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Effect of Shape of Core Wall in Tall Building

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Abstract

The world is becoming faster day by day with the advancement of science and technology. Many type structures are constructed now. Tall building is one of them. The tall building is analysed with various components. They may be shear wall or core wall. Various shape of core wall is used in tall building. The rectangular and square core walls are used mostly. Five different core walls are used to determine the more effective shape of core wall. Dead, live, wind and seismic loads in according with the code of practice, have been applied to observe the variation of bending moment, shear force and side sway respectively along height of building with different core wall. The bending moment, shear force and side sway are compared with respect to the height of building of five Models in tabular form and graphical.

Keywords: *ETABS, Core wall, Reinforced concrete structures, High-rise buildings.*

INTRODUCTION

The tall building is analysed with various components. They may be shear wall or core wall. Various types and shape of the core wall is used in tall building. The shape may be U-shape, V-shape, triangular shape, I-shape, L-shape, rectangular shape, circular shape and square shape. The rectangular and triangular core walls are used mostly. The triangular shape core wall is used in 1986 in Riverside center at Brisbane in Australia. The thickness of it is 8′′ and the strength of its concrete is 3500 psi. The circular shape core wall is used in Hope well center in Hong Kong in 1980. The thickness of it is 30′′ and the strength of it is 5800 psi. The rectangular shape core wall is built in city spire at New York in USA in 1987. The square shape core wall is constructed in two prudential plazas at Chicago in USA at 1990. The thickness of this core wall is 33′′ at ground. It is made of concrete. The strength of it is 1200 psi. The core wall also may be A shape. This core wall is built in Broad way Denver at Colorado in USA in 1999 (Robert Sinn 1995).

Many experimental studies have been conducted in recent years to core wall on tall building. Cao Wanlin, Chang Weihua and Zhang Jianwei had been worked on study on seismic behaviour of composite core walls with concealed steel truss subjected to combined action in 2009. Nor Hayati Abdul Hamid and Azli Shah Ali Bashah had been worked on damage avoidance design of warehouse buildings using the precast hollow core walls system in 2000. Makoto Maruta, Norio Suzuki, Takashi Miyashita and Takamasa Nishioka4 had been worked on structural capacities of h-shaped core wall subjected to lateral load and torsion in 2000.John W. Wallace had been worked on modelling issues for tall reinforced concrete core wall buildings in1993.R. Constantin and K. Beyer had been worked on modelling of reinforced concrete core walls under bi-directional loading in 2012.

a. Objectives

The objectives of study are as follows

i) To determine bending moment, shear force and side sway of five models using ETABS software.

ii) To compare bending moment, shear force and side sway of five models with story height.

iii) To point out the effective shape of those models.

b. Scope of the Study

The demand for tall building in the present time has been increasing day by day. The core wall is a very important component in tall building. To use an effective core wall in the tall building is the scope of the study. The design and analyse procedure can be pointed out from this study.

PROBLEM DEFINATION

There are five models here to analysis the problem. They are Model-1, Model-2, Model-3, Model-4 and Model-5. To analysis the problem, ETABS software is used. During solving the problems by ETAB software self-load, live load, dead load, seismic load and wind load are used in same magnitude for each structure. The bending moment shear force and side sway are taken for each analysed stricter. The moment, shear force, side sway and the geometric properties of core walls are compared. The description of Models is shown in Table 1.

***Table-1** The description of five Models.*

Various dimension and magnitude	Model-1	Model-2	Model-3	Model-4	Model-5
Length and breadth	90' x 70'	90' x 70'	90' x 70'	90' x 70'	90' x 70'
Thickness of core	10"	10"	10"	10"	10"
Thickness of slab	5"	5"	5"	5"	5"
Size of core	5' x 5.5'	6' x 6.5'	7' x 7.5'	14' x 6.5'	14' x 6.5'
Life load	40psf	40psf	40psf	40psf	40psf
Concrete compression strength, fc'	3000psi	3000psi	3000psf	3000psi	3000psi
Yield strength, fy	60000 psi	60000psi	60000psi	60000psi	60000psi

Load combinations used in this project as per BNBC Code are as follows:

1) 1.4 DL
2) 1.4DL+1.7LL
3) 0.9DL+1.3 WL
4) 0.9DL+ 1.43 EL
5) 0.75 [1.4DL+ 1.7LL+ 1.7WL]
6) 1.4 [DL + LL + EL].

To solve the **problem five number load combinations is used.**

Details of beams, columns, core wall etc. for Models are shown in tabular format as follows-

***Table-2** Dimension of beams, columns and opening of core.*

Components of building		Model-1	Model-2	Model-3	Model-4	Model-5
Column (in x in)	C1	10×10	10×10	10×10	10×10	10×10
	C2	15×15	15×15	15×15	15×15	15×15
	C3	24×24	24×24	24×24	24×24	24×24
Beam (in x in)	B1	18×12	18×12	18×12	18×12	18×12
	B2	24×14	24×14	24×14	24×14	24×14
Opening of core (ft)		3×7	3×7	3×7	3×7	3×7

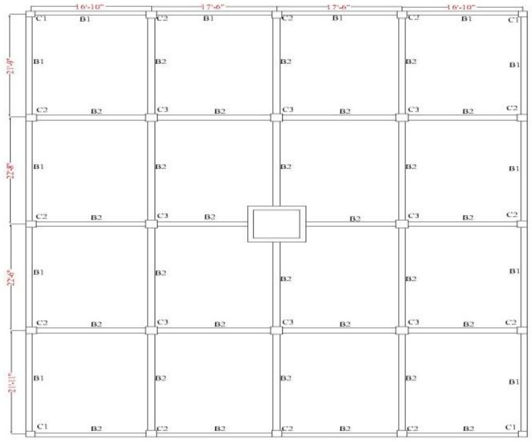
Fig-1 *Beam-column layout of Model-1*

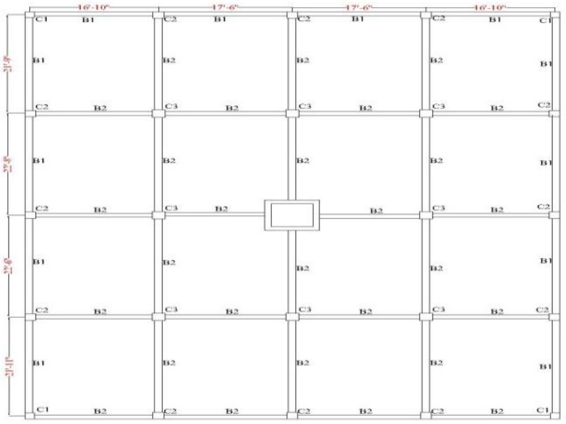
Fig -2 *Beam-column layout of Model-2*

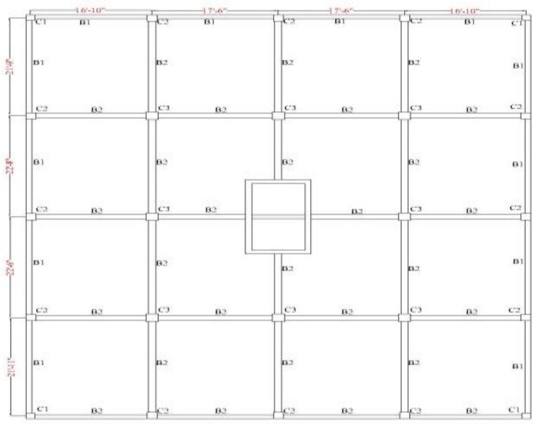
Fig-3 *Beam-column layout of Model-3*

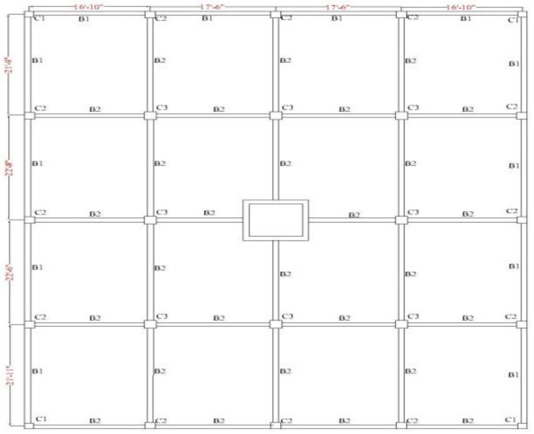
Fig-4 *Beam-column layout of Model-4*

RESULTS AND DISCUSSIONS

Table-3 *Variation of moment with respect to the building height.*

Height (ft)	Moment of Model-1 (kips-ft) (1)	Moment of Model-2 (kips-ft) (2)	Moment of Model-3 (kips-ft) (3)	Moment of Model-4 (kips-ft) (4)	Moment of Model-5 (kips-ft) (5)
0	0.00	0.00	0.00	0.00	0.00
11	47.47	53.17	58.87	53.17	58.87
21	152.55	170.85	189.16	170.85	189.16
31	313.35	350.95	388.55	350.95	388.55
41	527.16	590.42	653.68	590.42	653.68
51	792.12	887.17	982.23	887.17	982.23
61	1105.50	1238.16	1370.83	1238.16	1370.83
71	1465.03	1640.83	1816.64	1640.83	1816.64
81	1865.57	2089.44	2313.31	2089.44	2313.31
91	2301.96	2578.19	2854.43	2578.19	2854.43
101	2818.99	3157.27	3495.55	3157.27	3495.55

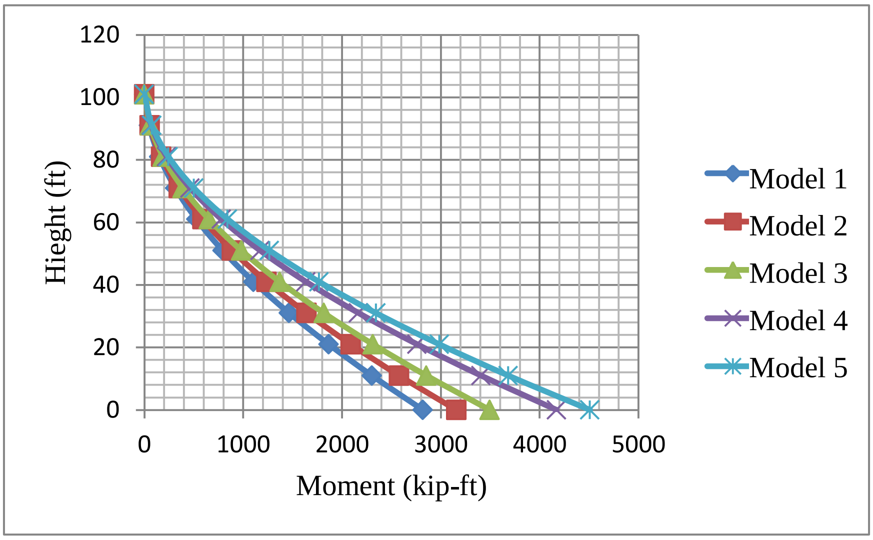

Fig-5 *Shows the variation of moment with respect to height.*

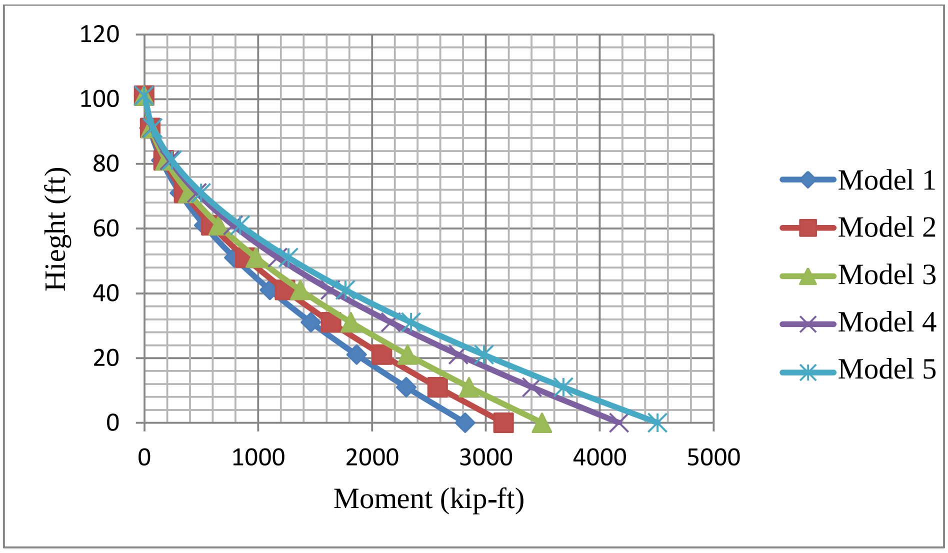

Fig-6 *Variation of moment to height of building along y-axis*

Table-4 *Variation of moment to the building height along y-axis.*

Height (ft)	Moment of Model-1 (kips-ft) (1)	Moment of Model-2 (kips-ft) (2)	Moment of Model-3 (kips-ft) (3)	Moment of Model-4 (kips-ft) (4)	Moment of Model-5 (kips-ft) (5)
0	0.00	0.00	0.00	0.00	0.00
11	61.42	68.79	76.16	90.90	98.27
21	197.35	221.03	244.71	292.08	315.76
31	405.37	454.02	502.66	599.95	648.60
41	681.98	763.82	845.66	1009.34	1091.18
51	1024.75	1147.72	1270.69	1516.63	1639.61
61	1430.18	1601.80	1773.42	2116.66	2288.29
71	1895.29	2122.73	2350.16	2805.03	3032.47
81	2413.47	2703.09	2992.71	3571.94	3861.56
91	2978.02	3335.38	3692.74	4407.47	4764.83
101	3646.90	4084.53	4522.15	5397.41	5835.04

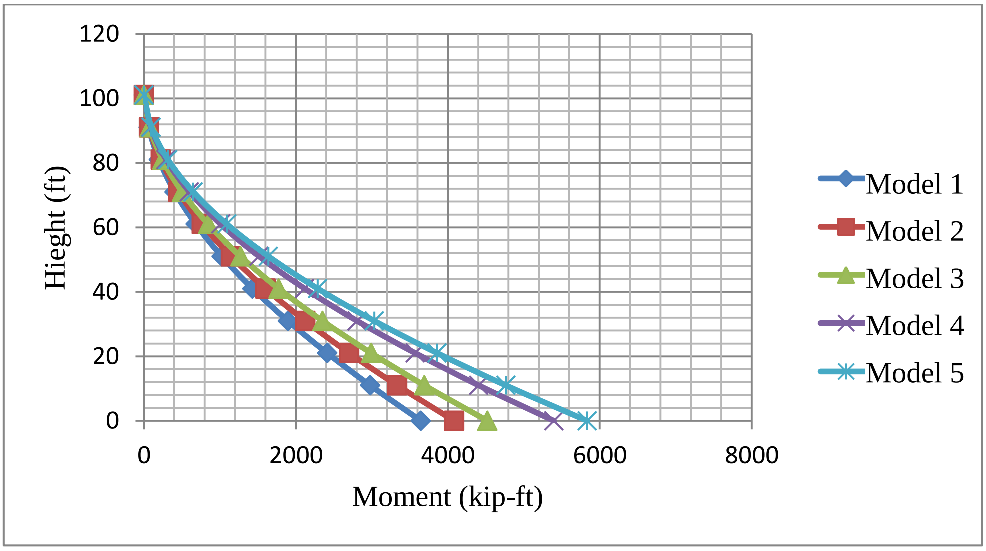

Fig-7 *Variation of the side sways with respect to height along x-axis.*

Table-5 *Variation of side sways along x-axis with respect to the height.*

Height (ft)	*Side Sway Model-1 (1)*	*Side Sway Model-2 (2)*	*Side Sway Model-3 (3)*	*Side Sway Model-4 (4)*	*Side Sway Model-5 (5)*
0	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
11	*0.072*	*0.053*	*0.044*	*0.043*	*0.032*
21	*0.191*	*0.140*	*0.116*	*0.116*	*0.086*
31	*0.330*	*0.243*	*0.207*	*0.208*	*0.154*
41	*0.472*	*0.352*	*0.306*	*0.310*	*0.231*
51	*0.607*	*0.458*	*0.406*	*0.413*	*0.308*
61	*0.731*	*0.558*	*0.503*	*0.514*	*0.383*
71	*0.837*	*0.646*	*0.594*	*0.610*	*0.454*
81	*0.927*	*0.724*	*0.676*	*0.698*	*0.521*
91	*1.000*	*0.790*	*0.751*	*0.778*	*0.580*
101	*1.059*	*0.846*	*0.818*	*0.851*	*0.636*

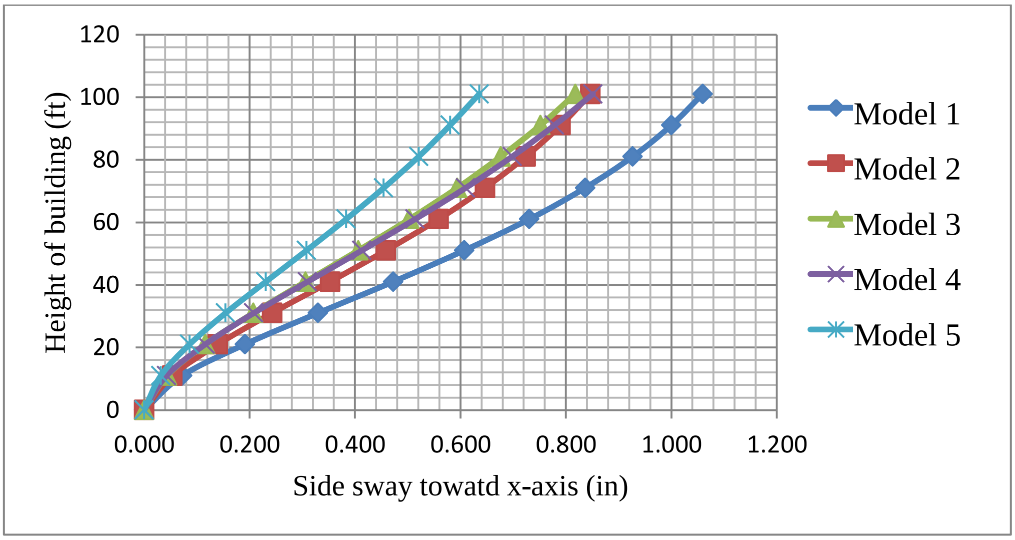

Fig-8 *Variation of the side sways with respect to height along y-axis.*

Table-6 *Variation of side sways along y-axis with respect to the height.*

Height (ft)	Side Sway Model-1(1)	Side Sway Model-2(2)	Side Sway Model-3(3)	Side Sway Model-4(4)	Side Sway Model-5(5)
0	0.000	0.000	0.000	0.000	0.000
11	0.080	0.057	0.069	0.051	0.043
21	0.195	0.145	0.168	0.130	0.108
31	0.321	0.245	0.276	0.217	0.181
41	0.445	0.347	0.384	0.306	0.253
51	0.560	0.447	0.487	0.392	0.323
61	0.665	0.540	0.581	0.471	0.386
71	0.754	0.622	0.664	0.544	0.442
81	0.830	0.693	0.736	0.608	0.489
91	0.889	0.753	0.795	0.662	0.528
101	0.934	0.804	0.842	0.709	0.560

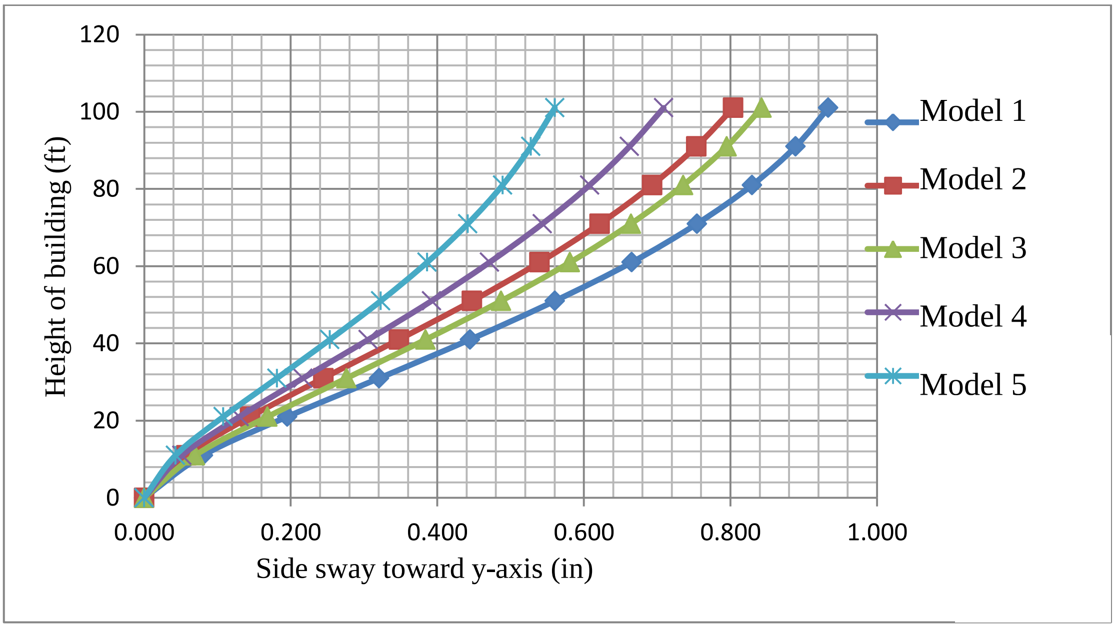

Fig-9 *Variation of shear force with respect to height along x-axis*

Table-7 *Variation of shear with respect to the height along x-axis*

Height (ft)	Shear of Model-1 (kips) (1)	Shear of Model-2 (kips) (2)	Shear of Model-3 (kips) (3)	Shear of Model-4 (kips) (4)	Shear of Model-5 (kips) (5
101	0	0	0	0	0
91	6.14	6.88	7.62	9.09	9.83
81	13.59	15.22	16.86	20.12	21.75
71	20.80	23.30	25.79	30.79	33.28
61	27.66	30.98	34.30	40.94	44.26
51	34.28	38.39	42.50	50.73	54.84
41	40.54	45.41	50.27	60.00	64.87
31	46.51	52.09	57.67	68.84	74.42
21	51.82	58.04	64.25	76.69	82.91
11	56.45	63.23	70.00	83.55	90.33
0	60.81	68.10	75.40	89.99	97.29

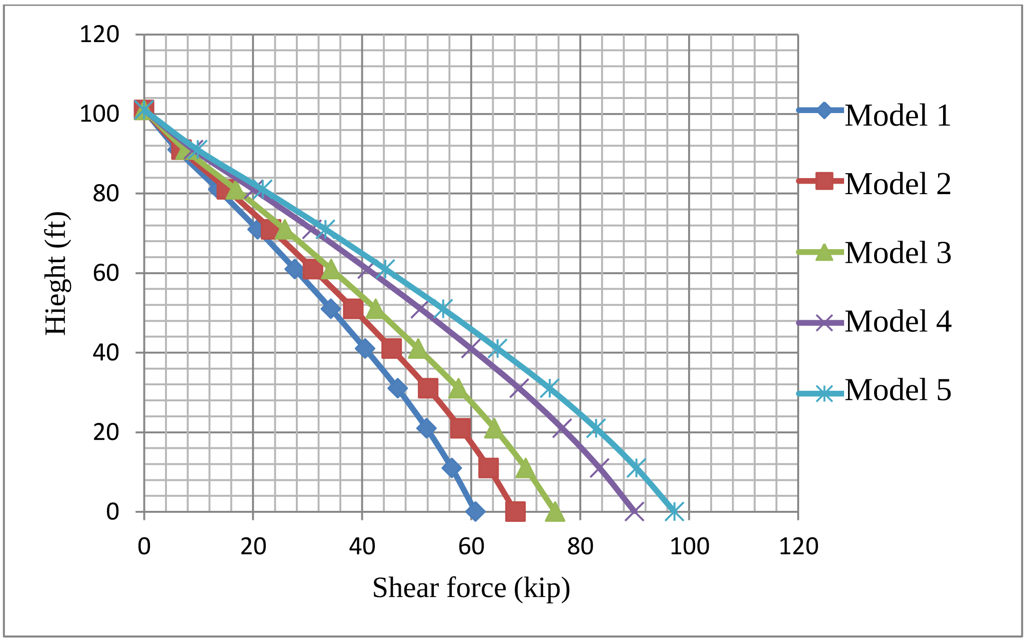

Fig-10 *Variation of shear force with respect to height along y-axis*

Table-8 *Variation of shear with respect to the height along y-axis.*

Height (ft)	Shear of Model-1 (kips) (1)	Shear of Model-2 (kips) (2)	Shear of Model-3 (kips) (3)	Shear of Model-4 (kips) (4)	Shear of Model-5 (kips) (5)
0	0	0	0	0	0
11	4.75	5.32	5.89	5.32	5.89
21	10.51	11.77	13.03	11.77	13.03
31	16.08	18.01	19.94	18.01	19.94
41	21.38	23.95	26.51	23.95	26.51
51	26.50	29.67	32.85	29.67	32.85
61	31.34	35.10	38.86	35.10	38.86
71	35.95	40.27	44.58	40.27	54.58
81	40.05	44.86	49.67	54.86	69.67
91	43.64	48.88	54.11	58.88	74.11
101	47.00	52.64	58.28	62.64	78.28

Table-9 *The variation of J with square core wall and different size of rectangular core wall on tall building.*

J of Model-1 (1) ft^4	J of Model-2 (2) ft^4	J of Model-3 (3) ft^4	J of Model-4 (4) ft^4	J of Model-5 (5) ft^4	Ratio of 5 and 1	Ratio of 5 and 2	Ratio of 5 and 3	Ratio of 5 and 4
4.10	4.82	5.73	9.64	11.46	2.79	2.37	2.00	1.18

Table-10 *The variation of Iw with square core wall and different size of rectangular core wall on tall building.*

Iw of Model-1 (1) ft^4	Iw of Model-2 (2) ft^4	Iwof Model-3 (3) ft^4	Iw of Model-4 (4) ft^4	Iw of Model-5 (5) ft^4	Ratio of 5 and 1	Ratio of 5 and 2	Ratio of 5 and 3	Ratio of 5 and 4
413.98	1072.8	1785	2144	3570	8.62	3.30	2.00	1.16

CONCLUSIONS

In tables and figure the bending moment, shear force and deflection along the height of different shape of core wall of a tall building are presented. The bending moment shear force and deflection of five Models are compared for the tall building. The torsional constant warping constants are also compared between among them. The following conclusions are drawn

1. The moment and shear of Model-1 along x-axis and y-axis are less with respect to Model-2, Model-3, Model-4 and Model-5 with respect to building height at different floor.
2. The side sway along x-axis and y-axis of Model-1 is more than the side sway along x-axis and y-axis type Model-2, Model-3, Model-4 and Model-5 at different floor.
3. The torsion constant and warping moment of inertia of core wall of Moedl-5 is more than the torsion constant and warping moment of core wall of Mode-1, Mode-2, and Mode-3and Mode-4.

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