CHAPTER 4 DYNAMIC ANALYSIS OF BASE-ISOLATED AND FIXED-BASE RC FRAME BUILDING UNDER NEAR-FIELD AND FAR-FIELD EARTHQUAKES

4.1 Introduction

The previous chapter focused on the finite element analysis of Lead Rubber Bearings and High Damping Rubber Bearings using ABAQUS software. In this chapter, the analysis extends to a Reinforced Concrete (RC) building integrated with LRB and HDRB, as referenced from the previous literature. The objective of this chapter is to examine the parametric variations in the responses of the RC frame building. A comparative study with a fixed-base building is conducted, revealing a significant reduction in structural responses when LRB and HDRB are utilized.

By employing flexible isolation bearings or isolators sandwiched between a buildings foundation and superstructure, this method decouples them from ground motion, enabling independent movement and absorbing seismic energy, as illustrated in Figure 4.1 [181]. Consequently, it diminishes the transmission of forces into the building, thus minimizing

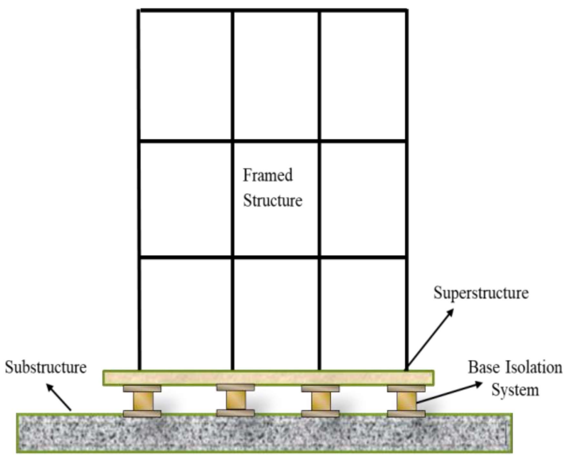


Figure 4.1 Schematic presentation of seismic base isolation system

structural damage and ensuring occupant safety. Furthermore, seismic base isolation aligns with contemporary design principles, promoting the longevity and durability of structures in earthquake-prone regions. Nonetheless, base isolation systems may experience significant displacement due to intense seismic forces [182]. Additionally, damping provided by the isolation elements dissipates earthquake energy and limits base displacements [183]. The technique was later implemented by Frank Lloyd Wright in the Imperial Hotel, Tokyo, in 1921 [184].

In the present chapter, the analysis of the dynamic responses of fixed base and isolated base reinforced concrete (RC) frames under both FF and NF earthquakes. The analysis aims to compare the seismic response of these buildings under several seismic events record. The fixed base structures are analyzed to establish a baseline, while the isolated base structures incorporate seismic isolation systems to mitigate seismic effects. The study focuses on evaluating parameters such as base shear response, floor acceleration, and displacement response to assess the efficiency of the seismic BI systems. The findings will provide insights into the behavior of RC buildings under different seismic conditions and the efficacy of seismic isolation techniques in reducing structural damage. Multi-story RC structures can be vulnerable to seismic and dynamic forces. Base isolation, a design strategy to separate structures from these effects, involves complex composite structures. In this analysis, the dynamic performance of a 10-story RC building with fixed base and base isolation are examined. Seismic base isolators, specifically LRB and HDRB, are employed to mitigate the effects of input earthquakes. The NLTH analysis is conducted using the SAP2000 software package. The applied seismic records are derived from the PEER NGA WEST2 records and COSMOS strong motion virtual data center (VDC), with both NF and FF seismic motions considered for analysis. The earthquake records are matched with the response spectrum of IS 1893 Part 1: 2016 Zone V using SeismoMatch software. These matched records are used as input time history records to evaluate the buildings responses. The analysis shows a substantial decrease in base shear, top floor acceleration, and absolute floor acceleration. Additionally, there is a notable increase in joint displacement at each story level, top floor displacement, and base displacement compared to fixed-base structures. Overall, the use of isolators effectively reduces the buildings responses. The flowchart of the present chapter has been presented in Figure 4.2.

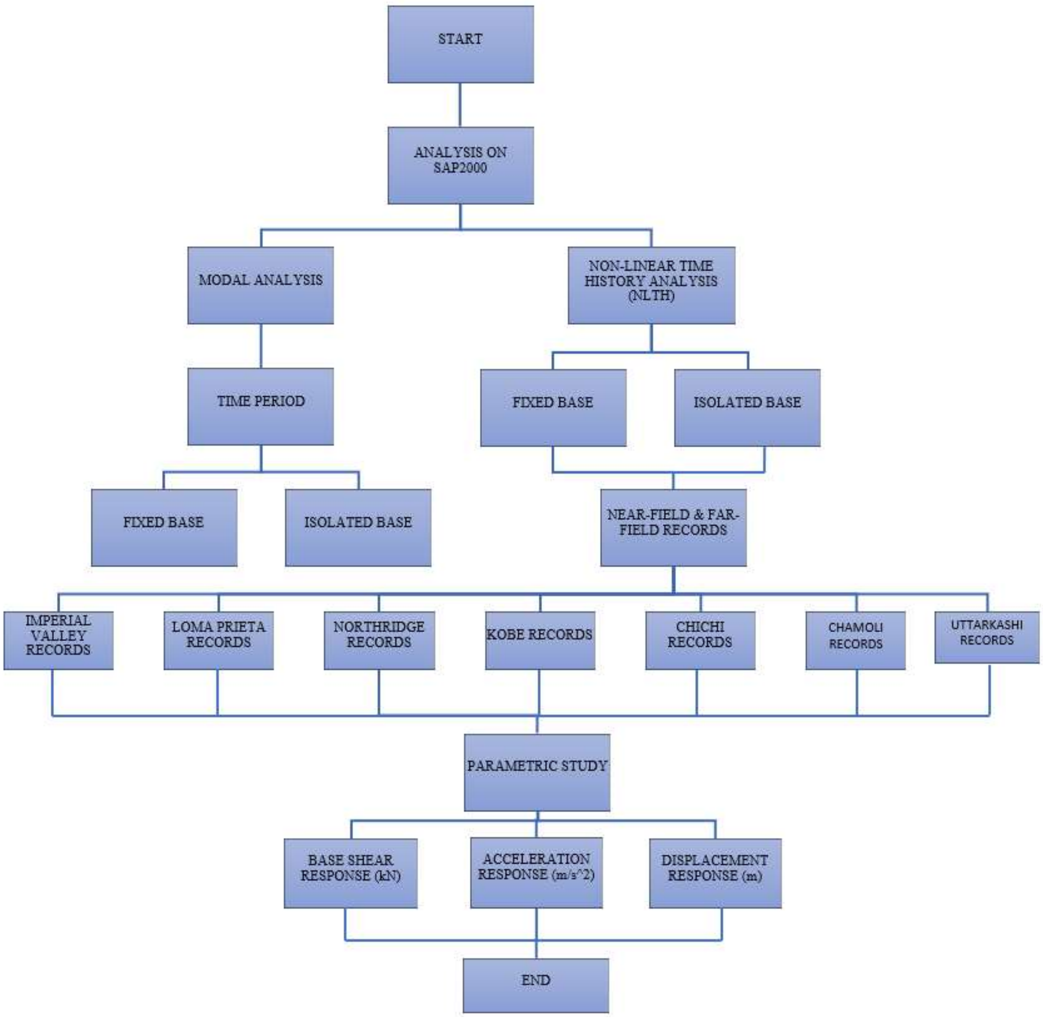


Figure 4.2 Flow Chart for the analysis performed in the present work

4.2 Methodology employed in SAP 2000

The study employs SAP2000 for nonlinear time history analyses of RC building frames, comparing base-fixed and BI structures under NF and FF seismic events. Ten-story RC building frames are analyzed with plastic hinges at beam and column ends. Damping is applied using 5% mass and stiffness proportional damping in the first and second modes. Nonlinear direct integration is performed with the Newmark method ($\gamma = 0.5$, $\beta = 0.25$). Five NF and FF records are used, matched to IS 1893 (Part 1) Zone V spectrum. The comparative study in SAP2000 involves developing three-dimensional models of buildings with fixed bases and isolated bases. The isolated base models include properties of the isolation systems, HDRB and LRB. Seismic forces are simulated with applied loads, and dynamic analysis is conducted using time history methods. Results are compared for parameters such as base shear reduction, acceleration response reduction and displacement enlargement to evaluate the usefulness of the BI systems in diminishing seismic performance. The analysis also includes evaluating the seismic performance of a RC building inserted with HDRB and LRB BI systems, comparing the results with those of a fixed base building to quantify the advantages of seismic BI.

4.3 Dimension and Material Properties

The analysis focuses on a 10-story residential RC structure in Dhaka [27], with a linear elastic structure. The building has a center-to-center spacing of 7.62m c/c in both directions. Key data includes a characteristic strength of 28 MPa, yield stress of 414 MPa, live load of 2.4 kPa, dead load (excluding self-weight) of 4.8 kPa, slab thickness of 150 mm. The dimensions of columns and beams employed in this analysis are presented in

Table 4.1 and Table 4.2, respectively. Figure 4.3 (a) illustrates the plan view, (b) presents the elevation of the exterior section, and (c) represents the elevation of the section next to exterior of the RC building. Two types of isolators are employed in this analysis: LRB and HDRB. The dimensions and properties of these isolators are as follows: for LRB, the plan dimension is 800 mm, layer thickness is 10 mm, number of layers is 16, lead core size is 150 mm, and total height is 240 mm. For HDRB, the plan dimension is 950 mm, layer thickness is 10 mm, number of layers is 16, lead core size is 175 mm, and total height is 240 mm.

Table 4.1 Column section size of RC Frame Building

S.No.	**Column Section**	**Size**
1.	Exterior corner column $C1$	750 mm × 750 mm
2.	Exterior middle column $C2$	950 mm × 950 mm
3.	Interior column $C3$	1000 mm × 1000 mm

Table 4.2 Beam section size corresponding to column section

S.No.	**Beam Section**	**Size**
1.	Grade beams (GB)	300 mm × 375 mm
2.	$B1$	525 mm × 825 mm
3.	$B2$	600 mm × 900 mm
4.	$B3$	550 mm × 900 mm

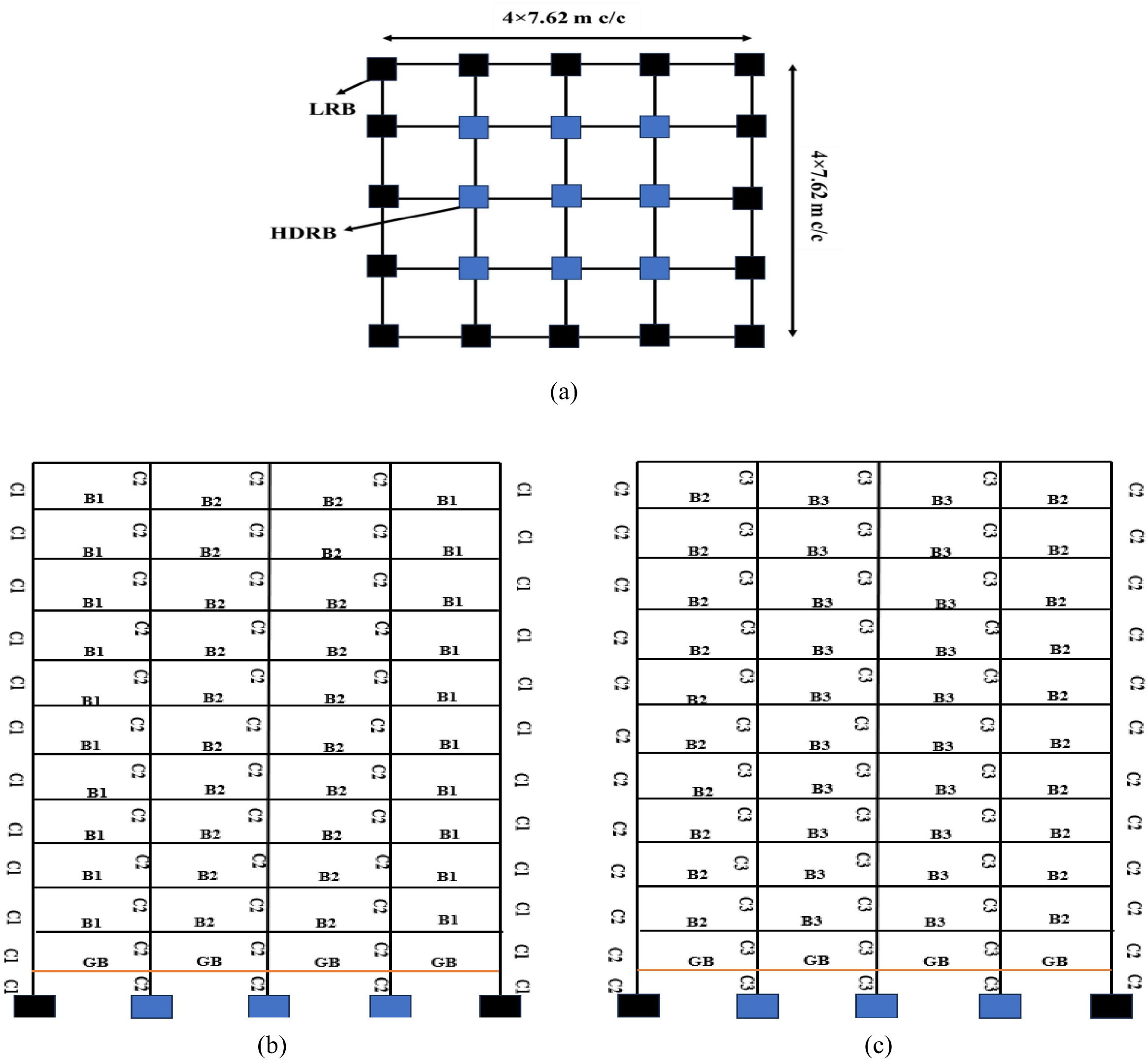


Figure 4.3 (a) represents the plan view (b) presents the elevation of the exterior section and (c) represents the elevation of the section next to exterior of the RC building

4.4 Input Ground Motion Record

Earthquake seismic motion results from the abrupt energy discharge due to fault rupture, impacted by the source mechanism, wave propagation, and local soil properties. Ground motions vary in magnitude, source, distance, direction, and site conditions. Selecting appropriate acceleration records for nonlinear response history analyses is crucial, as they can amplify or underestimate a building's response. Evidence shows structures suffer more damage from near-field ground motions than far-field ones. The literature [185][186] suggested that Near-fault events, typically within 10 km of an active fault, are particularly impactful due to their impulsive nature affecting long-period velocity and displacement motions. Far-field motions are those occurring 15 km or more from the fault. Selecting suitable ground motion records is vital for evaluating the behavior of masonry structures.

To examine the seismic response of LRB and HDRB under seismic excitations, NF and FF seismic records were chosen from the Pacific Earthquake Engineering Research Center [176] for Imperial Valley, Loma Prieta, Northridge, Kobe and ChiChi Earthquake and COSMOS Strong-Motion Virtual Data Center (VDC) for Chamoli and Uttarkashi ground motion, as listed in the Table 4.3 and Table 4.4, respectively. NF motions are categorized by long-period pulses and significant ground displacements, which are much greater than those observed in FF earthquake motions. Figure 4.4 and Figure 4.5 shows the matched response spectrum curve for Zone V using SeismoMatch software for both near-field and far-field records respectively.

Table 4.3 Features of Near-Fault Earthquake records

S.No.	Event	Year	Station	Magnitude	Mechanism	$R_{jb}(km)$	$R_{rup}(km)$	$V_s30(m/s)$
1.	Imperial Valley	1979	El Centro Meloland Geot. Array	6.53	Strike slip	0.07	0.07	264.57
2.	Loma Prieta	1989	Capitola	6.93	Reverse Oblique	8.65	15.23	288.62
3.	Northridge	1994	Pacoima Kagel Canyon	6.69	Reverse Oblique	5.26	7.26	508.08
4.	Kobe, Japan	1995	Nishi-Akashi	6.9	Strike Slip	7.08	7.08	609.0
5.	Chi-Chi	1999	TCU054	7.62	Reverse Oblique	5.28	5.28	460.69
6.	Chamoli	1999	Gopeshwar	6.6	-	-	-	-
7.	Uttarkashi	1991	Bhatwari	7.0	-	-	-	-

Table 4.4 Features of Far-Field Earthquake Records

S.No.	Event	Year	Station	Magnitude	Mechanism	$R_{jb}(km)$	$R_{rup}(km)$	$V_s30(m/s)$
1.	Imperial Valley	1979	Niland Fire Station	6.53	Strike slip	35.64	36.92	212.0
2.	Loma Prieta	1989	Larkspur Ferry Terminal	6.93	Reverse Oblique	94.56	94.64	169.72
3.	Northridge	1994	San Bernardino E and Hospitality	6.69	Reverse Oblique	108.18	108.29	296.97
4.	Kobe, Japan	1995	FUK	6.9	Strike Slip	158.07	158.61	256.0
5.	Chi-Chi	1999	TAP103	7.62	Reverse Oblique	114.28	116.02	429.49
6.	Chamoli	1999	Ukhimath	6.6	-	-	-	-
7.	Uttarkashi	1991	Ghanisiali	7.0	-	-	-	-

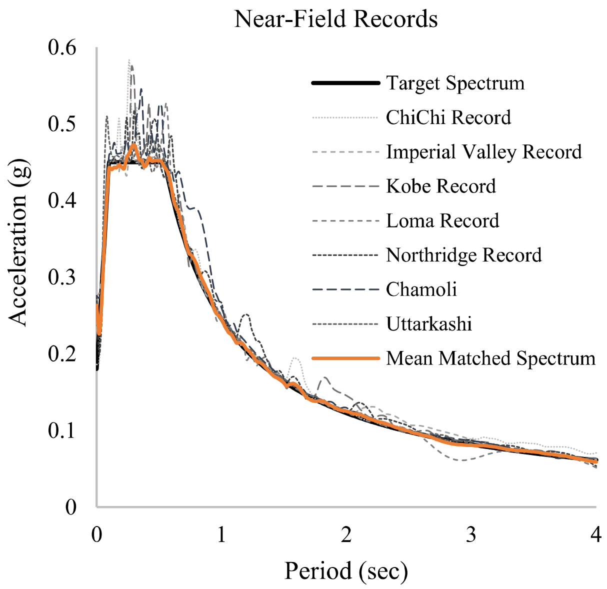


Figure 4.4 Show the matched acceleration response spectrum of IS 1893 Zone V for near-field ground motion

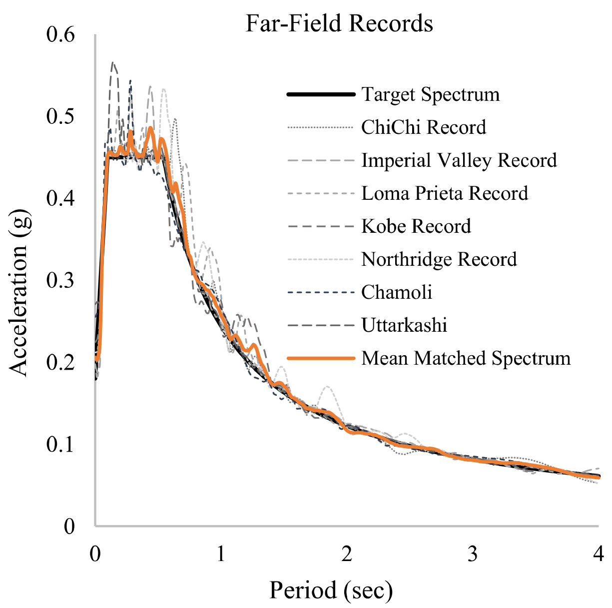


Figure 4.5 Show the matched acceleration response spectrum of IS 1893 Zone V for far-field ground motion

The comparative study in SAP2000 involves developing three dimensional models of a structure with fixed base and isolated base. The isolated base model includes properties of the BI system i.e. HDRB and LRB. Loads are applied to simulate seismic forces, and dynamic analysis is performed using NLTH methods. Results are compared for parameters like base shear and acceleration response to assess the isolation systems usefulness in reducing seismic response. The analysis includes evaluating the seismic behavior of a RC building isolated by using HDRB and LRB systems. The outcomes are equated with those of a fixed base building to quantify the advantages and benefits of BI for the structure.

The modal analysis is executed to specify the time period of the RC frame structure in both fixed and BI building. The modal analysis for fixed base, HDRB and HDRB+ fluid viscous dampers has been studied by Belbachir et al. [180]. This study demonstrates that seismic isolation significantly affects the fundamental period of a building matched to a fixed-base configuration. The fundamental time period enlarges markedly with the application of seismic BI methods. The first mode of trembling shows a significant alteration, with the period extending from 1.107558 seconds in the fixed-base to 2.702076 seconds in the BI structure, as shown in the Table 4.5. This enlargement of the time period indicates the improved flexibility of the building and the efficiency of the BI structure.

Table 4.5 Time Period for Fixed Base and Isolated Base models [182]

Mode	Fixed Base Time Period (s)	Isolated Base Time Period (s)
Mode 1	1.107558	2.702076
Mode 2	1.107558	2.702076
Mode 3	1.000222	2.485254

4.5 Result and Discussion

NLTH examination was conducted to assess the efficiency of the BI system by dynamically analyzing the structure. The analysis employed the direct integration method, considering the P-Δ effect and large displacement effects. Seismic records matched to the response spectrum were implemented in the X-direction, specifically using the Imperial Valley, Kobe, Northridge, Loma Prieta, and Chichi near-field and far-field records. The Hilber-Hughes-

Taylor time integration function was used for the analysis, which included calculating and comparing the base shear reduction, acceleration responses and increased displacement responses of both the isolated and fixed-base building.

4.5.1 Base Shear

The comparison of seismic mitigation between the BI system and the fixed-base building involved assessing the maximum base shear force. The Figure 4.6 and Figure 4.8 illustrates the NLTH responses of base shear force for both isolated base and fixed base structure during NF and FF earthquakes. It is evident that the base shear of the BI building is significantly lower as compared to the fixed-base building, confirming the usefulness of the seismic BI system in reducing base shear force. For a 10-story building, the peak base shear responses under NF and FF ground motions were obtained through NLTH analysis are shown in Figure 4.7 and Figure 4.9, respectively.

Table 4.6 shows the percentage decrease in base shear for the BI compared to the fixed-base under both conditions. The data specifies that the highest base shear responses for seven NF and seven FF ground motion records occur during the Imperial Valley, Loma Prieta, Northridge, Kobe, ChiChi, Chamoli and Uttarkashi quakes for both BI and fixed-base buildings. The maximum reduction of 38.37% in case of Northridge earthquake for NF records and in case of FF records the maximum decrease base shear is 35.65% for ChiChi ground motion. The minimum diminishes in base shear response for presently considered earthquakes are 28.19% for Imperial Valley in near-field and 30.18% for Kobe in far-field records.

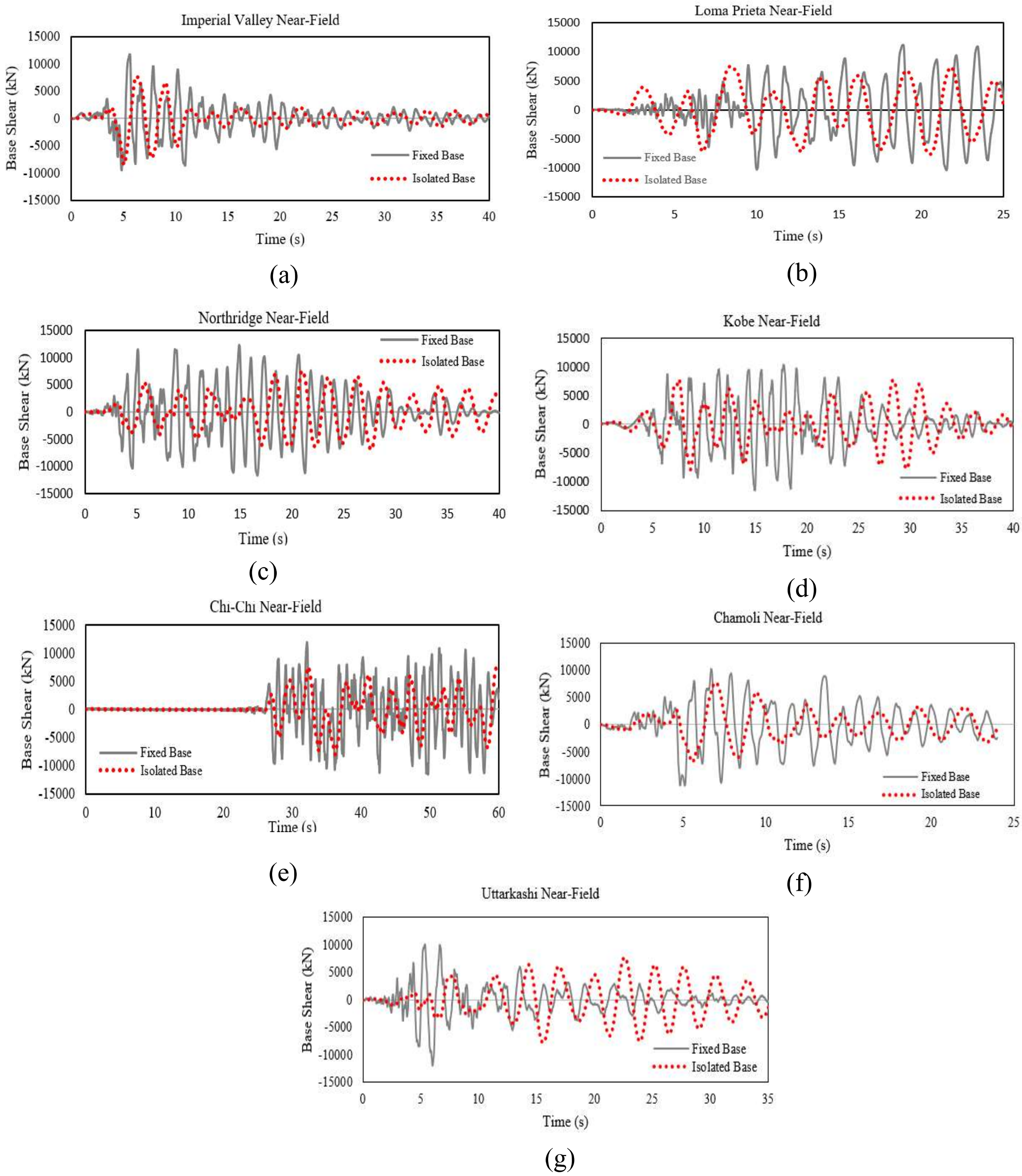


Figure 4.6 Base Shear response attained from NLTH analysis of isolated base and fixed base building models, subjected to near-field seismic event.

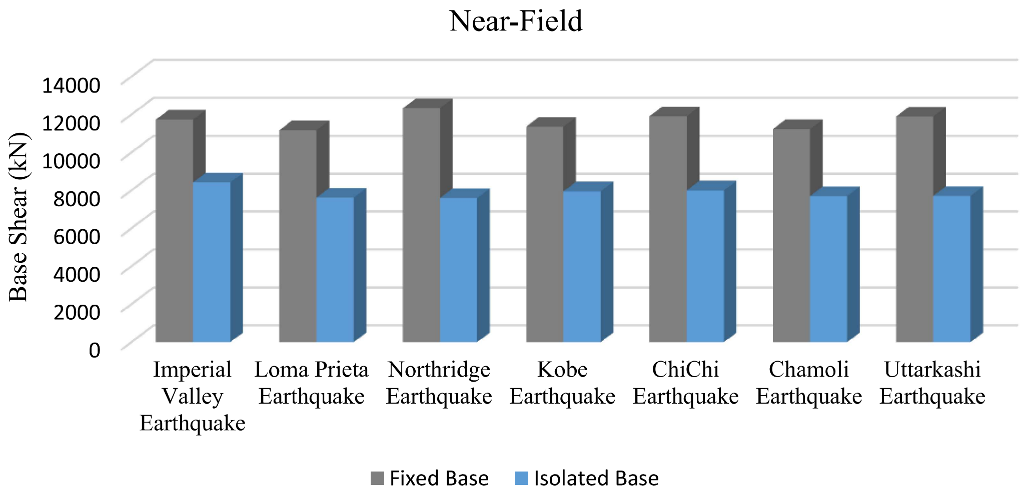
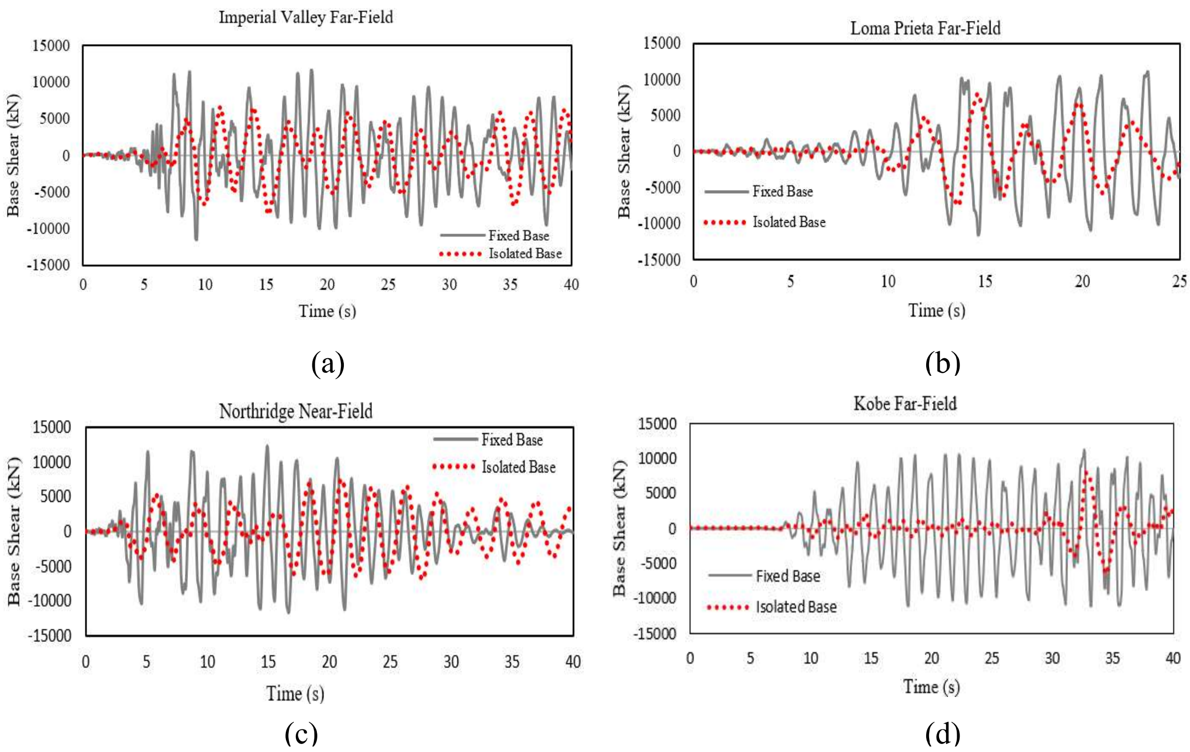


Figure 4.7 Peak Base Shear response attained from NLTH analysis of isolated base and fixed base building models, subjected to near-field earthquakes.



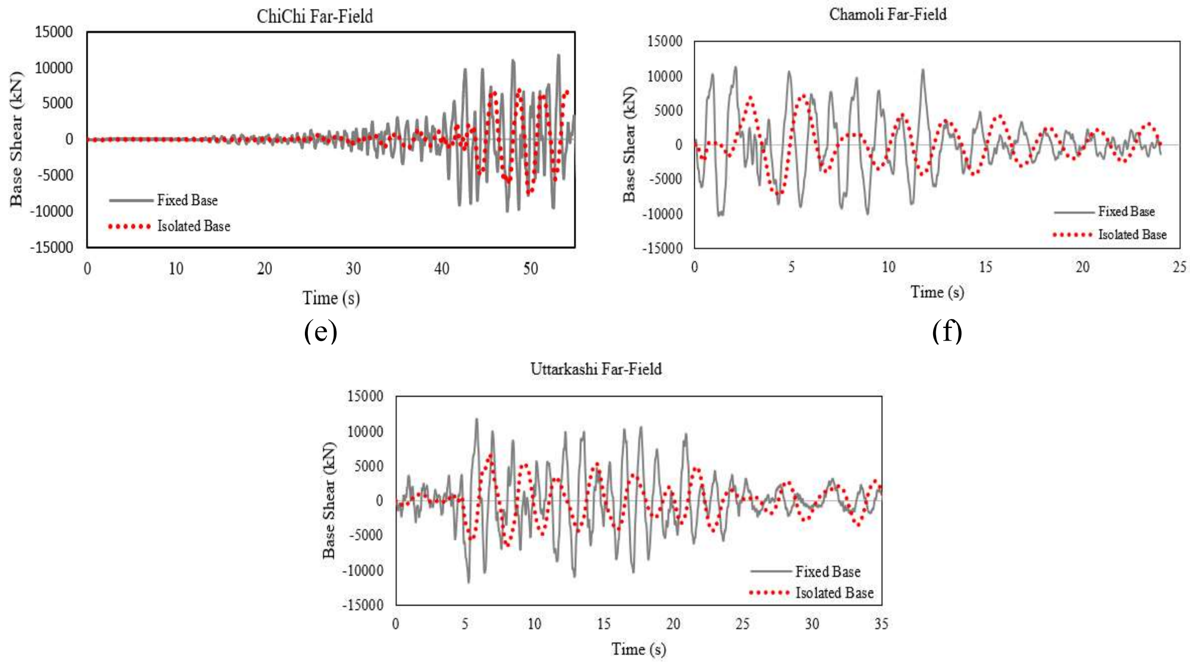


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Figure 4.8 Base Shear response attained from NLTH analysis of isolated base and fixed base building models, subjected to far-field seismic motion.

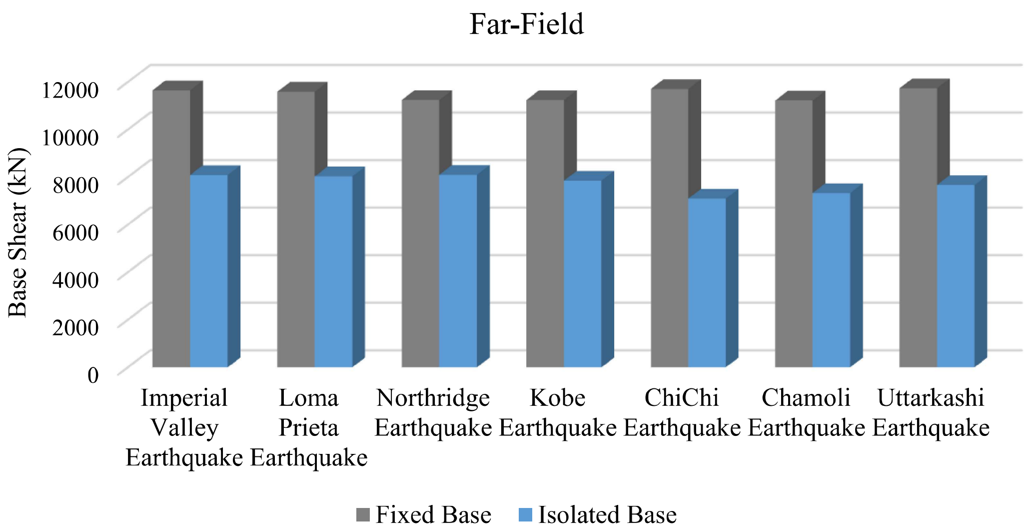


Figure 4.9 Peak Base Shear response attained from NLTH analysis of isolated base and fixed base building models, subjected to far-field ground motion

Table 4.6 The percentage reduction in base shear for an isolated base compared to a fixed base under both NF and FF earthquakes.

	Imperial valley Earthquake	Loma Prieta Earthquake	Northridge Earthquake	Kobe Earthquake	ChiChi Earthquake	Chamoli Earthquake	Uttarkashi Earthquake
Near-Field	28.19 %	31.78 %	38.37 %	29.99 %	32.87 %	31.43 %	35.22 %
Far-Field	30.58 %	30.72 %	30.20 %	30.18 %	35.65 %	34.67 %	34.67 %

4.5.2 Acceleration Response

In this analysis, the primary output parameter considered is the decrease in acceleration response. The BI system significantly reduces the responses compared to the fixed-base building, highlighting the usefulness of seismic BI system. An earthquake record matched with IS 1893 Part 1 (2016) Zone V is used as the input record in the X-direction for time-history analysis. The acceleration responses at the top floor are analyzed for both NF and FF events. The data indicates that the maximum acceleration response reduction for seven NF and seven FF ground motion records occurs during the Imperial Valley, Loma Prieta, Northridge, Kobe, ChiChi, Chamoli and Uttarkashi earthquakes for both base-isolated and fixed-base buildings. The roof acceleration response over time history for both fixed-base and isolated-base structures is shown in Figure 4.10 for NF records and Figure 4.12 for FF records. The analysis demonstrates a significant decrease in response with the use of isolators. Table 4.7 shows the story levels acceleration response reduction for near-field records. The maximum joint acceleration responses over time for each story are illustrated in Figure 4.11 Figure for NF records and Figure 4.13 for FF records. Table 4.8 shows the story levels acceleration response reduction for far-field records and Table 4.9 presents the maximum response reduction at the top floor. The analysis shows that acceleration responses are reduced by 65.28% for the Loma Prieta records in the near-field case, while for far-field ground motion, the maximum reduction is 71.53% for the Imperial Valley earthquake record. The minimum reduction using the isolated base compared to the fixed base is 50.43% for the Kobe record in near-field data and 45.12% for the Loma Prieta records in far-field analysis.

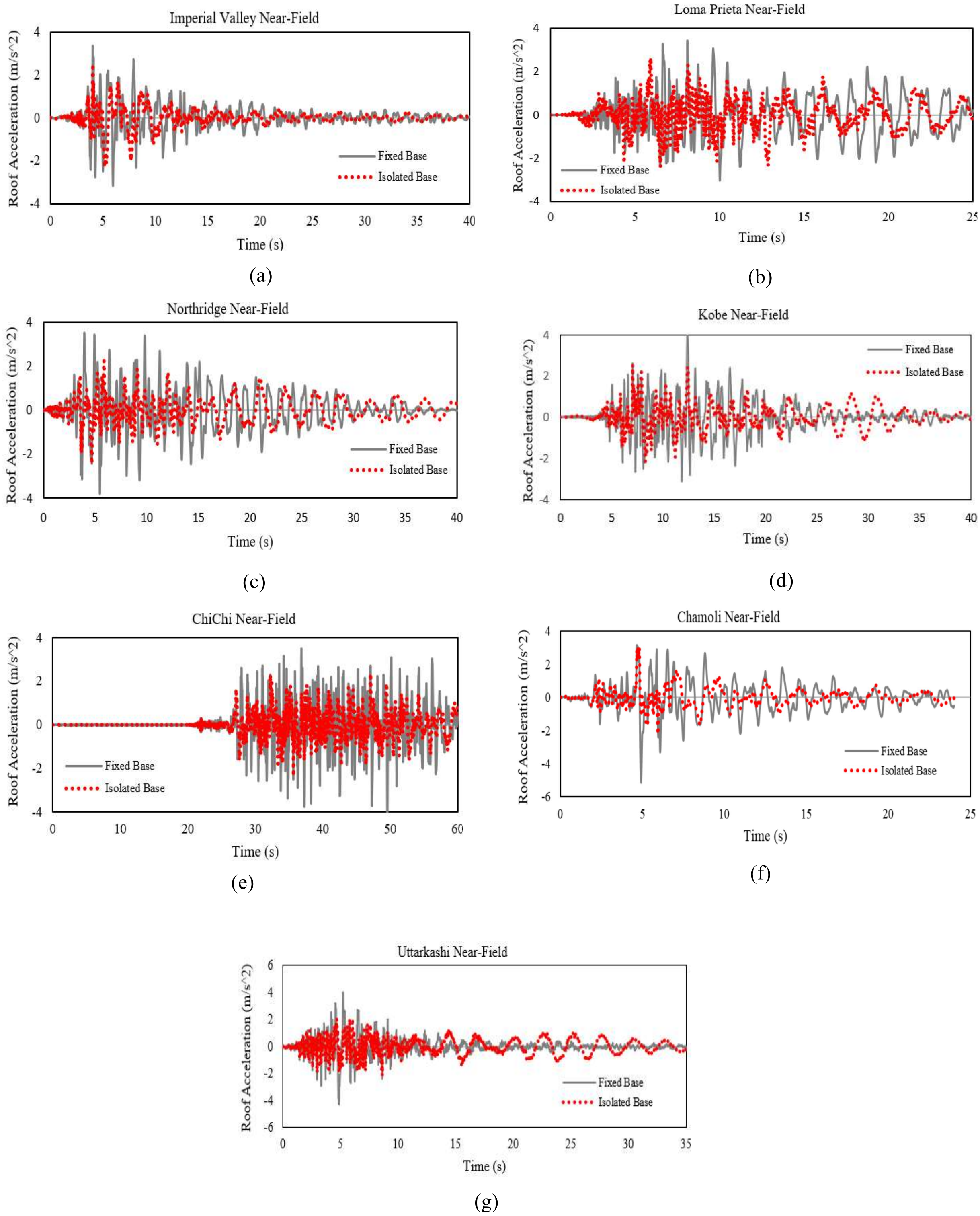


Figure 4.10 Top floor acceleration response obtained from NLTH analysis of isolated base and fixed base building models, subjected to near-field earthquakes

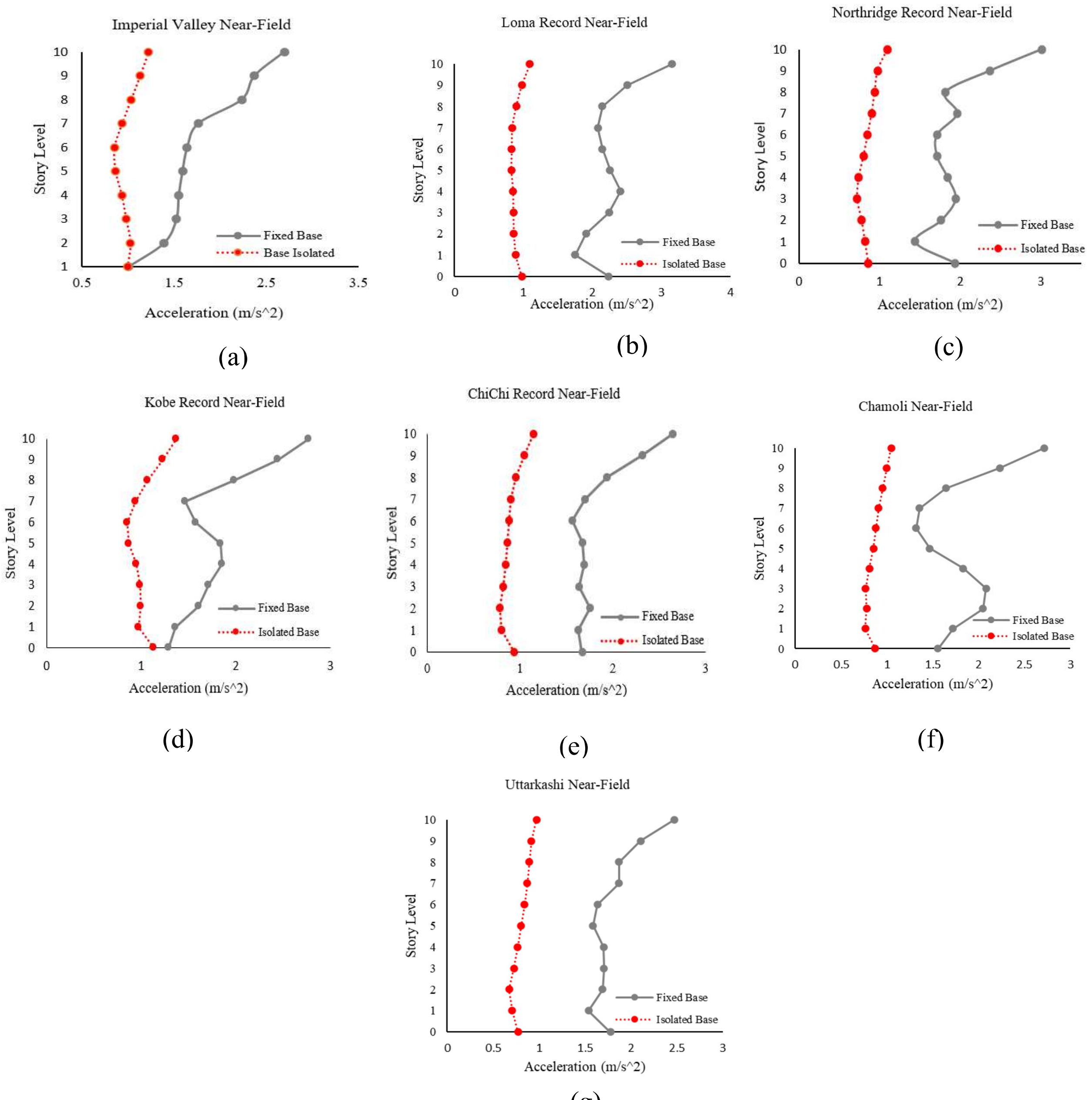


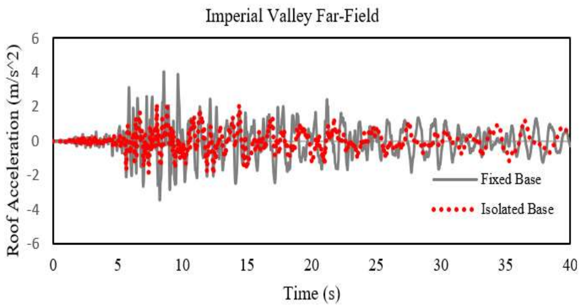
Figure 4.11 Peak absolute acceleration for each level in isolated base and fixed base building models, subjected to near-field earthquakes.

Table 4.7 The acceleration response of the near-field records at different floor levels

	Northridge			Kobe			ChiChi			Loma Prieta			Imperial Valley		
Story Level	IB	FB	% diff	IB	FB	% diff	IB	FB	% diff	IB	FB	% diff	IB	FB	% diff
GB	0.86	1.93	55.51	1.14	1.29	12.05	0.94	1.67	43.73	0.98	2.23	56.31	-	-	-
1	0.82	1.44	43.16	0.97	1.36	28.82	0.80	1.63	50.88	0.88	1.75	49.44	0.99	1.00	0.82
2	0.78	1.76	55.86	1.00	1.61	37.84	0.78	1.75	55.36	0.86	1.90	54.92	1.03	1.39	26.20

3	0.72	1.94	62.77	0.99	1.71	42.17	0.81	1.64	50.34	0.86	2.24	61.81	0.98	1.53	35.73
4	0.74	1.84	59.77	0.95	1.85	48.79	0.84	1.69	50.19	0.85	2.41	64.79	0.93	1.55	39.88
5	0.80	1.71	53.26	0.87	1.84	52.57	0.86	1.67	48.17	0.83	2.25	63.38	0.87	1.59	45.62
6	0.85	1.71	50.12	0.85	1.58	45.96	0.88	1.57	43.70	0.83	2.14	61.41	0.85	1.65	48.08
7	0.90	1.96	54.13	0.94	1.46	35.77	0.90	1.70	46.92	0.83	2.08	59.85	0.94	1.76	46.81
8	0.94	1.82	48.21	1.07	1.98	46.18	0.95	1.94	50.69	0.90	2.14	58.16	1.04	2.23	53.64
9	0.97	2.37	58.84	1.23	2.44	49.75	1.05	2.32	54.86	0.97	2.50	61.07	1.14	2.37	52.20
10	1.10	3.01	63.63	1.37	2.77	50.44	1.14	2.65	56.93	1.09	3.15	65.29	1.23	2.70	54.53

	Chamoli			Uttarkashi		
Story Level	IB	FB	% diff	IB	FB	% diff
GB	0.87	1.56	44.03	0.77	1.78	56.71
1	0.76	1.72	55.62	0.71	1.54	53.98
2	0.78	2.05	61.93	0.67	1.69	60.13
3	0.77	2.08	63.20	0.72	1.71	57.58
4	0.81	1.83	55.89	0.77	1.70	54.92
5	0.85	1.47	41.76	0.80	1.59	49.26
6	0.88	1.32	33.23	0.84	1.63	48.50
7	0.91	1.35	32.74	0.87	1.87	53.41
8	0.95	1.64	42.04	0.89	1.87	52.13
9	1.00	2.23	55.26	0.92	2.10	56.48
10	1.05	2.72	61.49	0.97	2.47	60.64



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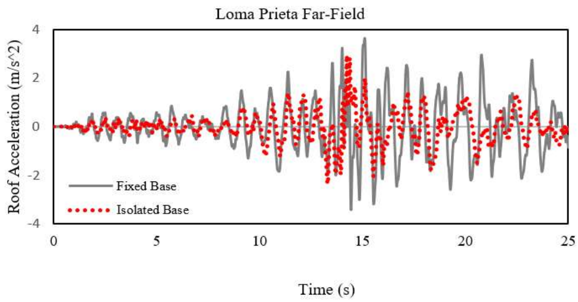

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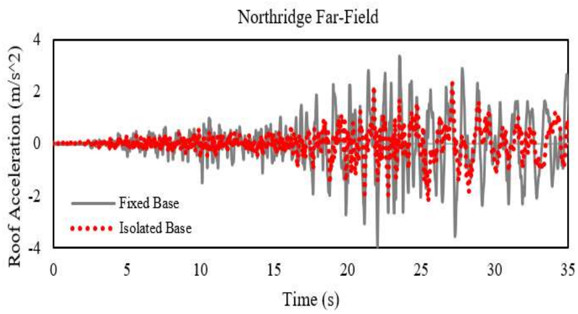

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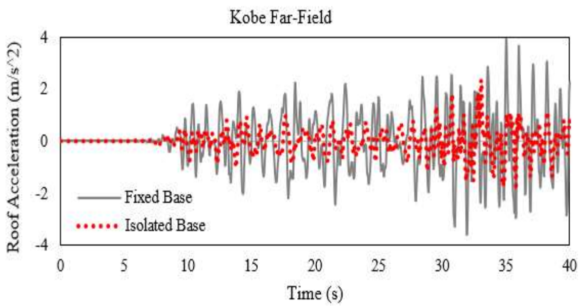

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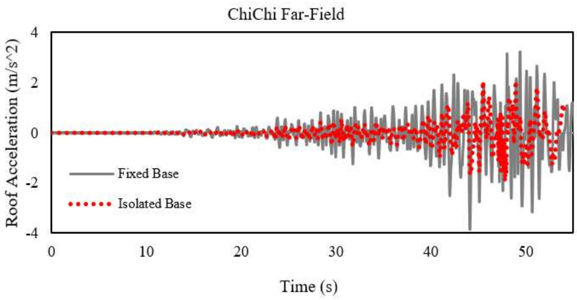

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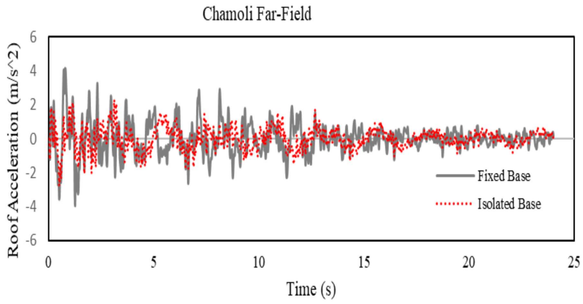

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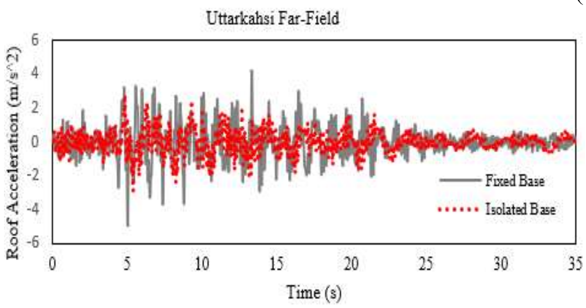

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Figure 4.12 Top floor acceleration response attained from NLTH analysis of isolated base and fixed base building models, subjected to far-field ground motion.

Table 4.8 The acceleration response of the time-history far-field records at different floor levels

	Northridge			Kobe			ChiChi			Loma Prieta			Imperial Valley		
Story Level	IB	FB	% diff	IB	FB	% diff	IB	FB	% diff	IB	FB	% diff	IB	FB	% diff
GB	1.10	1.91	42.57	1.20	1.93	37.68	0.95	1.36	29.87	1.14	1.78	36.25	-	-	-
1	1.05	1.52	30.72	0.97	1.48	34.06	1.02	1.42	27.83	1.05	2.16	51.32	0.94	2.22	57.63
2	0.98	1.63	39.82	0.95	1.72	44.63	1.02	1.58	35.88	1.06	2.37	55.03	0.92	2.20	58.16
3	0.88	1.75	49.54	0.95	1.77	46.71	0.98	1.76	44.30	1.04	2.31	54.78	0.87	2.02	56.96
4	0.82	1.60	48.93	0.91	1.78	48.81	0.92	1.74	47.04	0.99	2.07	52.26	0.82	2.07	60.31
5	0.85	1.58	46.28	0.86	1.67	48.50	0.83	1.72	51.50	0.90	1.68	46.69	0.76	1.83	58.31
6	0.88	1.57	44.11	0.91	1.60	43.06	0.80	1.60	50.32	0.87	1.82	52.23	0.71	1.81	60.76
7	0.90	1.60	43.52	1.02	1.79	42.94	0.85	1.71	50.15	1.03	1.81	43.07	0.75	1.80	58.52
8	0.93	1.79	48.23	1.17	2.20	46.99	0.94	1.75	46.56	1.25	2.24	44.17	0.86	2.20	60.99
9	0.95	2.16	55.99	1.32	2.64	50.11	1.11	1.96	43.42	1.46	2.58	43.50	0.96	2.89	66.69
10	1.09	2.68	59.20	1.46	3.49	58.32	1.26	2.29	44.95	1.64	2.98	45.12	1.07	3.75	71.54

	Chamoli			Uttarkashi		
Story Level	IB	FB	% diff	IB	FB	% diff
GB	0.96	2.35	59.08	1.24	2.18	43.23
1	0.90	1.72	47.73	1.14	1.84	38.14
2	0.91	1.86	50.86	1.07	2.04	47.67
3	0.91	1.94	53.24	0.99	1.96	49.68

4	0.87	1.89	54.01	0.90	2.09	56.94
5	0.80	1.66	51.68	0.80	1.96	59.20
6	0.79	1.62	51.11	0.84	1.67	49.97
7	0.84	1.76	52.02	0.88	1.85	52.36
8	0.93	2.38	60.78	0.94	2.00	52.98
9	1.01	2.90	65.07	1.11	2.44	54.68
10	1.08	3.59	69.87	1.25	2.91	56.94

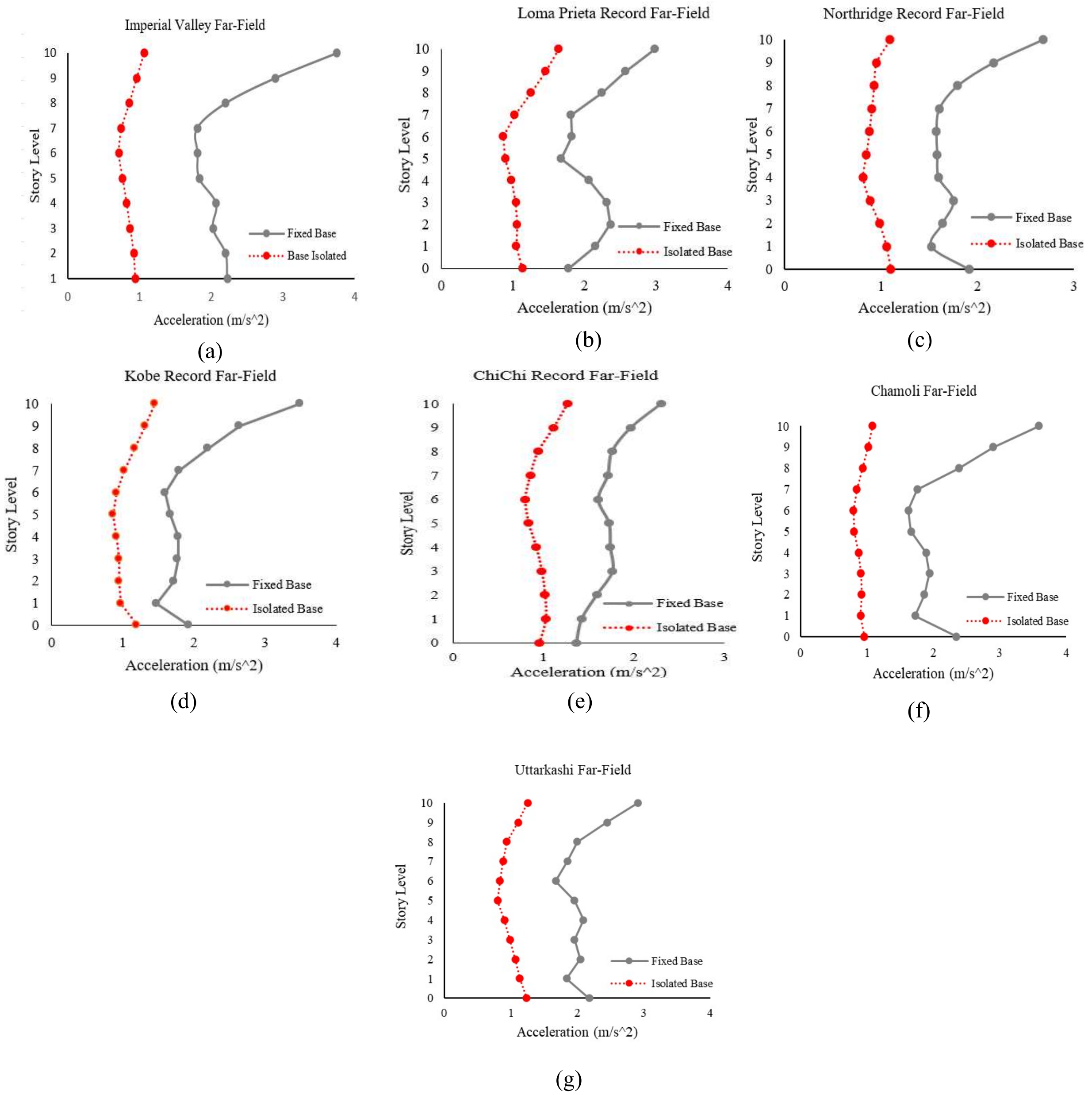


Figure 4.13 Peak absolute acceleration for each level in isolated base and fixed base building models, subjected to far-field earthquakes.

Table 4.9 The percentage reduction in acceleration response at the top story for both near-field and far-field ground motion

	Imperial valley Earthquake	Loma Prieta Earthquake	Northridge Earthquake	Kobe Earthquake	ChiChi Earthquake	Chamoli Earthquake	Uttarkashi Earthquake
Near-Field	54.52 %	65.28%	63.63	50.43 %	56.92 %	61.49 %	60.64 %
Far-Field	71.53 %	45.12%	59.20 %	58.31%	44.94 %	69.87 %	56.94 %

4.5.3 Displacement Response

This section presents the results from the analysis, focusing on the maximum responses from five separate records of NF and FF seismic events. By comparing the displacement values in models with and without base isolators, several observations can be made. Figure 4.14 and Figure 4.16 illustrate the top floor displacement over time for fixed-base and isolated-base models under NF and FF records, respectively. The analysis reveals that displacements are significantly higher in the BI models compared to the fixed-base models. This increase is due to the flexibility obtained by the base isolators, which allows for greater movement at the base and subsequently throughout the building. Figure 4.15 and Figure 4.17 show the peak floor displacement at each story for both fixed-base and isolated-base buildings under NF and FF records from the Imperial Valley, Loma Prieta, Northridge, Kobe, and ChiChi earthquakes.

Table 4.10 details the base story displacement under the impact of the five considered seismic events for both NF and FF records. The analysis indicates that the Imperial Valley records show a peak base displacement of 11.06 cm for near-field events, while the Kobe records show a displacement of 7.99 cm for far-field events.

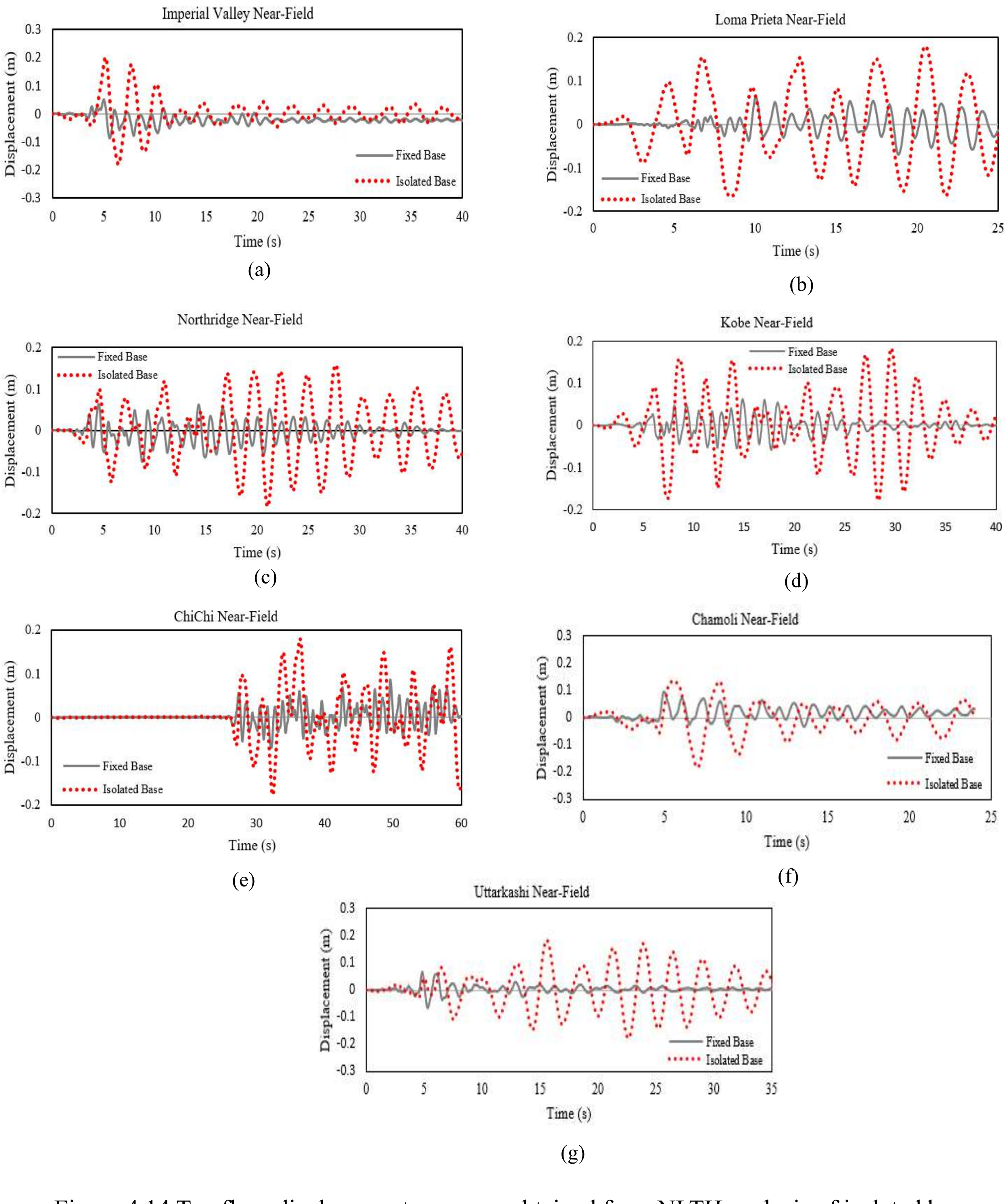


Figure 4.14 Top floor displacement response obtained from NLTH analysis of isolated base and fixed base building models, subjected to near-field earthquakes.

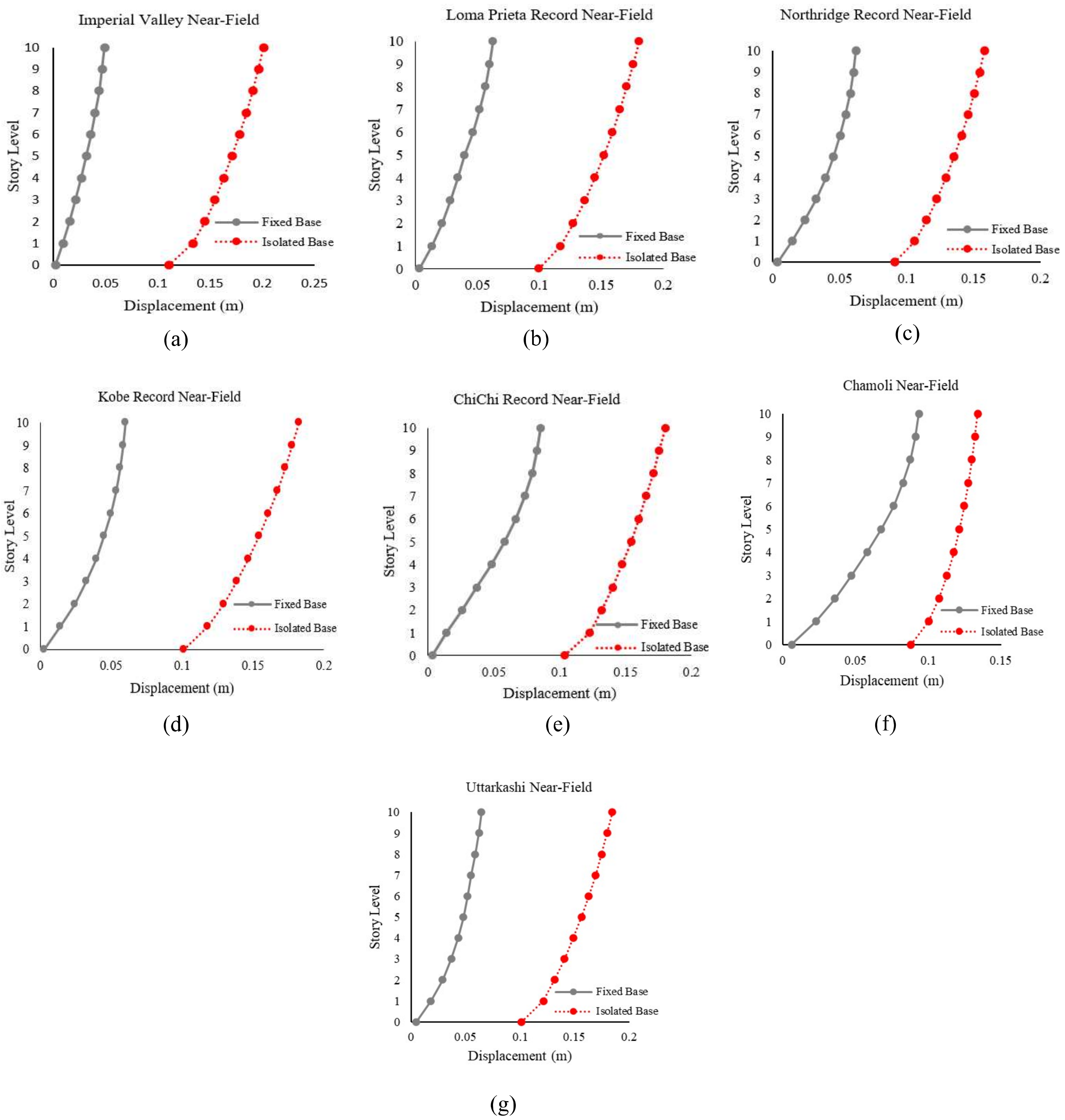


Figure 4.15 Peak floor displacement distribution for each level in isolated base and fixed base building models, subjected to near-field earthquakes.

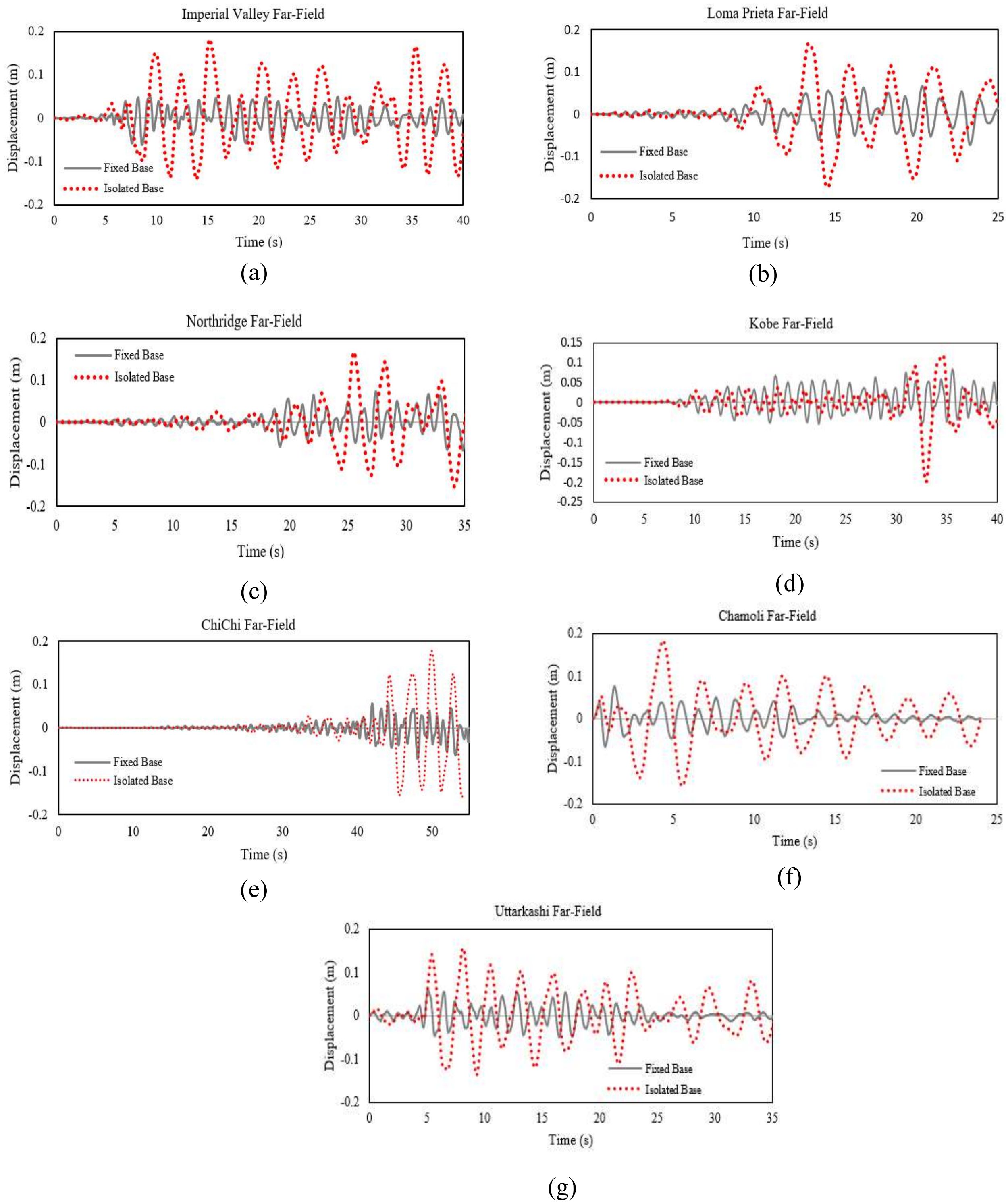
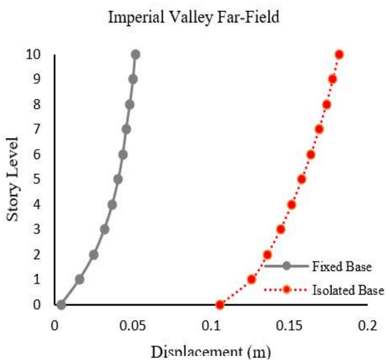
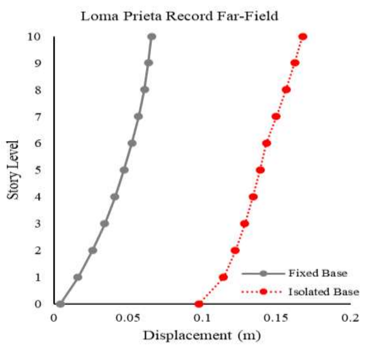


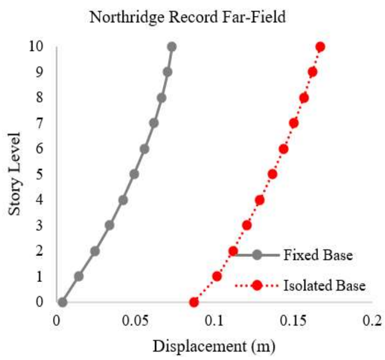
Figure 4.16 Top floor displacement response obtained from NLTH analysis of isolated base and fixed base building models, subjected to near-field earthquakes.



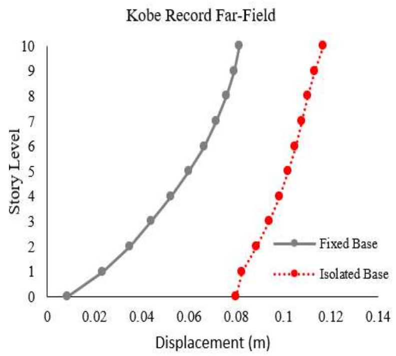
(a)



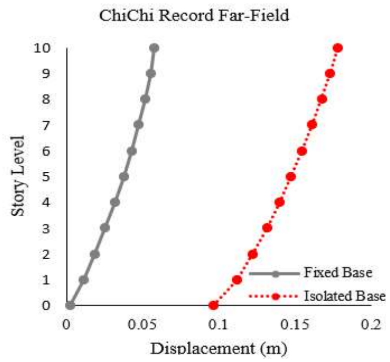
(b)



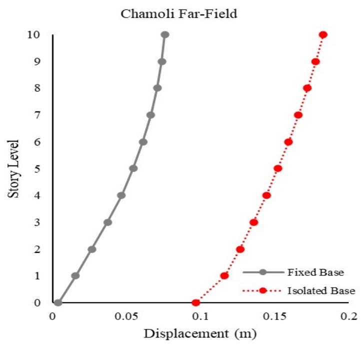
(c)



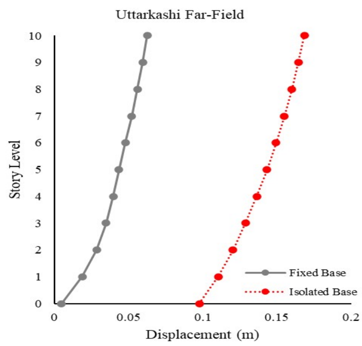
(d)



(e)



(f)



(g)

Figure 4.17 Peak floor displacement distribution for each floor level in isolated base and fixed base building models, subjected to far-field ground motion.

Table 4.10 The displacement response at the base story for isolated base models (cm) obtained from NLTH analysis for both near-field and far-field ground motion

	Imperial valley Earthquake	Loma Prieta Earthquake	Northridge Earthquake	Kobe Earthquake	ChiChi Earthquake	Chamoli Earthquake	Uttarkashi Earthquake
Near-Field	11.06	9.93	9.11	10.14	10.39	8.81	10.11
Far-Field	10.58	9.75	8.70	7.99	9.68	9.65	9.76

4.6 Summary

This study proposes a numerical technique to predict the seismic performance of fixed-base and isolated-base RC concrete structures. The procedure employs two devices collectively: HDRB and LRB. This highlights their potential to enhance structural seismic resilience and mitigate ground motion impacts. Using the nonlinear time history method, a 10-story building is assessed, with seven records each of FF and NF seismic events chosen. Simulations were performed using SAP 2000 software, and dynamic results were obtained by applying Imperial Valley, Loma Prieta, Northridge, Kobe, ChiChi, Chamoli and Uttarkashi excitations NF and FF records matched using Seismomatch software packages.

The key observation of this study highlights the noteworthy benefits of incorporating seismic BI systems for RC building. The BI structures have longer time periods compared to fixed-base structures as observed in modal study of both fixed base and BI structure, indicating greater flexibility and diminished vulnerability to dynamic responses.