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Seismic Response Study of Reinforced Concrete Buildings Under the Effect of Varying Frequency Content

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ABSTRACT

Earthquake causes damage to living things particularly people and harms the fabricated and common habitat. Keeping in mind the end goal to play it safe for the death toll and harm of structures because of the ground motion, it's essential to sense the qualities of the ground motion. The most essential unique qualities of seismic tremor are peak ground acceleration (PGA), frequency content, and duration. These qualities play a vital role in respect to the response of structures under seismic loads. The quality of ground motions is estimated in light of the PGA, frequency content and to what extent the shaking proceeds. Ground motion has distinctive low, intermediate, and high-frequency contents. Current research involves studying seismic frequency components of reinforced concrete structures. Time history analysis is performed in the extended three-dimensional analysis of building system (ETABS) software. The proposed strategy is to think about the response of low, mid, and high- rise reinforced concrete buildings under low, intermediate, and high- frequency content ground motions. The response of the structures because of the ground motions as far as displacement, velocity, acceleration, and base shear is found. The reactions of each ground motion for each sort of building are contemplated and looked at. The outcomes demonstrate that low-frequency content ground motions have the noteworthy impact on both regular as well as irregular RC structures. However, high-frequency content ground motions have very less effect on responses of the regular as well as irregular RC buildings.

Key Words: *Reinforced Concrete Building, Ground Motion, Peak Ground Acceleration, Frequency Content, Time History Analysis.*

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1. INTRODUCTION

A quake is the aftereffect of a fast arrival of strain vitality put away in the world's hull that produces seismic waves. Structures are defenceless against seismic tremor ground movement and harms the structures. With a specific end goal to play it safe in preventing damage to structures because of ground movement, it's essential to know the aspects of ground motion. The utmost vital unique attributes of seismic tremor are peak ground acceleration (PGA), frequency content, and duration. These qualities play transcendent run in concentrate the conduct of structures under seismic tremor ground motion. Ellen Rathje et al (1998) three streamlined frequency contents are considered: mean period (T_m), predominant period (T_p), and smoothed spectral predominant period (T_o). They recorded frequency parameters of 306 motion records from 20 earthquakes. They use this information to model the site dependency, size and distance of frequency content specifications. Model coefficients and standard error terms were evaluated by nonlinear regression analysis. Their results show that the traditional T_p parameters have the most shocking vulnerability to their expectations, suggesting that predicting the previous relationship of T_p is questionable for current information gathering. Furthermore, the optimum frequency content rendering parameter is Tm. David M. Boore (2003) Probabilistic technology is an important and epoch-making strategy for simulating terrestrial movements. Changes in mixing parameters or functional descriptions of the amplitude spectrum and the random phase spectrum of the seismic motion are determined such that the behaviour is distributed over a time span associated with the magnitude of the earthquake and the distance from the source. This technique is useful for simulating high frequency seismic motion (e.g., 0-1 Hz) and chronicles of possibly harming seismic tremors are not open, it is utilized to foresee them. Sekhar Chandra Dutta, et al. (2004) studied the response of low-rise building under seismic activity including soil-structure interaction. They studied the framework of low-rise building on a shallow foundation, i.e. isolation and the foundation of the grid. They used artificial earthquakes to analyse the reaction. Their study suggests that this response may be prolonged, taking into account the effects of soil structure interactions, especially the low level of rigid structure. Tufan Cakir (2012) Evaluation of the influence of seismic frequency on the seismic behaviour of the soil structure interaction of the cantilever retaining wall was studied. He to analyse the dynamic characteristics of the retaining wall of the cantilever that have undergone various ground motion, 3D backfill using the finite element method - executing the soil interaction phenomena. He assessed the impact of earthquake tremor frequency and earth and structure interaction using five different ground movements and six different soil compositions. We also tested finite element model verification by modal analysis technology and fully understood the results of numerical analysis. Finally, we expanded the strategy to study the parametric influence of vibration frequency component of earthquake motion and soil / ground interaction, and carried out a nonlinear time course study. His results show that as soil properties change, lateral displacement and stress response under various ground movements are tested. He concluded that the dynamic response of the cantilever wall is very sensitive to the frequency characteristics of earthquake micro tremor record and soil structure interaction. L. Di Sarno (2013) the effects of many earthquakes on the response of the inelastic structure are taken into account. Five sites representing the group of sites exposed to several fluctuations and site-to-site distance earthquakes were chosen. Of the several records collected from these five destinations, each location determined three records representing strong ground motions against driving conditions and loosening. The RC profile survey shows that not only does more than one earthquake guarantee a wide and urgent study, but the safety of the traditional design structure lacks a modest level of signs. Nayak and Biswal (2013) studied the seismic performance of the bottom mounted embedded block partially filled with a rigid rectangular storage tank. They used six different low frequency, medium frequency and high frequency seismic motions to check the dynamic behaviour of the tank immersion block system. They established a Galerkin finite element model based on velocity potential and demonstrated the effect of underwater blocks on the inaccurate and convective response of hydrodynamic conduction. The overturning moment of the foundation, the foundation shear and the count pressure distribution of the block wall along the reservoir. For all the earthquake motions studied, the corresponding convective response amplitude is lower than the peak impulse response component of the dynamic physical parameter, regardless of its frequency component. Furthermore, the impulse response is hardly dependent on the frequency component of the seismic motion, and depends on PGA, PGA is a measure of seismic intensity. However, the convective response is greatly influenced by the frequency component of ground excitation. The effect of the submerged block attached to the bottom has a substantial effect on the overall dynamics of the tank-liquid system, and this effect varies greatly under seismic motion at different frequency levels. Mahmood Hosseini, Banafshehalsadat Hashemi and Zahra Safi (2017) a survey was conducted to understand how the specifications of IBC 2009 and ACI 318-2014 effectively provide the life safety and performance levels of conventional buildings of reinforced concrete multi-layered structures. For this purpose, a multistate building with a maximum of 16 floors was designed in Tehran’s highest earthquake hazard area and designed according to specifications. Then a series of near-source three component acceleration maps were used according to the code, scaled and a series of nonlinear time history analysis were performed in all buildings. The displacement, acceleration, and base shear force of the top plate were calculated. As a result, in some earthquakes the performance of the building exceeds the LS, PL, sometimes reaching the collapse level.

Extreme tremors occurs once in a while. Despite the fact that it is in fact possible to design and fabricate structures for these seismic tremor occasions, it is generally viewed as wasteful and excess to do as such. The seismic design is made with the desire that the extreme earthquake causes a demolition, and a seismic plan theory in this beginning has been made over the years. The purpose of seismic design is to limit damage in a structure to a decent sum. Structures designed to be able to withstand low levels of undamaged earthquakes, withstand moderate levels of earthquakes without structural damage, but with the potential for non-structural damage and withstand large terrain movements without failure, but with structural and non-structural damage.

The damage in a structure starts from a point of weakness. These weaknesses additionally trigger the damage. Generally such weak spots are present inside the structure because of irregularity in mass and stiffness distribution. Structural irregularities are such weak spots in a structure from where the damage initiates and are explained in detail in the subsequent sections.

Irregular buildings are preferred due to their aesthetically pleasing appearance and optimized functionality. However, past earthquakes have demonstrated their poor seismic performance.

In this work, RC buildings of two, six and twenty story, regular and irregular, are subject to six low, medium and high frequency content ground motions. The structures are displayed as 3D and linear time history analysis is put through extended three-dimensional analysis of building system (ETABS) software and the results of each RC building due to each ground motion are studied and compared. It is found that low-frequency content ground motion has significant effect on responses of regular as well as irregular RC buildings irrespective of the building height. However, high-frequency content ground motion has very less effect on responses of both regular and irregular RC buildings regardless of the building height. Furthermore, the effect of the intermediate-frequency content ground motion is less than the low-frequency content ground motion and more than high-frequency content ground motion on responses of the RC buildings.

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1.1 Re–entrant corners:

IS 1893 (PART 1): 2002 defines re-entrant corner as a location in a structure where in the projection of the building component beyond that point outreach 15 % of its plan dimension in the given direction as shown in figure 1.1 and table 1.1 demonstrates its classification. When the building is subjected to ground motion inertial forces are mobilized. These forces travel along different paths known as „load paths‟ through various structural components and finally being transferred to the soil through foundation.

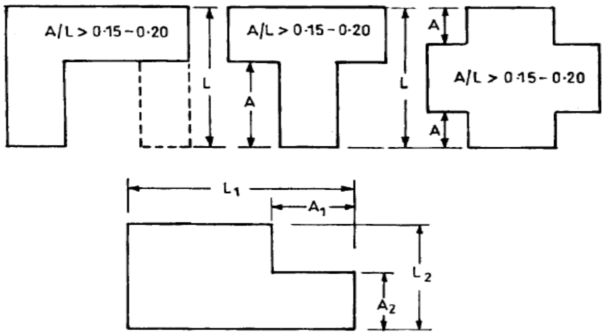

Figure 1.1: Re-entrant corners showing computation of A/L ratio.

Table 1.1 Classification of re- entrant corners based on A/L ratio

A/L Ratio	Condition
<0.15	Safe
0.15 – 0.20	Deficient
>0.20	Highly deficient

1.2 Objective

The main objective is to investigate the reflex of frequency content of ground motion on seismic response of structures with and without re-entrant corners.

1.3 Scope

Consider two ground motions in each frequency content category, six ground motions, and investigate the influence of frequency response on dynamic response. The motivation behind this undertaking is to consider the response to low, medium and high frequency seismic motion of low, medium and high level conventional and irregular 3D RC buildings in terms of story displacement, velocity, acceleration, and base shear with the help of ETABS software.

1.4 Methodology

For analysis, six low, medium, high frequency seismic motion records are considered i.e. 1979 Imperial Valley-06 (Holtville Post Office) component, 1994 Northridge-01 Canoga Park - Topanga Can component, 1957 San Francisco (Golden Gate Park) component, 1940 Imperial Valley-02 (El Centro Array #9) component, 1992 Landers (Fort Irwin) component, 1983 Coalinga-06 Coalinga-14th & Elm (Old CHP) component. Ground motion records are taken from Pacific Earthquake Engineering Research Center (PEER) Next Generation Attenuation (NGA) database. Reinforced concrete buildings with 2-story, 6-story, and 20-story are considered low, middle and high rise buildings modeled as 3 dimensional regular and irregular reinforced concrete buildings within ETABS. After that, above ground motions are introduced to the software and linear time history analysis is executed. The premise of this research is to study the behavior of reinforced concrete buildings within a variable frequency range. This survey shows how low, mid and high-rise reinforced concrete buildings function with low, medium and high frequency earthquake motions.

2. STRUCTURAL MODELING

2.1 Structural Parameters and Description

TABLE 2.1 - Structural parameters for models

1	No. of Bays	4 bays along longitudinal direction 5 bays along transverse direction
2	Spacing of each bays	4 m - longitudinal direction 5 m - transverse direction
3	No. of Story	2-story, 6-story, 20-storyregular and irregular buildings
4	Support condition at bottom	Fixed
5	Total height of building model	7m, 21m & 70m
6	Bottom Storey height	3.5 m
7	Typical Storey height	3.5 m
8	Size of Column	300 x 400 mm & 600 x 600 mm
9	Size of Beam	300 x 400 mm

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10	Compressive strength (f_{ck})	30 MPa
11	Yield strength (f_y)	500 MPa
11	Depth of Slab	125 mm
12	Beam Clear Cover	25 mm
13	Column Clear Cover	40 mm
14	Live Load	On Floor = 3.0 kN/m^2 On Roof = 1.5 kN/m^2
15	Floor Finish	On Floor = 1.5 kN/m^2 On Top Roof = 2.0 kN/m^2
16	Zone Factor	III [0.16]
17	Soil type	II -Medium soil
18	Importance Factor	1.0
19	Response Reduction Factor	[OMRF] = 3.0
20	Damping Ratio	5 %

2.2 Regular RC Buildings

2-story, 6-story, 20-story regular reinforced concrete buildings, which are low, mid, and skyscraper, are considered. The beam in (x) transverse direction is 4m and in (y) longitudinal direction 5m. Figure 2.1 demonstrates the plan and figure 2.2, 2.3, 2.4 demonstrates 3D view of the three buildings having five bays in x-direction and five bays in y-direction. Story height of each building is assumed as 3.5m.

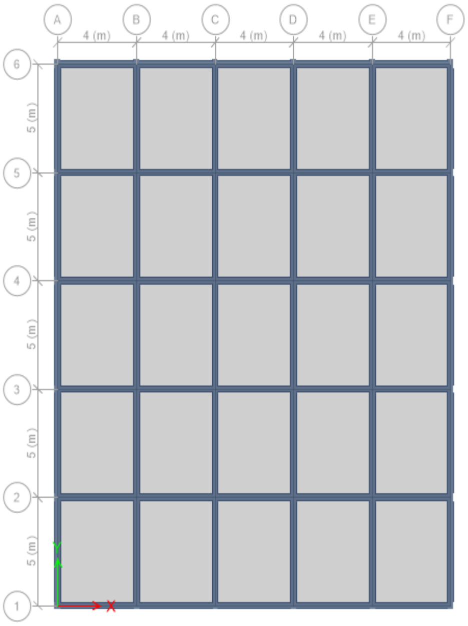

Figure 2.1: Regular Building Plan

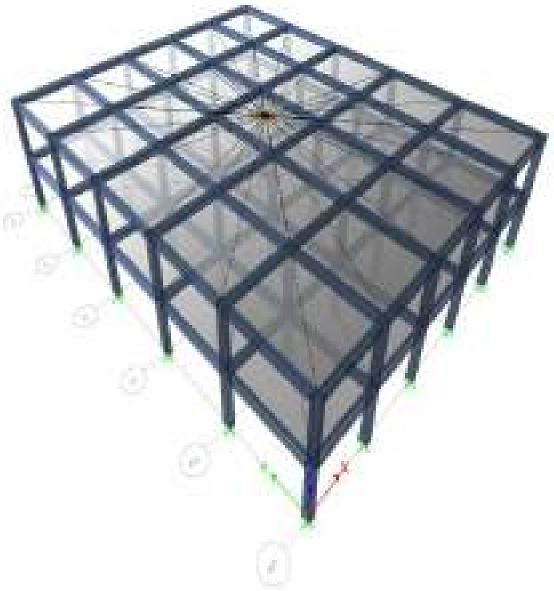

Figure 2.2: 3D View of 2-story regular RC building

Figure 2.3: 3D view of 6-story regular RC building

Figure 2.4: 3D view of 20-story regular RC building

2.3 Irregular RC Buildings

2-story, 6-story, and 20-story irregular reinforced concrete buildings, which are low, mid, and skyscraper, are considered. The beam in (x) transverse course is 4m and in (y) longitudinal direction is 5m. Figure 2.5 demonstrates the plan and figure 2.6, 2.7, 2.8 demonstrates 3D view of the three buildings having five bays in x-direction and five bays in y-direction. Story height of each building is assumed 3.5m.

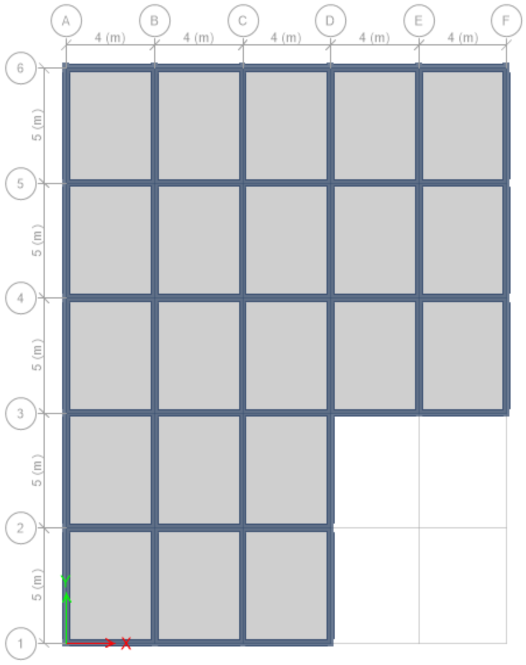

Figure 2.5: Irregular Building Plan

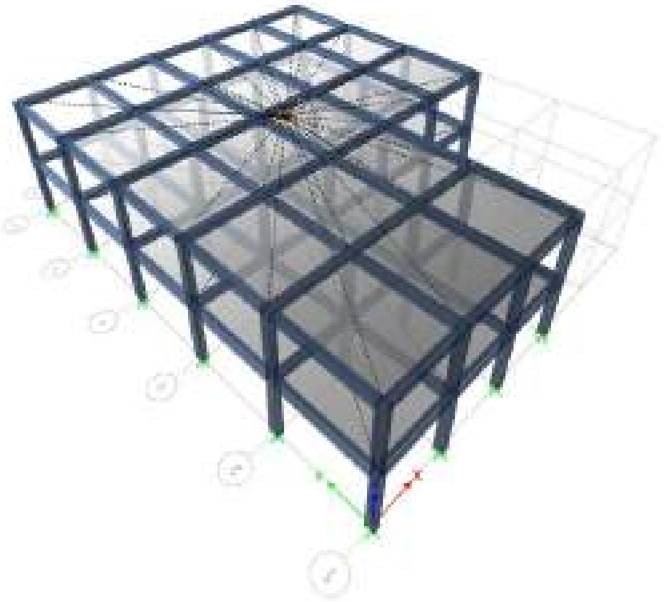

Figure 2.6: 3D View of 2-story irregular RC building

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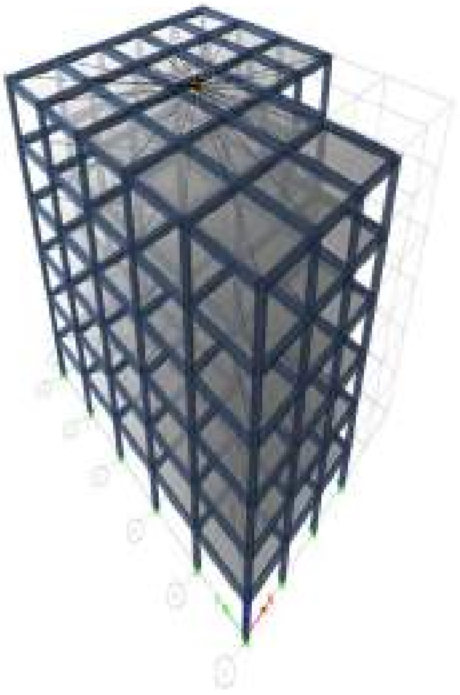

Figure 2.7: 3D view of 6-story irregular RC building

Figure 2.8: 3D view of 20-story regular RC building

3. GROUND MOTION RECORDS AND TIME HISTORY ANALYSIS

3.1 GROUND MOTION RECORDS

Records are chosen based on the peak ground acceleration (PGA) to the peak ground velocity (PGV), i.e. the ratio PGA/PGV. The justification behind this is close - source shallow quakes or records estimated on rock, will display high acceleration peaks of short duration, prompting low - velocity cycles. These records will give high estimations of PGA/PGV. Deep or distant earthquakes or records estimated on delicate ground will have lower acceleration values, however individual cycles are of longer duration, leading to high - velocity waves. These will yield low PGA/PGV ratios. Intermediate scenarios in both senses will yield intermediate values of PGA/PGV. Structures are exposed to ground motions which has dynamic attributes i.e. peak ground acceleration (PGA), peak ground velocity (PGV), peak ground displacement (PGD), frequency content, and duration. These qualities play dominating principle in concentrate the response of RC structures under seismic loads. The structure steadiness relies upon the structure slenderness, and also the ground motion amplitude, frequency and duration. Based on the frequency content, which is the ratio of PGA/PGV the ground motion records as appeared in table 3.1 are classified into three classes:

• High-frequency content	PGA/PGV > 1.2
• Intermediate-frequency content	0.8< PGA/PGV< 1.2
• Low-frequency content	PGA/PGV < 0.8

Where the acceleration PGA is expressed in ‘g’ and the velocity PGV in ‘m/s’

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Table 3.1: Attributes and classification of frequency-content

Earthquake (Station)	Component	Magnitude	Epicentral Distance (km)	Duration (s)	Time step for response	PGA (g)	PGV (m/s)	PGA/PGV	Frequency Content Ground Motion Classification
1979 Imperial Valley-06 (Holtville Post Office)	H-HVP225.AT2	6.53	19.80	37.86	0.0050	0.25815	0.53136	0.4858	Low(LGM)
1940 Imperial Valley-02 (El Centro Array #9	ELC270.AT2	6.95	12.98	53.45	0.0100	0.21074	0.31326	0.6727	Low(LGM)
Northridge-01 (Canoga Park-Topanga Can)	CNP106.AT2	6.69	4.85	24.98	0.0100	0.3576	0.3379	1.0583	Intermediate (IGM)
1992 Landers (Fort Irwin)	FTI000.AT2	7.28	120.99	39.98	0.0200	0.11357	0.09535	1.1910	Intermediate (IGM)
1957 San Francisco (Golden Gate Park)	GGP100.AT2	5.28	11.13	39.72	0.0050	0.09532	0.03932	2.4242	High(HGM)
1983 Coalinga-06 [Coalinga-14th & Elm (Old CHP)]	E-CHP000.AT2	4.89	9.27	59.995	0.0050	0.11381	0.06109	1.8629	High(HGM)

3.2 TIME HISTORY ANALYSIS

Time history investigation is a well ordered strategy where the loading and the response history are assessed at progressive time increments. During each progression the reaction is assessed from the initial conditions existing toward the start of the progression (displacements and velocities and the loading history in the interval). In this technique, the non-linear behavior might be effectively considered by changing the structural properties (e.g. stiffness, k) from one stage to another. Accordingly, this strategy is exceptionally viable to decide the non- linear response. However, in linear time history analysis, the structural properties are assumed to remain constant and a linear behavior of structure is assumed during the entire loading history. In structural analysis, the number of possible modes must be over 90% of the total seismic intensity. Tables 3.2-3.7 show that the number of modes considered here is more prominent or close to the standard. Table 3.2 demonstrates the dynamic characteristics of the 2-story regular reinforced concrete building for mode 1. The fundamental frequency of the structure is 9.3646 rad/sec and fundamental period is 0.671 sec.

Table 3.2: Dynamic characteristic of the 2-story regular RC building

Mode	Period	UX	UY	Sum UX	Sum UY	Frequency	Circular Frequency	Eigenvalue
	sec					cyc/sec	rad/sec	rad²/sec²
1	0.671	0.9231	0	0.9231	0	1.49	9.3646	87.6961

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Table 3.3 shows the dynamic characteristics of the 6-story regular reinforced concrete building for mode 1. The fundamental frequency of the structure is 2.679 rad/sec and fundamental period is 2.345 sec.

Table 3.3: Dynamic characteristic of the 6-story regular RC building

Mode	**Period**	**UX**	**UY**	**Sum UX**	**Sum UY**	**Frequency**	**Circular Frequency**	**Eigenvalue**
	sec					**cyc/sec**	**rad/sec**	**rad²/sec²**
1	2.345	0.8359	0	0.8359	0	0.426	2.679	7.1768

Table 3.4 shows the dynamic characteristics of the 20-story regular reinforced concrete building for mode 1. The fundamental frequency of the structure is 1.4837 rad/sec and fundamental period is 4.235 sec.

Table 3.4: Dynamic characteristic of the 20-story regular RC building

Mode	**Period**	**UX**	**UY**	**Sum UX**	**Sum UY**	**Frequency**	**Circular Frequency**	**Eigenvalue**
	sec					**cyc/sec**	**rad/sec**	**rad²/sec²**
1	4.235	0	0.7885	0	0.7885	0.236	1.4837	2.2015

Table 3.5 shows the dynamic characteristics of the 2-story irregular reinforced concrete building for mode 1. The fundamental frequency of the structure is 9.5121 rad/sec and fundamental period is 0.661 sec.

Table 3.5: Dynamic characteristic of the 2-story irregular RC building

Mode	**Period**	**UX**	**UY**	**Sum UX**	**Sum UY**	**Frequency**	**Circular Frequency**	**Eigenvalue**
	sec					**cyc/sec**	**rad/sec**	**rad²/sec²**
1	0.661	0.9224	0	0.9224	0	1.514	9.5121	90.4807

Table 3.6 shows the dynamic characteristics of the 6-story irregular reinforced concrete building for mode 1. The fundamental frequency of the structure is 2.7071 rad/sec and fundamental period is 2.321 sec.

Table 3.6: Dynamic characteristic of the 6-story irregular RC building

Mode	**Period**	**UX**	**UY**	**Sum UX**	**Sum UY**	**Frequency**	**Circular Frequency**	**Eigenvalue**
	sec					**cyc/sec**	**rad/sec**	**rad²/sec²**
1	2.321	0.8346	0.000003438	0.8346	0.000003438	0.431	2.7071	7.3282

Table 3.7 shows the dynamic characteristics of the twenty-story irregular reinforced concrete building for mode 1. The fundamental frequency of the structure is 1.4867 rad/sec and fundamental period is 4.226 sec.

Table 3.7: Dynamic characteristics of the 20-story irregular RC building

Mode	**Period**	**UX**	**UY**	**Sum UX**	**Sum UY**	**Frequency**	**Circular Frequency**	**Eigenvalue**
	sec					**cyc/sec**	**rad/sec**	**rad²/sec²**
1	4.226	0.001	0.7853	0.001	0.7853	0.237	1.4867	2.2103

4. RESULTS OF REGULAR RC BUILDINGS

4.1 Two-Story Regular RC Building

Figure 4.1-4.2 shows story displacement, velocity and acceleration of 2-story regular RC building due to six ground motions. The story displacement is maximum due to low frequency content time series and least because of high frequency content time series in both X and Y direction. The story velocity is greatest because of intermediate frequency content time series and least because of high frequency content time series in both X and Y direction. The story acceleration is most extreme because of intermediate and low frequency content time series in X and Y direction respectively and least because of high frequency content time series in X and Y direction. In figure 4.3, base shear is maximum due to low frequency content time series and minimum due to high frequency content time series along X and Y direction.

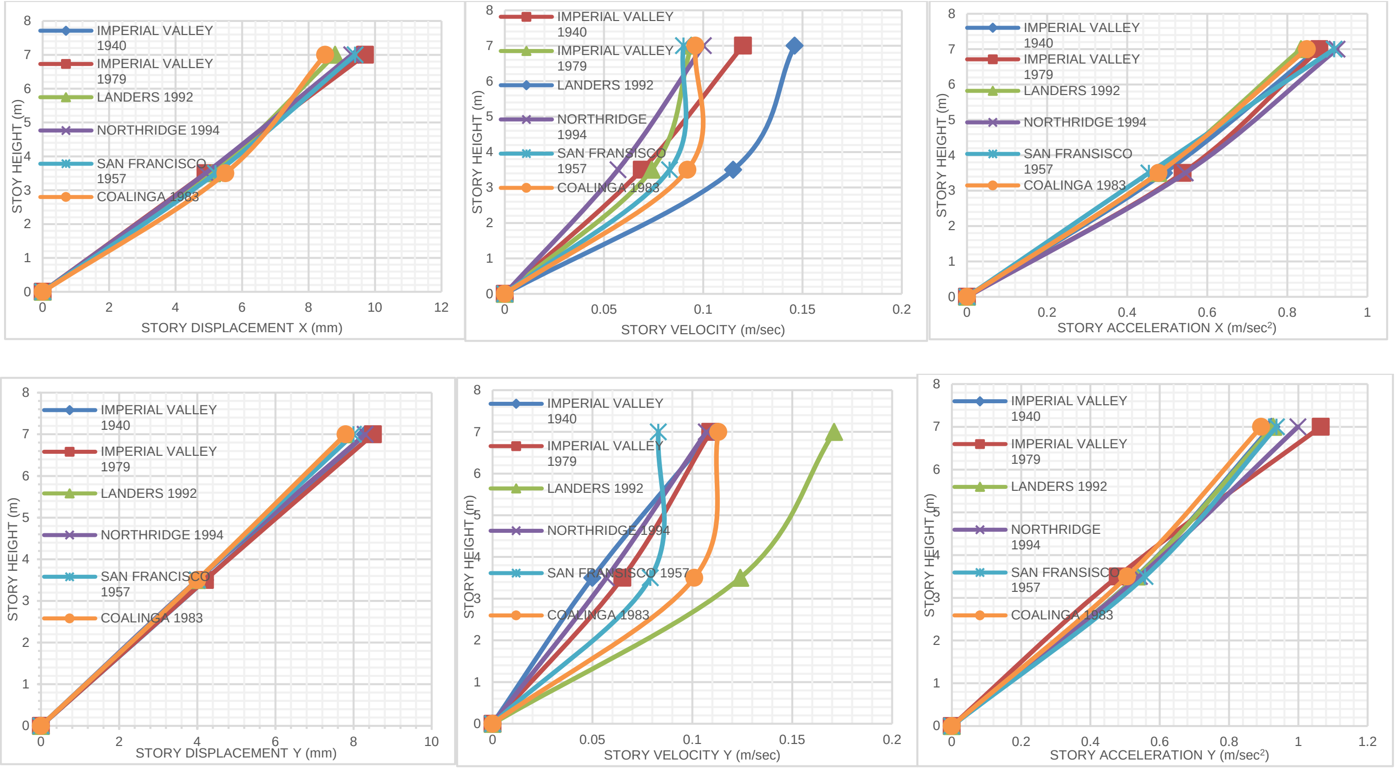
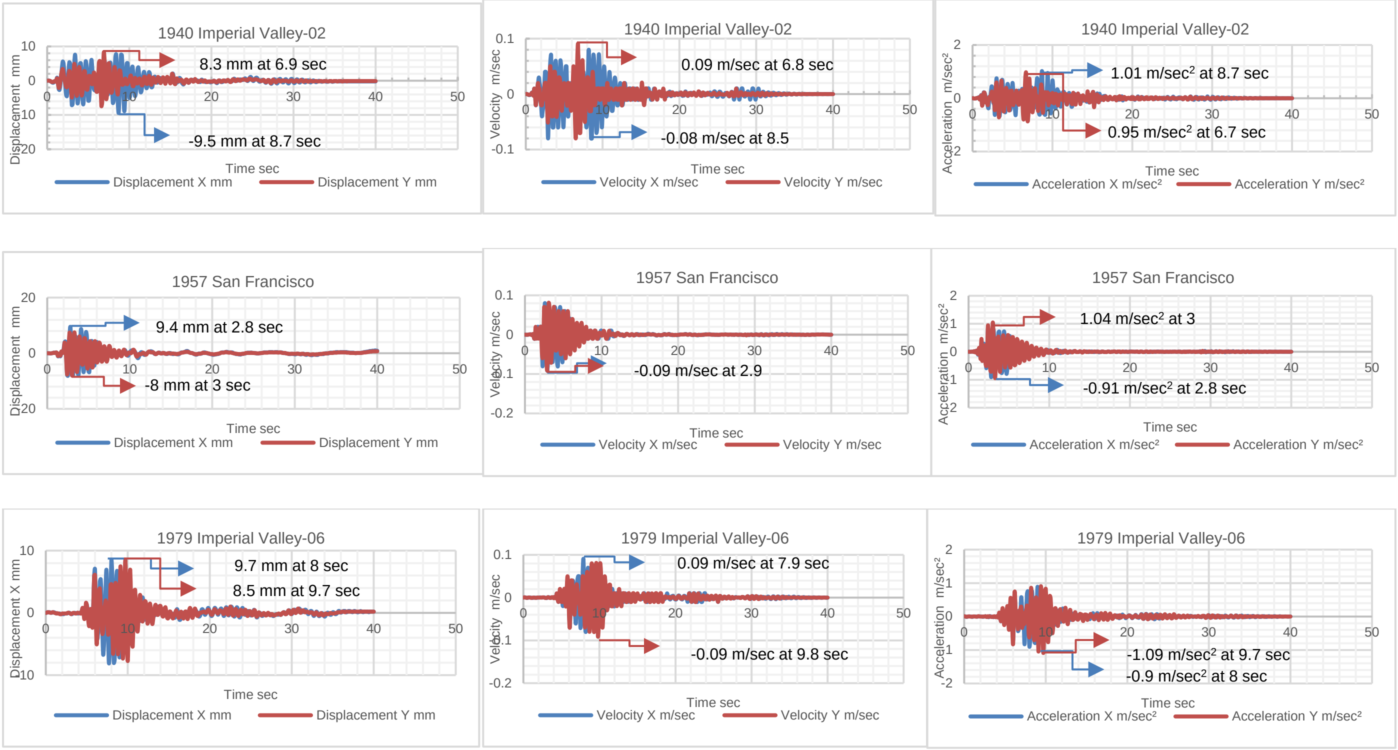


Figure 4.1: Displacement, Velocity, Acceleration response of 2-story regular RC building along X and Y direction



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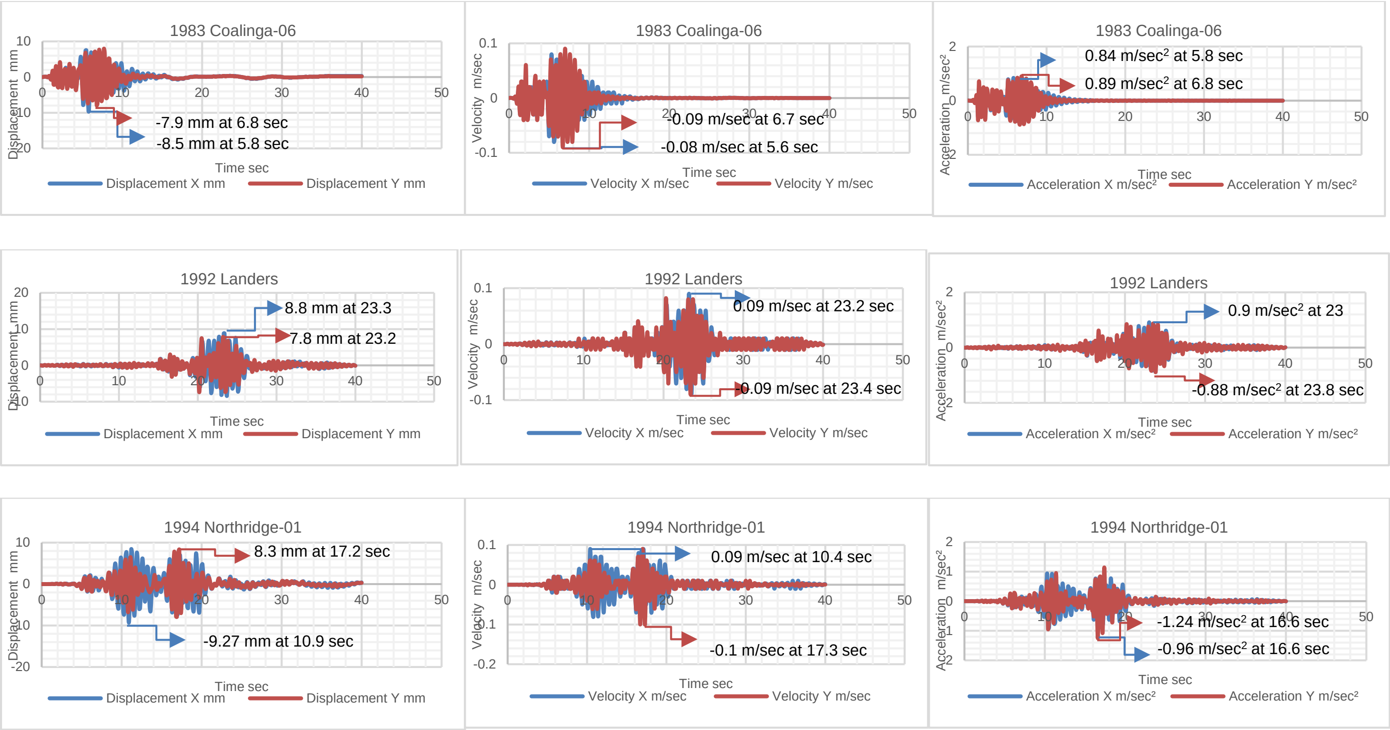


Figure 4.2: Roof Displacement, Roof Velocity, Roof Acceleration of 2-story regular RC building due to considered ground motion in X and Y direction.

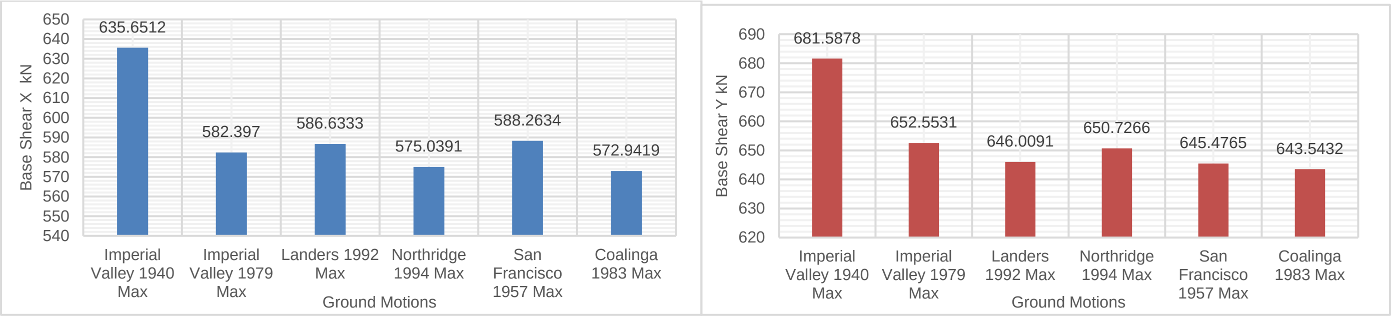
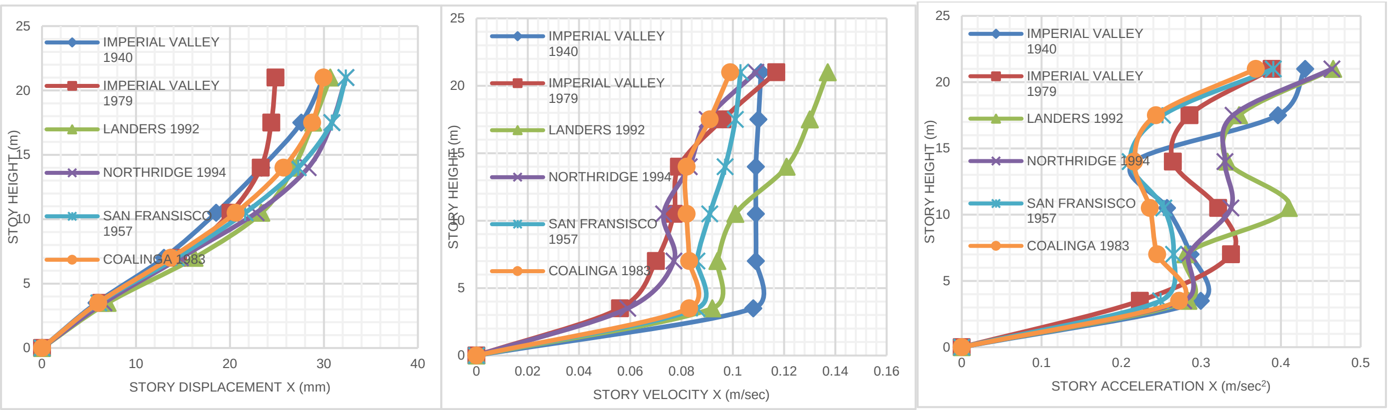


Figure 4.3: Maximum base shear along X and Y direction of regular 2-story building.

4.2 Six-Story Regular RC Building

Figure 4.4-4.5 shows story displacement, velocity, and acceleration of 6-story regular RC building due to six ground motions. The story displacement is maximum due to intermediate frequency content time series and least because of low frequency content time series in both X and Y direction. The story velocity is greatest because of intermediate frequency content time series and least because of high frequency content time series in both X and Y direction. The story acceleration is most extreme because of intermediate frequency content time series in X and Y direction and least because of high frequency content time series in X and Y direction. In figure 4.6, base shear is maximum due to intermediate and low frequency content time series along X and Y direction respectively and minimum due to high frequency content time series along X and Y direction.



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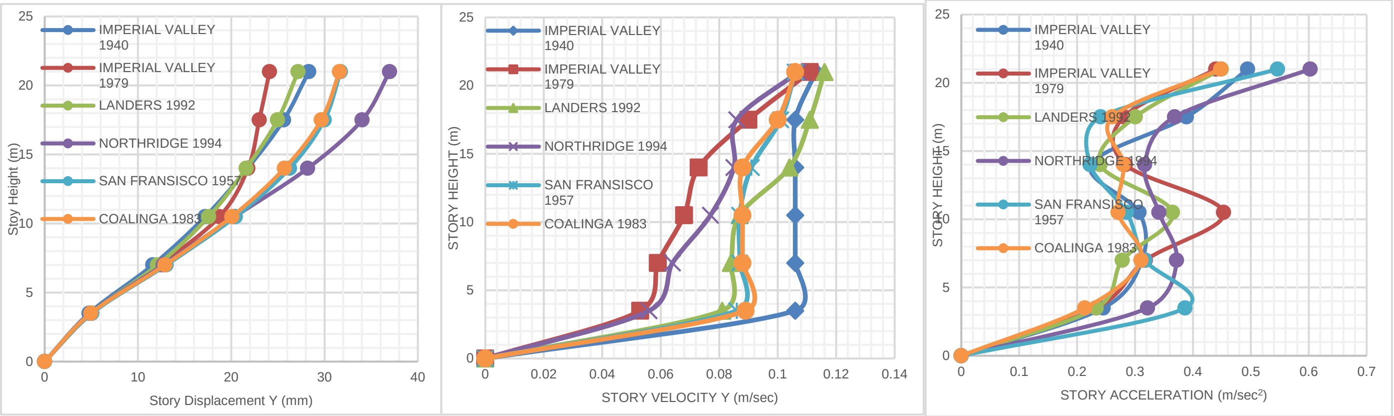
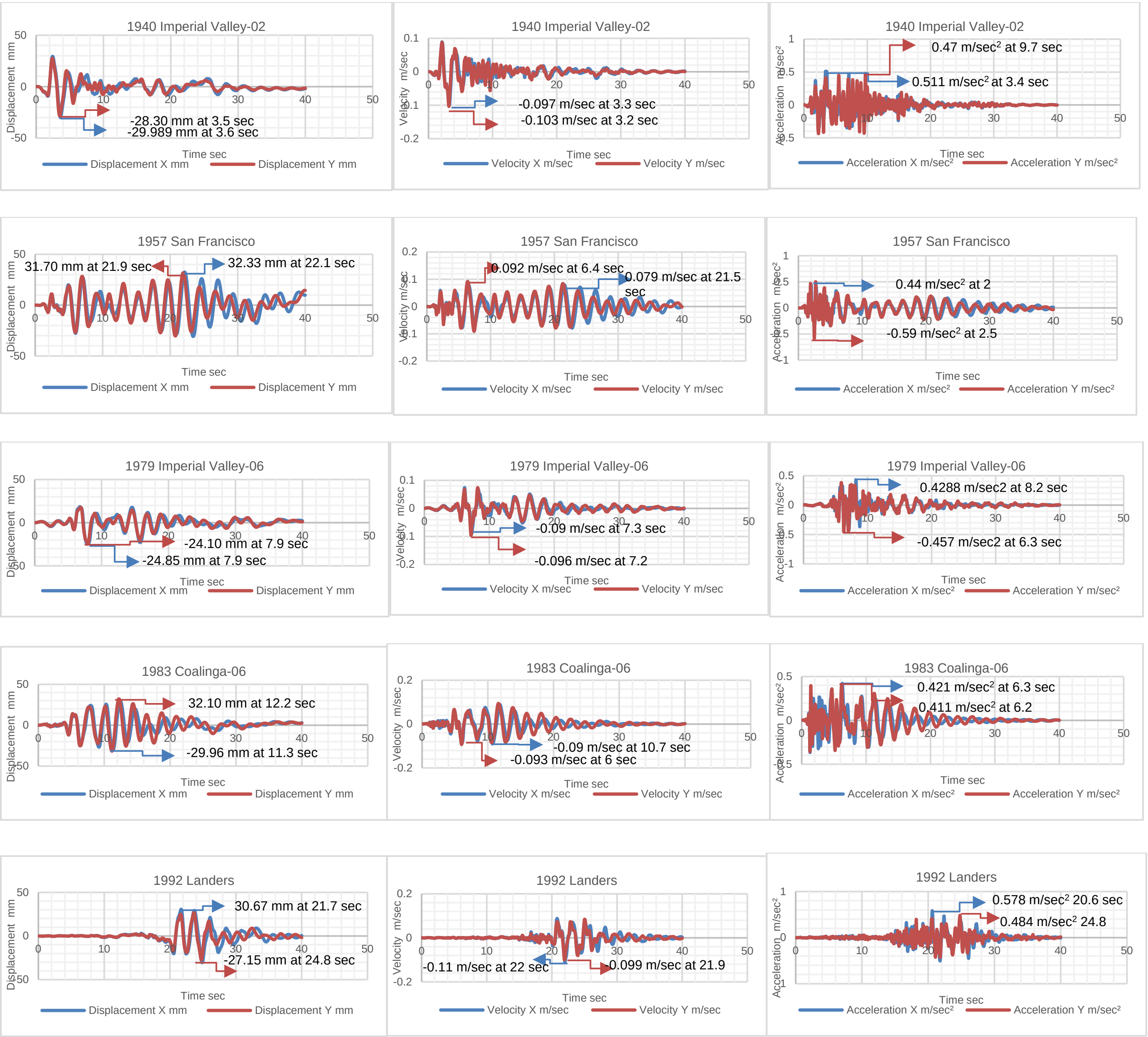


Figure 4.4: Displacement, Velocity, Acceleration response of 6-story regular RC building along X and Y direction



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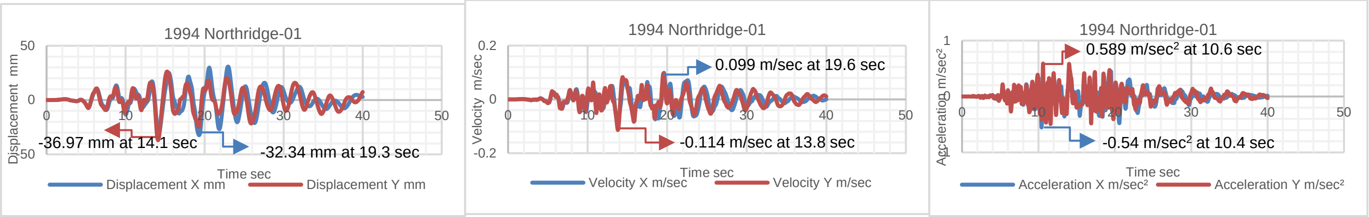

Figure 4.5: Roof Displacement, Roof Velocity, Roof Acceleration of 6-story regular RC building due to considered ground motion in X and Y direction.

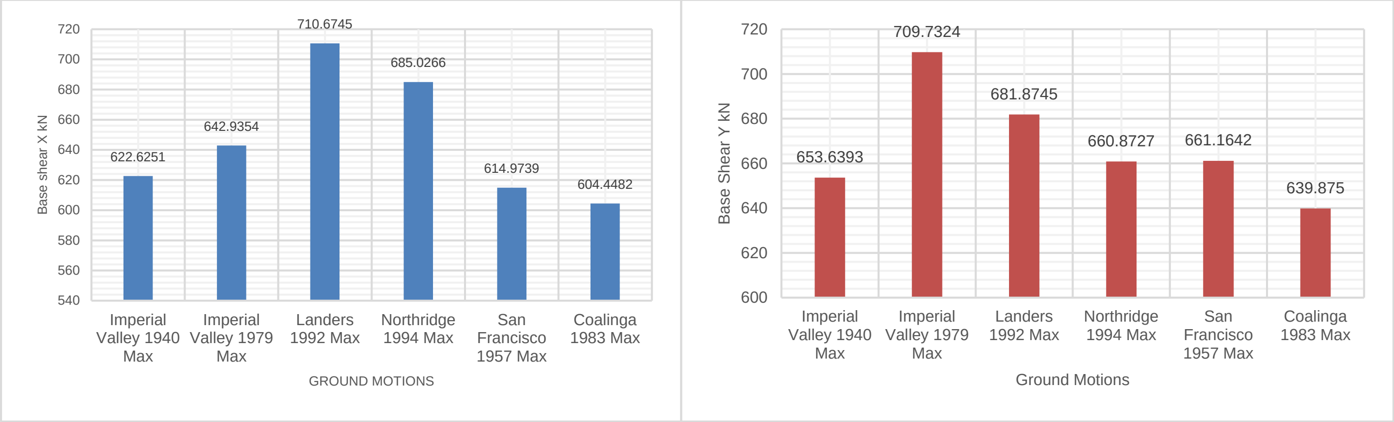

Figure 4.6: Maximum base shear along X and Y direction of regular 6-story building.

4.3 Twenty-Story Regular RC Building

Figure 4.7-4.8 shows story displacement, velocity, and acceleration of 20-story regular RC building due to six ground motions. The story displacement is maximum due to high frequency content time series and least because of low and intermediate frequency content time series in both X and Y direction. The story velocity is greatest because of intermediate frequency content time series and least because of low frequency content time series in both X and Y direction. The story acceleration is most extreme because of high and intermediate frequency content time series in X and Y direction and least because of intermediate and low frequency content time series in X and Y direction. In figure 4.9, base shear is maximum due to intermediate and low frequency content time series along X and Y direction respectively and minimum due to high frequency content time series along X and Y direction.

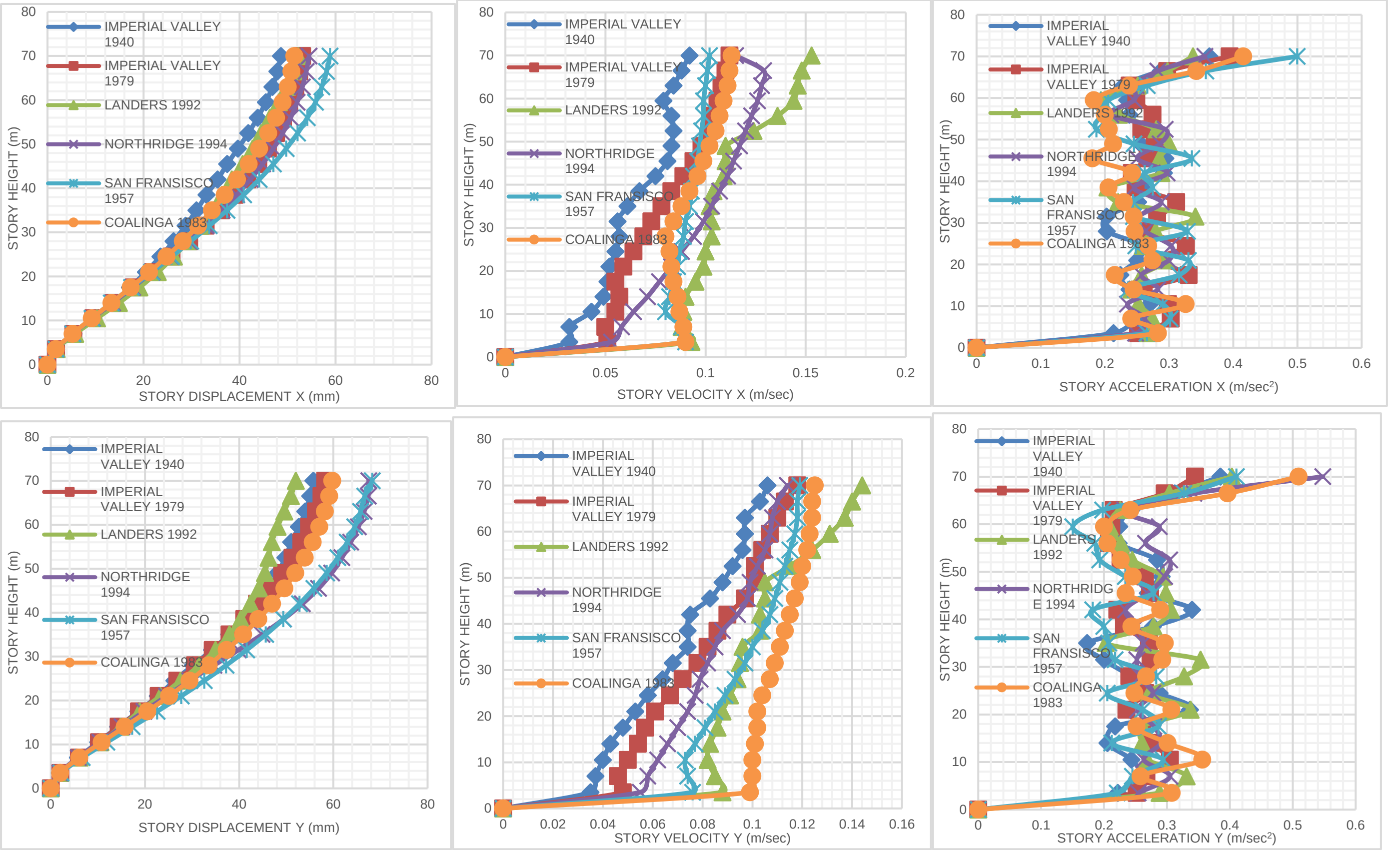

Figure 4.7: Displacement, Velocity, Acceleration response of 20-story regular RC building along X and Y direction

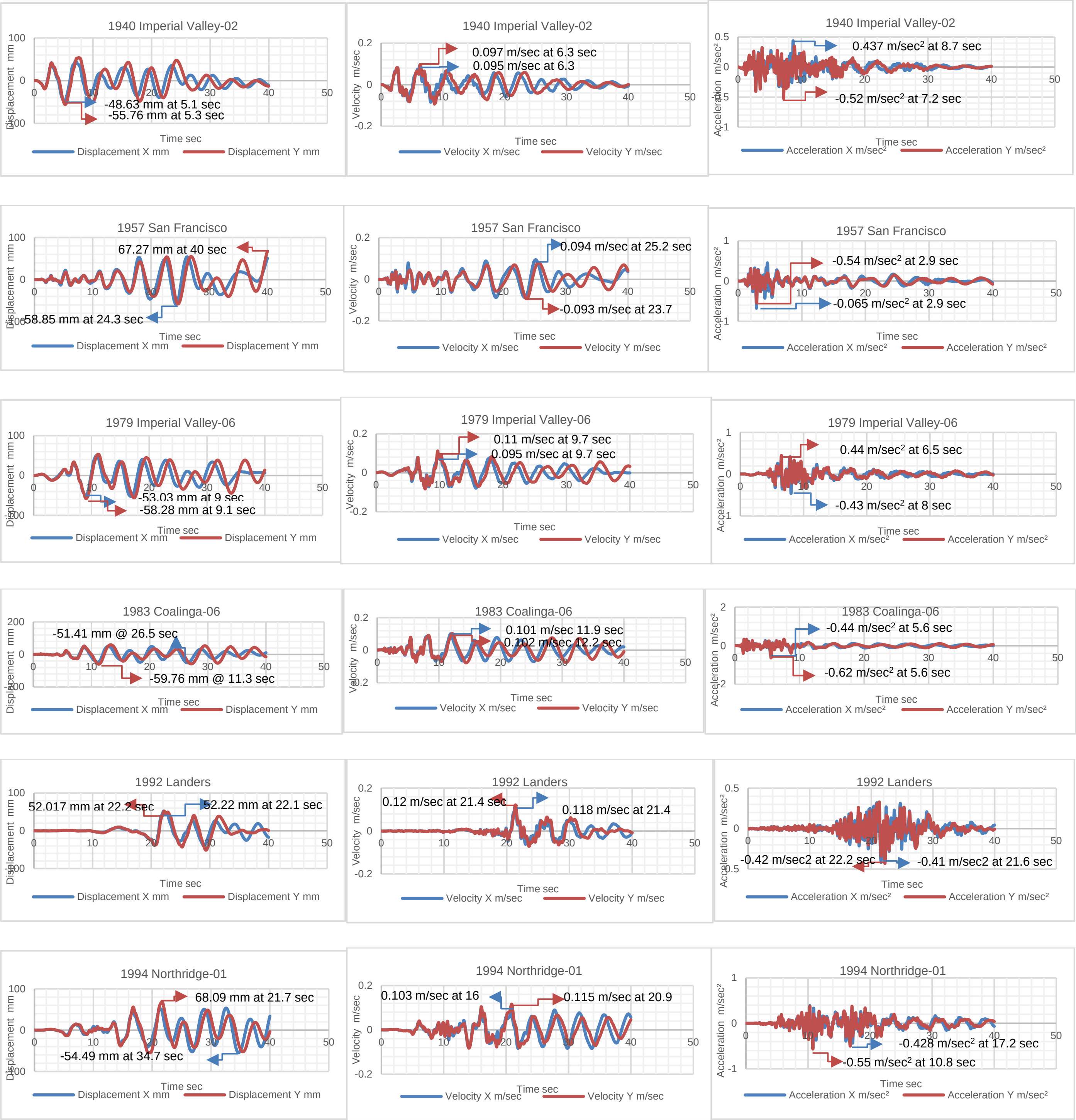

Figure 4.8: Roof Displacement, Roof Velocity, Roof Acceleration of 20-story regular RC building due to considered ground motion in X and Y direction.

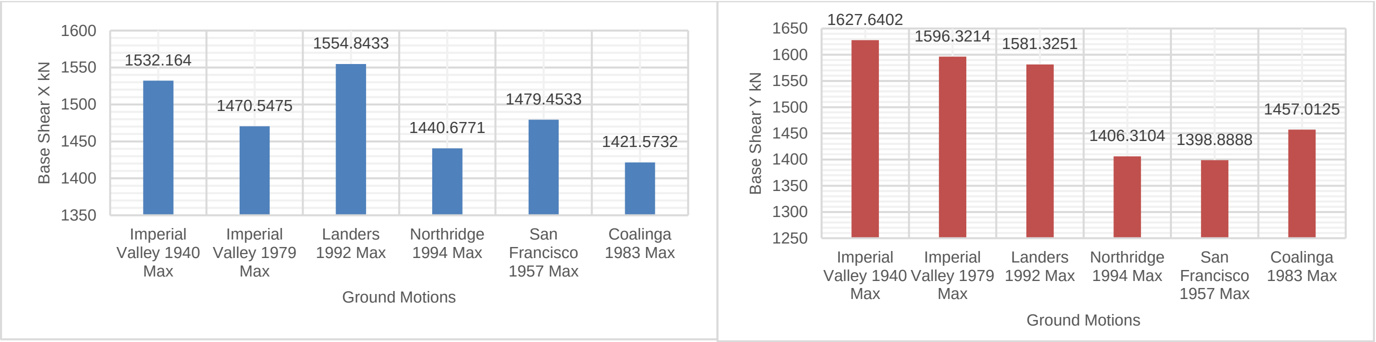

Figure 4.9: Maximum base shear along X and Y direction of regular 20-story building.

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5. RESULTS OF IRREGULAR RC BUILDINGS

5.1 Two-Story Irregular RC Building

Figure 5.1-5.2 shows story displacement, velocity, and acceleration of 2-story irregular RC building due to six ground motions. The story displacement is maximum due to high and low frequency content time series in both X and Y direction respectively and least because of intermediate and high frequency content time series in both X and Y direction respectively. The story velocity is greatest because of intermediate frequency content time series and least because of high frequency content time series in both X and Y direction. The story acceleration is most extreme because of high and low frequency content time series in X and Y direction respectively and least because of low and high frequency content time series in X and Y direction respectively. In figure 5.3, base shear is maximum due to low frequency content time series and minimum due to high frequency content time series along X and Y direction.

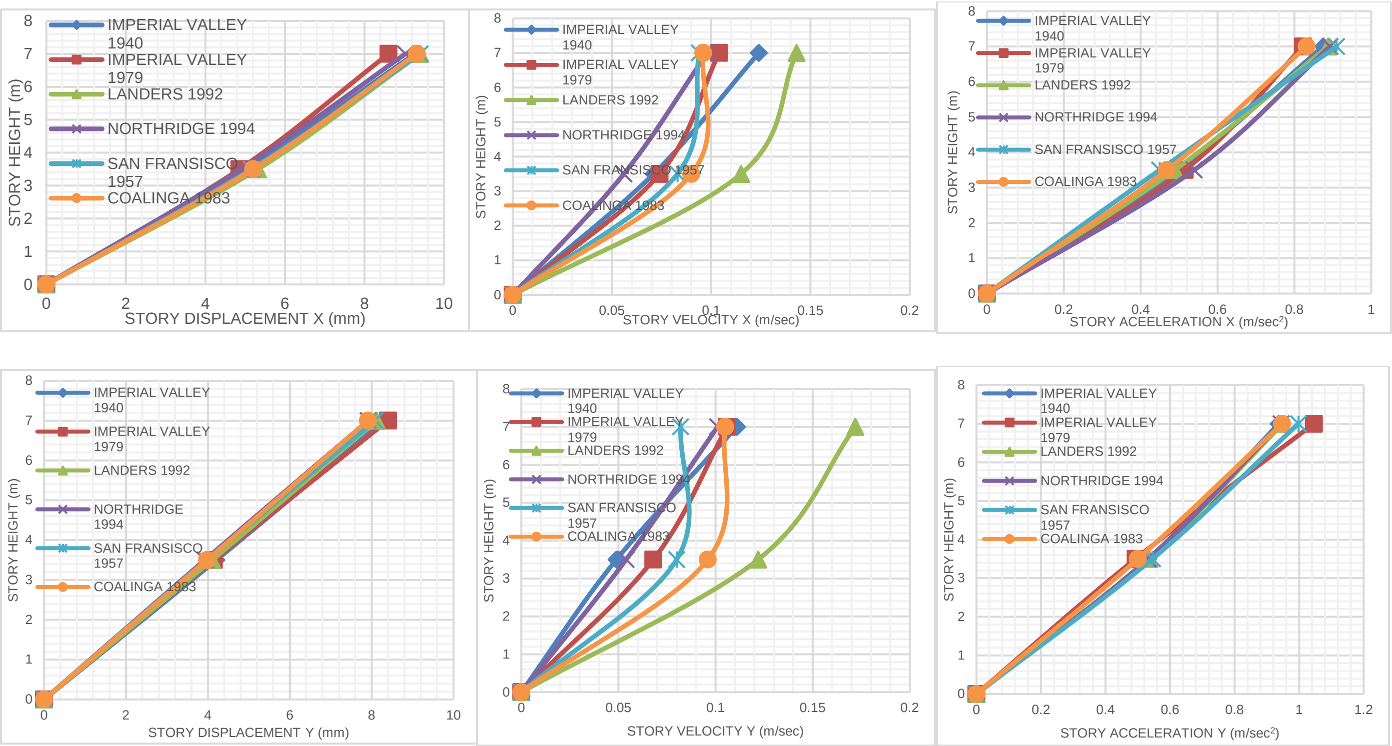
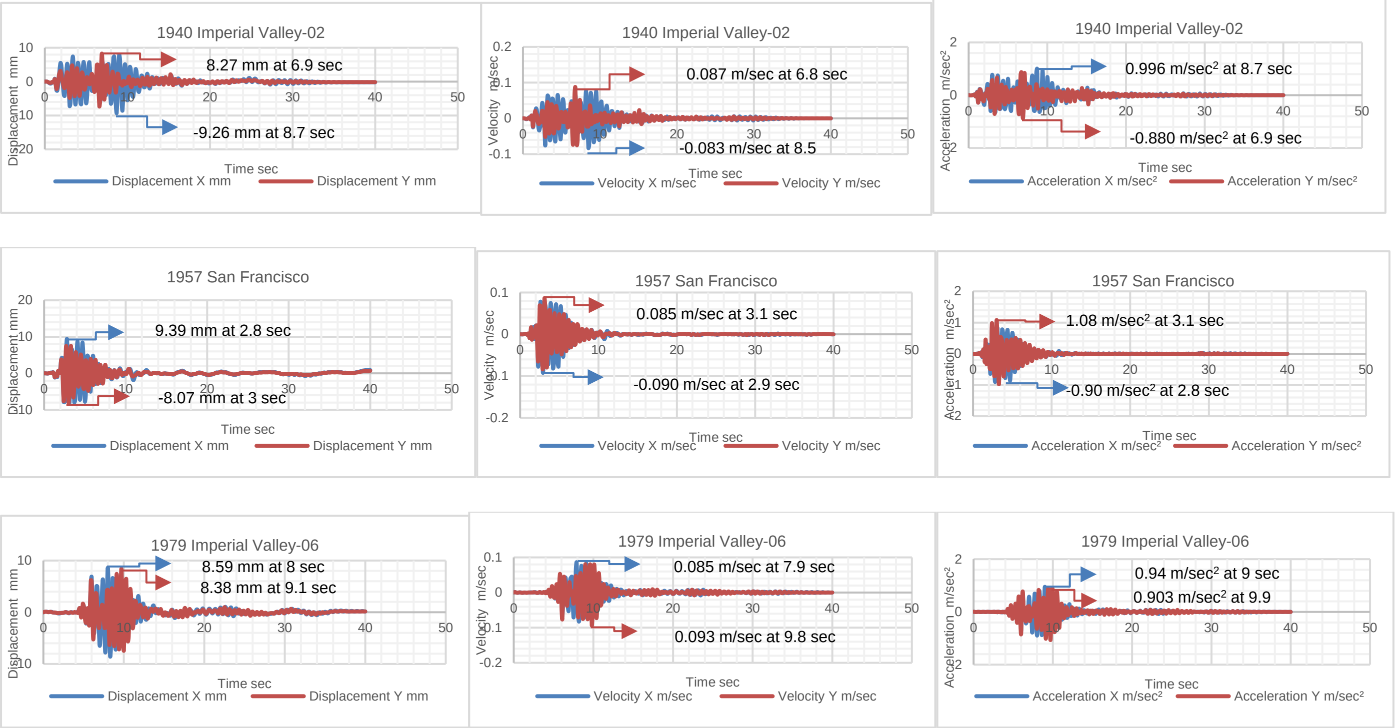


Figure 5.1: Displacement, Velocity, Acceleration response of 2-story irregular RC building along X and Y direction



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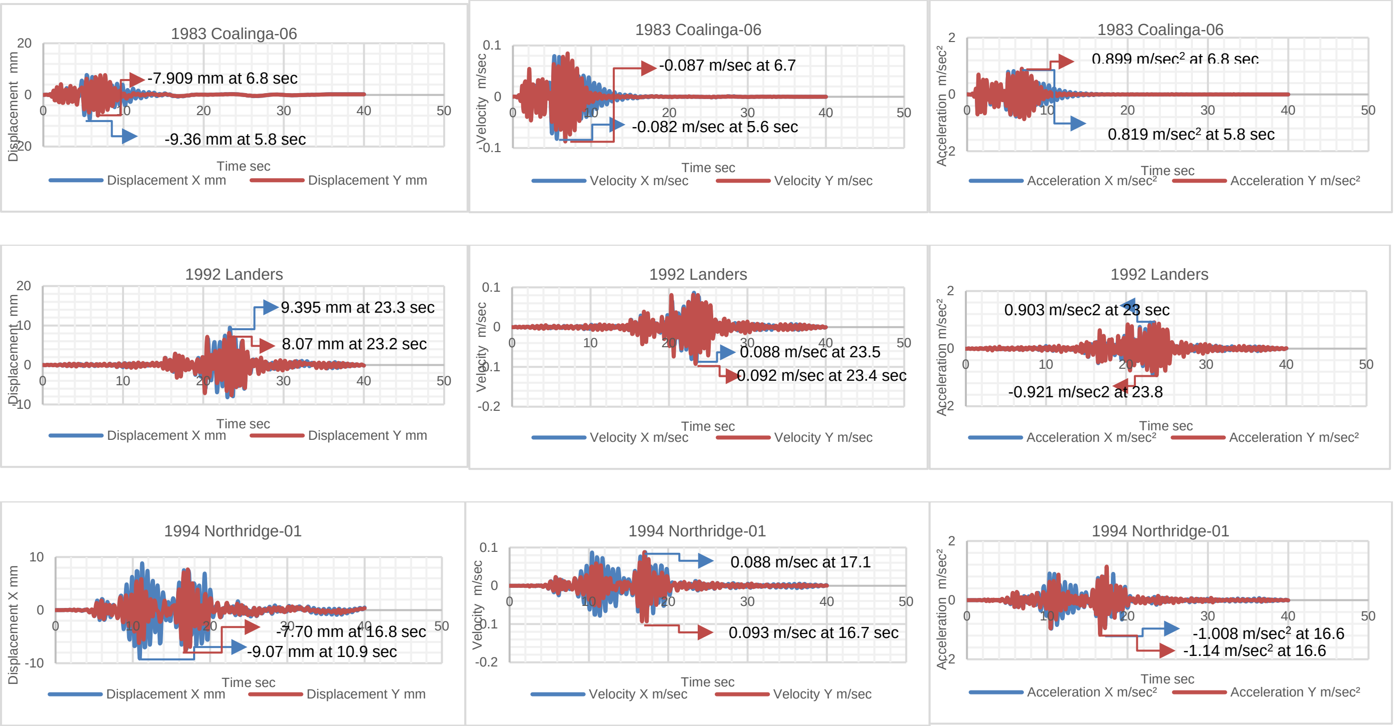


Figure 5.2: Roof Displacement, Roof Velocity, Roof Acceleration of 2-story irregular RC building due to considered ground motion in X and Y direction.

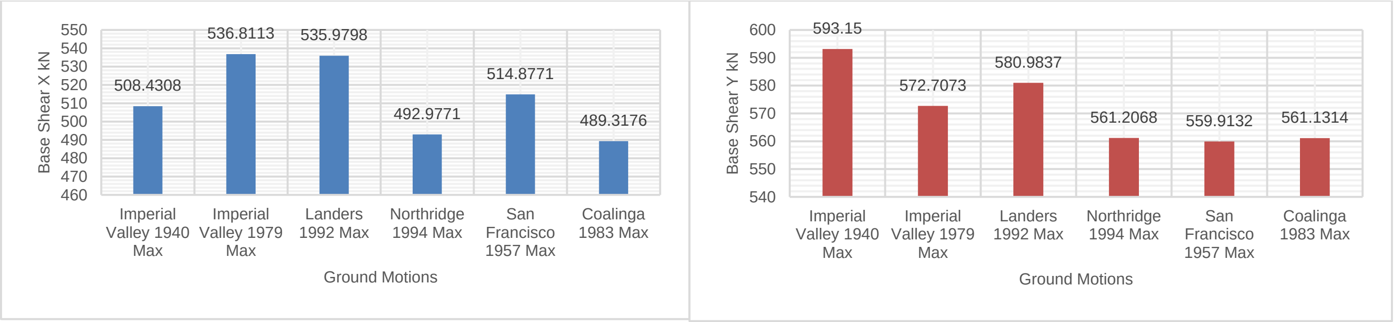
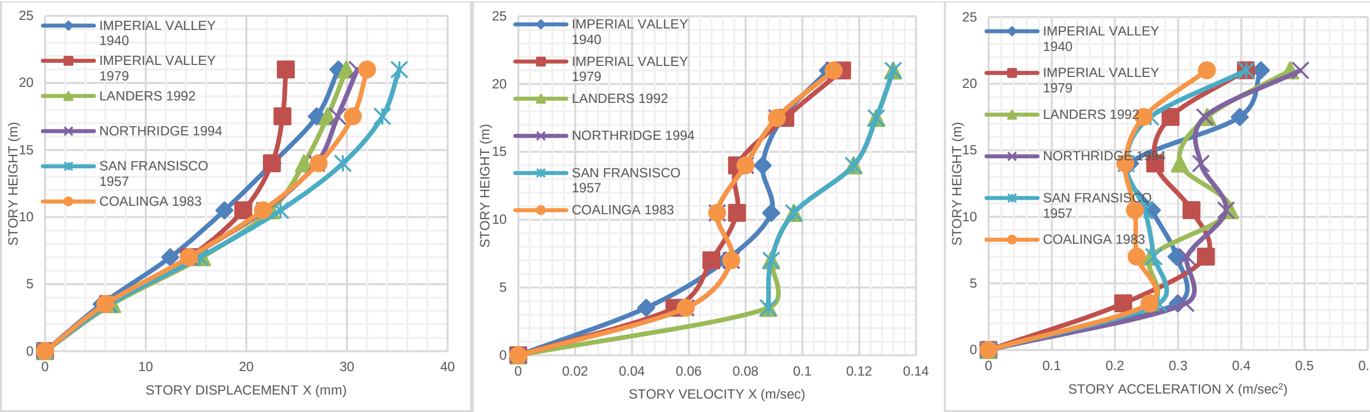


Figure 5.3: Maximum base shear along X and Y direction of irregular 2-story building.

5.2 Six-Story Irregular RC Building

Figure 5.4-5.5 shows story displacement, velocity, and acceleration of 6-story regular RC building due to six ground motions. The story displacement is maximum due to high and intermediate frequency content time series in X and Y direction respectively and least because of low frequency content time series in both X and Y direction. The story velocity is greatest because of high and intermediate frequency content time series in X and Y direction respectively and least because of low and high frequency content time series in both X and Y direction respectively. The story acceleration is most extreme because of intermediate frequency content time series in X and Y direction and least because of high frequency content time series in X and Y direction. In figure 5.6, base shear is maximum due to intermediate and low frequency content time series in X and Y direction respectively and minimum due to high frequency content time series along X and Y direction.



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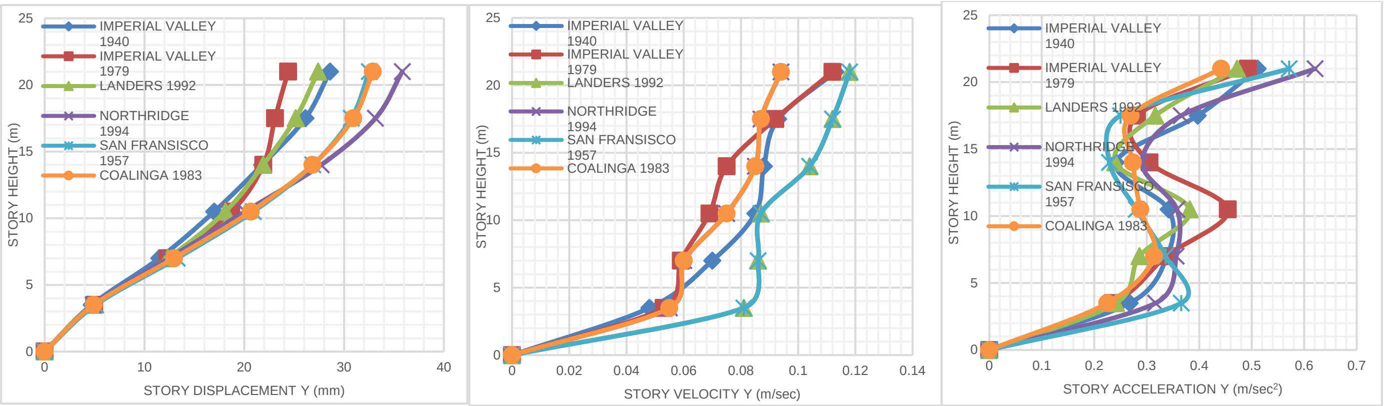
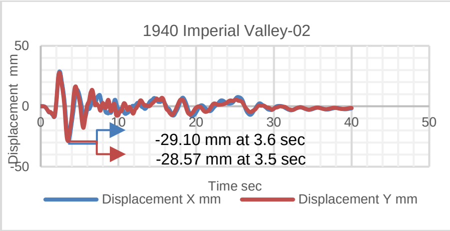
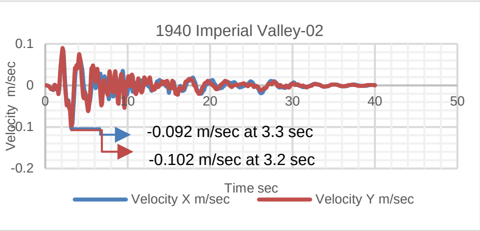
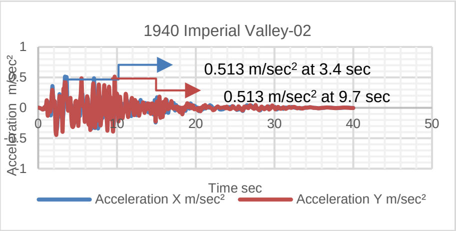
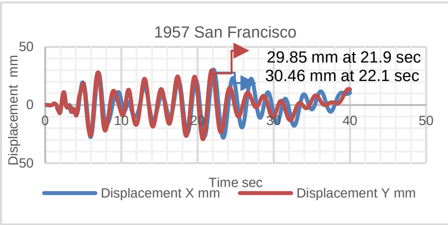


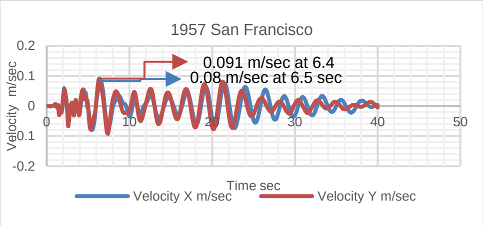
Figure 5.4: Displacement, Velocity, Acceleration response of 6-story irregular RC building along X and Y direction

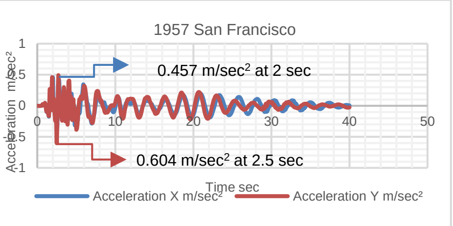


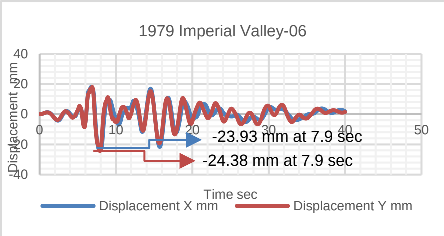


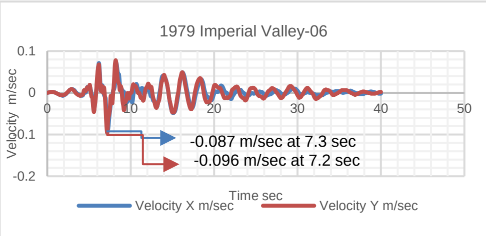


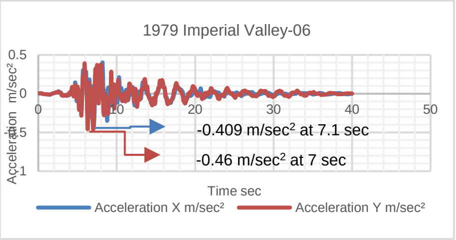


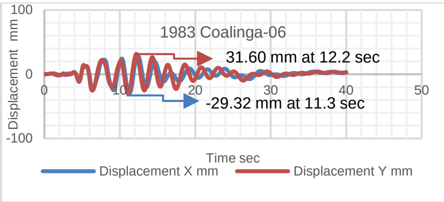


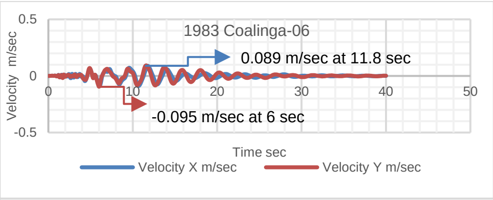


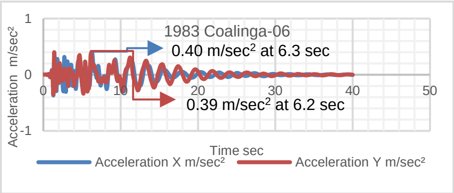


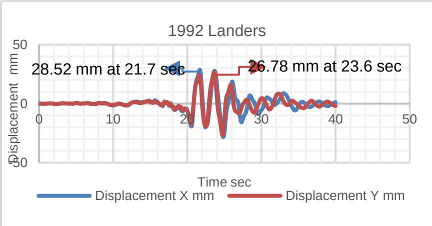


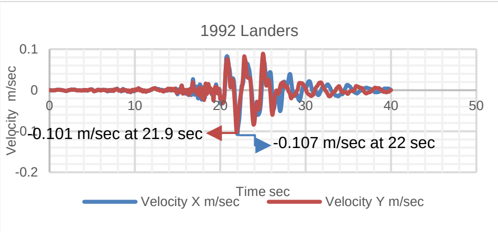


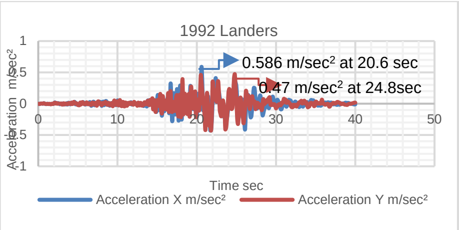












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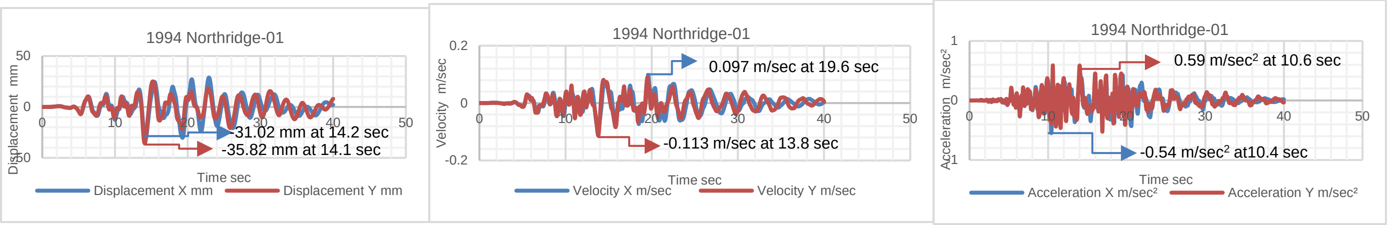

Figure 5.5: Roof Displacement, Roof Velocity, Roof Acceleration of 6-story irregular RC building due to considered ground motion in X and Y direction.

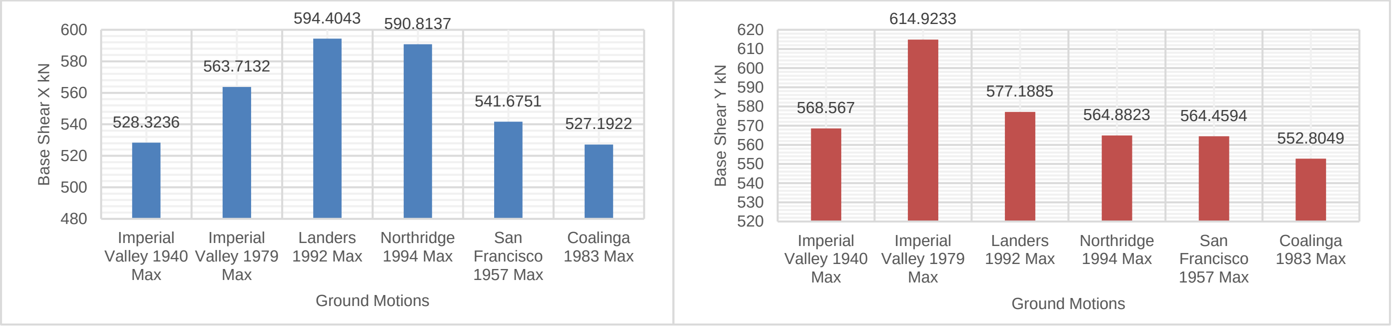

Figure 5.6: Maximum base shear along X and Y direction of irregular 6-story building.

5.3 Twenty-Story Irregular RC Building

Figure 5.7-5.8 shows story displacement, velocity, and acceleration of 20-story regular RC building due to six ground motions. The story displacement is maximum due to high and intermediate frequency content time series in X and Y direction respectively and least because of low frequency content time series in both X and Y direction. The story velocity is greatest because of intermediate frequency content time series and least because of low frequency content time series in both X and Y direction. The story acceleration is most extreme because of high and intermediate frequency content time series in X and Y direction respectively and least because of intermediate and low frequency content time series in X and Y direction respectively. In figure 5.9, base shear is maximum due to low frequency content time series in X and Y direction and minimum due to high frequency content time series along X and Y direction

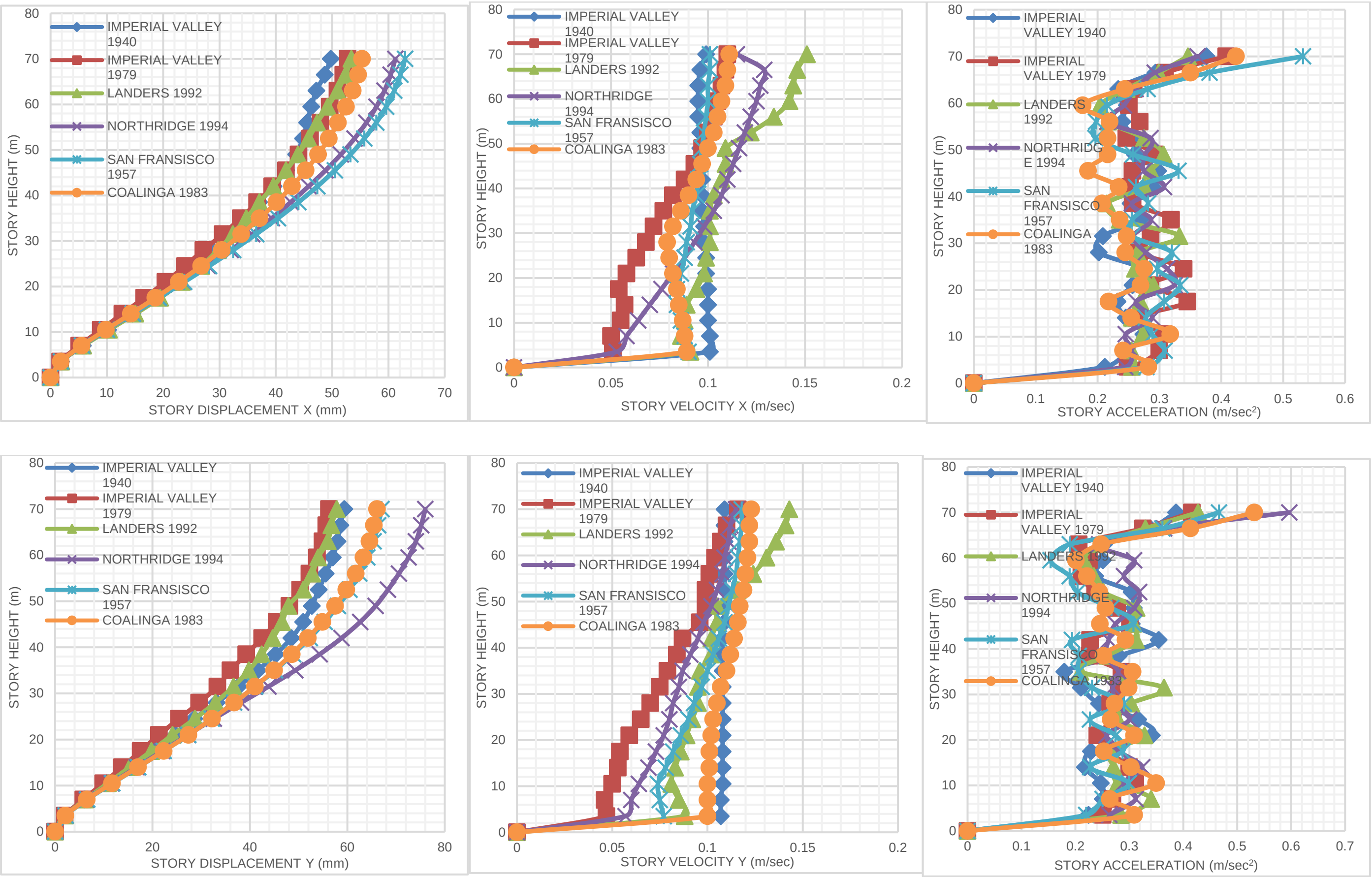

Figure 5.7: Displacement, Velocity, Acceleration response of 20-story irregular RC building along X and Y direction

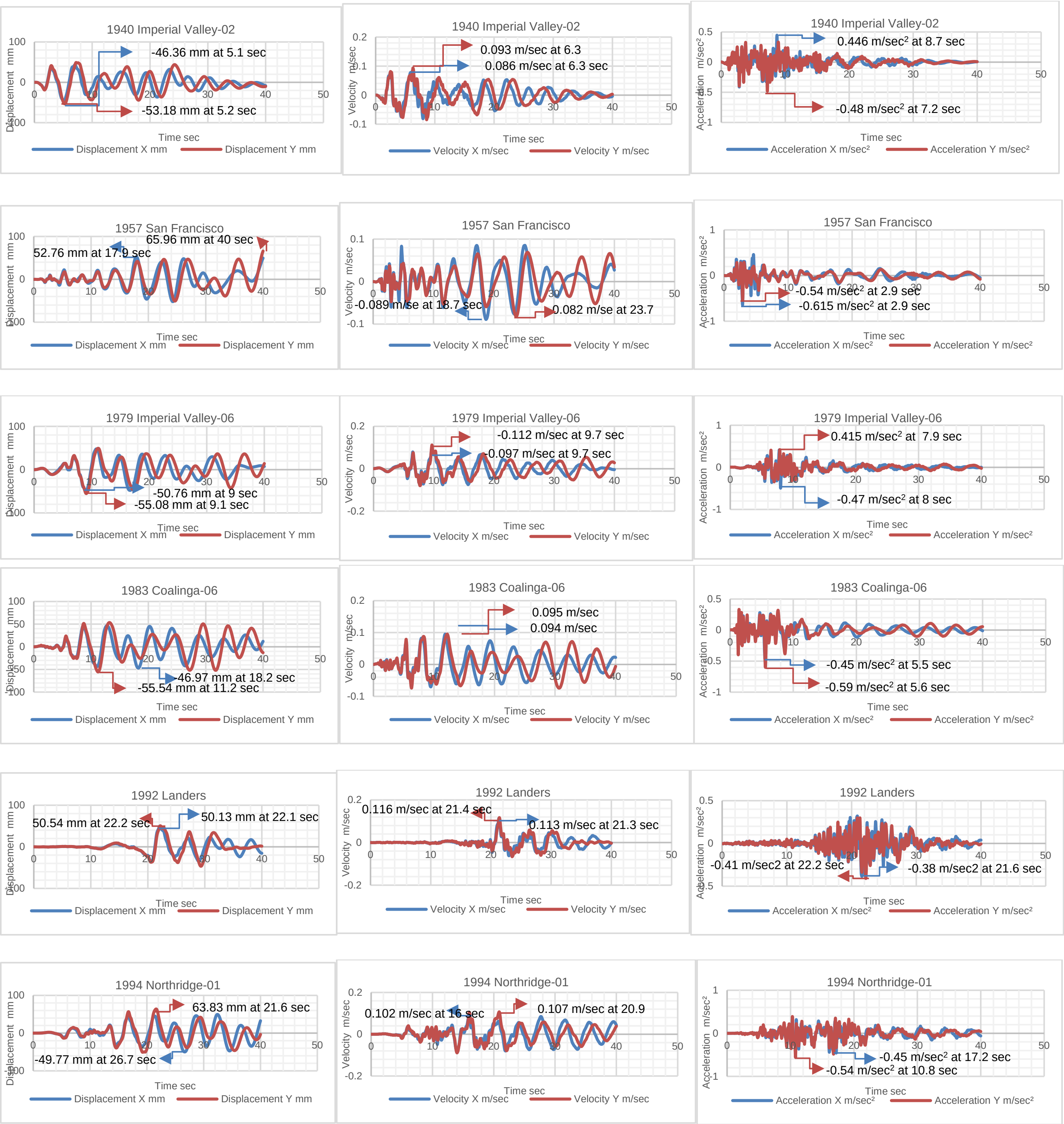

Figure 5.8: Roof Displacement, Roof Velocity, Roof Acceleration of 20-story irregular RC building due to considered ground motion in X and Y direction.

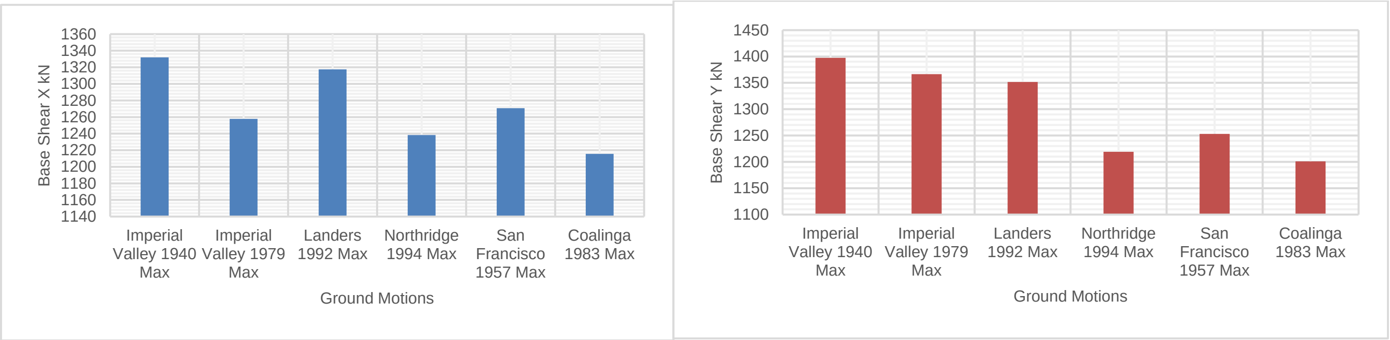

Figure 5.9: Maximum base shear along X and Y direction of irregular 20-story building.

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6. CONCLUSIONS

Here, low, mid, and high-rise regular as well as irregular 3D RC buildings are studied under low, intermediate, and high-frequency content ground motions. Linear time history analysis is performed using ETABS software. The responses of the buildings are shown in terms of story displacement, story velocity, story acceleration, and base shear. Then the results of each RC building due to each ground motion are studied and compared. It is found that time period of building increase with increase in the height of the building on the other hand frequency and circular natural frequency of the building decreases with increase in the height of the building. For all the models lateral displacement of the building increases with increase in the height of the building along both X and Y directions for different time series function. Low-frequency content ground motion has significant effect on responses of regular as well as irregular RC buildings irrespective of the building height. However, high-frequency content ground motion has very less effect on responses of both regular and irregular RC buildings regardless of the building height. Furthermore, the effect of the intermediate-frequency content ground motion is less than the low-frequency content ground motion and more than high-frequency content ground motion on responses of the RC buildings.

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