OPEN ACCESS

International
Journal
Of Modern Engineering Research (IJMER)

Investigation of Critical Angle of Seismic Incidence for The Analysis of RCC Frames by Time History Method of Dynamic Analysis Using STAAD PRO

[1]Ramchandani Jaya Rajkumar, [2]Mangulkar Madhuri N
[1] *P.G Student, Department of Civil Engineering, J.N.E.C, Aurangabad(M.S), India*
[2]*Asst. Professor, Department of Civil Engineering, J.N.E.C, Aurangabad (M.S), India*

ABSTRACT:- It is really a greatest challenge for Structural Engineers to construct a structure resistant to seismic forces. The approach to the design of Multi-storey building should be based mainly on lateral stability and deformation in static as well as dynamic analysis, because as per Bureau of Indian standard actual forces are much higher than design forces during an earthquake. The aim of present study is to investigate the critical angle of seismic incidence for analysis of RCC frames. In this paper 4-storey reinforced concrete building with moment resisting frame have been analysed by the time history dynamic method of analysis using STAAD PRO. A set of values from 0 to 90 degrees with an increment of 10 degrees, have been used for angle of excitation of seismic force. Buildings' columns have been divided into three main categories, including corner, side, and internal columns and column forces have been investigated in all cases. Also results are compared in case of different shapes of buildings.
The structure gets its maximum value of column forces with a specific angle of excitation of seismic force which is different from column to column as well as for different shapes of building.

Keywords:-Angle of Excitation, Time History Dynamic Method, B.I.S Provisions, Column forces, STAAD PRO.

I. INTRODUCTION

In almost all seismic design codes consideration of the simultaneous effect of two horizontal components of earthquake excitation is taken into account as per Bureau of Indian standard. The design lateral force shall be considered in each of two orthogonal horizontal directions of the structure.

For structures which have the lateral force resisting elements in the two orthogonal directions, the design lateral force shall be considered along one direction at a time, and not in both directions simultaneously.

It is known that for most world tectonic regions the ground motion can act along any horizontal direction, therefore, this implies the existence of a possible different directionof seismic incidence that would lead to an increase of structural response.Critical angles are earthquake incidence angles, producing critical responses.

In this study, a four storey reinforced concrete building with moment resisting frame, of different shapes i.e., square, rectangular, L shaped, T shaped and Irregular structures are analysed by Time history method of Dynamic analysis of Earthquake.A set of values from 0 to 90 degrees, with an increment of 10 degrees has 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.

1.1 DETAILS OF EARTHQUAKE

The 1967 Koynanagar earthquake occurred near Koynanagar town in Maharashtra, India on 11 December. The 6.5 magnitude shock hit near the site of Koyna dam and claimed at least 180 lives and injured over 1,500. More than 80% of the houses were damaged in Koyna Nagar Township, but it didn't cause any major damage to the dam except some cracks which were quickly repaired. There have been several earthquakes of smaller magnitude there since 1967. The deadly earthquake caused a 10–15 cm (3.9–5.9 in) fissure in the ground which spread over a length of 25 kilometers (16 mi).

Some geologists believe that the earthquake was due to reservoir-triggered seismic activity. Senior project officials have repeatedly denied this conclusion.

Date of Earthquake: 11th December 1967
Magnitude: 6.5
Epicenter: 17^{o}24'N 73^{o}46'E

Areas Affected: India
Casualties: 180

1. PARAMETRIC DETAILS OF MODEL

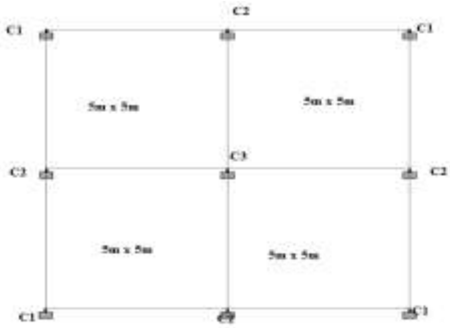

Figure No.1: Square Structure

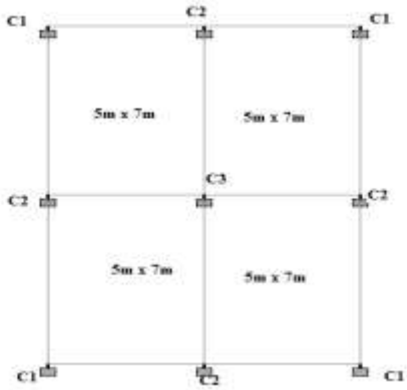

Figure No.2: Rectangular Structure

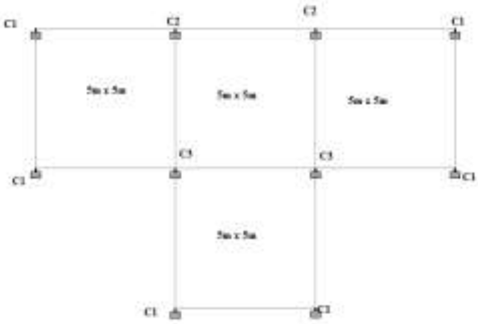

Figure No.3: T Structure

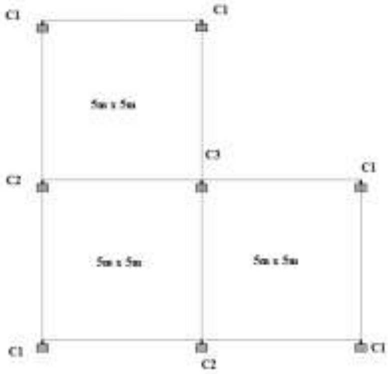

Figure No.4: L Structure

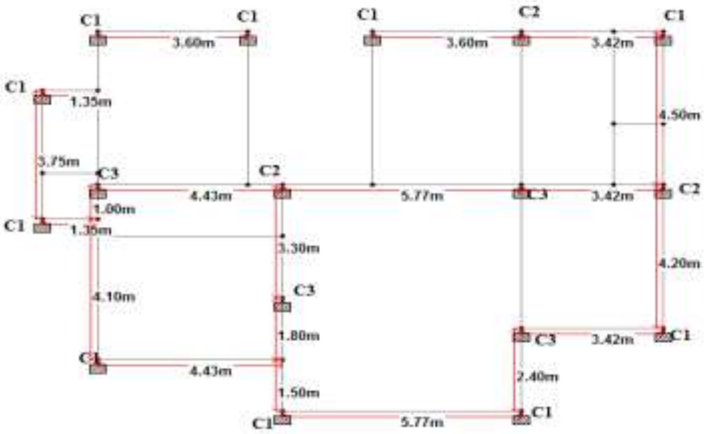

Figure No.5: Irregular Structure

The position of different types of columns i.e. Corner, Side and Middle, C1, C2, C3 respectively for different shapes of model is shown in figure 1, 2, 3, 4 and 5. And table 1 represents all the basic specification required for the analysis of the structure.

Table No. 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	3.15m
Specific weight of RCC	25 kN/m^3
Specific weight of brick Infill	18 kN/m^3
Infill wall	150mm
Corner Columns size	230 x 380 mm
Side Columns size	300 x 380 mm
Middle Columns size	300 450 mm

II. METHODOLOGY

The present study undertaken deals with time history method of dynamic analysis. Time history records of the koyna earthquake which took place in 1967 has been used for the present study. Time history is available only for X direction, so 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.

III. RESULTS AND DISCUSSION

Table No. 2 represents the percentage of variation of axial force of column for various cases with respect to the base case

Table No. 2: Critical Angles for Axial force, Moment in Y and Z direction in Column in various cases

Building Shape	Column Category	Critical Angle (Degrees)		
		Fx	**My**	**Mz**
Square	Corner	28	90	1
	Side	0	90	0
	Middle	47	90	0
Rectangular	Corner	2	90	1
	Side	0	90	0
	Middle	0	90	0
T	Corner	24	18	16
	Side	90	90	0

	Middle	27	31	4
L	Corner	0	80	0
	Side	0	92	0
	Middle	0	85	0
Irregular	Corner	106	90	0
	Side	3	112	2
	Middle	0	106	2

When we design the columns of a particular structure only three things are considered i.e., Shear Force (Fx), Moment about Y axis (My) and Moment about Z axis (Mz). So in order to design we shall use maximum values of these three. While analyzing the different shapes of building by STAAD Pro we come to a conclusion that for different shapes there are different critical angles of seismic incidence, even for same structure but for maximum values of Shear Force (Fx), Moment about Y axis (My) and Moment about Z axis (Mz) there is different angle of incidence which are represented in Table No. 2.

Table No. 3: Variation of Moments in Columns

Building shape	Column Category	Critical Angle (degrees)		Moments in kN-m (for 0 degrees)		Moments in kN-m for critical angle		Variation Percent %	
		My	Mz	My kN-m	Mz kN-m	My kN-m	Mz kN-m	My	Mz
Square	Corner	90	1	16.529	38.317	48.867	38.319	66.176	0
	Side	90	0	38.735	67.081	48.867	67.081	20.734	0
	Middle	90	0	0.271	85.569	48.867	85.569	99.445	0
Rectangular	Corner	90	1	44.636	48.165	63.485	48.169	29.691	0.001
	Side	90	0	95.178	71.277	114.590	71.277	16.940	0
	Middle	90	0	0.004	70.421	62.369	70.421	0.006413	0
T	Corner	18	16	22.566	57.626	30.910	58.507	99.993	1.504
	Side	90	0	38.995	57.565	53.786	57.565	27.499	0
	Middle	91	4	11.624	82.225	48.920	82.530	76.239	0.37
L	Corner	80	0	21.504	55.231	37.533	55.231	42.707	0
	Side	92	0	31.504	73.704	55.538	73.704	57.257	0
	Middle	85	0	17.869	83.772	48.171	83.772	62.906	0
Irregular	Corner	90	0	25.529	59.910	40.667	59.910	57.388	0
	Side	112	2	31.312	51.407	62.570	51.455	3.863	0.094
	Middle	106	2	27.417	81.745	71.142	81.815	61.462	0.086

It is seen in Table No. 3 that maximum bending moment in the entire columns was obtained by rotating the structure at different angles. It is observed from above table that variation percent of My is different for different shapes i.e. for corner column of square shape it is 66.176% where as for side column it is 20.734% and for middle column it is 99.445%. Similarly there are different variation percentages not only for different structures but also for different types of columns such corner, side and middle

Table No. 4: Variation of Shear Force in Columns

Building shape	Column Category	Critical Angle (degrees)	Shear Force in kN (for 0 degrees)	Shear Force in kN (for critical angle)	Variation Percent (%)
		Fx			
Square	Corner	28	706.689	715.785	1.271
	Side	0	1300	1300	0
	Middle	47	1750	1750	0
Rectangular	Corner	2	913.834	913.863	0.003
	Side	0	1690	1690	0
	Middle	0	2330	2330	0
T	Corner	24	829.710	838.718	1.074
	Side	90	1190	1260	5.556
	Middle	27	1750	1760	0.568

L	Corner	0	801.920	801.920	0
	Side	0	1310	1310	0
	Middle	0	1670	1670	0
Irregular	Corner	106	716.763	822.444	12.850
	Side	3	1380	1390	0.719
	Middle	0	1540	1540	0

It is seen from Table No. 4 that maximum shearforce in the entire columns is obtained by rotating the structure at different angles. It is observed that for some of the columns the maximum shear force is obtained at zero degree as per the clause of IS 1893. But for some columns maximum axial force is obtained at different angle which is mentioned in table.

IV. CONCLUSION

- The critical values of bending moments and shear forces are obtained by rotating the complete structure with the interval of 10 degrees.
- There is no unique specific angle of incidence for each structure which increases the value of internal forces of all structural members together; each member gets its maximum value of internal force by specific angle of structure.
- For different shapes of structure, there is a different angle at which the members attain maximum values.
- The columns are divided in three main categories i.e. corner, side and middle for all these types of columns there are different angles at which they attain maximum value which are represented in Table 2, 3 and 4.
- Thus while designing a structure each and every component shall be analysed at each particular angle and then the structure should be designed for maximum value.

ACKNOWLEDGEMENTS

The authors wish to thank the Management, Principal, Head of Civil Department and Staff of Jawaharlal Nehru Engineering College and Authorities of Dr. BabasahebAmbedkarMarathwada University and Mr. Kareem M Pathan for their support.

REFERENCES

[1]. Fernández-Dávila, I., Cominetti, S., and Cruz, E.F. (2000). “Considering the Bi-Directional Effects and the Seismic Angle Variations in Building Design”. 12th World Conference on Earthquake Engineering, E.Q.C., Auckland, paper 0435.

[2]. Smeby, W. And DerKiureghian, A. (1985). “Modal Combination Rules for Multicomponent Earthquake Excitation”. Earthquake Engineering and Structural Dynamics, 13, 1-12.

[3]. MahmoodHosseini and Ali Salemi “Studying the effect of earthquake excitation angle on the internal forces of steel building’s elements by using non-linear time history analyses” The 14thWorld Conference on Earthquake Engineering October 12-17, 2008, Beijing China.

[4]. FaramarzKhoshnoudian and Mehdi Poursha “Responses of three dimensional buildings under bi-directional and unidirectional seismic excitations” 13th World conference on Earthquake Engineering, Vancouver, B.C., Canada August 1-6, 2004 Paper No. 55.

[5]. Lopez, Oscar A. And Torres, R. (Sept. 1997). The critical angle of seismic incidence and the maximum structural response, Earthquake Engineering & Structural Dynamics, Vol. 26, no. 9, pp. 881-894

[6]. Victor I. Fernandez-Devila 1 and Ernesto F. Curz “ Study of the effect of in-plan asymmetry in multi-story buildings subjected to Uni and bidirectional seismic motions” 13thWorld conference on Earthquake Engineering, Vancouver B.C., Canada August 1-6,2004 Paper No. 1042.

[7]. Duggal S K (2010), “Earthquake Resistance Design of Structure”, Fourth Edition, Oxford University Press, New Delhi.

[8]. Sohel Ahmed Quadri, MangulkarMadhuri N, “Investigation of critical angle of incidence for the analysis of RCC frames”, International Journal of Advances in Science Engineering and Technology, ISSN 2321-9009, Volume-2, Issue-3, July 2014

[9]. Sohel Ahmed Quadri, MangulkarMadhuri N, “Investigation of critical direction of seismic force for the analysis of RCC frames”, International Journal of Civil Engineering and Technology (IJCIET), ISSN 0976-6308, Volume 5, Issue 6, Hune 2014, PP-10-15.

[10]. IS: 1893 (Part 1), 2002, “Criteria for Earthquake Resistant Design of Structures- General Provisions and Buildings”, Bureau of Indian Standards, New Delhi.