moments are calculated by considering each span as separate fixed member.

$M_{AC} = \frac{-Wab^2}{l^2} = \frac{-6X3X1^2}{4^2}$ = -1.12kN-m (1)

$M_{CA} = \frac{Wa^2b}{l^2} = \frac{6X3^2X1}{4^2}$ = 3.37kN-m (2)

$M_{CD} = \frac{-Wl^2}{12} = \frac{-20X2^2}{12}$ = -6.67kN-m (3)

$M_{DC} = \frac{Wl^2}{12} = \frac{20X2^2}{12}$ = 6.67kN-m (4)

$M_{DB} = \frac{-Wa^2b}{l^2} = \frac{-6X3^2X1}{4^2}$ = -3.37kN-m (5)

$M_{BD} = \frac{Wb^2a}{l^2} = \frac{6X1^2X3}{4^2}$ = 1.12kN-m (6)

E. Calculation of final moments

TABLE II. MOMENT DISTRIBUTION TABLE

JOINTS	**A**	**C**	**D**		**B**	
Members	***AC***	***CA***	***CD***	***DC***	***DB***	***BD***
Distribution Factor		$1/_5$	$4/_5$	$4/_5$	$1/_5$	
Fixed End Moments	**-1.125**	**3.375**	**-6.67**	**6.67**	**-3.375**	**1.125**
		0.66	2.64	-2.64	-0.66	
	0.33		-1.32	1.32		-0.33
		0.264	1.056	-1.056	-0.264	
	0.132		-0.528	0.528		-0.132
		0.105	0.422	-0.422	-0.105	
	0.0525		-0.211	0.211		-0.0525
		0.042	0.168	-0.168	-0042	
	0.021		-0.084	0.084		-0.021
		0.0168	0.067	-0.067	-0.0168	
Final Moments	-0.6	4.46	-4.46	4.46	-4.46	0.6

Therefore, final moments from the Moment Distribution Table are:

$M_{AC} = -0.6$kN-m

$M_{CA} = 4.46$kN-m

$M_{CD} = -4.46$kN-m

$M_{DC} = 4.46$kN-m

$M_{DB} = -4.46$kN-m

$M_{BD} = 0.6$kN-m

F. Bending Moment Calculation

Bending Moment for the column element is calculated as follows:

$M_{AC} = \frac{Pab}{l} = \frac{6X3X1}{4} = 4.5$kN-m

$M_{CD} = \frac{Wl^2}{8} = \frac{20X2^2}{8} = 10$kN-m

$M_{DB} = \frac{Pab}{l} = \frac{6X1X3}{4} = 4.5$kN-m

7. APPLICATIONS OF ETABS SOFTWARE

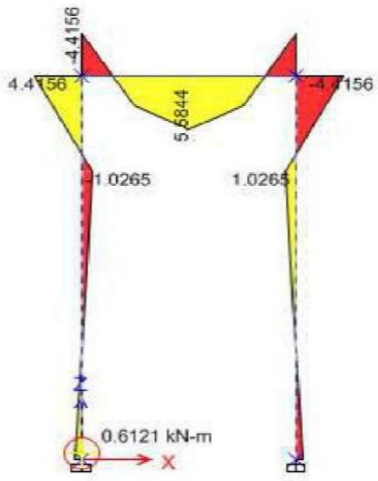

FIG: BENDING MOMENT DIAGRAM

8. INVESTIGATIVE ANALYSIS

After the analysis, the results obtained from manual method i.e., using moment distribution method and software analysis i.e., using ETABS is compared.

TABLE III. COMPARISON OF END MOMENTS BY MANUAL METHOD AND SOFTWARE

Moment at	*End Moments(kN-m)*	
	Moment Distribution Method	*Software Method (ETABS)*
M_{AC}	-0.6	-0.6121
M_{CA}	4.46	4.4156
M_{CD}	-4.46	-4.4156
M_{DC}	4.46	4.4156
M_{DB}	-4.46	-4.4156
M_{BD}	0.6	0.6121

9. CONCLUSION

The moments for the portal frame discussed above was calculated using Moment Distribution method and ETABS software. The maximum and the minimum results obtained from both the methods are as follows.

ETABS uses stiffness method and the results obtained are:

- M_{DB} = -4.4156 kN-m
- M_{BD} = 0.6121 kN-m

The moment distribution method uses an iterative process to eliminate errors and the results obtained are:

- M_{DB} = -4.46 kN-m
- M_{BD} = 0.6 kN-m

From the results it is observed that the

1. The results obtained from Moment Distribution method and ETABS (stiffness method) are nearly the same.
2. It is suggested that, ETABS can be opted in place of moment distribution method as it is faster, error is minimised and ease to work.
3. Moment distribution method proves to be difficult in analysing complicated structures.

10. REFERENCES

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