Analysis of Multi-Storeyed Residential Building

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Abstract— Urban regions are rapidly developing with huge buildings of different kind in which most common used is reinforced cement concrete framed structure. To have a safer stability of R.C.C structure the structural design should be run accordance with the codal provision with respective to the country. To understand the methodology and procedure for the analysis, a commercial multi-storied R.C.C building is of G+2 which is situated in sangareddy, dist is taken into consideration for the analysis. Manually the tributary loads distribution of floors to corresponding beams has been done, one of the frame of the building has been selected, and all the necessary loads have been worked out and distributed with respect to the storey levels. Manually linear static analysis has been done using KANI'S method of rotational contribution. The frame is also analyzed in SAP2000v17.3, and all the important results, such as major bending moment, major shear force and axial loads have been calculated and a comparison is made between manual calculations and SAP2000.

Key words: Bending Moment, Shear Force, and Axial Load

I. Introduction

Building construction is the engineering, deals with the construction of building such as residential houses. In a simple sence building can be define as an enclose space by walls with roof, food, cloth and the basic needs of human beings. In the early ancient times humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful houses. Buildings are the important indicator of social progress of the county. Every human has desire to own comfortable homes on an average generally one spends his two-third life times in the houses. These are the few reasons which are responsible that the person do utmost effort and spend hard earned saving in owning houses. Nowadays the house building is major work of the social progress of the county. Daily new techniques are being developed for the construction of houses economically, quickly and fulfilling the requirements of the community engineers and architects do the design work, planning and layout etc., of the buildings. A building frame consists of number of bays and storey, multi-storey, multi-panelled frame is a complicated statically intermediate structure. Design of R.C.C building of G+2 storey frame work is taken up. The building in plan (18mx11.5m) consists of columns built monolithically forming a network. The size of building is 18mx11.5m. Type of the building is residential building.

II. Literature review

"Comparative Study of Analysis and Design of RC Frame" By Prof.Sakshi A.Manchalwar (Author).This paper aims towards the comparative study of analysis and design of (G+2) storey frame. The design process of structural planning and design requires not only imagination and conceptual thinking but also sound knowledge of structural engineering besides the practical aspects. It is important to first obtain the plan of a particular building i.e. position of particulars rooms, position of columns, size of beams, and depth of slab are provided on the basis of structural requirement. Manual analysis of frames of selected plan is carried out by Kani's method and also SAP2000 software is used for the study and end moments of different span are validated with it. Paper shows the comparative analysis of end moments of frame by manual excel and SAP 2000. Design structural element as slab, beam, column, and footing is done. The moments and design obtained in this study is useful for engineers to understand the design procedure and utility of software for more complicated structure. At the end the results are compared and it is found that the analysis done by manual, excel and SAP2000 are nearly same which gives validation of manual results with software result.

KANI's method has the capability to analyze any frame section as compared to other methods. Frame structures are rarely symmetric and subjected to side way, hence KANI's method is best and much simpler than other methods like moment distribution and slope deflection method. By comparing the final moments obtained from manual analysis, SAP2000 analysis and EXCEL analysis are nearly same. So the calculations done manually and by SAP2000 and excel are correct and hence we conclude that SAP2000 software is beneficial for analysis of frames of building. In manual and software design area of different elements of the building is same.

III. Methodology

A. *Kani's Method*

This method was first developed by Prof. Gasper Kani of Germany in the year 1947. The method is named after him, this is an indirect extension of slope deflection method, this is an efficient method due to simplicity of moment distribution, and the method offers an iterative scheme for applying slope deflection method of structural analysis. Whereas the moment distribution method reduces the number of linear simultaneous equations and such equations needed are equal to the number of translator displacements, the number of equations needed is zero in case of the Kani's method. This method may be considered as a further simplification of moment distribution method wherein the problems involving sway were attempted in a tabular form thrice (for double story frames) and two shear coefficients had to be determined which when inserted in end moments gave us the final end moments. All this effort can be cut short very considerably by using this method.

- Frame analysis is carried out by solving the slope−deflection equations by successive approximations. Useful in case of side sway as well.
- Operation is simple, as it is carried out in a specific direction. If some error is committed, it will be eliminated in subsequent cycles if the restraining moments and distribution factors have been determined correctly.

1) Beams with No Translation

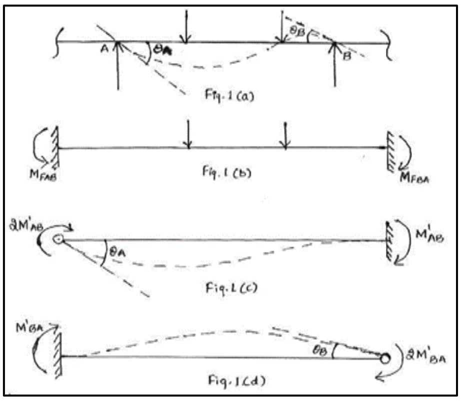

Fig. 1: Shows the beam with no translation

Let AB represent a beam in a frame, or a continuous structure under transverse loading, as show in fig. 1 (a) let the MAB& MBA be the end moment at ends A & B respectively. The end moments in member AB may be thought of as moments developed due to a superposition of the following three components of deformation.

- The member 'AB' is regarded as completely fixed. (Fig. 1 b). The fixed end moments for this condition are written as MFAB& MFBA, at ends A & B respectively.
- The end an only is rotated through an angle θA by a moment 2 M 'AB inducing a moment M 'AB at fixed end B.
- Next rotating the end B only through an angle θB by moment 2MBA while keeping end 'A' as fixed. This induces a moment M'BA at end A. Thus the final moment MAB & MBA can be expressed as super position of three moments.

$$M_{AB} = M_{FAB} + 2M_{AB} + M_{BA}$$

$$M_{BA} = M_{FBA} + 2M_{BA} + M_{AB} \ldots\ldots\ldots\ldots(1)$$

For member AB we refer end 'A' as near end and end 'B' as far end. Similarly when we refer to moment M_{BA}, B is referred as near end and end A as far end. Hence above equations can be stated as follows. The moment at the near end of a member is the algebraic sum of (a) fixed end moment at near end. (b) Twice the rotation moment of the near end (c) rotation moment of the far end.

2) Rotation Factors

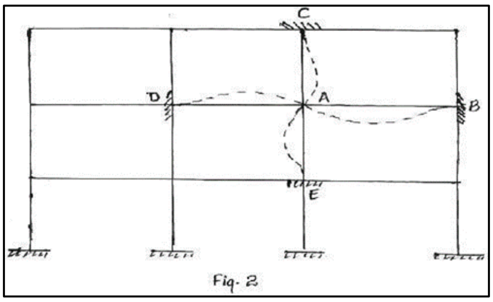

Fig. 2: shows a multistoried frame.

Consider various members meeting at joint A. If no translations of joints occur, applying equation (1), for the end moments at A for the various members meeting at A is given by:

$M_{AB} = M_{FAB} + 2M'_{AB} + M'_{BA}$

$M_{AC} = M_{FAC} + 2M'_{AC} + M'_{CA}$

$M_{AD} = M_{FAD} + 2M'_{AD} + M'_{DA}$

$M_{AE} = M_{FAE} + 2M'_{AE} + M'_{EA}$

For equilibrium of joint A, $\sum M_A = 0$

$$\therefore \sum M_{FAB} + 2\sum M_{AB} + \sum M_{BA} = 0 \ldots\ldots\ldots\ldots (2)$$

Where,

$\sum M_{FAB}$ =Algebraic sum of fixed end moments at A of all members.

$\sum M'_{AB}$ = Algebraic sum of rotation moments at A of all members.

$\sum M'_{BA}$ = Algebraic sum of rotation moments of far ends from equation (2)

$$\sum M'_{AB} = -\frac{1}{2}\left[\sum M_{FAB} + \sum M_{BA}\right] \ldots\ldots\ldots\ldots (3)$$

We know that $2M'_{AB} = 4EI_{AB}/L_{AB}\theta_A = 4EK_{AB}\,\theta_A$

Where $K_{AB} = I_{AB}/L_{AB}$, relative stiffness of member AB

$$M_{AB} = 2E\,K_{AB}\,\theta_A \ldots\ldots\ldots\ldots (4)$$

$$\therefore \sum M'_{AB} = 2E\theta_A \sum K_{AB} \ldots\ldots\ldots\ldots (5)$$

(At rigid A all the Rotation θ_A)

Dividing Equation (4)/(5) gives

$M_{AB}/\sum M_{AB} = K_{AB}/\sum K_{AB}$

$$\therefore M_{AB} = K_{AB}/\sum K_{AB}\left(\sum M'_{AB}\right) \ldots\ldots\ldots\ldots (6)$$

Substituting value of $\sum M'_{AB}$ from (3) in (6)

$$M_{AB} = \left(-\frac{1}{2}\right) K_{AB}/\sum K_{AB}\left[\sum M_{FAB} + \sum M_{BA}\right] = U_{AB}\left[\sum M_{FAB} + \sum M_{BA}\right] \ldots\ldots\ldots\ldots (7)$$

Where $U_{AB} = -\frac{1}{2} K_{AB}/\sum K_{AB}$ is called as rotation factor for member AB at joint A.

IV. ANALYSIS

A. Design Data

Slab Thickness= 125mm
Storey Height=3.0m
Beam Size= 230×400mm
Column Size=230×400mm
Grade of Concrete= M20
Grade of Steel= Fe415 HYSD
Live Load= 2.5KN/m^2
Floor Finish=1KN/m^2
Wall Thick = 230mm
Density of Brick=20KN/m^3
Density of Concrete= 25KN/m3

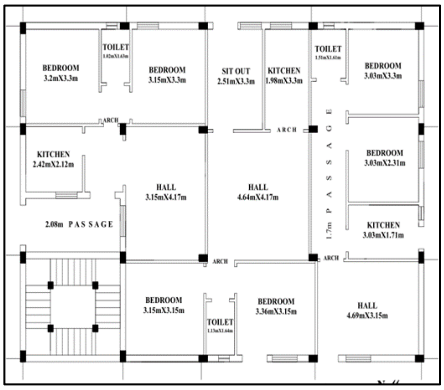

Fig. 3: Plan

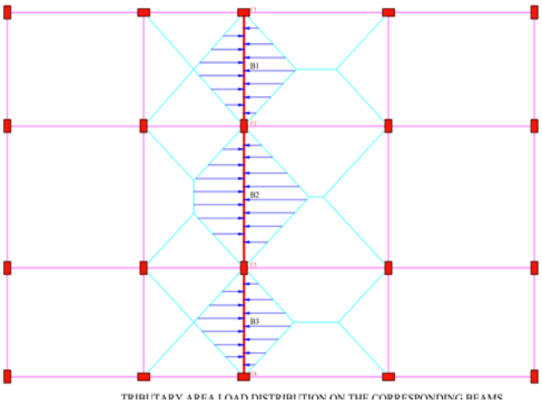

Fig. 4: Tributary Load distribution (from slab to selected frame)

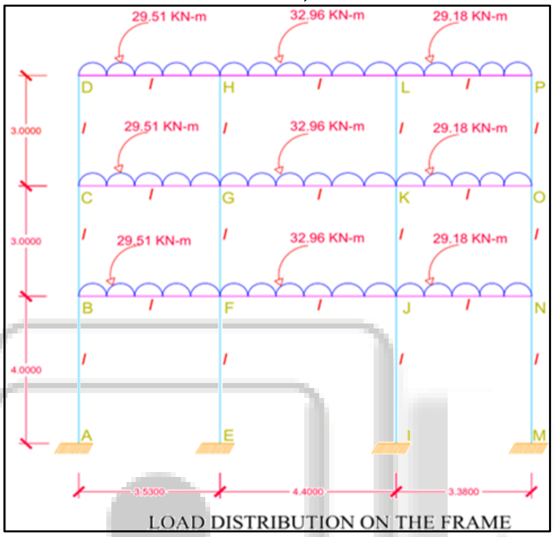

Fig. 5: Loading on frame

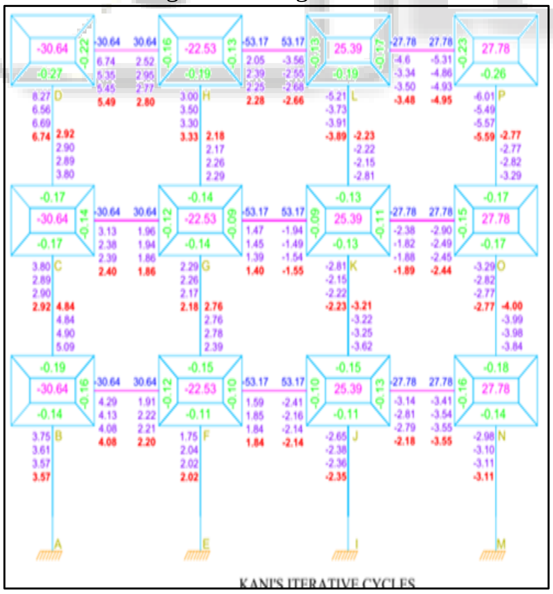

Fig. 6: Kani's method iteration cycles

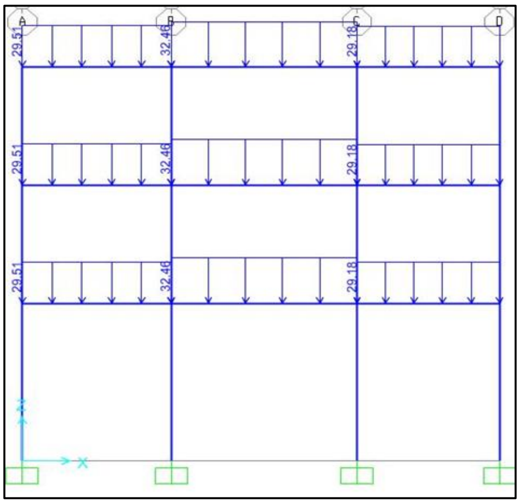

Fig. 7: shows loading diagram in SAP2000

Sl.No	Member End	Column End Moments In (KN-m)	
		Manual Calculation.	SAP2000 Results.
1	M_{AB}	3.57	4.50
2	M_{BA}	7.14	8.99
3	M_{BC}	12.6	15.24
4	M_{CB}	10.68	13.54
5	M_{CD}	12.57	16.11
6	M_{DC}	16.38	21.45
7	M_{EF}	2.02	2.67
8	M_{FE}	4.04	5.37
9	M_{FG}	7.7	9.70
10	M_{GF}	7.12	9.23
11	M_{GH}	7.69	10.47
12	M_{HG}	8.84	12.69
13	M_{IJ}	-2.35	-3.10
14	M_{JI}	-4.7	-6.16
15	M_{JK}	-8.66	-11.00
16	M_{KJ}	-7.67	-10.42
17	M_{KL}	-8.35	-11.90
18	M_{LK}	-10.02	-14.48
19	M_{MN}	-3.11	-4.13
20	M_{NM}	-6.22	-8.14
21	M_{NO}	-10.77	-13.83
22	M_{ON}	-9.54	-12.46
23	M_{OP}	-11.13	-14.82
24	M_{PO}	-13.95	-19.51

Table 1: Column Moments Comparison between Manual and Sap2000

Sl. No	Beam End Moment (KN-m)			Span Bending Moment (KN-m)		
	Mem ber End	Manual Calcula tion	SAP2 000	Sp an	Manual Calcula tion	SAP2 000
1	M_{BF}	-20.28	-24.24	BF	16.26	16.23
2	M_{FB}	39.12	35.23			
3	M_{FJ}	-51.63	-50.30	FJ	28.58	27.60
4	M_{JF}	50.73	49.73			
5	M_{JN}	-36.89	-32.57	JN	14.27	14.31
6	M_{NJ}	17.90	21.97			
7	M_{CG}	-23.98	-29.65	C G	15.59	15.76
8	M_{GC}	36.76	30.76			

9	M_{GK}	-51.92	-50.45	G	28.09	27.26
10	M_{KG}	51.47	50.22	K		
11	M_{KO}	-34.00	-27.89	K	14.16	13.28
12	M_{OK}	21.01	27.28	O		
13	M_{DH}	-16.88	-21.45	D	16.66	16.95
14	M_{HD}	41.72	36.58	H		
15	M_{HL}	-51.27	-49.27	HL	29.06	28.77
16	M_{LH}	50.13	48.46			
17	M_{LP}	-39.19	-33.97	LP	15.12	15.11
18	M_{PL}	13.9	19.51			

Table 2: Beam Moments Comparison between Manual and SAP2000

Sl.No	Member End	Coloumn Shear Force (KN)	
		Manual Calculation	SAP2000
1	R_{AB}	-2.67	-3.37
2	R_{BA}	2.67	3.37
3	R_{BC}	-7.76	-9.59
4	R_{CB}	7.76	9.59
5	R_{CD}	-9.65	-12.52
6	R_{DC}	9.65	12.52
7	R_{EF}	-1.51	-2.01
8	R_{FE}	1.51	2.01
9	R_{FG}	-4.94	-6.31
10	R_{GF}	4.94	6.31
11	R_{GH}	-5.51	-7.72.
12	R_{HG}	5.51	7.27
13	R_{IJ}	1.76	2.32
14	R_{JI}	-1.76	-2.32
15	R_{JK}	5.44	7.14
16	R_{KJ}	-5.44	-7.14
17	R_{KL}	6.12	8.8
18	R_{LK}	-6.12	-8.8
19	R_{MN}	2.33	3.07
20	R_{NM}	-2.33	-3.07
21	R_{NO}	6.77	8.76
22	R_{ON}	-6.77	-8.76
23	R_{OP}	8.36	11.44
24	R_{PO}	-8.36	-11.44

Table 3: column Shear Force Comparison between Manual and SAP2000

Sl.No	Member End	Beam Shear Force (KN)	
		Manual Calculation	SAP2000
1	R_{DH}	45.05	47.80
2	R_{HD}	59.12	56.37
3	R_{HL}	72.77	71.60
4	R_{LH}	72.25	71.23
5	R_{LP}	56.79	53.59
6	R_{PL}	41.83	45.04
7	R_{CG}	48.47	51.77
8	R_{GC}	55.70	52.40
9	R_{GK}	72.62	71.46
10	R_{KG}	72.40	71.36
11	R_{KO}	53.15	49.50
12	R_{OK}	45.47	49.31
13	R_{BF}	46.75	48.97
14	R_{FB}	57.42	55.20
15	R_{FJ}	72.72	71.54
16	R_{JF}	72.30	71.28
17	R_{JN}	54.93	52.45
18	R_{NJ}	43.69	46.18

Table 4: Beam Shear Force Comparison with Manual and SAP2000

Column Axial Load In (KN)			
Column Name	Column End	Manual calculation	SAP2000
DC	TOP	45.05	47.75
	BOT	51.95	54.25
CB	TOP	100.42	106.02
	BOT	107.32	112.52
BA	TOP	154.07	161.45
	BOT	163.27	170.12
HG	TOP	131.89	129.12
	BOT	138.79	135.62
GF	TOP	267.11	260.58
	BOT	274.01	267.09
FE	TOP	404.15	394.96
	BOT	413.35	403.65
LK	TOP	129.04	125.97
	BOT	135.94	132.48
KJ	TOP	261.49	254.43
	BOT	268.39	260.94
JI	TOP	395.62	385.81
	BOT	404.82	394.48
PO	TOP	41.83	44.98
	BOT	48.73	51.48
ON	TOP	94.2	100.61
	BOT	101.1	107.11
NM	TOP	144.79	153.25
	BOT	153.99	161.92

Table 5: Column Axial Force Comparison with Manual and SAP2000

V. CONCLUSION

1) KANI's method has got capability to analyze any structural frame.
2) The software used in the present work such as SAP2000V17 is most user friendly.
3) SAP2000V17 will give clear information about various structural elements.
4) KANI's method is best and much simpler than the other method like moment distribution and slope deflection method.
5) By comparing the result obtained from manual analysis and SAP2000v15 are nearly same.
6) For complex boundary conditions kani's method can't be sufficient SAP2000v15 can be recommended for such conditions.

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