Vibrational Analysis of Framed Structures

Dipanshu khandelwal[1] Prof. Vinay Kumar Singh Chandrakar[2] Dr.P.D Porey[3] Prof. Praveen Singh Tomar[4]
[1]M.Tech Scholar [2]Professor [3]Director [4]Head of Dept.
[1,2,3,4]Department of Civil Engineering
[1,2,4]Patel College of Science and Technology, Indore [3]PGOI Bhopal

Abstract— Generally the stress and deformation analysis of any structure is done by constructing and analyzing a mathematical model of a structure. One such technique is Finite element method (FEM). A frame is subjected to both static and dynamic loading with dead load comprising the static load and the all other time varying loads making up the dynamic load. This project titled " Vibration Analysis of Frames " aims at analyzing the frame both statically and dynamically using the matrix approach of FEM by developing generalized codes in MATLAB. The analysis comprises of the static analysis of frame and the variation of various parameters such as displacement, moment etc with increasing number of storey's as well as dynamic analysis wherein a code is developed to find the natural frequency of the structure along with the various other parameters. A structure is always vibrating under dynamic loading such as wind etc and if the vibrating frequency equals the natural frequency of the structure, resonance might take place. It is thus necessary to analyze all these aspects of a structure first which we aim with our study.

Key words: Vibrational, Framed Structures

I. Introduction

The ever increasing population and limited land resources have made our present day population heavily dependent on the use of multi-storied structures and that too effectively. In order for the structure to be made efficient, it is the role of the civil engineer to analyze it properly and comprehensively. The structure should be stable and serviceable in every situation and thus we need to analyze all the parameters relating to the structure and its failure conditions.

Structural design can be classified into three epochs- classical, modern and post modern. The classical era of structural design dealt with static loading, the modern era added to it the dynamic spectrum of analysis, while the post modern era combines the and necessitates the satisfaction of both static and dynamic requirements in the presence of specified range. But the aim of all three is same- to increase the survivability of any building.

impact stacking parameters. The impact stacking on a structure brought about by a high-dangerous explosion is based upon a few factors.

II. Objective of Paper

Analyzing the frame both statically and dynamically using the matrix approach of FEM by developing generalized codes in MATLAB.

To find the natural frequency of the structure along with the various other parameters..

To compare the static and dynamic analysis

III. Theoretical and Finite Element Formulation

The finite element method (FEM), which is sometimes also referred as finite element analysis (FEA), is a computational technique which is used to obtain the solutions of various boundary value problems in engineering, approximately. Boundary value problems are sometimes also referred to as field value problems. It can be said to be a mathematical problem wherein one or more dependent variables must satisfy a differential equation everywhere within the domain of independent variables and also satisfy certain specific.

A. *Static Analysis of Frame:-*

A plane frame can be defined as connection of bars or framework of bars which are connected in a same plane rigidly. A frame experiences reactions at various supports along with deflection, when it is subjected to a load or moment at various nodes. As the effect of the deflections induced, internal forces are induced in the frame bars. The analysis of frame comprises of determination of all these values.

B. *Use of Matrices*

While solving the problems we have observed that many simultaneous equations are formed to express the equilibrium and force displacement, which are solved with the help of series of substitution. This can be done more conveniently with the help of matrices and it has a distinct advantage in MATLAB environment as it can be expressed easily using arrays.

For the analysis of frame, the general notation used is,

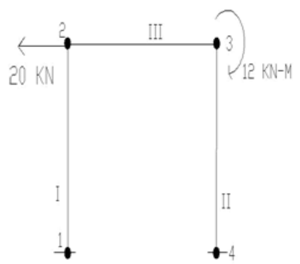
$$[F]=[K][U]$$

Where, [F] is the force matrix
is the stiffness matrix and

IV. Results and Discussion

4.1 Static analysis

4.1.1 Problem Statement (Ref 8)



Given data:

Modulus of Elasticity, E: 210 GPa

Moment of Inertia, I : 5 x10 $^{(-5)}$ m^4

Area of cross-section, A: 2 x10$^{(-2)}$ m^2

Length of the column: 3 m

Length of the beam: 4 m

(Figure 4)

Case 1: Intermediate Nodes in beam and column= 0 (Ref 8)

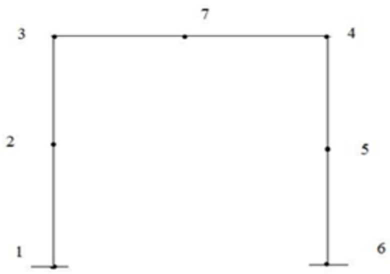
Nodal Connectivity table:

(Table 1)

Element	Node 1	Node 2
1	1	2
2	3	4
3	2	3

Displacement at nodes (in m):

Case 2: Number of intermediate nodes in beam and column=1



(Figure 5)

Nodal Connectivity Table:

Nodal Connectivity Table:

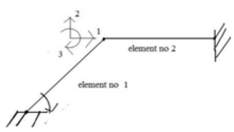
(Table 3)

Element Number	Node 1	Node 2
1	1	2
2	2	3
3	4	5
4	5	6
5	3	7
6	7	4

4.2 Dynamic analysis

4.2.1 PROBLEM STATEMENT (Ref. 3)

Consider a plane frame having two prismatic beam elements and three degrees of freedom as indicated in the following figure. using the consistent mass formulation find the three natural frequencies.

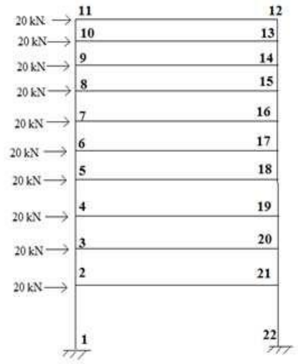


(Figure 18)

Given Data:
$A = 6\ in^2$
$I = 100\ in^4$
$M = 4.20\ lb^2/in^2$
$E = 10^7 lb/in^2$
$L = 100\ in$

Node no	1	2	3	4
X	0(0)	-0.0038(-0.0038)	-0.0038(-0.0038)	0(0)
Y	0(0)	0(0)	0(0)	0(0)
	0(0)	0.0008(0.0008)	0.0014(0.0014)	0(0)

4.1.2 PROBLEM STATEMENT



(Figure 7)

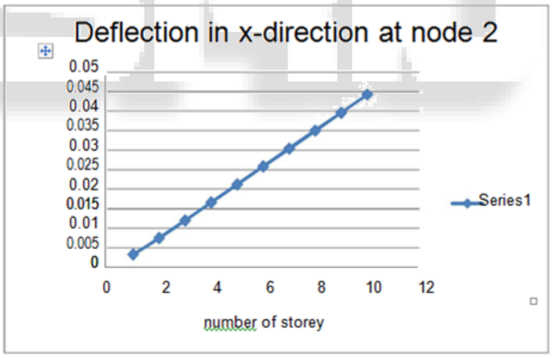
Generalize the program for n storeyed frame and then find the variation in displacement at node 2, 3, 4, 5, 6 with the variation in increasing number of storey's say up to 10.

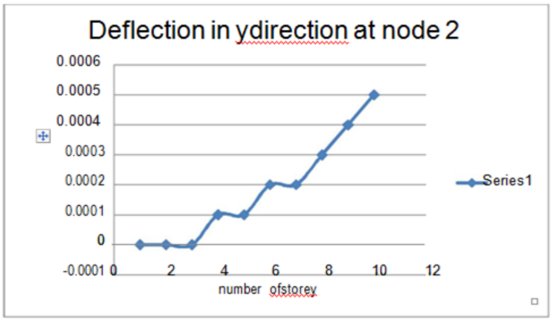
Results:

For node 2

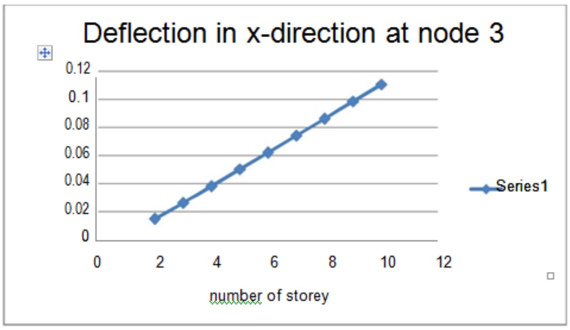
(Table 7)

No. of storey	x-displacement(m)	y-displacement(m)
1	0.0033	0
2	0.0075	0
3	0.012	0
4	0.0166	0.0001
5	0.0212	0.0001
6	0.0258	0.0002
7	0.0304	0.0002
8	0.035	0.0003
9	0.0396	0.0004
10	0.0442	0.0005





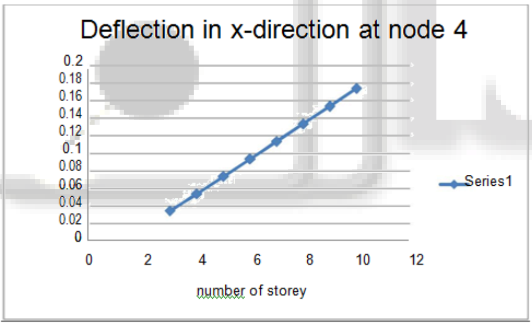
No. of storey	x-displacement(m)	y-displacement(m)
2	0.0147	0
3	0.0261	0.0001
4	0.038	0.0001
5	0.05	0.0002
6	0.062	0.0003
7	0.0741	0.0004
8	0.0862	0.0006
9	0.0984	0.0008
10	0.1105	0.0009



For node 4:

(Table 9)

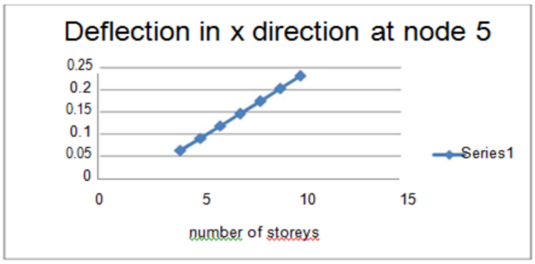
No. of storey	x-displacement(m)	y-displacement(m)
3	0.0344	0.0001
4	0.0536	0.0002
5	0.0735	0.0003
6	0.0935	0.0004
7	0.1135	0.0006
8	0.1337	0.0008
9	0.1539	0.001
10	0.1742	0.0013



For node 5

(Table 10)

No. of storey	x-displacement(m)	y-displacement(m)
4	0.0623	0.0002
5	0.0896	0.0003
6	0.1176	0.0005
7	0.1458	0.0007
8	0.1741	0.0009
9	0.2026	0.0012
10	0.2312	0.0016



Percentage change in sway with respect to a single storey frame by increasing the number of storeys:

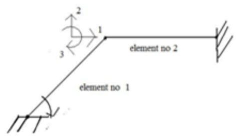
(Table 12)

Number of storey	x-displacement or sway(m)	Percentage change in sway
1	0.0033	0
2	0.0147	345.4545455
3	0.0344	942.4242424
4	0.0623	1787.878788
5	0.0985	2884.848485
6	0.1433	4242.424242
7	0.1969	5866.666667
8	0.2596	7766.666667
9	0.3318	9954.545455
10	0.4141	12448.48485

4.2 Dynamic analysis

4.2.1 PROBLEM STATEMENT (Ref. 3)

Consider a plane frame having two prismatic beam elements and three degrees of freedom as indicated in the following figure. using the consistent mass formulation find the three natural frequencies.



(Figure 18)

Given Data:
A=6 in^2
I=100 in^4
M=4.20 lb^2/in^2
E=10^7 lb/in^2
L=100 in

Mode Number	Natural Frequency(rad/sec)				
	Natural frequency for 1storey frame(n=1)	Natural frequency for 2 storey frame(n=2)	Natural frequency for 3 storey frame(n=3)	Natural frequency for 4 storey frame(n=4)	Natural frequency for storey frame(n=5)
1	2.5656	1.1905	0.7513	0.5453	0.4270
2	9.5564	4.0236	2.5327	1.7911	1.3727
3	22.7890	8.2212	4.6938	3.3724	2.5422
4	69.8116	12.6355	7.9128	5.0498	3.9187
5	74.5805	17.3866	10.6588	7.8052	5.2495

From the above table, it is concluded that with increase in number of storey natural frequency of a frame decrease.

V. CONCLUSION

A general formulation for static analysis of a single storey n bay frame was established and the same used to study the sway characteristics of a frame with increase in number of storeys. It was found that the deflection at any node increases with the increase in number of storey. Also the sway or deflection of the topmost node increases steeply with increase in number of storeys.

A general formulation for dynamic analysis of single bay n storeyed frames was established and a code developed in MATLAB environment showing that the natural modal frequencies decrease as the numbers of storey's are increased.

VI. FUTURE SCOPE OF STUDY

Both the static and dynamic formulations can be extended to n bay frames.

REFERENCES

[1] K. N. V. Prasada Rao, K. Seetharamulu, and S. Krishnamoorthy, " FRAMES WITH STAGGERED PANELS: EXPERIMENTAL STUDY" , Journal of Structural Engineering, VOL 110, No. 5, Page no: 1134-1148, 1984.
[2] Maison Bruce F. and Neuss Carl F., "DYNAMIC ANALYSIS OF A FORTY-FOUR STORY BUILDING", Journal of Structural Enginee ring, Vol. 111, No. 7, Page No:1559-1572,July, 1985.
[3] Paz Mario, Structural dynamics, CBS publishers, 1987
[4] Krishnamoorthy S, Finite element analysis, TMH Publications, 1987
[5] Maison Bruce F. and Ventura Carlos E., "DYNAMIC ANALYSIS OF THIRTEEN-STORY BUILDING", Journal of Structural Eng ineering, Vol. 117, No. 12, Page no:3783-3803,1991.
[6] Hartley Gilbert and Abdel-Akher Ahmed, "ANALYSIS OF BUILDING FRAMES" Journal of Structural Engineering", Vol. 119, No. 2 , Page no:468-483, 1993.
[7] Chopra, Anil k., Dynamics of structures, Prentice Hall, 1995.
[8] Awkar J. C. and Lui E.M, " Seismic analysis and response of multistory semirigid frames", Journal of Engineering Structure s, Volume 21, Issue 5, Page no:425-442,1997.
[9] Kattan P.I., MATLAB guide to finite elements, springer, 2002
[10] Sekulovic Miodrag, Salatic Ratko and Nefovska Marija, "Dynamic analysis of steel frames with flexible connections", Journal of computer and structures, Volume 80, Issue 11, Page no :935-955, Volume 80, 2002
[11] Wilson E.L "Three dimensional Static and Dynamic analysis of structures-A physical approach with emphasis on 12.Fall H.G, "Direct Stiffness Method For 2D Frames-Theory of structure", 2006.
[12] Vasilopoulosa A.A and Beskos D.E., " Seismic design of plane steel frames usingadvanced methods of analysis", Soil Dynamics and Earthquake Engineering Volume 26, Issue 12, December 2006, Pages 1077-1100.
[13] Brodericka B.M., Elghazouli A.Y. and Goggins J, " Earthquake testing and response analysis of concentrically-braced sub-frames", Journal of Constructional Steel Research ,Volume 64, Issue 9, Page no: 997-1007,2008.
[14] Ozyiğit H. Alper, "LINEAR VIBRATIONS OF FRAMES CARRYING A CONCENTRATED MASS", Mathematical and Computational Applications, Vol. 14, No. 3, pp. 197-206, 2009.
[15] Jyoti Prakash Samal " Free Vibrations of Framed Structures with Inclined Members" 2012.
[16] Arshad Mehmood "USING FINITE ELEMENT METHOD VIBRATION ANALYSIS OF FRAME STRUCTURE SUBJECTED TO MOVING LOADS",IJME Vol 4 No.1 "January 2015".