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Comparison between Different Shapes of Structure by Response Spectrum Method of Dynamic Analysis

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Abstract

Several procedures for non-linear static and dynamic analysis of structures have been developed in recent years. In this paper, the response spectrum analysis is performed on two different shapes *i.e.* regular and irregular shape of structure by using STAAD PRO. And the comparison results are studied and compared accounting for the earthquake characteristics and the structure dynamic characteristics. As the results show that the earthquake response peak values and the main response frequencies are very close and comparable. It can be referred to by the engineering applications.

Keywords

Seismic Response Spectrum Analysis, STAAD PRO, Dynamic Characteristics, Earthquake Response Peak

1. Introduction

Response spectrum is one of the useful tools of earthquake engineering for analyzing the performance of structures especially in earthquakes, since many systems behave as single degree of freedom systems. Thus, if you can find out the natural frequency of the structure, then the peak response of the building can be estimated by reading the value from the ground response spectrum for the appropriate frequency. In most building codes in seismic regions, this value forms the basis for calculating the forces that a structure must be designed to resist (seismic analysis).

A response spectrum is a plot of the maximum response amplitude (displacement, velocity or acceleration) versus time period of many linear single degree of freedom oscillators to a give component of ground motion.

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The resulting plot can be used to select the response of any linear SDOF oscillator, given its natural frequency of oscillation. One such use is in assessing the peak response of buildings to earthquakes.

In Payam Tehrani [2006] study, he compared the nonlinear static (pushover) and nonlinear dynamic procedures in the determination of maximum displacements of an existing steel structure retrofitted with different methods [1]. In A. R. Touqan [2008] a comparison of the Response spectrum analysis and Equivalent Static Lateral Load with the more elaborate Response Spectrum Method of analysis as they apply to a repertoire of different structural models [2]. In Prof Dr. Qaiseruz Zaman Khan's [2010] paper Response spectrum analysis of 20 story building has been discussed in detail and comparison of static and dynamic analysis and design results of buildings up to 400 feet height (40 story) in terms of percentage decrease in bending moments and shear force of beams, bending moments of columns, top story deflection and support reaction are discussed [3]. Romy Mohan [2011] paper highlights the accuracy and exactness of Time History analysis in comparison with the most commonly adopted response spectrum analysis and equivalent static analysis considering different shape of shear walls [4].

In this paper, a four storey reinforced concrete building with moment resisting frame of different shapes *i.e.*, Regular shaped and Irregular shaped is analyzed by Response spectrum method of Dynamic analysis of Earthquake. A set of values from 0 to 90 degrees with an increment of 10 degrees have been used of excitation of seismic force. The details of the study and its result are described briefly in the following section of the paper.

2. Parametric Details of Model

The position of three different types of columns C1, C2, C3 *i.e.* corner, side and middle respectively of Regular (Square) and Irregular structure is shown in **Figure 1** and **Figure 2** respectively. And **Table 1** represents all the basic specification required for the analysis of the structure.

3. Methodology

The present study undertaken deals with response spectrum method of dynamic analysis. In order to apply forces in different angles, the structure has to be rotated with incidence angle from 0 to 90 degrees, with an increment of 10 degrees and column forces have been investigated in all cases. Further in order to find the accurate angle the interval of one degree is used. The columns have been divided into three main categories, including corner, side and internal (middle) columns and the results are compared.

4. Results and Discussion

Table 2 and **Table 3** show the values of shear force, moment about Y axis and moment about Z axis for square (regular) and irregular shaped structure for three different types of columns C1 (Corner), C2 (Side), C3 (Middle) respectively. And **Figure 3** to **Figure 8** show the graph of these values v/s angle of rotation in degrees.

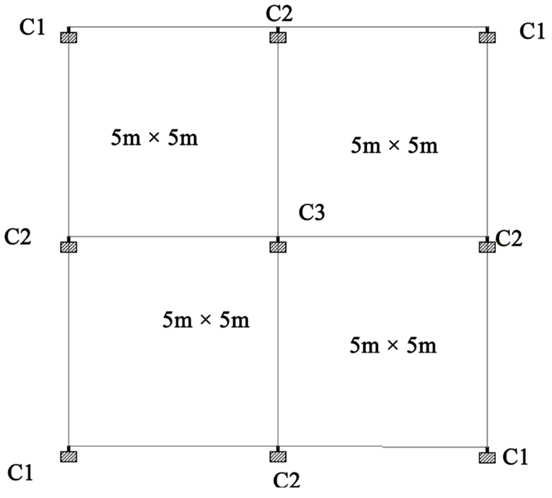


Figure 1. Regular square structure.

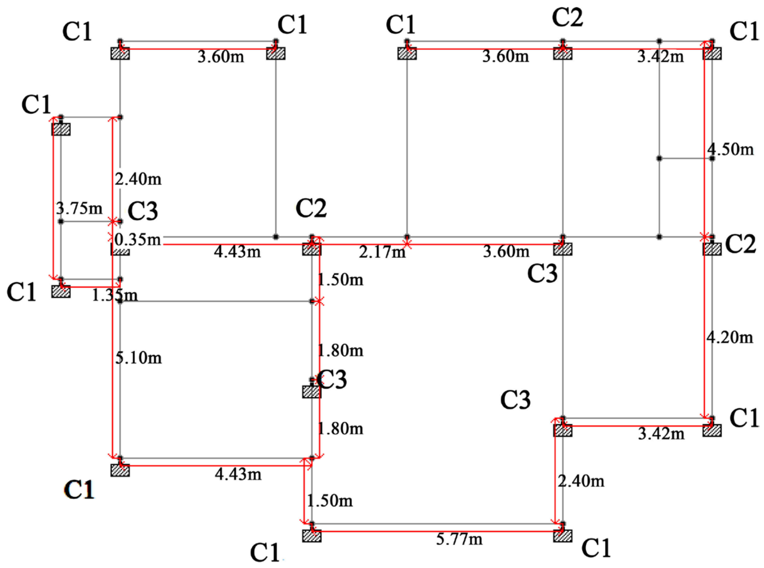


Figure 2. Irregular structure.

Table 1. Specification of models.

Type of Structure	G + 4 Storied Rigid Jointed frame (RC Moment Resisting Frame)
Seismic Zone	V, As per IS 1893 Part I, Z = 0.36
Importance Factor	For All General Buildings = 1
Rock and Hard Soil Site Factor	Hard Soil = 1
Damping Ratio	0.05
Imposed load	2 kN/m^2
Storey Height	3.15 m
Specific Weight of RCC	25 kN/m^3
Specific Weight of Brick Infill	18 kN/m^3
Infill Wall	150 mm
Corner Columns Size C1	230 × 380 mm
Side Columns Size C2	300 × 380 mm
Middle Columns Size C3	300 × 450 mm

Table 2. (a) Square corner column C1, (b) square side column C2, (c) square middle column C3.

(a)

ANGLE	SHEAR+	SHEAR-	My	Mz
0	970.012	22.407	30.192	35.383
10	970.387	25.826	30.063	35.243
20	970.579	28.443	29.726	34.869
30	970.568	30.167	29.002	34.663
40	970.338	30.956	28.069	33.125
50	970.335	30.95	28.042	33.125
60	970.571	30.157	29.004	34.114
70	970.574	28.436	29.726	34.85
80	970.362	25.829	30.079	35.307
90	970.012	22.407	30.192	35.383

(b)

ANGLE	SHEAR+	SHEAR-	My	Mz
0	1800	36.428	57.846	70.539
10	1800	35.861	57.845	70.538
20	1800	34.187	57.844	70.539
30	1800	31.502	57.846	71.822
40	1800	27.906	57.845	70.539
50	1800	27.915	57.845	70.539
60	1800	31.509	57.845	70.539
70	1800	34.178	57.846	70.539
80	1800	35.856	57.846	70.539
90	1800	36.428	57.846	70.539

(c)

ANGLE	SHEAR+	SHEAR-	My	Mz
0	2630	0	34.007	76.776
10	2630	0.013	33.435	77.903
20	2630	0.026	31.826	83.024
30	2630	0.035	32.734	88.858
40	2630	0.038	48.696	90.263
50	2630	0.034	61.298	78.24
60	2630	0.024	64.879	55.101
70	2630	0.012	63.401	41.277
80	2630	0.003	61.659	42.388
90	2630	0	60.996	42.68

Table 3. (a) Irregular corner column C1, (b) irregular side column C2, (c) irregular middle column C3.

(a)

ANGLE	SHEAR+	SHEAR-	My	Mz
0	1490	498.005	113.578	151.874
10	1510	449.561	111.365	150.096
20	1500	462.702	106.863	145.736
30	1480	467.989	100.753	152.748
40	1530	460.181	92.826	146.705
50	1560	437.8	93.146	144.016
60	1570	435.481	102.2	141.085
70	1560	414.88	108.509	147.596
80	1520	373.862	111.489	151.09
90	1490	388.607	113.578	151.874

(b)

ANGLE	SHEAR+	SHEAR-	My	Mz
0	2130	304.889	208.223	212.46
10	2170	294.171	208.431	210.068
20	2200	273.37	202.316	202.152
30	2210	281.698	190.323	188.827

Continued

40	2200	313.914	172.83	170.256
50	2200	375.673	194.204	167.194
60	2180	424.402	175.391	186.58
70	2140	459.777	189.406	200.649
80	2100	482.009	201.666	209.302
90	2130	491.464	208.223	212.46

(c)

ANGLE	SHEAR+	SHEAR-	My	Mz
0	2360	327.852	263.663	310.705
10	2340	337.015	261.208	307.573
20	2320	339.325	250.968	296.569
30	2290	334.766	233.18	278.177
40	2240	322.064	208.368	252.987
50	2280	299.139	204.524	244.832
60	2320	264.573	228.088	272.289
70	2340	269.179	247.877	292.813
80	2360	275.786	259.901	305.753
90	2360	275.524	263.662	310.705

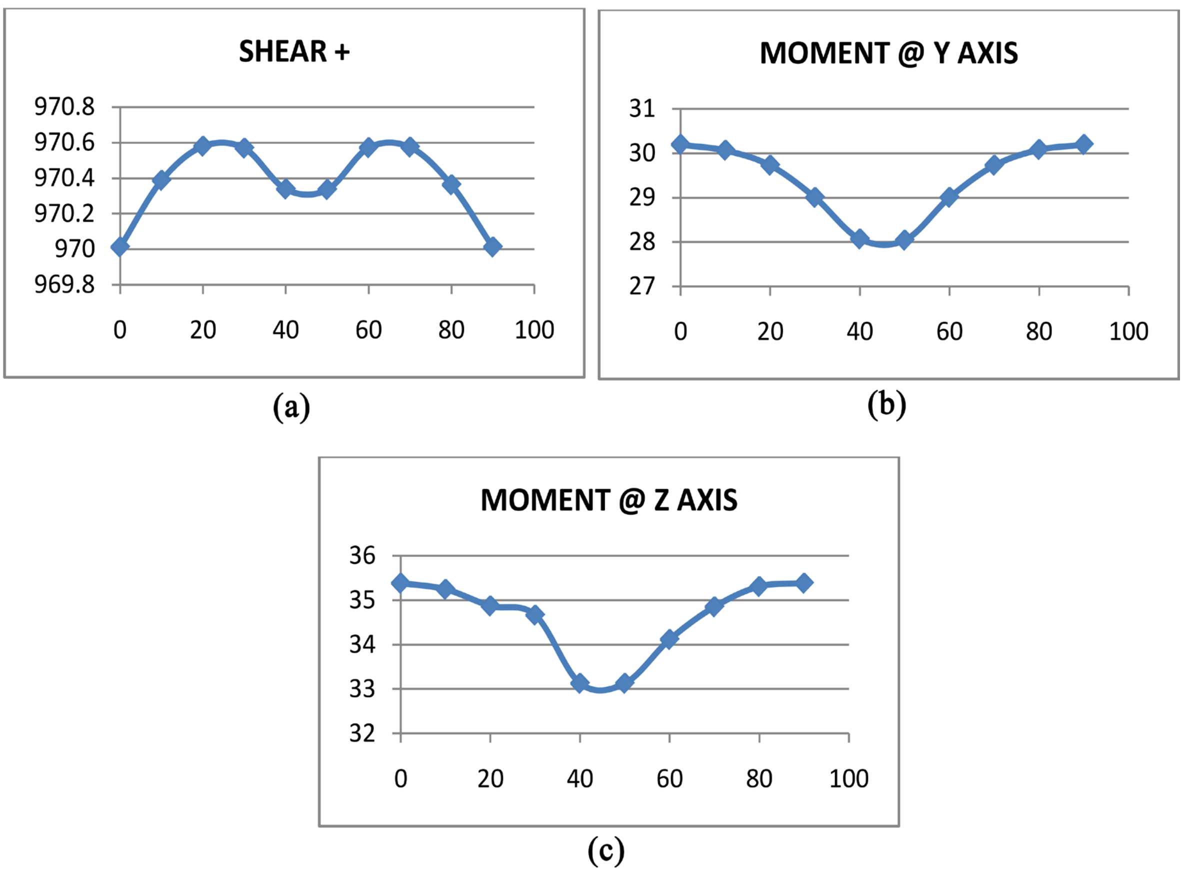


Figure 3. (a) Graph of Fx v/s angle of rotation in degrees, (b) graph of My v/s angle of rotation in degrees, (c) graph of Mz v/s angle of rotation in degrees.

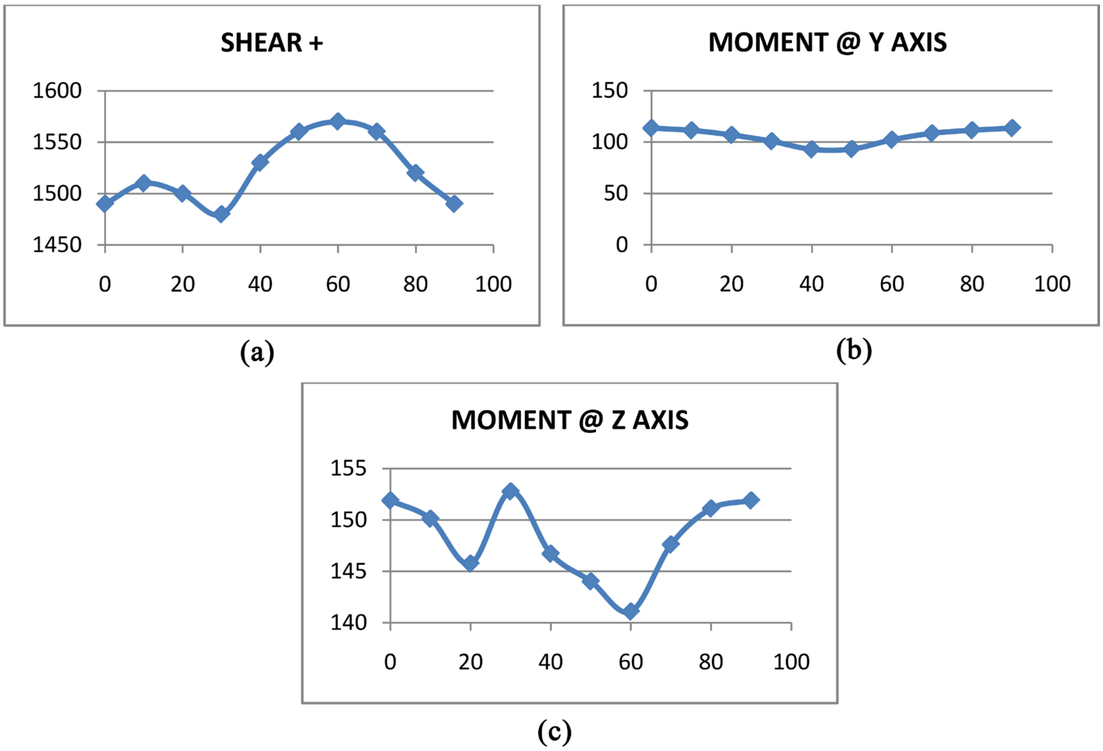


Figure 4. (a) Graph of Fx v/s angle of rotation in degrees, (b) graph of My v/s angle of rotation in degrees, (c) graph of Mz v/s angle of rotation in degrees.

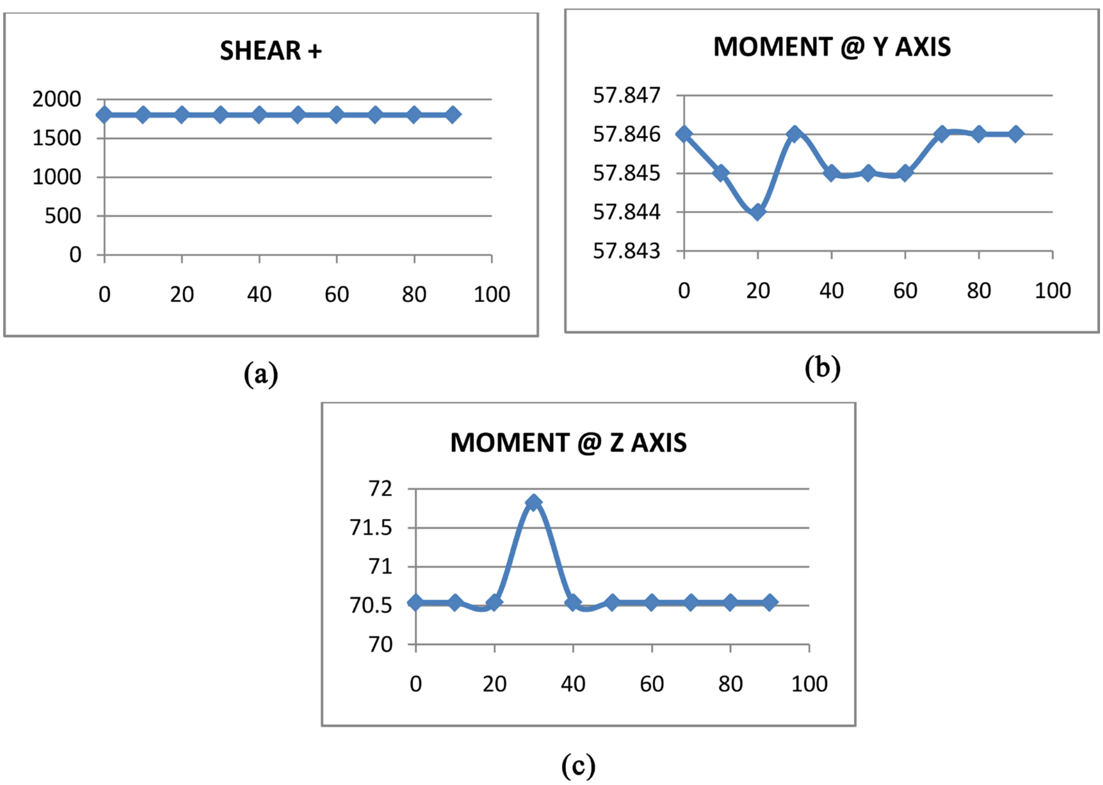


Figure 5. (a) Graph of Fx v/s angle of rotation in degrees, (b) graph of My v/s angle of rotation in degrees, (c) graph of Mz v/s angle of rotation in degrees.

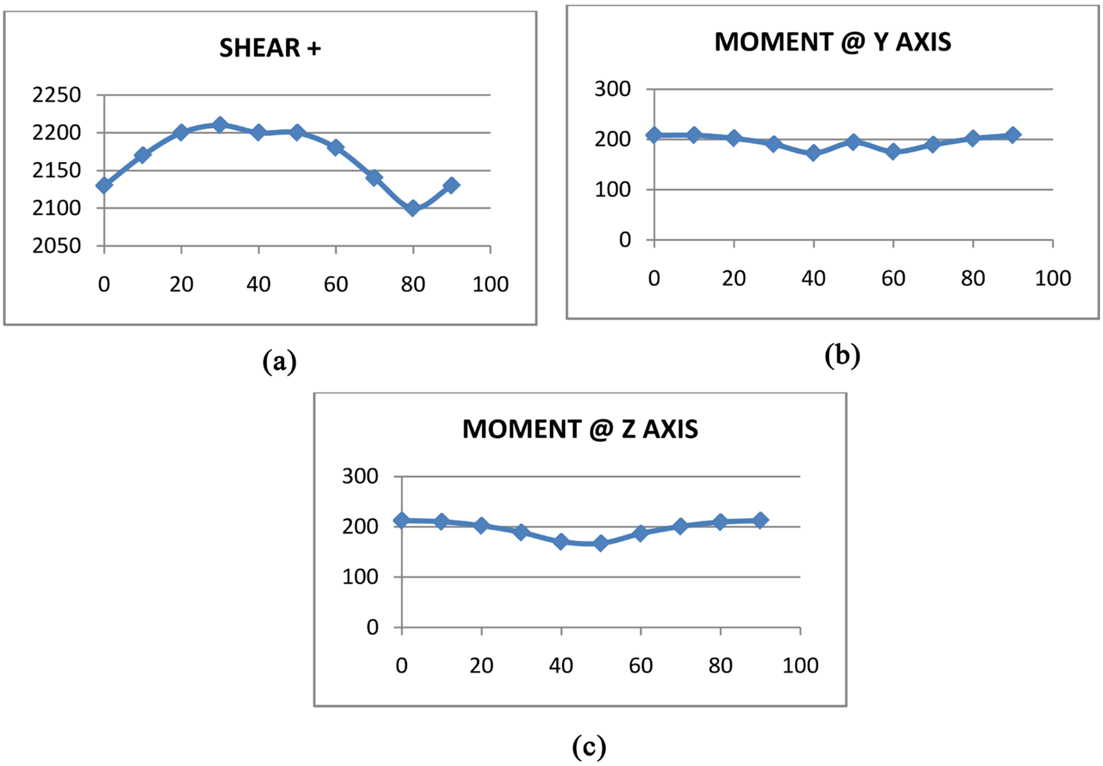


Figure 6. (a) Graph of Fx v/s angle of rotation in degrees, (b) graph of My v/s angle of rotation in degrees, (c) graph of Mz v/s angle of rotation in degrees.

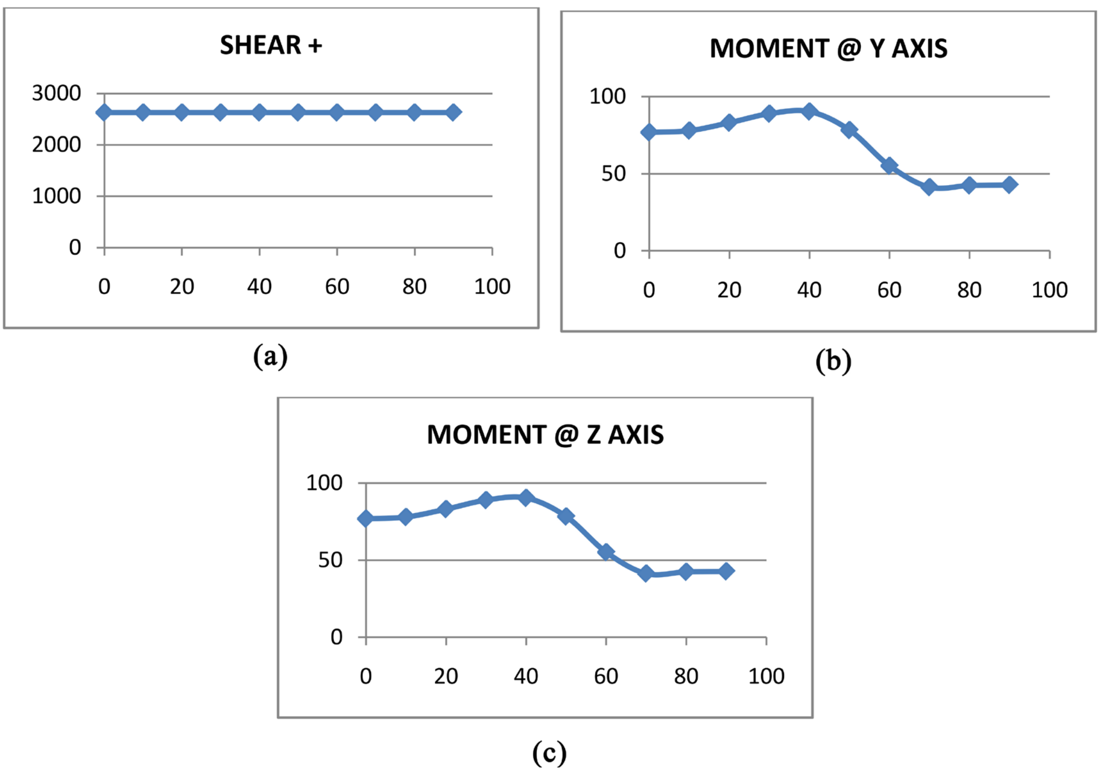
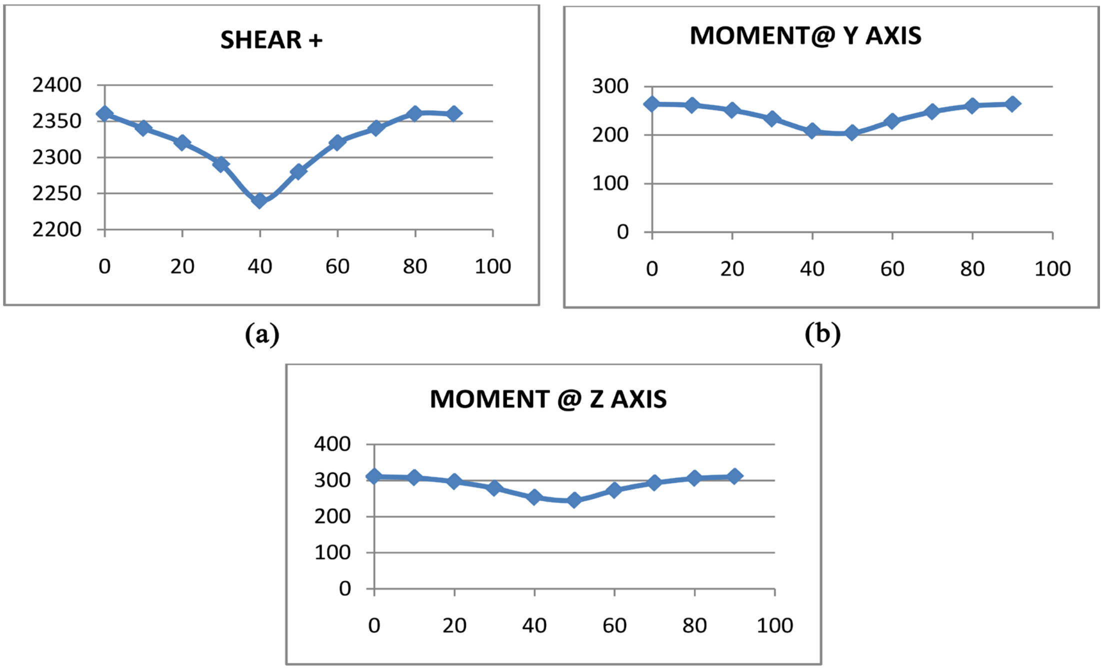


Figure 7. (a) Graph of Fx v/s angle of rotation in degrees, (b) graph of My v/s angle of rotation in degrees, (c) graph of Mz v/s angle of rotation in degrees.



(c)

Figure 8. (a) Graph of Fx v/s angle of rotation in degrees, (b) graph of My v/s angle of rotation in degrees, (c) graph of Mz v/s angle of rotation in degrees.

5. Conclusions

1) For Corner Column C1: The shear force along X direction has a symmetrical parabolic curve about Y axis for regular square structure whereas for irregular structure the curve is un-symmetric as shown in **Figure 3(a)** and **Figure 4(a)** respectively.

2) The graph of Moment about Y axis is symmetrical about Y axis for both the structures. And the graph of Moment about Z axis is unsymmetrical for both the structures as shown in **Figure 3(c)** and **Figure 4(c)** respectively.

3) For Side Column C2: The shear force in X direction is constant throughout for regular square structure whereas for irregular structure the curve is symmetric about Y axis which attains maximum value at 30 degrees as shown in **Figure 5(a)** and **Figure 6(a)** respectively.

4) Similarly the graphs for moments about Y and Z axis can be compared for both the structures.

5) For Middle Column C3: Again the shear along X direction is constant for regular square structure and symmetric parabolic nature for irregular structure.

6) The above conclusions show that structure behaves in different manner for different shape of structure. Thus, the structure should be analyzed for each particular angle and it should be designed for maximum value of shear force and maximum moments.

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