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Analysis of Multistorey RCC Frame subjected to Mainshock and Aftershock Earthquake

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Abstract: Structure analysis and design are significantly influenced by earthquake. It is believed that seismic evaluation is required for the viability and serviceability of both present and future building structures. When a structure's base is subjected to a certain type of ground motion, a time history analysis is performed to examine the dynamic reaction of the structure at each time interval. The near-field earthquake ground motion verification may have specific impacts for both forward and backward directivity. The initial's velocity and displacement motions, respectively, exhibit pulse and fling-step characteristics. Therefore, it is crucial to assess how well structures built solely to withstand the primary shock would work through future aftershocks. Using modern seismic protection systems, such as base isolations or / and supplemental dampening devices, that significantly reduce building damages during main shocks and their related aftershocks is one of the appropriate solutions to this issue. Due to changes in both static and dynamic stress that take place during the earthquake process, aftershock events are set off by the primary shock. In order to better understand the ground motion features of a sizable collection of mainshock and subsequent aftershock ground motion data recorded in accelerograph stations around the region, this study reviews pertinent literature in the field. The G+9 RCC building will be used in this study to conduct a time history analysis of the mainshock and aftershock data of the Chamoli earthquake provided by the Centre for Engineering Strong Motion Research Ground Motion Database. For designing purposes, the IS 456-2000 code is taken into consideration. Live loads are measured in accordance with IS 875-part 1, and seismic zone IV is selected for analysis in accordance with IS 1893-2016. Storey drift, base shear, joint reactions, and storey displacement are just a few of the variables that can have an impact on how well a building performs. Since each of these variables has a significant impact on how a structure responds to seismic loads, they are also taken into account when evaluating the results.

Keywords: Time History analysis, Mainshock, Aftershock, Reinforced Concrete Building, Ground Motions, ETABS software, seismic response.

I. INTRODUCTION

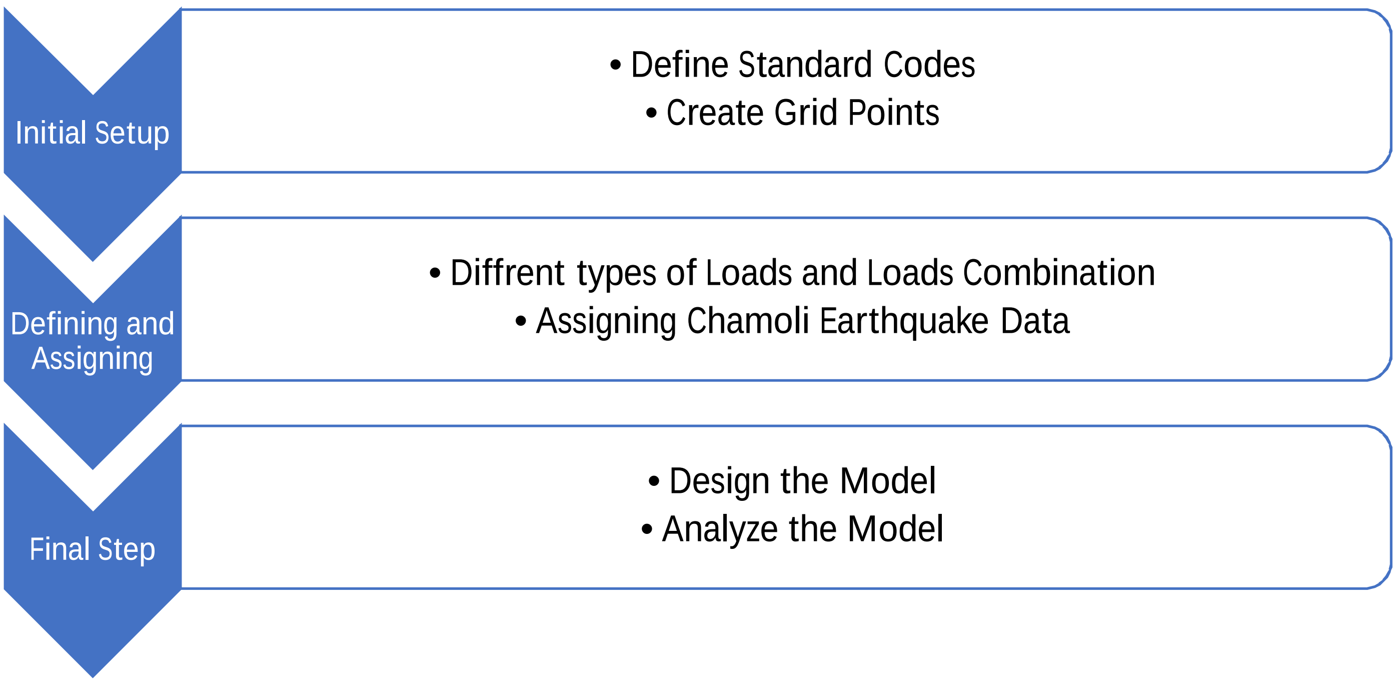
In earthquake-prone areas, man-made structures are subject to a seismic sequence of aftershocks, the mainshock, and aftershocks in addition to a single seismic event. Due to changes in both static stress and dynamic stress that take place during the earthquake process, aftershock events are set off by the mainshock[1]. A minor seismic event known as an aftershock takes place in the same general area as a previous large earthquake. When an aftershock is larger than the mainshock, the mainshock that originally occurred is reclassified as a foreshock and the aftershock is given the role of the mainshock[2]. The mainshock aftershock ground motion sequence was found to significantly affect the structure's reaction in terms of top displacements and story drifts. ETABS carried performed the analysis. Few places on earth are subject to many earthquakes in a reasonably brief period of time because of their unique seismic-tectonic context[3]. The ability of designing structures to withstand numerous earthquakes with significant ground shaking is still in its infancy. There aren't any parameterized solutions that can forecast how multiple powerful earthquakes will affect buildings[4]. On March 29, 1999, at 00:35:13.4 hours IST, a moderate earthquake with a Richter value of 6.8 shook the Garhwal-Kumaun region of the Western Himalayas. The focal depth has been calculated to be 21 kilometers, and the epicenter was situated at 30.408 N, 79.416 E[5]. A significant earthquake with a focal depth of 19 kilometers occurred in the area in 1991 and had an epicenter at 30.74N, 78.79E close to Uttarkashi. The topography of the area damaged by the earthquake is incredibly uneven, and there are relatively few people living there[6]. Undressed stone brickwork in mud mortar with hefty yet flexible stone slab roofs is the most typical type of building in the area. Due to the challenging hilly terrain and landslides that the earthquake caused, which blocked numerous travel routes, the rescue and relief activities were impeded[7].

The neighboring cities of Chamoli and Gopeshwar as well as the nearby region of Rudraprayag were all shaken by the earthquake. The Alakananda River valley contains the majority of the worst-affected areas[8].

The severity of the shaking was very unevenly distributed, with the maximum intensity on the damage-based MSK scale being reported between positions VII and VIII. According to Indian standards for setting the requirements for earthquake-resistant structures, the impacted area is located in seismic zone V, which carries the highest level of risk. The seismic zone V is predicted to have an intensity of IX or higher by the code[9].

We compare the seismic behaviour of G+9 multi-story buildings during Mainshock and Aftershock earthquakes individually in this work, and we assess seismic metrics including story displacement, story drift, story shears, and story stiffness for suggested structural models[10]. Additionally, we will investigate the seismic properties of the same building using Time history analysis using unscaled data from the Centre for Engineering Strong Motion Research Ground Motion Database. March 29, 1999, GOPESHWAR STATION (Latitude & Longitude: 30'24"N - 79'20"E), CHAMOLI (NW HIMALAYA) EARTHQUAKE

II. METHODOLOGY



A. Building Parameters

A G+9 building is represented in ETABS v16 with a storey height of 3.1m, a structure's length of 20m in one direction and 15m in the other, and member sizes that vary depending on the building's design specifications. The slab measures 150 centimetres in thickness. As per IS 456-2000 and IS 1893-2016, the model is evaluated and created.

Material properties:

Name	Type	Design strength	E (Mpa)	Unit weight KN/m^3
Concrete	M30	Fc=30Mpa	27386.13	25
HYSD	500	Fy=500 MPa	200000	76.9729

Column 1	450*450
Column 2	450*500
Beam 1	230*400
Beam 2	230*450
Thickness of slab	150mm

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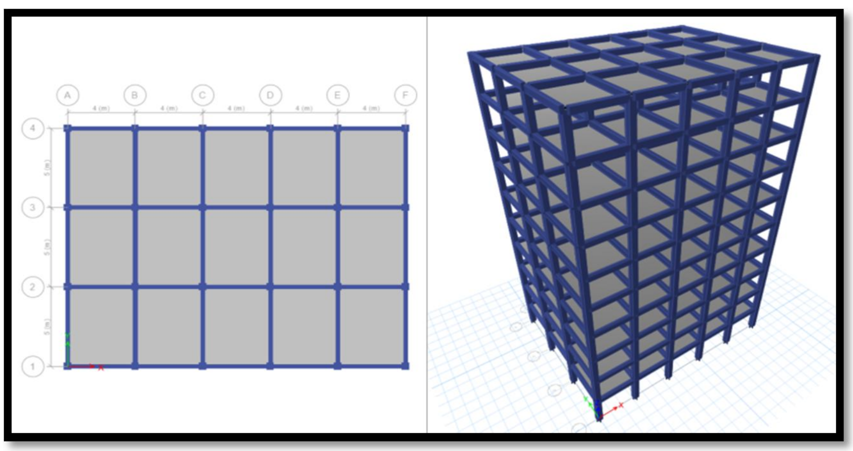
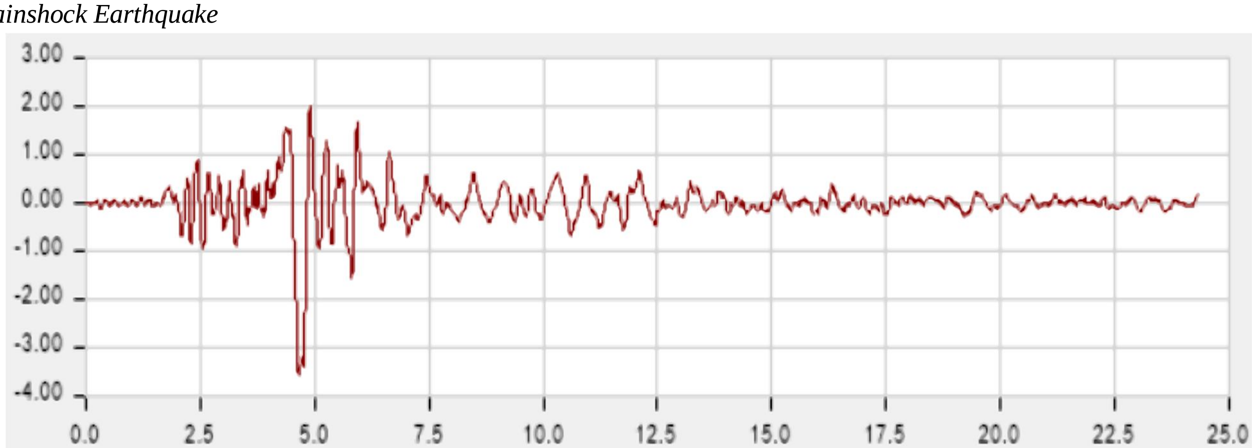
Loads are taken from Indian standard codebooks for dead loads we have IS 875 part 1, for Live loads IS 875 part 2 and seismic analysis is done according to the IS 1893 part 1 2016.

Loading data Type of Load	**Intensity of Load**
Live load	5 kN/m2 (IS 875-Part 2)
Floor finishing	1.1 kN/m2 (IS 875-Part 1)
Seismic zone	IV
Type of soil	Medium
Acceleration due to gravity	9.81m/sec^2
Response reduction factor	5
Importance factor	1
Scale factor (I.g/R)	1.9622D-plan extruded



Plan and 3D view

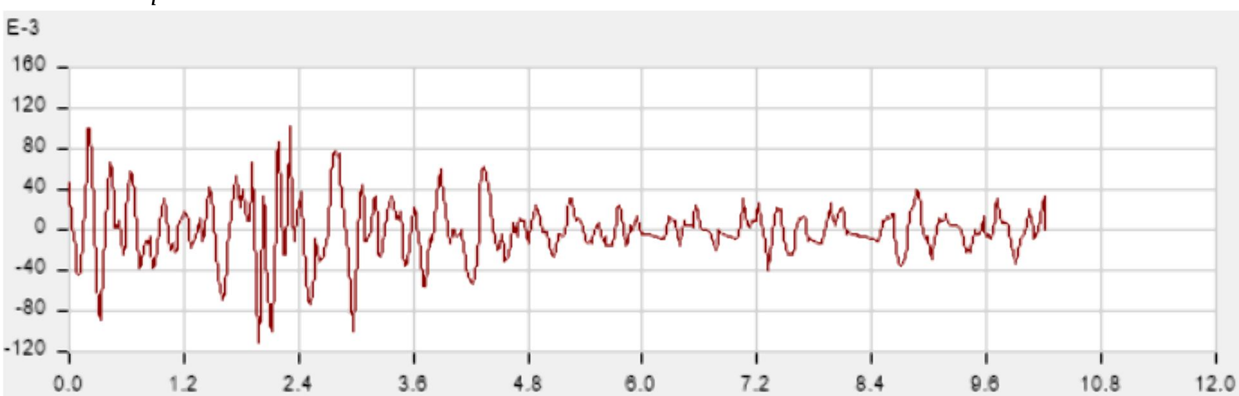
B. Mainshock Earthquake



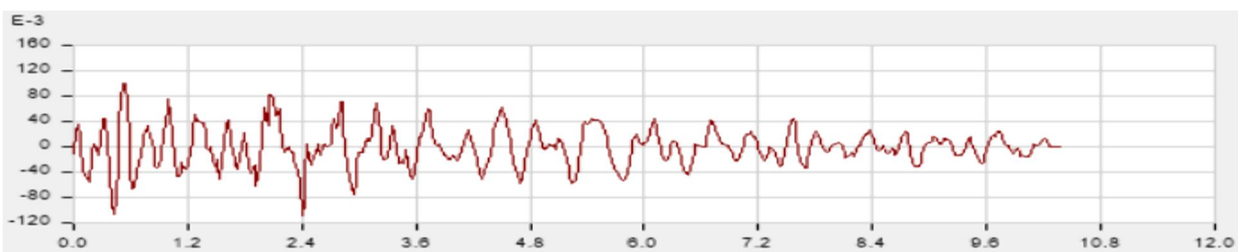
Acceleration vs Time data along Horizontal N-E Direction

Acceleration vs Time data along Horizontal N-W Direction

C. Aftershock Earthquake



Acceleration vs Time data along Horizontal N-E Direction

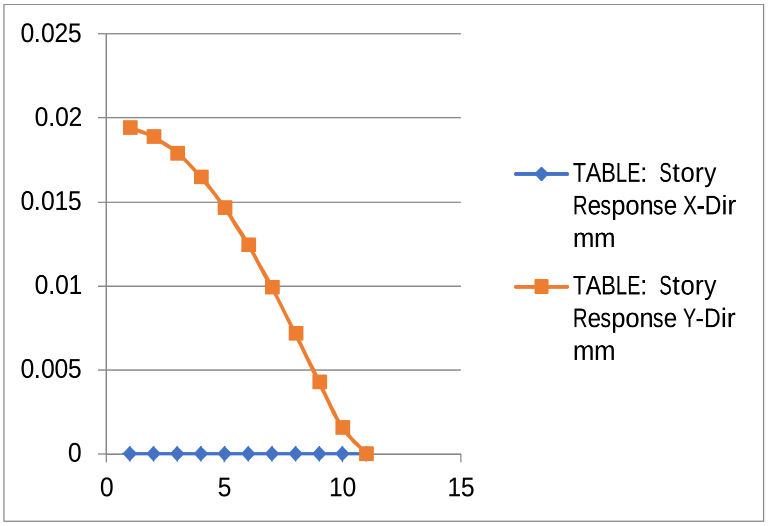


Acceleration vs Time data along Horizontal N-W Direction

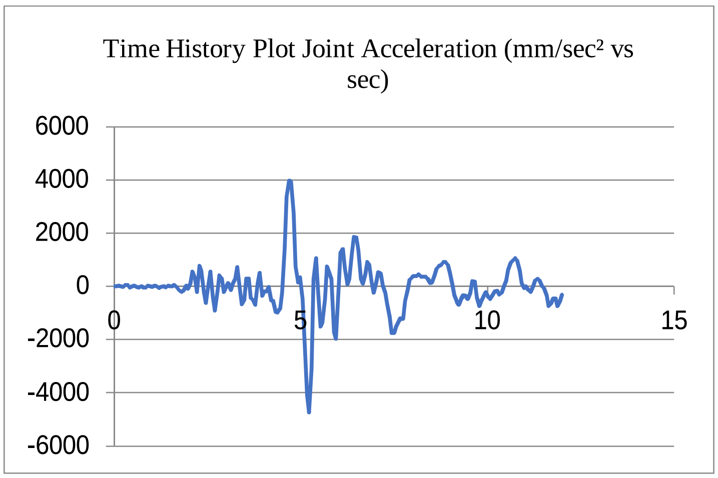
III. RESULTS AND DISCUSSION

A. Storey Displacement of the RC Building

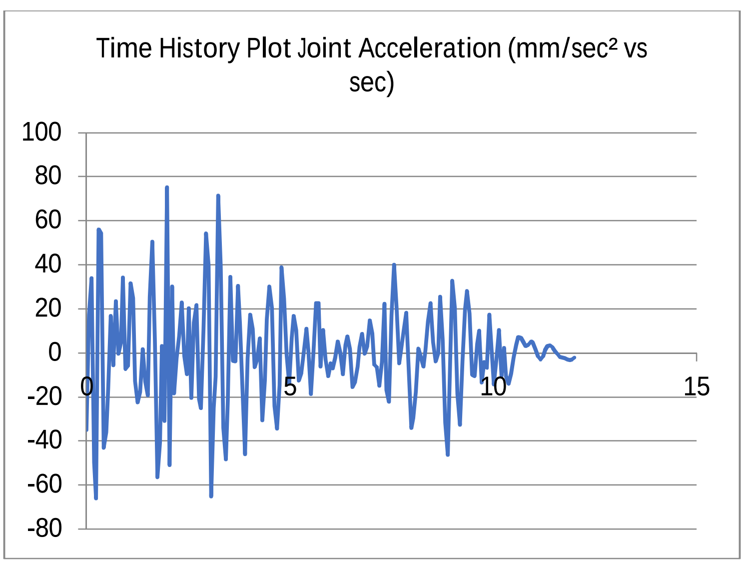
TABLE: Story Response				
Story	Elevation	Location	X-Dir	Y-Dir
	m		mm	mm
Story10	31	Top	1.13819E-14	0.019418139
Story9	27.9	Top	3.66613E-13	0.018871415
Story8	24.8	Top	3.25539E-14	0.017913719
Story7	21.7	Top	7.45633E-14	0.016505395
Story6	18.6	Top	5.81135E-13	0.014671334
Story5	15.5	Top	3.54744E-13	0.012459277
Story4	12.4	Top	1.60841E-13	0.00993157
Story3	9.3	Top	4.41174E-13	0.007167294
Story2	6.2	Top	5.9224E-13	0.004286584
Story1	3.1	Top	5.64031E-13	0.001568096
Base	0	Top	0	0



B. Joint Acceleration for Storey 10



Mainshock



Aftershock

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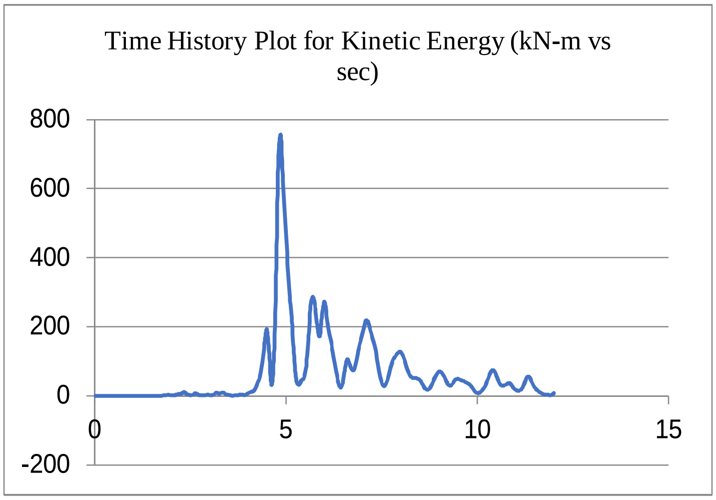
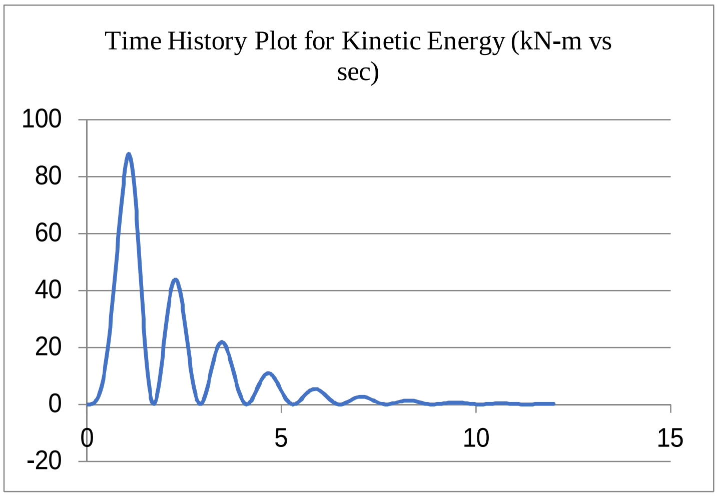
C. Kinetic Energy Stored during Earthquake

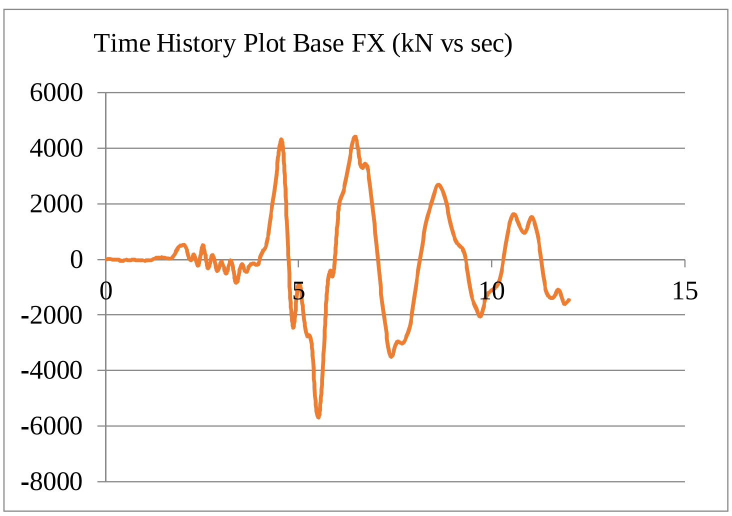


Mainshock



Aftershock

D. Base Shear



Mainshock

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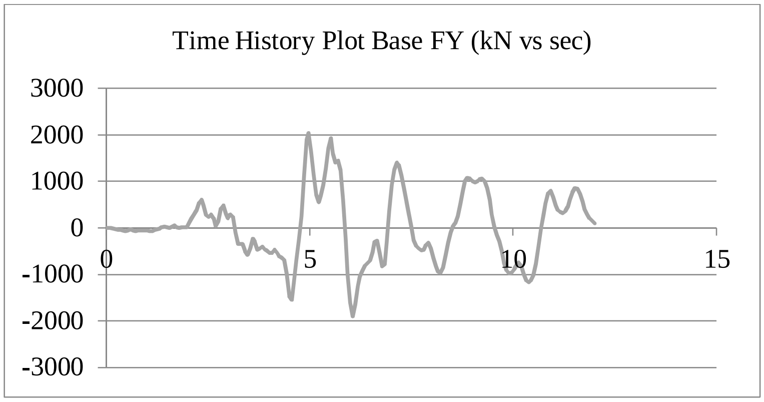
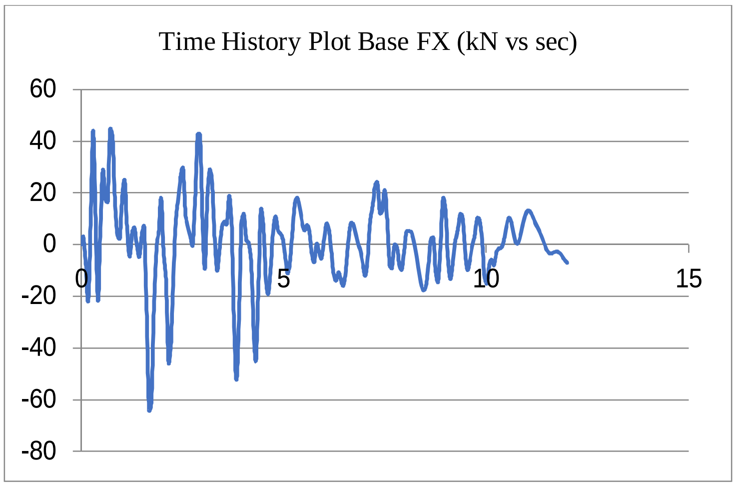
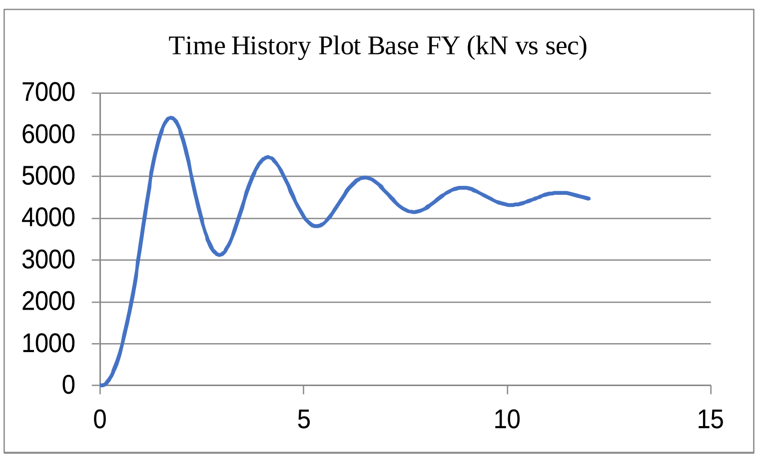


Aftershock





As a result of comparison with Mainshock and Aftershock Earthquake on G+9 RC structure, following has been observed:

1) According to IS 1893 (part 1): 2002 CI. 7.11. 3, any storey's storey drift caused by the specified minimum design lateral force, with a partial load factor of 1.0, may not be greater than 0.004 times the storey height. The maximum drift calculated from the graphs is 0.019418 and is within the permitted range.
2) Joint acceleration and base shear occur more frequently during aftershocks than during mainshocks.
3) The Storey 10 joint's maximum joint acceleration after the aftershock is approximately 2% of the joint acceleration during the mainshock.
4) Approximately 11.52 percent of the maximum energy which is stored during the mainshock is added during the aftershock.
5) Storey drifts, storey displacement, and stiffness are seen to be within acceptable ranges as advised by the IS 1893 code.

IV. CONCLUSION

Based on time history analysis, conclusions for structural framework have been established for a G+9 structure in India with various types of soil in seismic zone IV.

1) As a result of the discussion When building for earthquake resistance, aftershocks should always be considered, especially if a structure has already sustained damage from a more severe mainshock.
2) Any construction that has already experienced a mainshock can suffer catastrophic consequences from aftershocks with frequency higher and lower amplitude on the Richter scale.
3) Toward the top storey of the construction, the story shear starts to increase at the lowest level. The magnitude of storey shear grows along with a building's height.
4) Base isolation systems, in which the building (superstructure) is segregated from the base, can be given to prevent the mainshock and aftershock sequence (foundation or substructure). The quantity of energy is transferred to the structure during an earthquake is greatly reduced by separating the building from its base.
5) Time history analysis is a sophisticated programme that helps you see how well a building and its components—such as the supporting columns, beams, and slab—are working. By choosing an appropriately selected ground motion data of an earthquake that has already occurred, the seismic performance of the building can be determined.
6) Cross bracing can also be employed to keep structures stable during seismic occurrences like earthquakes and when the wind blows.

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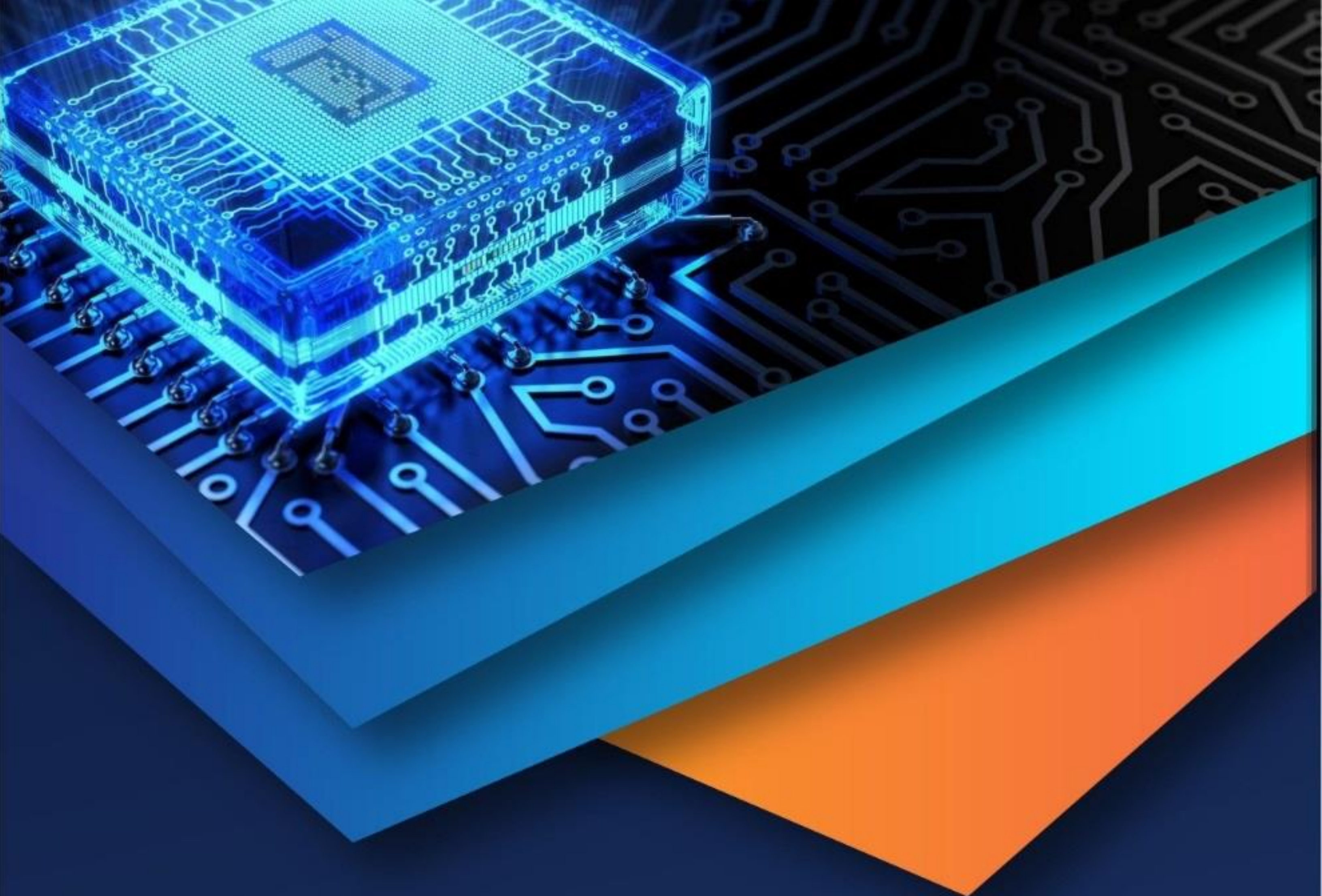

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