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Impact of Earthquake Incident Angles on Displacement in Un-Symmetrical Buildings

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Abstract: Seismic performances of building frames are greatly influenced by shape (plan geometry of structure). The more realistic seismic performance can be studied by applying the real life Earthquake forces i.e. Time Histories of various Earthquakes. In the present study an attempt is made to evaluate performance of structure of L shape, Plus shape and Square shape building frames of G+5. The El Centro (1940) time history is used to study the variation in the displacement. The performance of building changes at various incident angles of earthquake forces. So the study is carried on various unsymmetrical building frames at various incident angles 0^0, 30^0 and 60^0.
Keywords: Seismic Response, Time History Analysis, Incident Angle

I. INTRODUCTION

India is one of the most disaster prone country, unsafe to almost all natural and manmade disasters. About 85% area is unsafe to one or multiple disasters and about 57% area is in high seismic zone including the capital of country. Seismic risk in the country has been increasing rapidly in recent years.

India has a number of world's greatest earthquakes in the last century. In north eastern region of India the great earthquakes are observed in symmetry of the building both in elevation and plan which plays important role in the seismic performance. In the event of real earthquake, the forces hit the structure in various directions and depending upon the stiffness of the structure in that direction the behaviour depends.

However the realistic simulation of earthquake is complex. Therefore there is a scope to study on various unsymmetrical structures at various incident angles.

The multi-storey structure generally fails due to seismic forces at the location where there is a weakness. The presence of irregularities in mass, stiffness and strength contribute to those weaknesses. Excess mass on upper floors has a more unfavourable effect than those at lower floors.

The collapse of structure is due to reduction in ductility of vertical load resisting element and increase in inertial force. Hence there is need to study effect on building for various time history for unsymmetrical building. Hence, the real earthquake force simulation is really difficult as it cannot be predicted.

Seismic forces can act on building from any direction. Thus seismic performance of a building depends on angle of incidence of earthquake forces. In the present study the incident angle 0^0, 30^0 and 60^0 is considered.

II. OBJECTIVE

The objective of the present study is to investigate the seismic response of building frames using time history analysis. The results are obtained by using structural analysis software ETABS 2018.

The objectives are as below,

1) Study the seismic performance of building frame having different plan geometry.
2) To analyze displacement responses of various building frames with different plan geometries under seismic conditions.
3) Study effect of various incident angle of earthquake force on building frame.

III.RC BUILDING FRAME CONSIDERED FOR THE ANALYSIS

In the present work, three RC building frames are considered which are analysed and designed as per codal provision. The structures considered are L shape, Plus shape and Square shape in plan. Dimensional characteristics are illustrated below.

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Table 1 geometric and material properties of building frames

Sr. No	Contents	Description		
1	Building Shapes	L	Plus	Square
2	No. of stories	G+5	G+5	G+5
3	Storey Height	4 m	4 m	4 m
4	Grade of Concrete	M 20	M 20	M 20
5	Grade of Steel	Fe 415	Fe 415	Fe 415
6	Bay width (Both Direction)	3 m	3 m	3 m
7	Slab thickness	0.15 m	0.15 m	0.25 m
8	Size of Column	0.45m X 0.45m	0.45m X 0.45m	0.45m X 0.45m
9	Size of Beam	0.23m X 0.3m	0.23m X 0.3m	0.23m X 0.3m
10	Live load	3 kN/m²	3 kN/m²	3 kN/m²
11	Seismic Zone	III	III	III

IV. TIME HISTORY USED IN THE STUDY

A. El Centro Time History

Imperial Valley, California, 19th May 1940 04:36 UTC, Magnitude 7.1the main earthquake took nine lives and caused property damage estimated at $6 million. The first shock damaged about 80 percent of the buildings in Imperial. Many buildings in the business district were condemned, and older residences sustained severe damage. Damage to a lesser extent occurred at El Centro.

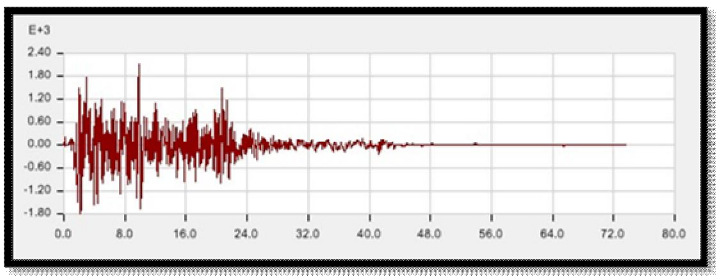
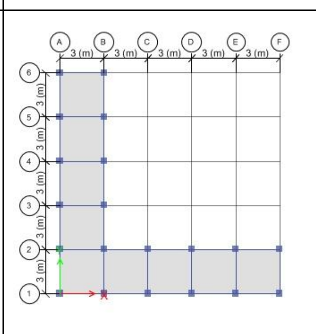
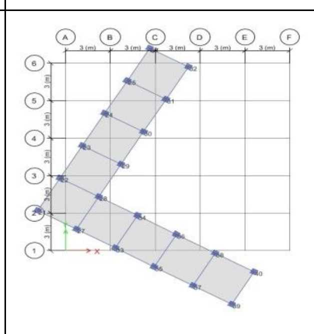
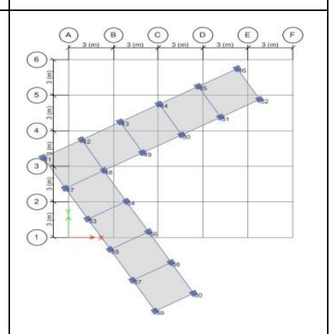


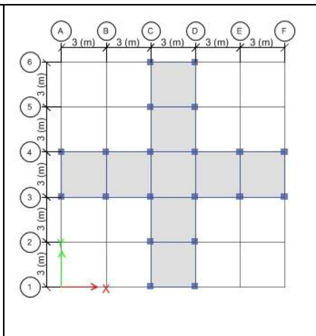
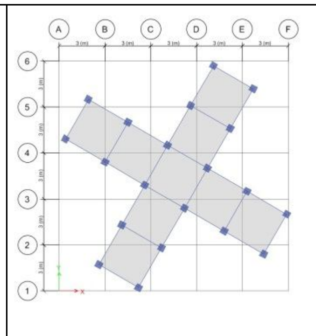
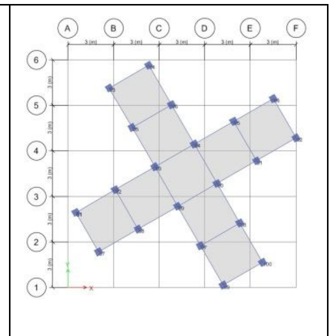
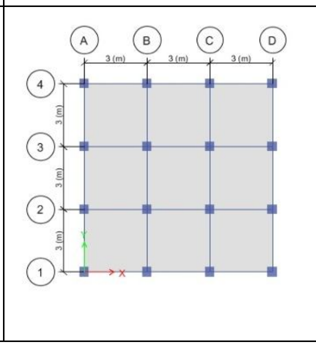
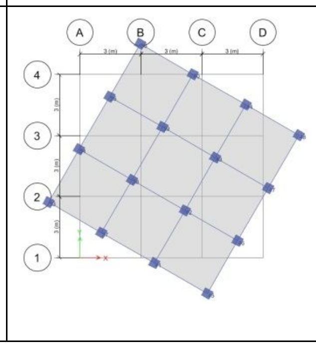
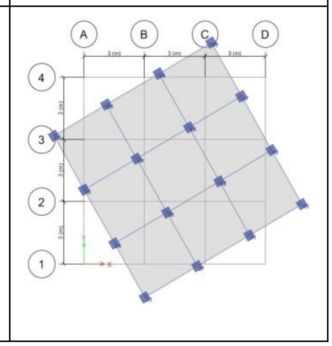
Fig. 1 El Centro Time History

V. ANALYSIS OF STUDY

Analysis of L shape, Plus shape and Square shape building is carried out using ETABS 2018 software for various incident angles and the performance of these structures are studied by applying the El Centro time history. The ETAB models for various incident angles are presented in Table 2.

TABLE 2 VARIOUS INCIDENT ANGLES FOR VARIOUS SHAPES

Shape	**0^0**	**30^0**	**60^0**
L			

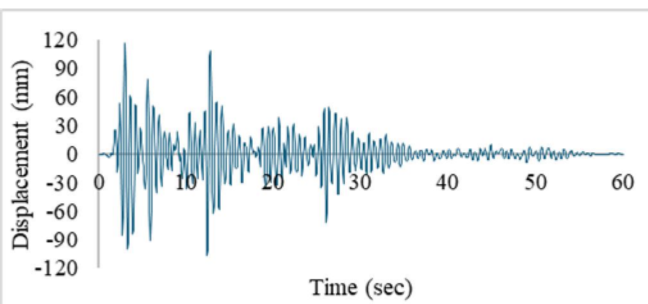
PLUS			
SQUARE			

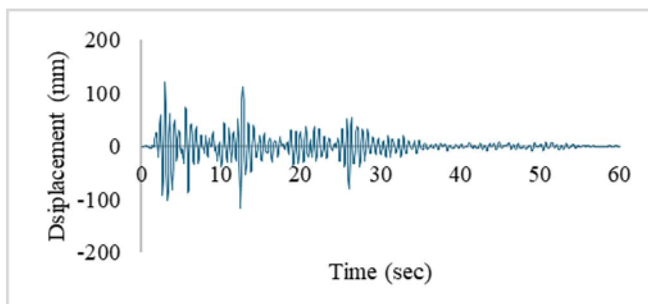
VI. RESULTS

The present study is carried out by using El-Centro time history. The results are obtained from time history on different plan geometry buildings (L shape, Plus shape and Square shape). The results are obtained for various Angle of Incident (0^0, 30^0, 60^0). The Incident Angle is presented as I.A.

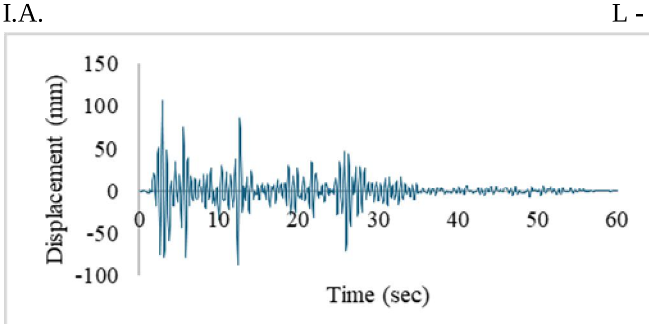
All the results obtained are shown in the following figures.

TABLE 3 ROOF DISPLACEMENT FOR L SHAPE BUILDING





L - 0^0 I.A. L - 30^0 I.A.



L - 60^0 I.A.

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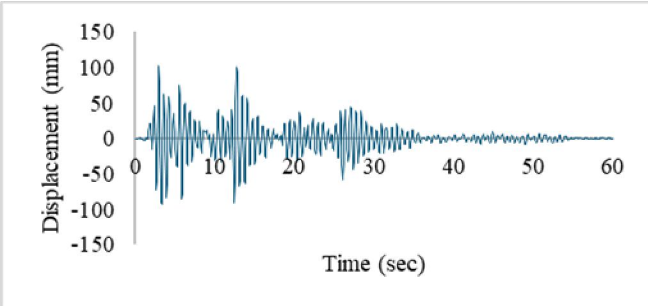
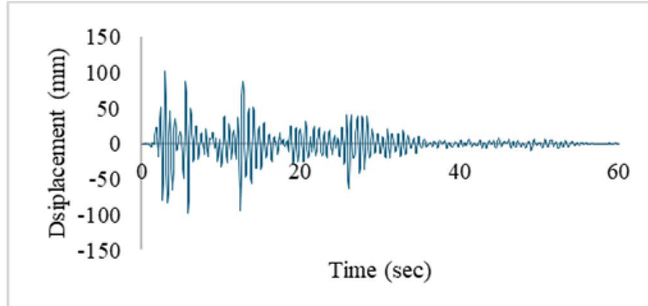
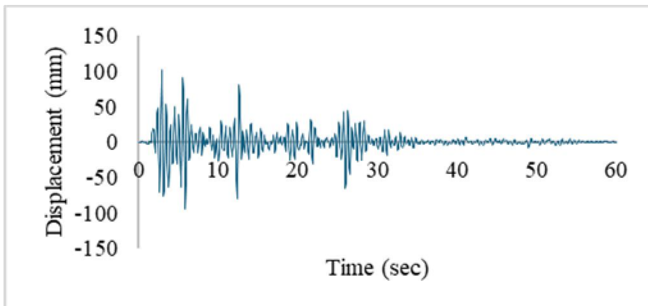
TABLE 4 ROOF DISPLACEMENT FOR PLUS SHAPE BUILDING



PLUS - 0^0 I.A.

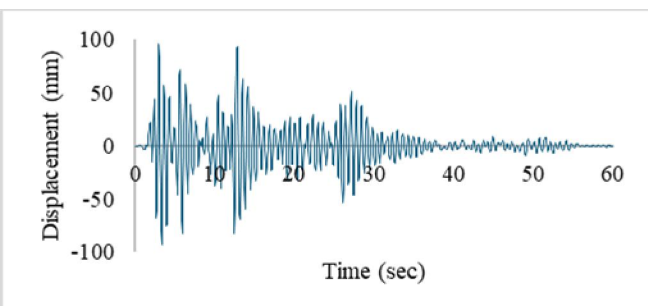


PLUS - 30^0 I.A.

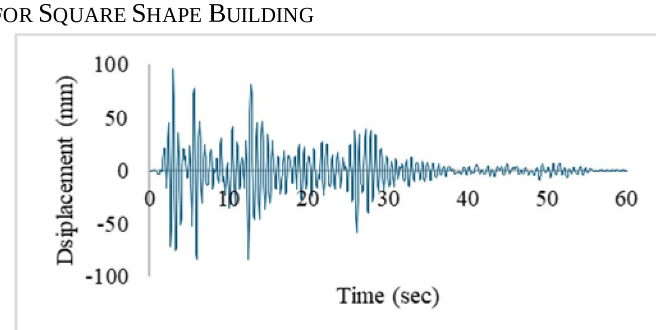


PLUS - 60^0 I.A.

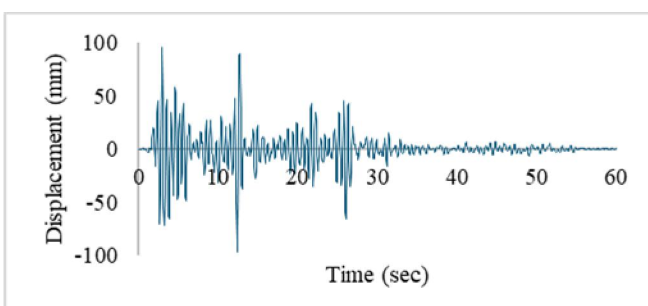
TABLE 5 ROOF DISPLACEMENT FOR SQUARE SHAPE BUILDING



SQUARE-0^0 I.A.



SQUARE-30^0 I.A.



SQUARE-60^0 I.A.

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VII. COMPARISION OF ROOF DISPLACEMENT FOR VARIOUS INCIDENT ANGLE

The result obtained for various shape are studied and the maximum displacement produced at roof level is identified and a comparision for various plan geometry are presented in fig 6.

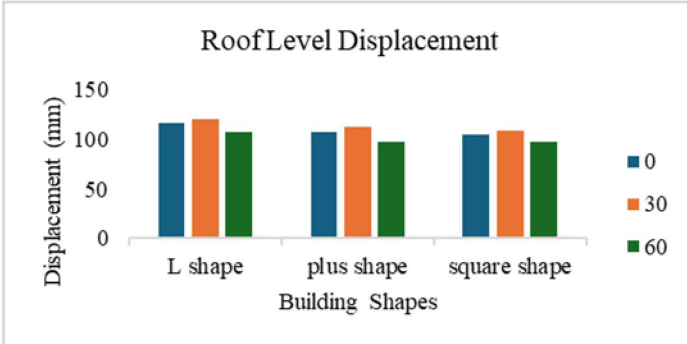

Fig 6. Comparision of Displacement

Fig.6 shows the variation of displacement for various shapes. It is observed from the fig. 6 that roof displacement increases about (2%-3%) from 0^0 to 30^0 incident angle. However, it decreases by about (7%-8%) from 30^0 to 60^0 incident angle. This trend is observed to be same for all the shapes. Among all the shape it is observed that the displacement produced in L shape building are 14.34% higher. This revels that building produces maximum displacement for 30^0 incident angle. Also it can be stated that the variation from 30^0 to 60^0 need to be studied by changing incident angle with small increment, so that the severe effect can be identified. The pattern of graph is same for both plus and square shape building.

VIII. CONCLUSION

Following conclusion are found.

1) The analysis indicates that displacement reaches its peak at an incident angle of 30° for all building shapes. However, to accurately identify the most critical incident angle, it is recommended to conduct further investigations with smaller increments between 30° and 60°.
2) The findings reveal that L-shaped buildings exhibit higher displacement under seismic forces compared to other configurations, such as plus-shaped and square-shaped buildings. This suggests that asymmetrical structures are less favorable due to their reduced strength and stability against earthquake-induced forces.
3) Square-shaped buildings demonstrate superior resistance to seismic forces and exhibit enhanced structural stability. Therefore, symmetrical building configurations are recommended to ensure optimal seismic performance.

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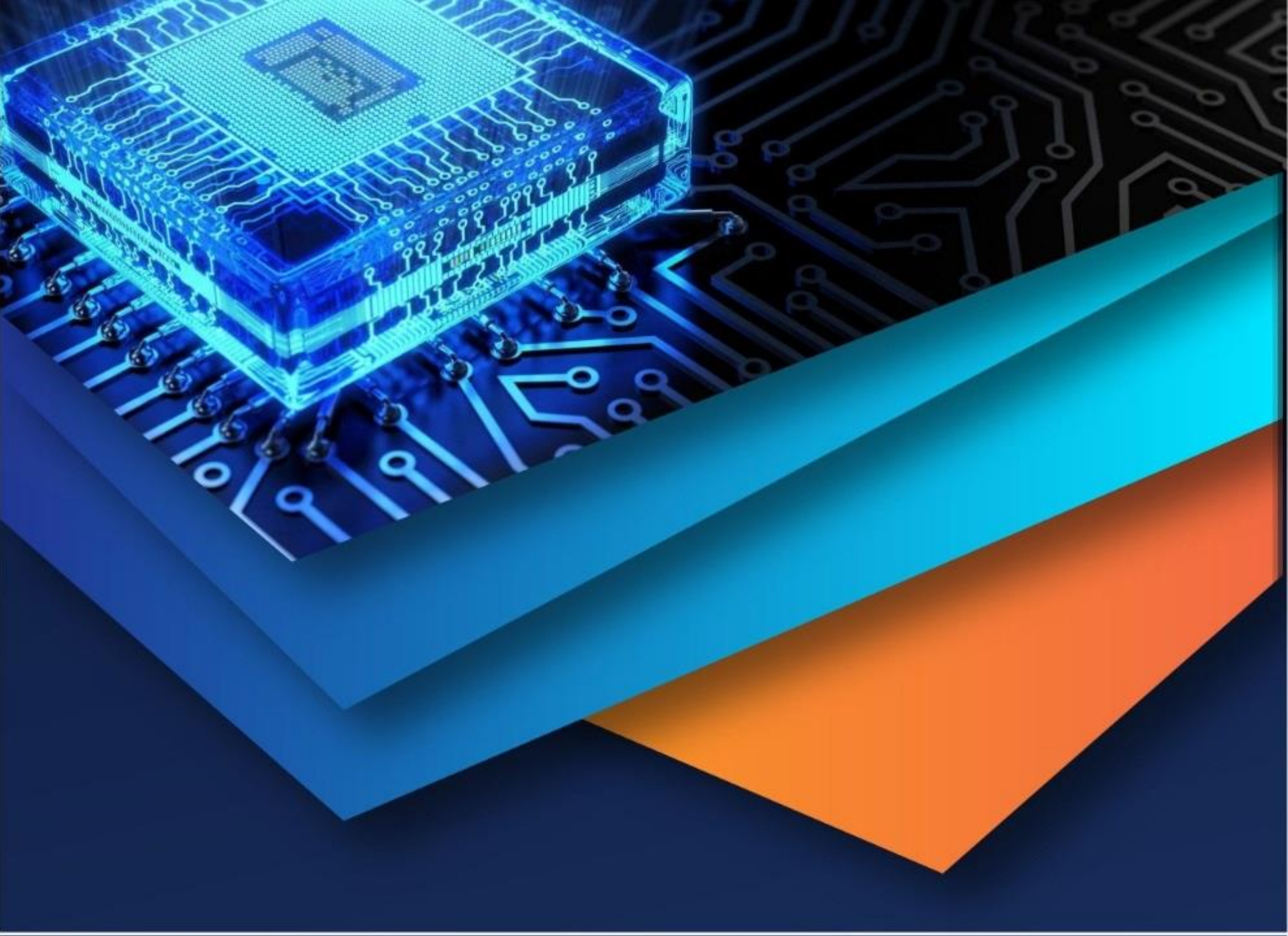

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