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COMPARATIVE STUDY ON END MOMENTS REGARDING APPLICATION OF ANALYTICAL METHODS AND STAAD.Pro SOFTWARE

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Abstract

Analysis of portal frames involves lot of complications and tedious calculations by conventional methods. To carry out such analysis it is a time consuming task. The Moment Distribution Method & Kani's 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 uniform distributed 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 by using STAAD.Pro Software separately. The result obtained from manually is mostly matched with the results obtained from STAAD.Pro software.

Keywords:

Portal Frame;
Moment Distribution Method;
Kani's Method;
STAAD.Pro Software.

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Introduction

For the analysis of portal frames, Moment distribution method and Kani's 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.

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

2. History and Methods of Analysis

2.1Structure

In engineering and architecture, a structure is the combination of two or more basic structural components connected together in such a way that they serve the user functionally and carry the loads arising out of self and super-imposed loads safely without causing any problem of utility.

2.2 Structural Analysis

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 composite nature

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certain simplifying assumptions with consider to the quality of material, geometry of the members, nature and distribution of loads and the extent of network at the joints and the supports are always made to make the analysis easier.

2.3 Moment Distribution Method

This method analyzing beams and frames using moment distribution was developed by Prof.Hardy Cross in 1930's at the University of Illionos. It is considered one of the most important contributions ever made to the structural analysis continuous beams and rigid frames.

It is widely used for the analysis of intermediate structures and basically an iterative process. It involves artificially restrainingtemporarily all the joints against rotations and writing down the fixed end momentsfor all the members. The joints are then released one by one in succession. At each released member joint the unbalanced moments are distributed to all the ends of themembers meeting at that joint.A certain factor of these distributed moments's arecarried over to the far end of members. The released joint is again restrained temporarily before proceeding to the next joint. The same sets of operations arecarried out at each joint till all the joints are completed. This completes one cycle ofoperations. The process is repeated for a number of cycles till the values obtainedare within the desired accuracy. This method is also a displacement analysis.

2.4 Kani's Method

This method for analysis of frames was developed by Prof.G Kani of Germany in 1947. This is an extension of slope- deflection method and is quite efficient due to simplicity of moment distribution. This is aniteration method in which the contribution of rotation moments are distributed till the desired degree of accuracy is achieved. It is very useful method of analysis for frames. It is simple in application and saves lot of time of analysis with sufficient accurate results.

This methodprovides a systematicapproach for the analysis and design of rigid jointed frames. It is a numerical approach for the solution of slope deflection equations. This is iterative in nature in which the end moments in the members of a rigid jointedskeletal structure are determined by correcting successively the fixed end momentsin the corresponding restrained structure.

2.5 Staad Pro Software

STAAD.Pro is a general purpose structural analysis and design program with applications basically in the building industry - commercial buildings, bridges and highway structures, industrial structures, chemical plant structures, dams, retaining walls, turbine foundations, culverts and other embedded structures, etc.

STAAD Pro is basically based on Finite Element Analysis and is programmed in C for carrying out the caculations for Analysis and Design of a Structure. STAAD Pro works in a very user friendly environment with an option of shifting between graphical and analytical modes any time between the works.

3. Methodology Adopted

This paper presents the analysis of portal frame, considering mainly the case of single bay, which is the most common in practice, by using two most common methods viz. moment distribution method & rotation contribution method (Kani's method). The vertical and top members are rigidly joined. The frame is fixed at both ends. The portal frame consists of a horizontal beam resting on two columns.

Size of Beam = 230 × 500for all beams, I =>2I

Size of Column = 230 × 400 for all columns, I => I

The junction of the beam with the column consists of rigid joints. (Fig.1)

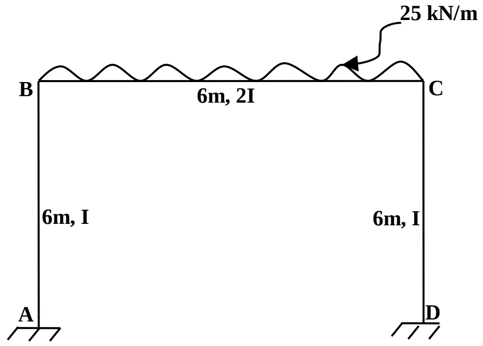

Fig .1: Portal Frame

4. Application of Analysis Methods forthe Portal Frame

4.1. Application of Moment Distribution Method for the analysis of portal frame:

4.1.1 Calculation of Fixed End Moments

The fixed end moments due to externally loads applied are,

$M_{FAB} = 0$

$M_{FBA} = 0$

$M_{FBC} = \frac{-WL^2}{12} = \frac{-25 \times 6^2}{12} = -75$ kN-m

$M_{FCB} = \frac{WL^2}{12} = \frac{-25 \times 6^2}{12} = 75$ kN-m

$M_{FCD} = 0$

$M_{FDC} = 0$

4.1.2Stiffness and Distribution Factor

Now calculate stiffness and distribution factors,

Table.1: Stiffness and Distribution Factors

Joint	Member	Relative Stiffness Factor (K)	ΣK	D.F = $\frac{K}{\Sigma K}$
B	BA	$\frac{I}{L} = \frac{I}{6} = 0.167I$	0.5I	0.334
	BC	$\frac{I}{L} = \frac{2I}{6} = 0.333I$	0.5I	0.666
C	CB	$\frac{I}{L} = \frac{2I}{6} = 0.333I$	0.5I	0.666
	CD	$\frac{I}{L} = \frac{I}{6} = 0.167I$	0.5I	0.334

4.1.3 Iteratiom Processsby Moment Distribution Method (Non- Sway)

JOINT	A		B		C	D
Member	AB	BA	BC	CB	CD	DC
D.F		0.334	0.666	0.666	0.334	
F.E.M	0	0	-75	+75	0	0
BALANCE		+25.05	+49.95	-49.95	-25.05	
C.O	+12.53		-24.98	+24.98		-12.53
BALANCE		+8.343	+16.637	-16.637	-8.343	
C.O	+4.172		-8.319	+8.319		-4.172
BALANCE		+2.779	+5.540	-5.540	-2.779	
C.O	+1.389		-2.77	+2.77		-1.389
BALANCE		+0.92	+1.845	-1.845	-0.92	
C.O	+0.46		-0.923	+0.923		--0.46
BALANCE		+0.31	+0.615	-0.615	-0.31	
C.O	+0.16		-0.31	+0.31		+0.16
BALANCE		+0.104	+0.21	- 0.21	-0.104	
C.O	+0.052		-0.11	0.11		-0.052
FINAL END MOMENT	+18.76	+37.51	-37.62	+37.62	-37.51	-18.76

4.1. Application of Kani's Method for the analysis of portal frame:
4.1.2Stiffness andRotation Contribution

Now calculate stiffness and Rotation Contribution,

Table.2: Stiffness and Rotation Contribution

Joint	Member	Relative Stiffness Factor (K)	ΣK	$R.C = -\frac{1}{2}\frac{K}{\Sigma K}$
B	BA	$\frac{I}{L} = \frac{I}{6} = 0.167I$	0.5I	- 0.167
	BC	$\frac{I}{L} = \frac{2I}{6} = 0.333I$	0.5I	- 0.333
C	CB	$\frac{I}{L} = \frac{2I}{6} = 0.333I$	0.5I	- 0.333
	CD	$\frac{I}{L} = \frac{I}{6} = 0.167I$	0.5I	- 0.167

4.1.3 Iteration Process by Kani's Method

Joint	A	B		C		D
Member	M'_{AB}	M'_{BA}	M'_{BC}	M'_{CB}	M'_{CD}	M'_{DC}
Iteration (1)		-0.167(-75 +0) = 12.525	- 0.333 (-75 +0) = 24.98	0.333(75+24.975) = -33.292	-0.167(75 +24.975) = -16.696	
Iteration (2)		-0.167(-75-33.292) = 18.085	-0.333(-75–33.292) = 36.061	-0.333(75+36.06) = -36.983	-0.167(75 +36.061) = -18.54	
Iteration (3)		-0.167(-75-36.061) = 18.54	-0.333(-75– 36.983) = 37.29	-0.333(75+37.29) = -37.393	-0.167(75+37.29) = -18.75	
Iteration (4)		-0.167(-75-37.393) = 18.77	-0.333(-75–37.43) = 37.427	-0.333(75+37.42) = -37.436	-0.167(75 +37.42) = -18.77	
Iteration (5)		-0.167(-75-37.393) = 18.77	-0.333(-75-37.43) = 37.427	-0.333(75+37.42) = -37.436	-0.167(75 +37.42) = -18.77	

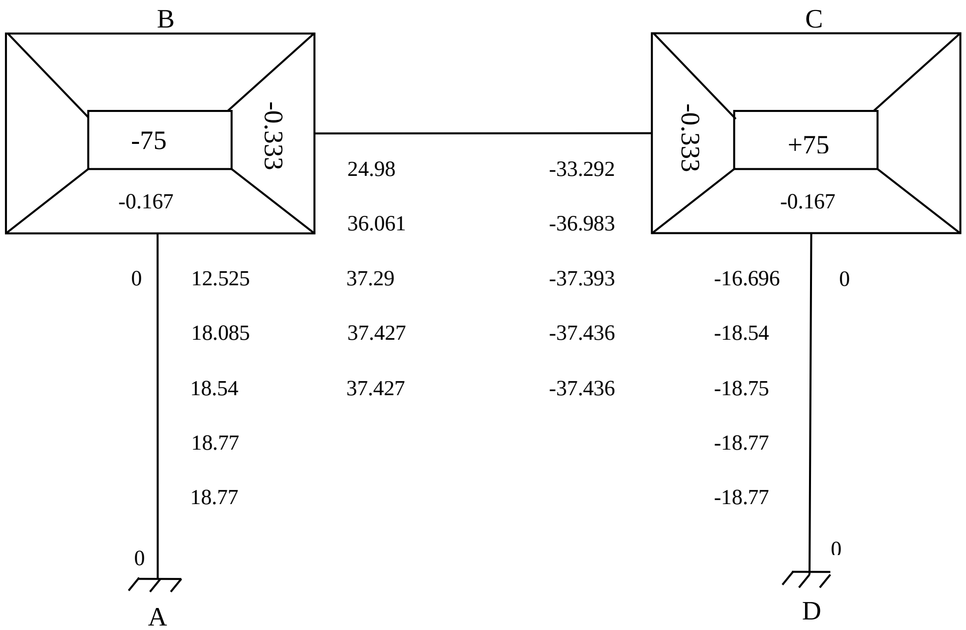

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Fig.3: Analysed by Kani's Method

4.1.4 Final Moments

$M_{AB} = M_{FAB} + 2M'_{AB} + M'_{BA}$ = 0 + 2 (0) + 18.77 = 18.77 kN-m.

$M_{BA} = M_{FBA} + 2M'_{BA} + M'_{AB}$ = 0 + 2 (18.77) + 0 = 37.54 kN-m.

$M_{BC} = M_{FBC} + 2M'_{BC} + M'_{CB}$ = -75 + 2 (37.427) – 37.436 = - 37.582 kN-m.
$M_{CB} = M_{FCB} + 2M'_{CB} + M'_{BC}$ = 75 + 2 (-37.436) + 37.427 = 37.552 kN-m.
$M_{CD} = M_{FCD} + 2M'_{CD} + M'_{DC}$ = 0 + 2 (-18.77) + 0 = - 37.54 kN-m.
$M_{DC} = M_{FDC} + 2M'_{DC} + M'_{CD}$ = 0 + 2 (0) – 18.77 = - 18.77 kN-m.

4.1.5 Application of Staad.Pro Software:

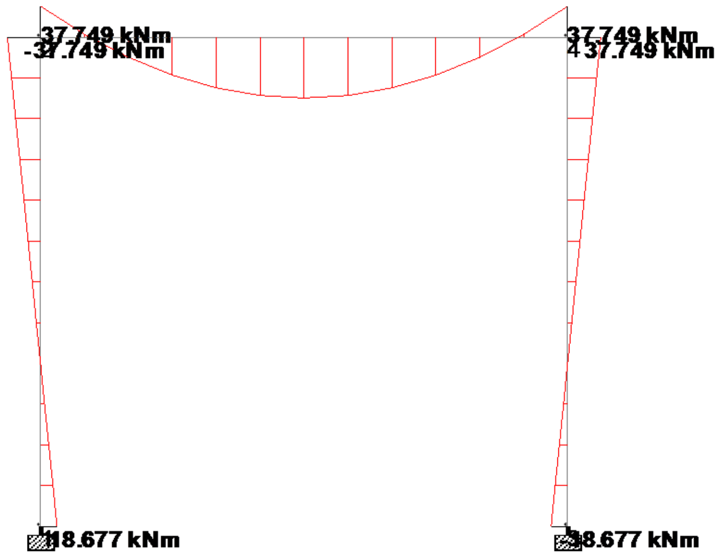

Fig.2: Final End Moments

5. Investigative Analysis

After the analysis is completed, the results obtained from Moment Distribution method and Kani's method has been compared with results obtained from Staad.Pro.

Table.3: Comparison of End Moments by Manual Methods and STAAD.Pro

Moment at	End Moments (kN-m)		STAAD.Pro Software
	Analytical Methods		
	Moment Distribution Method	Kani's Method	Staad.Pro
M_{AB}	18.76	18.77	18.68
M_{BA}	37.51	37.54	37.75
M_{BC}	-37.62	- 37.582	-37.75
M_{CB}	37.62	37.552	37.75
M_{CD}	-37.51	- 37.54	-37.75
M_{DC}	-18.76	- 18.77	-18.68

6. CONCLUSION

The End Moments of a Portal Frame solved by the application of Moment Distribution Method and Kani's Method successfully substanntiated by using STAAD.Pro software. In this paper the results obtained from manually by two different methods are comparing with the results obtained from STADD.Pro software. There is slightly variation in the value of End Moments by manual analysis as well as software analysis. In manual calculation the Moment Distribution Method results are nearly same when compared with STAAD.Pro results. But in Moment Distribution Method, if numbers of iterations aremore, then it gives more exactresult and in other hand Kani's Method gives more adequate results only 3-4 iterations. Differenece between both manual methods can be reduced by increasing the number of iterations. The final iteration only needs to be correct in kani's method because it can correct thesolution automatically.

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