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Dynamics Behaviour of Multi Storeys Framed Structures by of Iterative Method

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***Abstract** -- Dynamics refers to the branch of mechanics that deals with the movement of objects and the forces that drive that movement. Structural analysis which covers the behaviour of structures subjected to dynamic (actions having high acceleration) loading. Dynamic loads include people, wind, waves, traffic, earthquakes, and blasts. Any structure can be subjected to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time history, and the frequency content of the load. One analysis technique for calculating the linear response of structures to dynamic loading is a modal analysis. In modal analysis, we decompose the response of the structure into several vibration modes. A mode is defined by its frequency and shape. Structural engineers call the mode with the shortest frequency (the longest period) the fundamental mode. This paper presents a study on mode shape, inertia force, spring force and deflection of multi storied framed structures by comparison of stodola's and Holzer method. This study involves in examination of theoretical investigations of multi storied framed structures. Overall four storey multi storied framed structures and two methods were analysed & comparison of all the mode shape, inertia force, spring force and deflection at the critical cross-section with same configuration loading by keeping all other parameters constant. The theoretical data are calculated using code IS 1893, IS 4326, IS 13920. The all storey mass and stiffens are analysed under the cantilever condition. The research project aims to provide which method is most accuracy to find the mode shape, spring force deflection and inertia force. The studies reveal that the theoretical investigations Stodola's method is most accuracy compare to the Holzer method. The maximum mode shape, spring force, spring deflection and inertia force is 87.29%, 80 %, 89% and 72% is higher the Stodola's method compare than Holzer method in same configuration.*

Key words: ***mass, stiffness, inertia force, spring deflection, spring force, mode shape***

I. INTRODUCTION

Structural analysis is mainly concerned with finding out the behaviour of a physical structure when subjected to force. This action can be in the form of load due to the weight of things such as people, furniture, wind, snow, etc. or some other kind of excitation such as an earthquake, shaking of the ground due to a blast nearby, etc. In essence all these loads are dynamic, including the self-weight of the structure because at some point in time these loads were not there. The distinction is made between the dynamic and the static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure's natural frequency. If a load is applied sufficiently slowly, the inertia forces (Newton's first law of motion) can be ignored and the analysis can be simplified as static analysis.

An analytical model is proposed to study the nonlinear interactions between beam and cable dynamics in stayed systems. The integro-differential problem, describing the in-plane motion of a simple cable-stayed beam, presents quadratic and cubic nonlinearities both in the cable equation and at the boundary conditions. Mainly studied are the effects of quadratic interactions, appearing at relatively low oscillation amplitude. To this end an analysis of the sensitivity of modal properties to parameter variations, in intervals of technical interest, has evidenced the occurrence of one-to-two and two-to-one internal resonances between global and local modes. The interactions between the resonant modes evidences two different sources of oscillation in cables, illustrated by simple 2dof discrete models [1]. Modal analysis is the study of the dynamic properties of structures under vibrational excitation. Modal analysis is the field of measuring and analysing the dynamic response of structures and or fluids during excitation. This paper examines local parametric vibrations in the stay cables of a cable-stayed bridge. The natural frequencies of the global modes are obtained by using a three-dimensional FE model. The global motions generated by sinusoidal excitations using exciter, a traffic loading, and an earthquake are analyzed by using the modal analysis method or the direct integration method [2].

An analytical and experimental modal analysis has been carried out on the Qingzhou cable-stayed bridge in Fuzhou, China. Its main span of 605 m is currently the longest span among the completed composite-deck cable-stayed bridges in the world. An analytical modal analysis is performed on the developed three-dimensional finite element model starting from the deformed configuration to provide the analytical frequencies and mode shapes [3]. An accurate analysis of the natural frequencies and mode shape of a cable stayed bridge is fundamental to the solution of its dynamic responses due to seismic, wind and traffic loads. in most previous studies, the stay cables have been modelled as single truss elements in conventional finite element analysis. this method is simple but it is inadequate for the accurate dynamic analysis of a cable stayed bridge because it essentially precludes the transverse cable vibrations [4].

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. A proprietary programming language developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python. Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing abilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems. MATLAB is generally programming software as C, unlike C and other programming languages MATLAB is problem-solution kind of software which is much useful to evaluate results instantly. In the present topic use of software is done for calculating Natural Frequencies and Mode shapes of a 20 storey building with basic functions by using MATLAB. The furthur work can be extended for writing the programs of much more complex equations in MATLAB and obtains exact solution. This analysis indicates that the MATLAB can also be used in civil applications and to obtain exact solution with our knowledge [5].

Finite element analysis (FEA) is a computerized method for predicting how a product reacts to real-world forces, vibration, heat, fluid flow, and other physical effects. Finite element analysis shows whether a product will break, wear out, or work the way it was designed.Finite element method (FEM) is a numerical technique based on principle of discretization to find approximate solutions to engineering problems. The information about the natural frequencies for rotating systems can help to avoid system failure by giving the safe operating speed range. In the present work, finite element method has been used to find these natural frequencies for different possible cases of multi-rotor systems. The various mode shapes for several cases are also shown to illustrate the state of the system at natural frequencies. The results obtained have been compared with Holzer's method and Ansys 14 and ansys 14.5 software version to establish the effectiveness of finite element method for such systems [6]. The objective of current dissertation work is to analysis of vibration characteristics of circular cutters with free boundary condition but having different (numbers of cutting teeth, aspect ratio, effect of radial slots, and enlargement of stress concentration holes) is done here. Analysis for circular cutters with inner edge clamped and outer edge free is done here. For same aspect ratio of annular cutter but variable numbers and variable lengths of radial cracks for inner edge clamped and outer edge frees boundary condition [7]. Theoretical modal analysis of beam made with different materials such as aluminium and mild steel. The beams were excited assign impact hammer excitation frequency response functions (FRFS) were obtained using lab view.(Signal Express). The FRFS were processed using signal express to identify the natural frequency and mode safe of aluminium and mild steel beam [8].

II. AIM OF THE STUDY

The research project aims to provide which method is most accuracy to find the mode shape, spring force deflection and inertia force by Stodola's and Holzer method

III .EXPERIMENTAL INVESTIGATION

3.1 STODOLA'S METHOD:

A method of calculating the deflection of a uniform or non uniform beam in free transverse vibration at a specified frequency, as a function of distance along the beam, in which one calculates a sequence of deflection curves each of which is the deflection resulting from the loading corresponding to the previous deflection, and these deflections converge to the solution.

3.1.1 THEORETICAL INVESTIGATIONS OF STODOLA'S METHOD FOR MULTI STORED FRAMED STRUCTURES SHOWN IN TABLE 1 & FIGURE 1

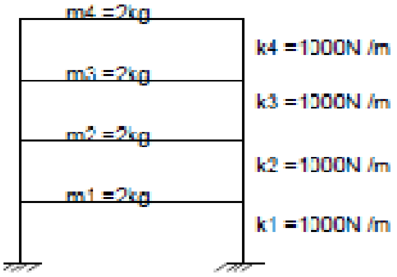

Figure 1 Multi stored framed structures

TABLE 1. THEORETICAL INVESTIGATIONS OF MODE SHAPE, INERTIA FORCE, SPRING FORCE AND SPRING DEFLECTION BY STODOLA'S METHOD

Storey level	First Storey		Second Storey		Third Storey		Fourth Storey	
Description	K1=1000 (N/m)	M1 =2 (kg)	K2=1000 (N/m)	M2 =2 (kg)	K3=1000 (N/m)	M3 =2 (kg)	K4=1000 (N/m)	M4 =2 (kg)
Trial 1								
Deflection (δ) mm		4		3		2		1
Inertia Force ($E= m\delta\omega_n^2$)		$8\omega_n^2$		$6\omega_n^2$		$4\omega_n^2$		ω_n^2
Spring Force (F)	$19\omega_n^2$		$11\omega_n^2$		$5\omega_n^2$		ω_n^2	
Spring Deflection ($\Delta = F/K$)	$0.019\omega_n^2$		$0.011\omega_n^2$		$0.005\omega_n^2$		$0.001\omega_n^2$	
Mode shape (δ_{cal})		1		2.72		7		36
Trial 2								
Deflection (δ) mm		1		2.72		7		36
Inertia Force ($E= m\delta\omega_n^2$)		$2\omega_n^2$		$5.44\omega_n^2$		$14\omega_n^2$		$36\omega_n^2$
Spring Force (F)	$57.44\omega_n^2$		$55.44\omega_n^2$		$50\omega_n^2$		$36\omega_n^2$	
Spring Deflection ($\Delta = F/K$)	$0.057\omega_n^2$		$0.055\omega_n^2$		$0.050\omega_n^2$		$0.036\omega_n^2$	
Mode shape (δ_{cal})		1		2.03		3.24		5.5
Trial 3								
Deflection (δ) mm		1		2.03		3.24		5.5
Inertia Force ($E= m\delta\omega_n^2$)		$2\omega_n^2$		$4.06\omega_n^2$		$6.48\omega_n^2$		$5.5\omega_n^2$
Spring Force (F)	$18.04\omega_n^2$		$16.04\omega_n^2$		$11.98\omega_n^2$		$5.5\omega_n^2$	
Spring Deflection ($\Delta = F/K$)	$0.018\omega_n^2$		$0.016\omega_n^2$		$0.011\omega_n^2$		$0.005\omega_n^2$	
Mode shape (δ_{cal})		1		2.125		4.09		10
Trial 4								
Deflection (δ) mm		1		2.125		4.09		10
Inertia Force ($E= m\delta\omega_n^2$)		$2\omega_n^2$		$4.25\omega_n^2$		$6.1\omega_n^2$		$10\omega_n^2$
Spring Force (F)	$24.43\omega_n^2$		$22.43\omega_n^2$		$18.18\omega_n^2$		$10\omega_n^2$	
Spring Deflection ($\Delta = F/K$)	$0.024\omega_n^2$		$0.022\omega_n^2$		$0.018\omega_n^2$		$0.01\omega_n^2$	
Mode shape (δ_{cal})		1		2.09		3.5		7.4
Trial 5								
Deflection (δ) mm		1		2.09		3.5		7.40
Inertia Force ($E= m\delta\omega_n^2$)		$2\omega_n^2$		$4.18\omega_n^2$		$6.1\omega_n^2$		$7.4\omega_n^2$
Spring Force (F)	$19.75\omega_n^2$		$17.75\omega_n^2$		$13.5\omega_n^2$		$7.7\omega_n^2$	
Spring Deflection ($\Delta = F/K$)	$0.019\omega_n^2$		$0.017\omega_n^2$		$0.013\omega_n^2$		$0.007\omega_n^2$	
Mode shape		1		2.11		3.55		7.41

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3.1.2 Analysis of mode shape for Multi stored framed structures Figure .2

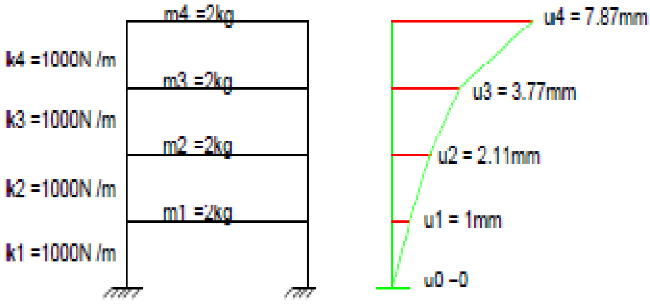

Figure .2 Mode shape diagrams for multi stored framed structures by Stodola's method

3.2 Holzer's method

Holzer's method of finding natural frequency of a multi-degree of freedom system. Holzer's Method. This method is an iterative method and can be used to determine any number of frequencies for a multi DOF of system.

3.2.1 Theoretical investigations of Holzer method for multi stored framed structures shown in Table 2 & Figure 3

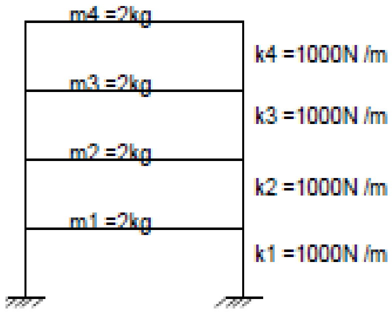

Figure 3 Multi stored framed structures

TABLE 2. THEORETICAL INVESTIGATIONS OF MODE SHAPE, INERTIA FORCE, SPRING FORCE AND SPRING DEFLECTION BY HOLZER METHOD

Storey level	First Storey		Second Storey		Third Storey		Fourth Storey	
Description	K1=1000 (N/m)	M1 =2 (kg)	K2=1000 (N/m)	M2 =2 (kg)	K3=1000 (N/m)	M3 =2 (kg)	K4=1000 (N/m)	M4 =2 (kg)
Natural frequency 15.70 rad / sec								
Inertia Force ($E= m\delta\omega_n^2$)	$0.258\omega_n^2$		$0.5120\omega_n^2$		$1.008\omega_n^2$		$2\ \omega_n^2$	
Spring Force (F)	$3.77\omega_n^2$		$3.512\omega_n^2$		$3.008\omega_n^2$		$2\omega_n^2$	
Spring Deflection ($\Delta = F/K$)	$0.0639\omega_n^2$		$0.127\omega_n^2$		$0.248\omega_n^2$		$0.496\omega_n^2$	
Mode shape	0.129		0.256		0.504		1	

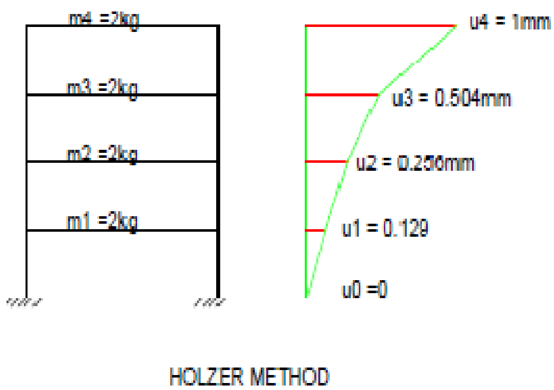

Figure .4 Mode shape diagrams for multi stored framed structures by Holzer method

IV RESULT AND DISCUSSION

Four storied framed structures is analysis and comparison of all the inertia force , spring forces ,spring deflection & inertia forces by Stodola's and Holzer method .in this study the mass ,stiffness , natural frequency is same for all storey level and other parameters is constant for all the storey. The all storey mass and stiffens are analysed under the cantilever condition of structures. The theoretical data are calculated using code IS 1893, IS 4326, IS 13920. The theoretical results of Stodola's method the maximum deviation of mode shape, spring force, spring deflection and inertia force in top storey is 87.29% ,80 %, 89% & 72% , in third storey is the maximum deviation mode shape, spring force, spring deflection and inertia force is 86.66% ,77.77 %, 94.31% & 83.47% , in second storey is the maximum deviation mode shape, spring force, spring deflection and inertia force is 87.86% ,80.15 %, 96.31% and 87.67% , in first storey is the maximum deviation mode shape, spring force, spring deflection and inertia force is 87.86% ,80.85 %, 96.28 % & 87.11% higher the compare than Holzer method in same configuration. In this analyse the final result, the mode shape and spring deflection is no deviation for all storey but inertia force & spring deflection is small deviation for all storey. The results are shown in table 3,4,5,6 & 7and comparison mode shape, spring force, deflection and inertia force given in figure 5,6,7 ,8 & 9

TABLE 3. COMPARISON OF MODE BY STODOLA'S METHOD & HOLZER METHOD

	STODOLO'S METHOD				HOLZER METHOD			
Storey level	First Storey	Second Storey	Third Storey	Fourth Storey	First Storey	Second Storey	Third Storey	Fourth Storey
Mode shape	1	2.11	3.77	7.87	0.129	0.256	0.504	1

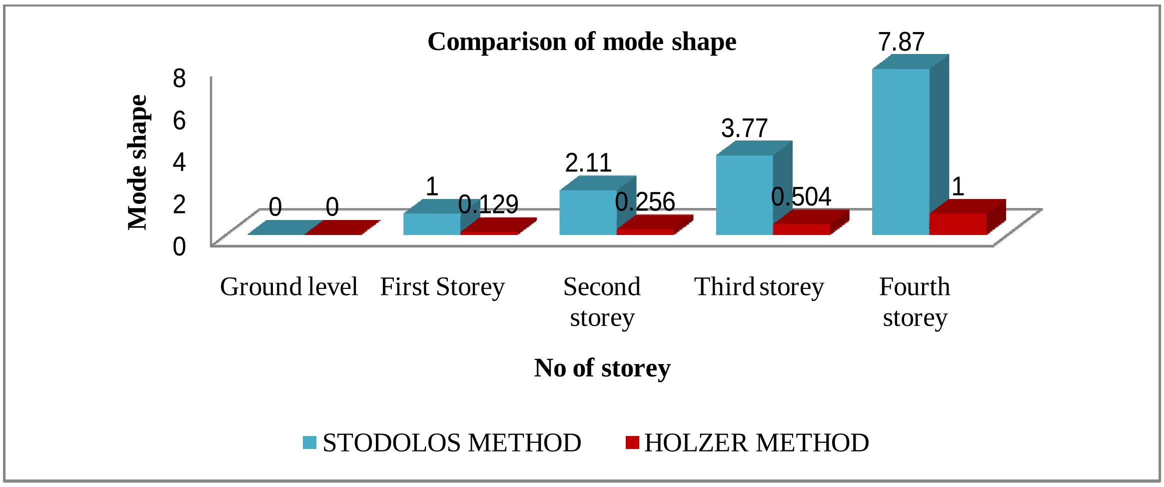

Figure .5 Comparison of mode shape

The mode shape is same deviation for all storeys and average of mode shape is 87 % higher the Stodola's method compare than the Holzer method. Shown in table .3 & figure .5

TABLE 4. COMPARISON OF SPRING FORCE BY STODOLA'S METHOD & HOLZER METHOD

	STODOLO'S METHOD				**HOLZER METHOD**			
Storey level	First Storey	Second Storey	Third Storey	Fourth Storey	First Storey	Second Storey	Third Storey	Fourth Storey
Spring Force	4868.175	4375.19	3327.61	492.75	931.96	868.37	741.21	492.75

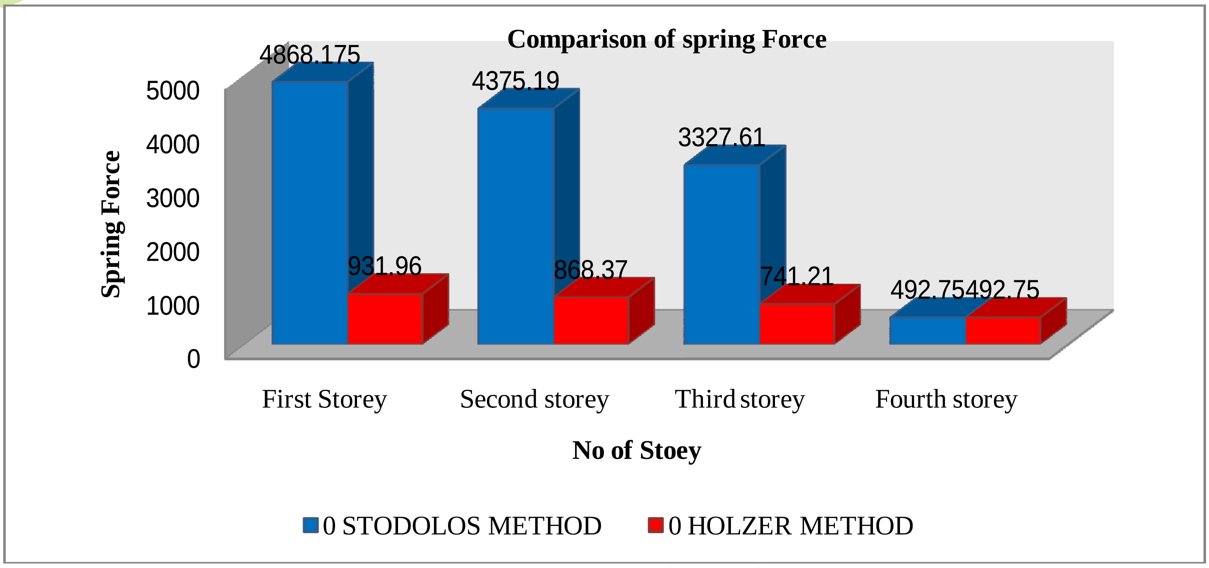

Figure .6 Comparison of spring force

The spring force is same deviation for all storeys and average of mode shape is 80 % higher the Stodola's method compare than the Holzer method. Shown in table .4 & figure .6

TABLE 5. COMPARISON OF SPRING DEFLECTION BY STODOLA'S METHOD & HOLZER METHOD

STODOLO'S METHOD					HOLZER METHOD			
Storey level	First Storey	Second Storey	Third Storey	Fourth Storey	First Storey	Second Storey	Third Storey	Fourth Storey
Spring Deflection	1.72	3.32	4.36	4.85	0.0639	0.122	0.248	0.496

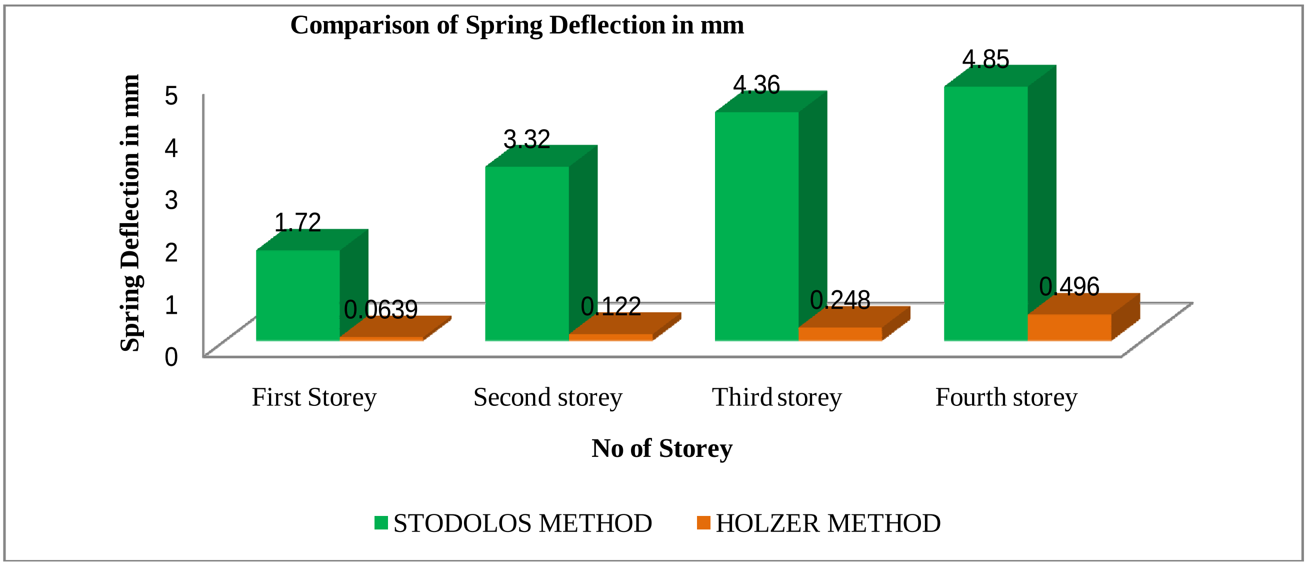

Figure .7 Comparison of Spring Deflection

The spring deflection is small deviation for all storeys and average of mode shape is 93 % higher the Stodola's method compare than the Holzer method. Shown in table .5 & figure .7

TABLE 6. COMPARISON OF INERTIAL BY STODOLA'S METHOD & HOLZER METHOD

STODOLO'S METHOD					HOLZER METHOD			
Storey level	First Storey	Second Storey	Third Storey	Fourth Storey	First Storey	Second Storey	Third Storey	Fourth Storey
Inertia Force	492.98	1030.32	1503.58	1824.029	63.59	127.16	248.46	492.75

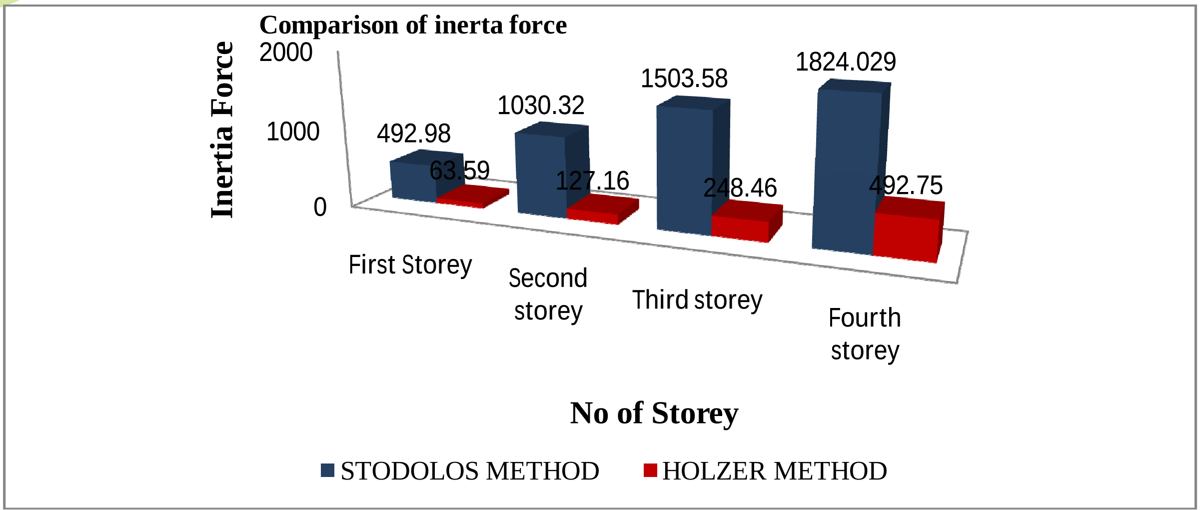

Figure .8 Comparison of inertia force

The inertia force is small deviation for all storeys and average of mode shape is 85 % higher the Stodola's method compare than the Holzer method. Shown in table .6 & figure .8

TABLE 7. COMPARISON DEVIATION OF MODE SHAPE, SPRING FORCE, DEFLECTION AND INERTIA FORCE BY STODOLA'S METHOD & HOLZER METHOD

% OF DEVIATION BETWEEN STODOLA'S METHOD TO HOLZER METHOD				
Storey level	First Storey	Second Storey	Third Storey	Fourth Storey
Inertia Force	87.11	87.67	83.47	72
Spring Force	80.15	80.15	77.77	80
Spring Deflection	96.28	96.31	94.31	89
Mode shape	87.86	87.86	86.66	87.29

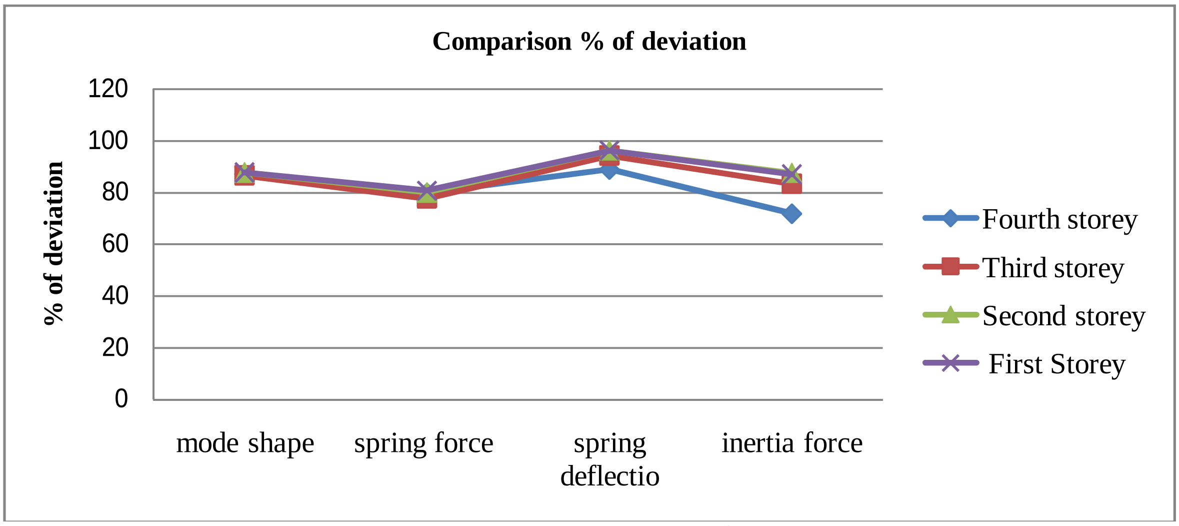

Figure 9.Comparison percentage of deviation

In this analyse the final result, the mode shape and spring deflection is no deviation for all storey but inertia force & spring deflection is small deviation for all storey by **Stodola's method & Holzer method**

V. CONCLUSIONS

- *The theoretical investigation , Stodola's method have higher mode shape, spring force, deflection and inertia force for all storey's compare than the Holzer method.*
- *The conclusions of in this study find the mode shape ,spring deflection, spring force and inertia force by theoretical investigation of Stodola's and Holzer method in same mass ,stiffness and Natural frequency & other parameters are constant for all stores.*

- *The final result and conclusions of theoretical investigation, Stodola's method is most accuracy method to find the mode shape and spring deflection, spring force and inertia force.*
- *The maximum mode shape, spring force, spring deflection and inertia force is 87.29% ,80 %, 89% and 72% is higher the Stodola's method compare than Holzer method in same configuration.*

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