

EFFECT OF THE NUMBER OF STORIES AND ASPECT RATIO ON THE
SEISMIC PERFORMANCE OF BASE ISOLATED BUILDINGS

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ABSTRACT

EFFECT OF THE NUMBER OF STORIES AND ASPECT RATIO ON THE SEISMIC PERFORMANCE OF BASE-ISOLATED BUILDINGS

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Despite the advanced engineering solutions, earthquakes remain to be one of the causes of casualties and property damage for humankind among natural disasters. To ensure that the essential services are not interrupted after an earthquake, it is crucial for some buildings to remain functional with minimal structural or non-structural damage. These buildings include administrative buildings, law enforcement buildings, fire stations, hospitals, and communication centers. Seismic base isolation systems are frequently used for reducing quake-induced structural and non-structural damage. This thesis mainly focuses on the feasibility of seismic base-isolated structures and determining the maximum feasible number of storeys of the base-isolated structures. Moreover, the effect of the following parameters on the seismic behavior is investigated: (i) isolator parameters, (ii) soil stiffness, (iii) earthquake intensities, and (iv) the aspect ratio of the structure. For this purpose, a comparative assessment is conducted to determine the feasibility of base-isolated structures. The feasibility of the base-isolated structures is assessed by considering the structural and non-structural performance goals.

Keywords: Earthquake, Seismic Base Isolation, Friction Pendulum Bearing, Feasibility, Parametric Study

ÖZ

KAT SAYISI VE YÜKSEKLİK-GENİŞLİK ORANININ DEPREM YALITIMLI BİNALARIN PERFORMANSINA ETKİSİ

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Gelişmiş mühendislik çözümlerine rağmen depremler hala insanlık için yüksek can kayıplarının ve maddi zararların yaşandığı doğal afetlerin başında geliyor. Deprem sonrasında hayati derecede önemli hizmetlerin durmaması için bazı binaların en az yapısal veya yapısal olmayan zararlar ile işlevsel kalması çok önemlidir. Bu binaların içerisinde idari binalar, kolluk kuvvetleri binaları, itfaiye binaları, hastaneler ve haberleşme merkezleri bulunmaktadır. Sismik taban izolasyon sistemleri deprem kaynaklı yapısal ve yapısal olmayan hasarları azaltmak için sıklıkla kullanılmaktadır. Bu tez esas olarak tabandan izole edilmiş yapıların fizibilitesine ve tabandan izole edilmiş yapıların maksimum uygulanabilir kat sayısını belirlemeye odaklanmaktadır. Ayrıca, aşağıdaki parametrelerin sismik davranış üzerine etkisi araştırılmıştır: (i) izolatör parametreleri, (ii) Zemin rijitliği, (iii) deprem şiddetleri ve (iv) yapının yükseklik-genişlik oranı. Bu amaçla sismik taban izolasyonu uygulanmış yapıların fizibilitesini belirlemek için karşılaştırmalı bir değerlendirme yapılmıştır. Tabandan izole edilmiş yapıların fizibilitesi yapısal ve yapısal olmayan performans hedefleri dikkate alınarak değerlendirilmiştir.

Anahtar Kelimeler: Deprem, Sismik Taban Yalıtımı, Sürtünmeli Sarkaç İzolatör, Fizibilite, Parametrik Çalışma



To My Family

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CHAPTER 1

INTRODUCTION

1.1 Introduction

One of the most important challenges of civil engineering is to design buildings that can withstand earthquakes. Current design codes have been prepared by engineers and scientists to ensure earthquake-resistant building design by providing strict rules and restrictions. The principal goal of these design codes is to avoid building damage or collapse. Furthermore, some buildings carry important roles in times of natural disasters, such as administrative buildings, law enforcement buildings, fire stations, hospitals, and communication centers. Therefore, it is essential that these buildings must remain functional. In addition, hospitals and communication centers may have sensitive and expensive non-structural equipment, such as medical imaging devices or data servers. So, protecting these non-structural elements is as important as preserving the structure intact. For this purpose, additional performance goals must be satisfied for these particular buildings. Seismic isolation systems are frequently used to satisfy these additional performance goals.

Seismic base isolation is an important disaster-prevention technology. Makris (2019) mentioned a construction method patented in 1870 for reducing quake-induced damage by using an array of opposite-facing concave spherical surfaces. The first modern use of the base isolation technology was known as Pestalozzi School in Skopje, Macedonia, in 1969 (Botiş & Harbic, 2012). This technology's effect on the systems' response has been studied since the 1960s (Veletsos & Newmark, 1960). Prior work also studied the effect of different parameters on the effectiveness of the seismic isolation element (Alhan & Gavin, 2004). Being one of the buildings of

importance as discussed above, hospitals were also cases of study for seismic isolation systems. For example, Nagarajaiah & Xiaohong (2000) investigated the response of base-isolated University of Southern California (USC) Hospital in the Northridge earthquake. In this study, nonlinear analytical modeling techniques were used for conducting a dynamic analysis of the base-isolated hospital. The computed response of the structure was verified by using recorded data. The response of the base-isolated structure was compared to the response of the fixed-base structure. This study states that the superstructure remained elastic after the earthquake due to the effectiveness of the base isolation system.

The main principle of the seismic base isolation systems is decoupling the superstructure from the ground. Seismic base isolation systems have been used in many structures to protect the superstructure from quake-induced damage. Lead rubber bearings, high damping rubber bearings, and friction pendulum sliding bearings can be counted among well-known base isolation systems.

Friction pendulum bearings (FPB) have a steel concave surface that is in contact with an articulated friction slider. During an earthquake, the superstructure slides along the steel concave surface, and the friction force generated during sliding causes energy dissipation. Sliding during an earthquake increases the natural period of the superstructure. Thus, demands on the members significantly decrease.

Base isolation systems are used for high-rise or mid-rise buildings in some countries. But do these buildings really satisfy the feasibility criteria for structural and non-structural components? How many stories can be reached for base-isolated structures by satisfying the additional performance goals considering the different earthquake intensities and soil site classes? This thesis aims to answer these questions.

The scope of this thesis is threefold. First, the thesis focuses on understanding the effects of the following four different parameters on seismic behavior: (i) pendulum bearing parameters, (ii) soil stiffness, (iii) earthquake intensities, and (iv) aspect ratio of buildings. Second, the thesis also focuses on how the same three parameters affect the feasibility of the base-isolated structure. Third, the maximum feasible storey numbers are investigated considering the selected parameters.

1.2 Research Objectives and Scope

The present study's main objectives are (i) to study the effect of the number of storeys and the aspect ratio on the seismic performance of base-isolated buildings, and (ii) to study the effect of the properties of the seismic isolation system and the building, as well as, soil type and peak ground acceleration on the seismic performance of base-isolated buildings. This thesis focuses on reinforced concrete structures isolated with friction pendulum sliding bearings (FPSB). In particular, this thesis focuses on hospitals isolated using FPSBs, as they contain vital and expensive non-structural elements. A parametric study is conducted to understand the behavior of the base-isolated building under earthquake ground motions. The main parameters of this study are selected as different peak ground accelerations (PGA), friction pendulum sliding bearings with various properties, various soil types, and building width-height aspect ratios to obtain a better understanding of these parameters on the seismic performance of base-isolated buildings.

1.3 Literature Review

Many analytical and experimental studies have been conducted on the following topics: (i) dynamic response of the base-isolated structures, (ii) the seismic base isolation systems' performance, and (iii) the non-structural damage during earthquakes. Although there are many studies in the literature, those studies are examined under three main headings as follows:

- Friction Based Isolators
- Other types of Isolators
- Base-Isolated Hospitals and Non-Structural Damage

Below, a summary of the prior related work on selected topics is provided.

1.3.1 Friction Based Isolators

As described above, friction-based isolators rely on friction happening between surfaces of the seismic isolator. These isolators can be roughly classified as friction pendulum systems (FPS), variable frequency pendulum isolators (VFPI), variable friction pendulum systems (VFPS), variable frequency, and variable friction pendulum isolators (VFFPI), and variable friction isolator (VFI), etc.

Mazza & Sisinno (2017) investigated the seismic behavior of the base-isolated structures by using near-fault earthquakes. In this study, friction pendulum bearings were used as a base isolation system. A six storey, L-shaped reinforced concrete office building was examined. For this purpose, three different isolator curvature radius values and two different in-plan distributions were used. Seven near-fault ground motions with significant horizontal components were selected for studying torsional and re-centering problems, and seven near-fault ground motions with significant vertical components were selected for studying the nonlinear response of the base-isolated structures. The maximum effects were evaluated by considering different angles of the horizontal component. The orientation of the strongest pulse and accelerograms were applied in line with the direction of the recording station. The behavior of the structure was evaluated by using floor rotations, residual displacements, and uplift. Babu & Jose (2018) performed an assessment of the seismic behavior of base-isolated irregular reinforced concrete frame structures. In this study, triple friction pendulum bearing was selected as the base isolation system. Response spectrum analysis was conducted for both fixed base and base-isolated

cases to evaluate the seismic behavior of the structure. Behaviors of the regular, T-shaped, L-shaped, C-Shaped, and cross-shaped structures were compared, considering periods and base shears. Wang & Li (2008) investigated the seismic response of the three storey reinforced concrete structure isolated with friction pendulum systems under bilateral ground motions. In this study, peak storey accelerations, inter-storey drifts, hysteresis loops, and isolator displacements were taken into consideration to evaluate the seismic response. In total, 4 ground motions were used to compare the seismic response of the under unilateral and bilateral ground motions.

Deringöl & Güneyisi (2019) investigated the effect of friction pendulum bearing properties on the seismic behavior of steel structures. In this parametric study, 3 different building height (3, 6, and 9 storey), 3 different damping ratio ($\beta = 0.05, 0.15, \text{ and } 0.25$), 3 different isolation period values ($T = 2, 2.5, 3 \text{ s}$), and 3 different yield strength ratios ($F_y/W = 0.025, 0.05, \text{ and } 0.10$) were used. In total, 27 friction pendulum bearings were used in the nonlinear time-history analyses. The seismic behavior of the base-isolated structures was evaluated by using isolator displacements, inter-storey drift ratios, roof drift ratios, relative displacements, absolute accelerations, base shear values, and hysteretic curves and dissipated energies. Baghaei & Razani (2019) investigated the linear and nonlinear seismic behavior of 10 storey steel frame considering four different cases. In this study, friction pendulum systems were used as an isolation system. Fixed based, base-isolated, roof isolated, and top two floor isolated systems were selected. The selected cases' seismic behaviors were evaluated by comparing the maximum total floor displacements, the maximum relative drifts, maximum storey shear forces, and maximum base shears. Deringol (2018) investigated the performance of the steel moment frames by using different types of friction pendulum systems. Three and seven storey steel structures were analyzed. For isolation systems, the radius of curvature of isolators, isolation period, and friction coefficient were selected as the parameters of the study. In total, three different ground motions were selected and

scaled to approximately the same intensity level. The paper examines displacement, relative displacement, inter-storey drift ratio, absolute acceleration, base shear, and hysteretic curves of seismic isolations. Tajammolian et al. (2016) investigated the seismic response of 3, 6, and 9 storey base-isolated steel frames with mass asymmetry. In this study, triple concave friction pendulum bearings were used. Structures with different aspect ratios (1, 2, and 3) were selected. Dynamic analyses were conducted using 25 near-field ground motions. Isolator displacement, base shear, and roof acceleration of the superstructure were selected as the main parameters to evaluate the seismic response. Sharma & Jangid (2010) investigated the seismic response of base-isolated structures by using different sliding isolators. In this study, an L-shaped 8 storey steel braced frame system was used. Nonlinear time-history analyses were conducted to evaluate the seismic behavior of the structure. Seven ground motion couples were selected and applied bidirectionally. As base isolation systems, variable friction pendulum system (VPFS), variable frequency pendulum isolator (VPFI), variable curvature friction pendulum system (VCFPS), and conventional friction pendulum system (FPS) were used.

Shahbazi & Taghikhany (2017) performed a sensitivity analysis of variable curvature friction pendulum (VCFP) bearings under near-fault ground motions. In this study, minimum friction coefficient (0.02, 0.035, 0.05, and 0.065), initial period (1, 2, 3, 4, and 5 s), isolator function (O4, and O6), and displacement values (0.1, 0.2, and 0.3 m) were used as parameters of VCFP bearings. The effect of sliding surface geometry on the seismic performance of the structure was evaluated by using those parameters. Morgan & Mahin (2008) evaluated the effects of multi-stage friction pendulum bearings on the seismic response of structures. In this study, nonlinear dynamic analyses were conducted for realistic building systems. Inter-storey drifts and floor accelerations were investigated under multiple seismic hazard levels. Aviram et al. (2012) carried out an analytical study to evaluate and compare the seismic performance of typical reinforced concrete bridges in California. In this study, lead rubber and friction pendulum bearings were used. Single and double

concave friction pendulums were selected as the friction pendulum system. In total, 140 three-component ground motion records with a wide range of characteristics (Different fault mechanisms, magnitudes, and distance to fault) were used. Maximum column ductility demand, peak column shear, maximum bearing displacement, minimum/maximum isolator axial load, deck vertical acceleration, and peak column top rotation were considered in the evaluation. Ozbulut & Hurlebaus (2012) performed a comparative study on the seismic performance of superelastic-friction base isolators. Performance assessment was conducted by using near-field earthquakes. In this study, lead rubber bearings (LRB), friction pendulum systems (FPS), resilient-friction base isolators (R-FBI), and superelastic-friction base isolators (S-FBI) were used. Dynamic time-history analyses were conducted to evaluate the seismic performance of a multi-span continuous bridge by using ten near-field ground motions. Spectral matching was done for different damping levels (5%, 10%, and 25%). Additionally, different cases were compared in terms of peak deck drift, residual deformation, peak deck acceleration, peak normalized base shear, and hysteresis curves of the isolators. Pokhrel et al. (2016) carried out comparative studies on lead rubber bearings and friction bearings. Five storey reinforced concrete building is investigated. Loads were calculated according to IBC. In total, 12 bearings were categorized into three groups. Dynamic time-history analyses were carried out by using four different ground motions. In this study, evaluation of the behavior was done according to roof acceleration, base shear, isolator displacement, and inter-storey drift.

1.3.2 Other Types of Isolators

Khan et al. (2019) conducted a comparative study on the performance of the different types of base isolation systems. In this study, High Damping Rubber Bearing (HDRB), Low Damping Rubber Bearing (LDRB), and Lead Core Rubber Bearing (LCRB) were used. An eight-storey building system was analyzed to determine the seismic performance by using the state-space approach. Two ground motions were

used to conduct the time-history analysis. The dynamic performance of the structure was evaluated by considering inter-storey drift, transmissibility ratio, and relative peak displacement. Cilsalar & Constantinou (2019) investigated the seismic performance of two storey residential buildings. A rolling isolation system was used as a base isolation system. Dynamic time-history analyses were conducted using 40 pairs of ground motions. Ground motions were applied as one-directional (combined horizontal) and vertical. The study also checked inter-storey drift, isolator displacement, numerical divergence, and uplift to evaluate the collapse performance.

Komur et al. (2011) conducted nonlinear dynamic analyses on 4 and 8 storey reinforced concrete isolated and fixed base structures. In this study, lead-rubber bearings were selected as the isolation system. To evaluate the seismic response of the structure, periods, storey accelerations, inter-storey drifts, base shear forces, plastic hinge locations, and weighted damage histories were compared. The inelastic behavior of the structural members was taken into consideration while modeling the superstructure. Hameed et al. (2015) evaluated the seismic response of the base-isolated reinforced concrete buildings. In this study, nonlinear dynamic analyses were conducted on a 10 storey reinforced concrete building, which was base-isolated by using lead rubber bearing. This study was divided into three phases. At first phase of the study, fixed base and base-isolated responses were compared. At the second phase, effect of the height and bay number of the base-isolated structure were examined. At the last phase of the study, effects of the parameters of the isolation system were examined. Erdem & Saifullah (2016) evaluated the soft-storey effect on the behavior of base-isolated buildings under near and far fault earthquakes. In this study, 3 and 8 storey reinforced concrete structures isolated with two different rubber isolation systems were investigated. The seismic behaviors of base-isolated and fixed base systems were compared by using floor accelerations, storey shears, and inter-storey drifts.

Win & Htun (2017) carried out a comparative study on the performance assessment of steel structure with lead rubber bearing system by performing nonlinear dynamic time-history analyses for design-basis earthquake (DBE). Storey displacement, storey acceleration, Inter-storey drift ratio, and structural period were compared with the fixed base. The performance of the base isolation system was assessed by considering damage cost, repair time, and injuries. Güneyisi & Deringöl (2018) investigated the seismic response of friction damped and base-isolated frames by considering the serviceability limit state. In this study, 5 and 10 storey steel moment-resisting frames were used. Friction dampers, lead rubber bearings, and a combination of both systems was used as structural protective systems. Nonlinear time-history analyses were conducted to evaluate the seismic response of the structures by using seven ground motions. The seismic responses of structures with and without a seismic protection system were evaluated by using roof drift ratios, maximum roof absolute accelerations, relative displacements, inter-storey drift ratios, base shear values, and hysteretic curves. Deringol & Bilgin (2018) performed an analytical study on steel structures with lead rubber bearings. In this study, 5 and 10 storey moment-resisting frames were used. Nonlinear time-history analyses were conducted to propose an optimum base isolation system by using six earthquake records. For this purpose, isolation periods ($T = 2.25, 2.5, 2.75, \text{ and } 3 \text{ s}$) and strength to weight ratio ($Q/W = 0.05, 0.10, \text{ and } 0.15$) were used as lead rubber bearing properties. The evaluation was based on roof displacements, absolute roof accelerations, relative displacements, inter-storey drifts, base shear, and hysteretic curves of the isolators.

1.3.3 Base-Isolated Hospitals and Non-Structural Damage

X. Wang et al. (2013) performed a pre-test simulation of a full-scale five-storey reinforced concrete structure. In this study, non-structural components and system design criteria were developed by considering passenger elevator, prefabricated metal stairs, complete façade, interior furnishing, mechanical and electrical

subsystems, and various medical equipment. Nonlinear analyses were conducted using OpenSees and DIANA. Yamaguchi-Sekino et al. (2016) investigated the effectiveness of disaster-prevention technologies against seismic damage on non-structural elements during the Great East Japan Earthquake (GEJE). In this study, statistical analyses were conducted to investigate damages in magnetic resonance (MR) scanners during this disaster. In total, 456 facilities and 602 MR scanners were selected as the dataset of this study. The data collection was classified into two groups by considering the seismic intensity scale. Cosenza et al. (2015) evaluated the seismic fragility of hospital rooms by conducting shake table tests. In this study, fragility curves were derived by using the shake table test results. A single-storey steel framed system was used for simulating the hospital room. The rooms were considered to have different types of medicine cabinets, a desktop computer, and a desk. High-quality digital accelerometers were placed to monitor the seismic response of the non-structural components.

Dolce et al. (2007) performed shaking table tests on reinforced concrete frames isolated with different base isolation systems. In this study, rubber-based, steel based, shape memory alloy (SMA)-based, and hybrid isolation systems were used. Maximum base displacements, maximum inter-storey drifts, maximum storey accelerations, and maximum storey shears were compared by the fixed-based structural response to evaluate the seismic response of both structural and non-structural members. Vilca-Cordova et al. (2017) assessed Piura's hospital in Peru by using different types of base isolation systems to evaluate the response of the structure. In this research, rubber bearings and triple friction pendulums were used. Five of the 16 blocks of the hospital have been analyzed. Reinforced concrete frames were used as the structural system of the hospital. Ground motions used in the study were selected by considering near-fault characteristics. The interval of moment magnitude was taken 6.7 to 7.1. The distance was in the range of 3 to 12 km. The site class was either C and D. Seven pairs of ground motions were selected, scaled, and applied in both X and Y directions. For the interval of 1.8 and 5.0 s periods, the

weighted scaling methodology, which is mentioned at ASCE 7-10, was conducted. Nonlinear time-history analyses were conducted to evaluate the performance. Additionally, average floor acceleration, average inter-storey drift, average base shear, and isolator response were investigated.

Achour et al. (2005) demonstrated a high percentage of damage to the diagnosis and treatment equipment in hospitals, even under the acceleration of 200-300 cm/s². Miura & Kohiyama (2012) states that during Hyogo-ken Nanbu earthquake (1995), much of the medical equipment was exposed to quake-induced damage. Even though heavy equipment like CT and MR scanners fixed to the floor, their movements were reported during the earthquake. For this purpose, another seismic isolation device is installed to prevent damage to sensitive and expensive medical equipment. Miura & Kohiyama, (2012) determined the performance objective of the equipment as 0.6 m/s². Moreover, to evaluate the evacuation capability, the limit curve of evacuation under a sinusoidal wave (Takahashi et al., 2007) was used in this study. Takahashi et al. (2007) introduced a relation between floor accelerations and action difficulty. Action difficulties were classified into five levels (0 to 4). Miura & Kohiyama (2012) was used the second curve, which corresponds to the “disturbed” action. Parisi et al. (2010) described the design approach used in the Mills Peninsula Hospital, which is located in Burlingame, California. In this study, nonlinear time-history analyses were conducted to evaluate the seismic behavior of the structure, which is isolated with friction pendulum bearings. Then, prototype tests were conducted to verify the stability of the isolators. The results of this study show that friction pendulum bearings can stay functional under 1” (2.54 cm) horizontal displacement.

1.4 Outline of the Thesis

In Chapter 1, introductory information, literature review, and research objectives and scope are presented.

In Chapter 2, the parameters selected for the study are presented. This chapter also explains the isolator properties, the building selection, and how the loads are determined. Loads are determined by considering the intended purpose of the building. The preliminary design of the structural members and modeling approaches are presented in this chapter. The development of the analysis model generation and post-processing tools are explained. C#, VB.Net, and SAP2000 API are used for conducting the parametric study.

In Chapter 3, the procedure of the equivalent linear analysis is discussed. Since the effective periods of the base-isolated structures must be determined to conduct ground motion scaling, this chapter presents the iterative procedure used to determine the effective periods, as well.

In Chapter 4, the ground motions are selected, and parameters taken into consideration for this selection are discussed. This chapter also presents the scaling procedures on the selected ground motion sets. After determining the effective periods of the base-isolated structures, ground motion scaling is conducted by considering determined intervals.

In Chapter 5, selected performance objectives for evaluating the efficiency of the base isolation systems are presented.

In Chapter 6, the effect of the bay number on seismic behavior and the effectiveness of the sensitive equipment isolation are evaluated.

In Chapter 7, the parametric study and the analysis results are discussed.

In Chapter 8, a brief summary and conclusions obtained from this study are presented.



CHAPTER 2

PARAMETERS SELECTED FOR THE STUDY AND MODELING

2.1 Selected Parameters for the Study

In order to examine the effect of seismic base isolation, reinforced concrete structures with different heights and widths are selected. In the scope of this study, structures with 2, 4, 8, 12, 16, and 20 storeys and 3, 5, 7, and 9 bays are selected. The intended use of the structures is selected as a hospital. The Bay width of the structures is selected as 6 m, and storey height is selected as 3m, as shown in Figure 2.1. Materials are determined as C40 for reinforced concrete and S420 for rebars. Selected building properties are shown in Table 2.1.

In total, 48 (24 Equivalent Linear and 24 Nonlinear Time-History) 2D structural analysis models are prepared by taking the selected storey numbers and bay numbers into consideration. Those 48 analysis models are used as base models for model generation algorithm prepared by using C#, VB.Net, and SAP2000 API. Isolator properties of each base model are modified by considering the analysis model parameters. Side views of the base analysis models are shown in Figure 2.2.

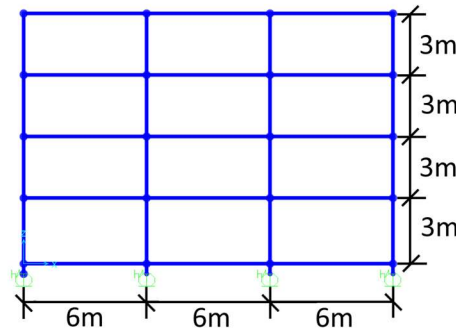


Figure 2.1. Bay Width and Storey Height Dimensions of Typical Analysis Model

Table 2.1 Selected Building Properties

St No	Bay No	Aspect Ratio (H/B)	Abbreviation
2	3	0.33	St2B3
4	3	0.67	St4B3
8	3	1.33	St8B3
12	3	2.00	St12B3
16	3	2.67	St16B3
20	3	3.33	St20B3
2	5	0.2	St2B5
4	5	0.40	St4B5
8	5	0.80	St8B5
12	5	1.20	St12B5
16	5	1.60	St16B5
20	5	2.00	St20B5
2	7	0.14	St2B7
4	7	0.29	St4B7
8	7	0.57	St8B7
12	7	0.86	St12B7
16	7	1.14	St16B7
20	7	1.43	St20B7
2	9	0.11	St2B9
4	9	0.22	St4B9
8	9	0.44	St8B9
12	9	0.67	St12B9
16	9	0.89	St16B9
20	9	1.11	St20B9

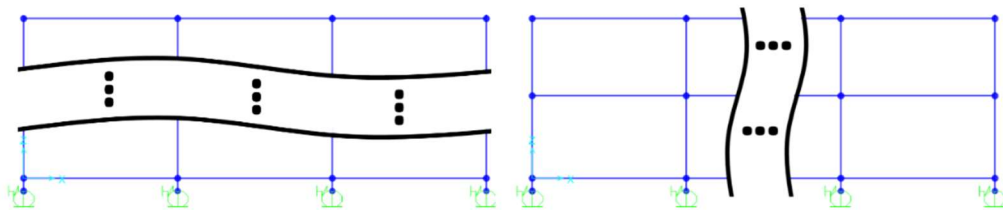


Figure 2.2. Side views of the Base Analysis Models (2 to 20 Storey and 3 to 9 Bay)

In this study, Single concave friction pendulum bearings are used for isolating the hospitals. Single concave friction pendulums have stainless steel concave sliding surface, which is in contact with an articulated friction slider, as shown in Figure 2.3.

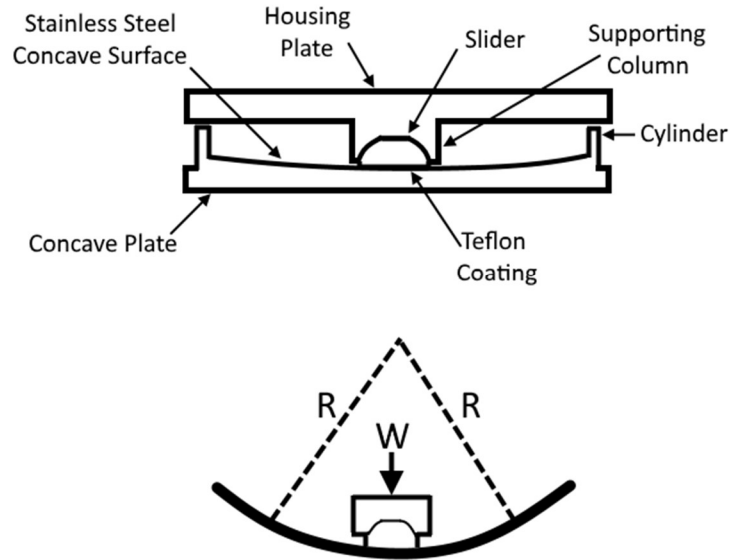


Figure 2.3. Friction Pendulum Bearing

In the scope of this study, sliding surface curvature radius ($R = 3, 5, \text{ and } 7 \text{ m}$) and friction coefficient ($\mu = 0.03, 0.05, \text{ and } 0.07$) of single friction pendulums are selected as main isolator parameters. As a benchmark value, 5 m sliding surface curvature radius and 5% friction coefficient are chosen. In total, five different isolators are used in this study, as shown in Table 2.2.

Table 2.2 Selected Isolator Properties

μ	R (m)	Abbreviation
0.03	5	$\mu 3R5$
0.05	3	$\mu 5R3$
0.05	5	$\mu 5R5$
0.05	7	$\mu 5R7$
0.07	5	$\mu 7R5$

Abbreviations of analysis models are prepared by using the above information. For example, an eight-storey, and five-bay reinforced concrete hospital isolated with friction pendulums with 5 m sliding surface curvature radius and 5% friction coefficient is represented as St8B5 μ 5R5. To indicate the analysis type, suffixes, “EL” for equivalent linear and “NL” for nonlinear analysis, are appended at the end of the abbreviation.

2.2 Response Spectrum Functions

The location of the structure is selected near the Los Angeles International Airport. Response spectrum functions are obtained from USGS by selecting the risk category IV (e.g., essential facilities). In this study, three different soil site classifications (B, C, and D) are used. In order to understand the seismic behavior by considering the intensity of the earthquake, all response spectrum functions are scaled by using selected PGA values (0.2, 0.4, 0.6, and 0.8). All Response spectrum functions are shown in Figure 2.4, Figure 2.5, and Figure 2.6.

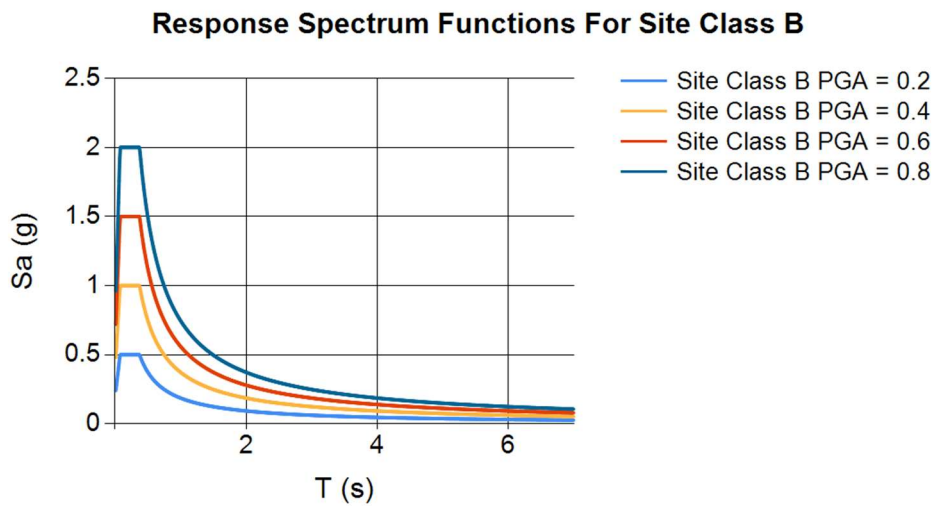


Figure 2.4. Response Spectrum Functions for Soil Class B

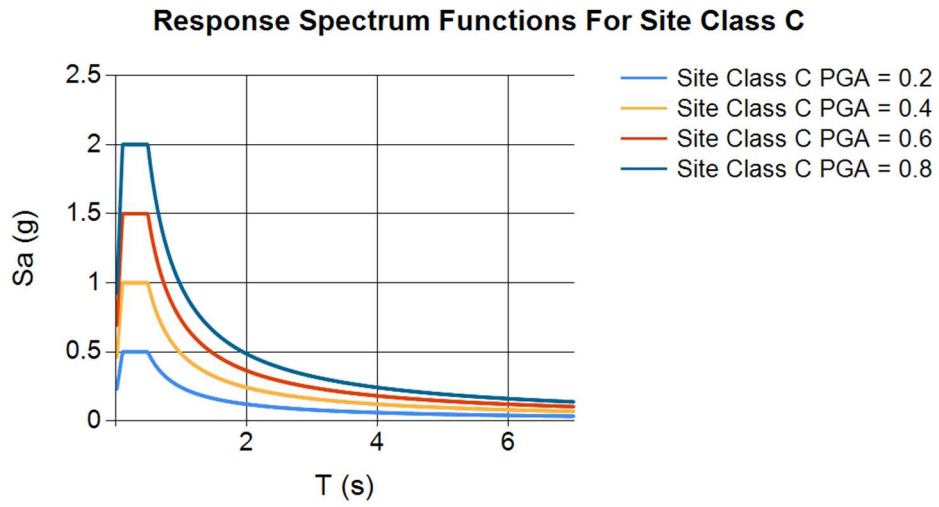


Figure 2.5. Response Spectrum Functions for Soil Class C

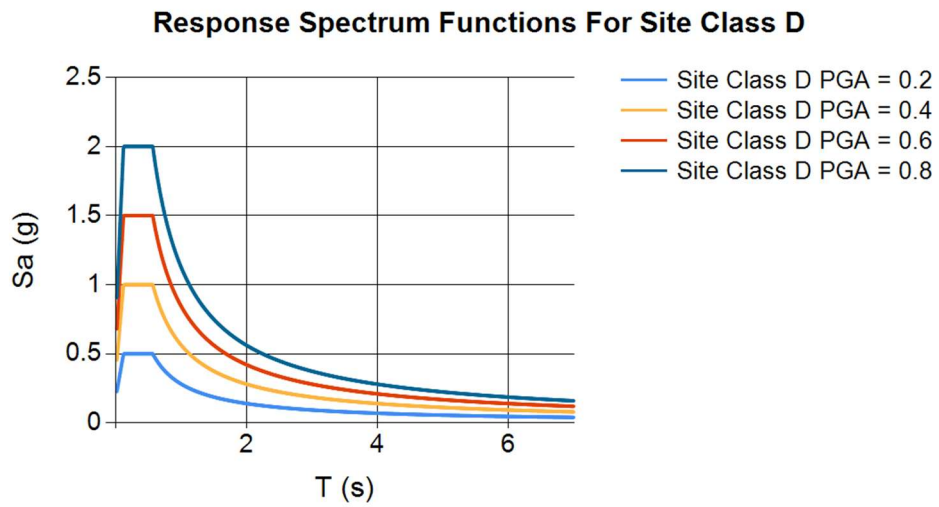


Figure 2.6. Response Spectrum Functions for Soil Class D

2.3 Loads

Since analysis models are prepared as 2D, plan drawings of the hospitals constructed in real life are examined to get a closer response to the real case. In order to determine the gravity loads of the structure, the ratio of the areas of the corridors to the floor area is measured. After measuring the ratio from several structural plan drawings, the ratio of areas of the corridors to the total floor area is determined between 20 and 30 per cent. By using data obtained from examined hospital drawings, 25 per cent is assumed as the corridor area ratio per floor.

The applied loads are obtained from ASCE 7-16 to select dimensions of the structural members. Thicknesses of the slabs are determined as 30 cm at isolation level and 15 cm for all other floors. A 25 mm cement finish, ceramic on 25 mm mortar bed, and suspended metal lath and cement plaster are also taken into consideration. From ASCE 7-16, Table C3.1-2 Minimum Densities for Design Loads from Materials self-weight of the concrete, reinforced, stone (including gravel) is taken as 23.6 kN/m^2 . From Table C3.1-1b Minimum Design Dead Loads, the distributed load of the cement finish (25 mm) is taken as 1.53 kN/m^2 , ceramic on 25 mm mortar bed is taken as 1.1 kN/m^2 , and suspended metal lath, and cement plaster is taken as 0.72 kN/m^2 .

Live loads are taken from ASCE 7-16 Table 4.3-1 Minimum Uniformly Distributed Live Loads as 2.87 kN/m^2 for operating rooms or laboratories, 1.92 kN/m^2 for patient rooms, and corridors 3.83 kN/m^2 for corridors. At ASCE 7-16 C4.3.2 mentions that “If the partitions are spaced throughout the floor area creating rooms on a grid 10 ft (3.05 m) on center, which would be an extremely dense spacing over a whole bay, the average distributed load would be 16 psf (0.77 kN/m^2). A design value of 15 psf (0.72 kN/m^2) is judged to be reasonable in that the partitions are not likely to be spaced this closely over large areas. Designers should consider a larger design load for partitions if a high density of partitions is anticipated.”. By considering this, 0.77

kN/m² is selected as a distributed partition load and applied as a live load. Roofs of the structures are classified as not intended for occupancy, and related distributed load value is taken from Table 4.3-1. (Continued) Minimum Uniformly Distributed Live Loads as 0.96 kN/m². Distributed loads on the beams are modified by using the ratio of the total area of the corridors to the floor area. Modified distributed loads are presented in Table 2.3.

Table 2.3 Dead Loads and Live Loads applied to the Floors

Dead Load	
Load Description	Value (kN/m ²)
Total Dead Load (kN/m ²)	6.89
Live Load With Corridors	
Load Description	Value (kN/m ²)
Operating rooms, laboratories	3.11
Patient rooms	2.3975

The purpose of the use of the stories are determined as follows:

- For 2 storey hospitals, the first storey is determined as laboratories and operating rooms, and the second storey is determined as the patient room.
- For 4, 8, and 12 storey hospitals, the first two storeys are determined as laboratories and operating rooms, and the other stories are determined as patient rooms.
- For 16 and 20 storey hospitals, the first four storeys are determined as laboratories and operating rooms, and other stories are determined as patient rooms.

2.4 Preliminary Design of the Structural Members

Column dimensions are obtained from constructed hospitals in real life to create more realistic behavior. In order to use the obtained column dimensions, a preliminary design is conducted by using ACI 318-14 Chapter 22.4. Design axial

loads are obtained for 2 to 20 storey buildings by load combinations taken from ACI 318-14 Table 5.3.1. After obtaining the design axial loads, the below formulations are used to obtain the required concrete area.

$$P_u = \phi P_{n,max} \quad (2.1)$$

$$\phi = 0.65 \quad (2.2)$$

$$P_{n,max} = 0.8P_0 \quad (2.3)$$

$$P_0 = 0.85 f'_c (A_g - A_{st}) + f_y A_{st} \quad (2.4)$$

A_{st} is taken as zero to be on the safe side and also to keep the formulation simple. From preliminary design results, all selected section dimensions are satisfying the checks. The preliminary design of the typical column members is presented in Table 2.4. Section assignments of the column members are done by using the determined cross-sections. For example, for 20 storey building, column dimensions are assigned as follows:

- Column dimensions of the 1st to 4th floors are determined as 120x120 cm,
- Column dimensions of the 5th to 8th floors are determined as 100x100 cm,
- Column dimensions of the 9th to 12th floors are determined as 90x90 cm,
- Column dimensions of the 13th to 16th floors are determined as 75x75 cm,
- Column dimensions of the 17th to 18th floors are determined as 60x60 cm,
- Column dimensions of the 19th to 20th floors are determined as 40x40 cm.

Beam dimensions are selected as 40/60 for 40x40 and 60x60 columns, 40/70 for 75x75 and 90x90 columns, and 40/80 for 100x100 and 120x120 columns. Isolator level beams are selected as 100x100. After the selection of the beam dimensions, strong column weak beam behavior is controlled for all joints.

Table 2.4 Preliminary Design for Typical Column Members

For 2 Storey		For 12 Storey	
P_d (kN)	1043.51	P_d (kN)	6096.9
A_c (cm ²)	590.22	A_c (cm ²)	3448.477
Selected Dimensions (cm)	40x40	Selected Dimensions (cm)	90x90
For 4 Storey		For 16 Storey	
P_d (kN)	2087.02	P_d (kN)	8183.92
A_c (cm ²)	1180.44	A_c (cm ²)	4628.92
Selected Dimensions (cm)	60x60	Selected Dimensions (cm)	100x100
For 8 Storey		For 20 Storey	
P_d (kN)	4091.966	P_d (kN)	9687.63
A_c (cm ²)	2314.46	A_c (cm ²)	5479.43
Selected Dimensions (cm)	75x75	Selected Dimensions (cm)	120x120

2.5 Modeling

All slabs are assumed as two-way, and their dimensions are selected as 6 m x 6 m. Since the two-way slab assumption is made, beams connected to the columns from out-of-plane are also taken into consideration. Loads on the out-of-plane beams are calculated and applied as point loads, as shown in Figure 2.7.

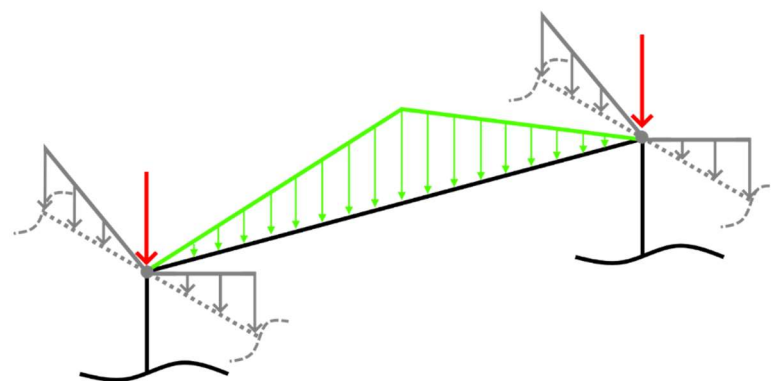


Figure 2.7. In-plane and out-of-plane loading on beam members (Gray: Distributed loads on the out-of-plane beams, Red: Applied point loads, Green: Distributed loads on the in-plane beams)

In order to get realistic behavior from analysis models, beams are modeled as T-Beams. Massless materials are used for T-Beams, and their self-weights are applied to the model as different load cases to take loads into consideration correctly, not taking slab loads twice (from distributed load from slabs and flanges of the T-Beams).

Two types of approaches are followed while modeling the seismic isolators. The first approach is modeling seismic isolators by using springs and roller supports. This modeling approach aims to determine the behavior of the seismic isolator by using effective stiffness (k_e). The second approach is using the friction isolator of the SAP2000. Friction coefficient (μ) and net pendulum radius (R) of the selected seismic isolator are also entered as parameters. For both approaches, initial stiffness (k_i) is taken as $100 * W / R$ where W is the weight on the seismic isolator. The first modeling approach is used in the equivalent linear analysis, and the second modeling approach is used in the nonlinear time-history analysis. The idealized bilinear hysteresis loop of the FPBs is shown in Figure 2.8. In order to determine the hysteretic behavior, post-elastic stiffness (k_p), characteristic strength (F_{yi}), yield force (F_y), design force (F_d), yield displacement (D_y), design displacement (D_d) are used. These parameters are given as follows:

$$k_i = 100 \frac{W}{R} \quad (2.5)$$

$$F_{yi} = \mu W \quad (2.6)$$

$$k_p = \frac{W}{R} \quad (2.7)$$

$$k_e = \frac{F_d}{D} = \frac{F_{yi}}{D} + k_p \quad (2.8)$$

$$F_d = k_p D + F_{yi} \quad (2.9)$$

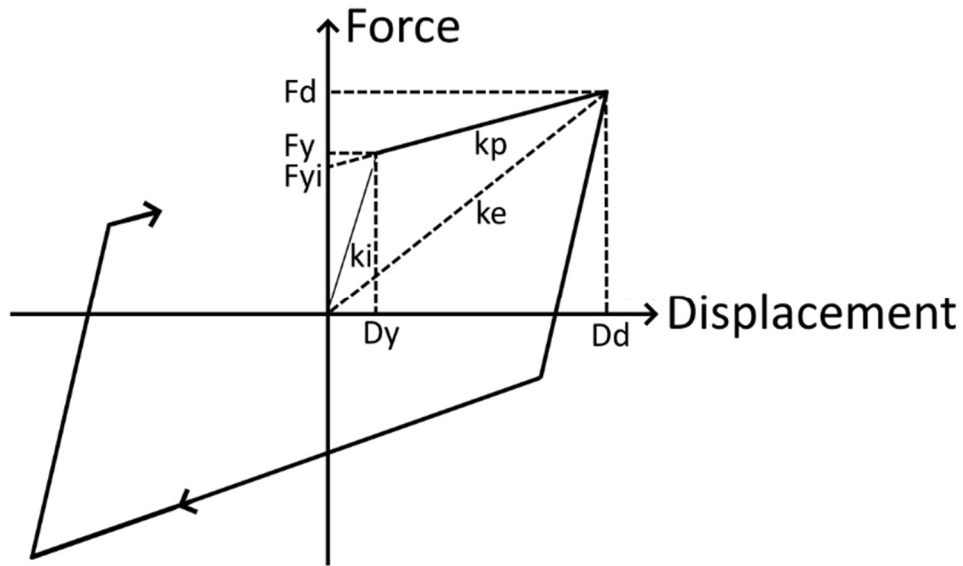


Figure 2.8. Hysteresis Loop of Friction Pendulum Bearing

Both isolators are defined 0.5 m under the column at the base level to obtain realistic behavior by considering the thickness of isolator level beams. Rigid frame elements are placed between the lower joint of the column at the base level and the isolator joint for both equivalent linear and nonlinear isolator definitions, as shown in Figure 2.9 and Figure 2.10.

Rigid frame elements are modeled as compression-only members to model the uplift on the isolation level. Uplift behavior can be observed by using this modeling approach. Stiffness modifiers are used to define the section of the rigid element. For each analysis model, the column section used at the base level is selected, and 50 times stiffer rigid frame elements are modeled.

Rigid diaphragm definition is done for all storeys. For the isolation level, both isolator joints and base level column bottom joints are included in the diaphragm. Rigid end zones are taken into consideration while generating the analytical model of the buildings. Rigid zone factor 0.5 is used for the determination of the end offsets.

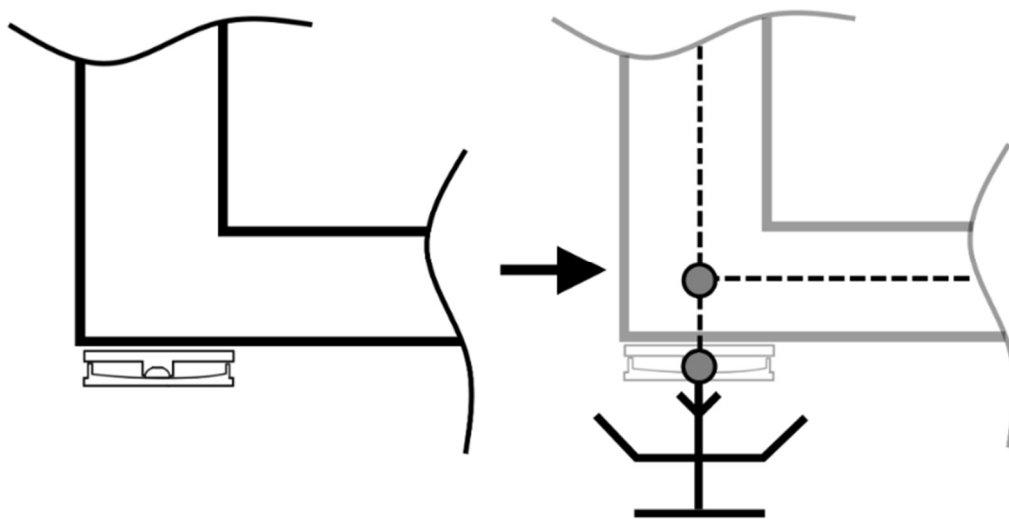


Figure 2.9. Modeling of Nonlinear Friction Pendulums Elements

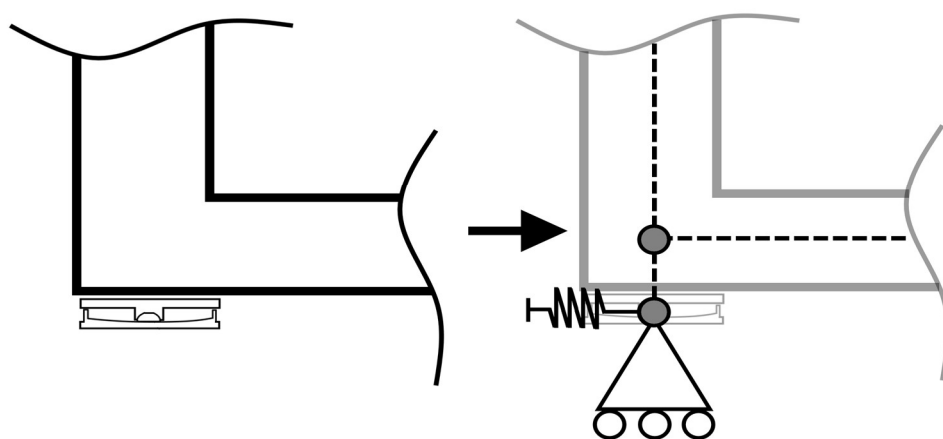


Figure 2.10. Modeling of Equivalent Linear Friction Pendulums Elements

2.6 Developing Analysis Model Generation, Scaling, and Post-Processing Tool

C# and VB.Net are used to develop the tools. Visual Studio is used as an integrated development environment (IDE). The user interface is prepared to handle the analysis procedure and to examine the analysis parameters. SAP2000 API and MS Excel API are used for analysis model generation and scaling. Instead of generating analysis models from scratch, prefabricated base models are used. Analysis models are prepared by the Modeling Tool using parameters of the parametric study. The Object-Oriented Programming (OOP) approach is used when generating the libraries. Class diagrams used in the tools are presented in the below figures.

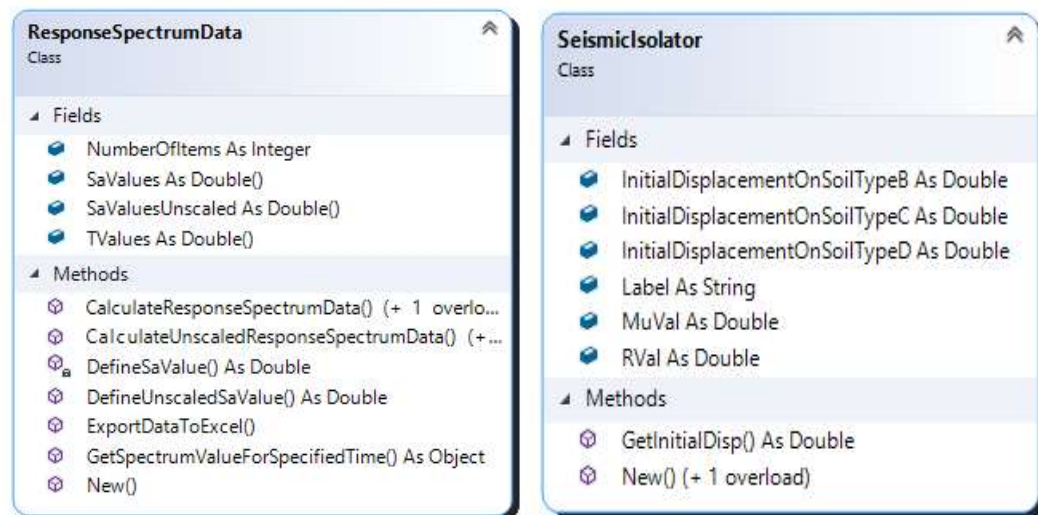


Figure 2.11. Class Diagrams of ResponseSpectrumData (left) and SeismicIsolator (right)

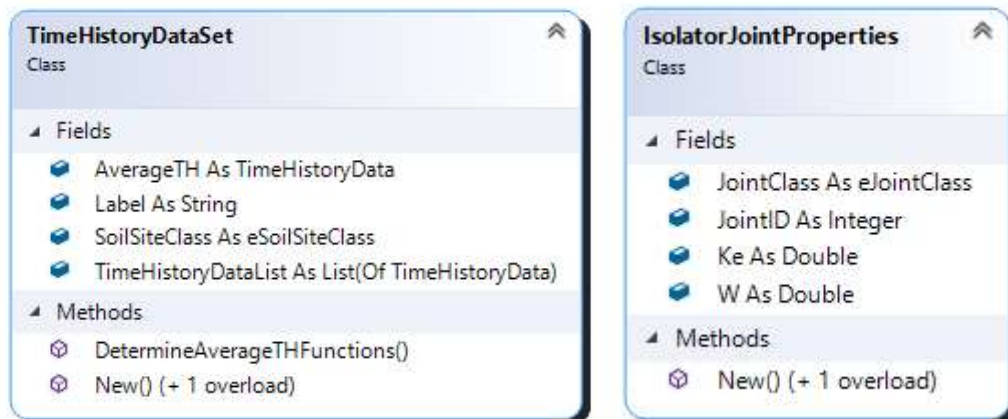


Figure 2.12. Class Diagrams of TimeHistoryDataSet (left) and IsolatorJointProperties (right)

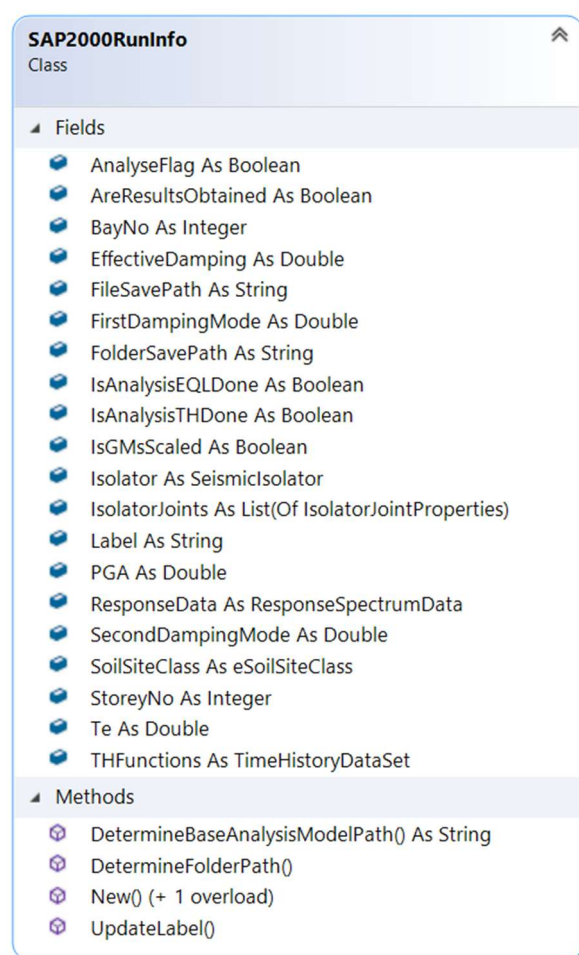


Figure 2.13. Class Diagram of SAP2000RunInfo

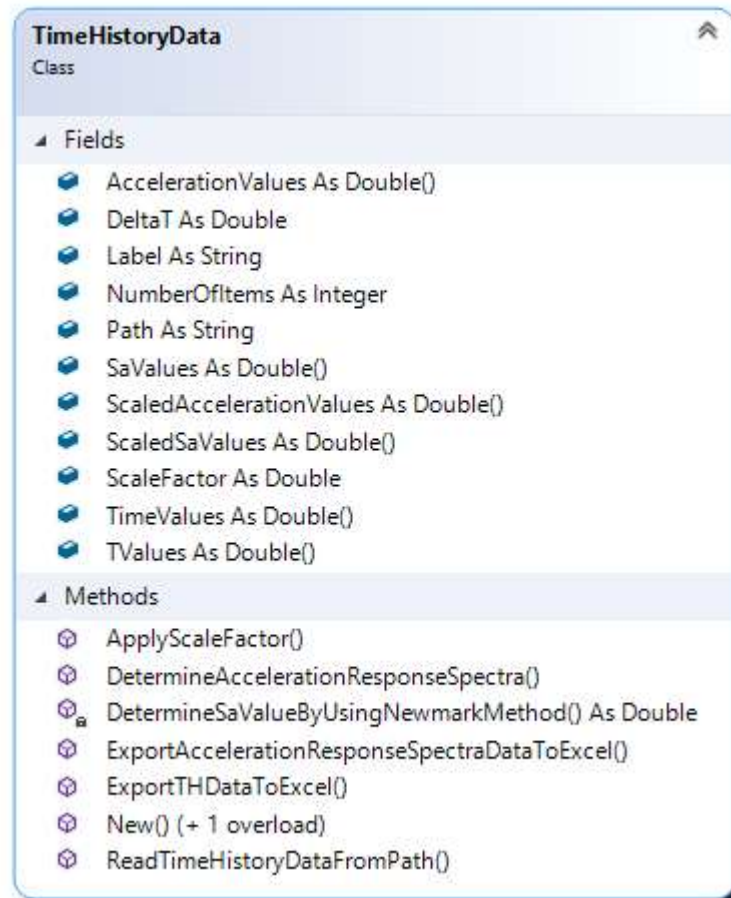


Figure 2.14. Class Diagram of TimeHistoryData

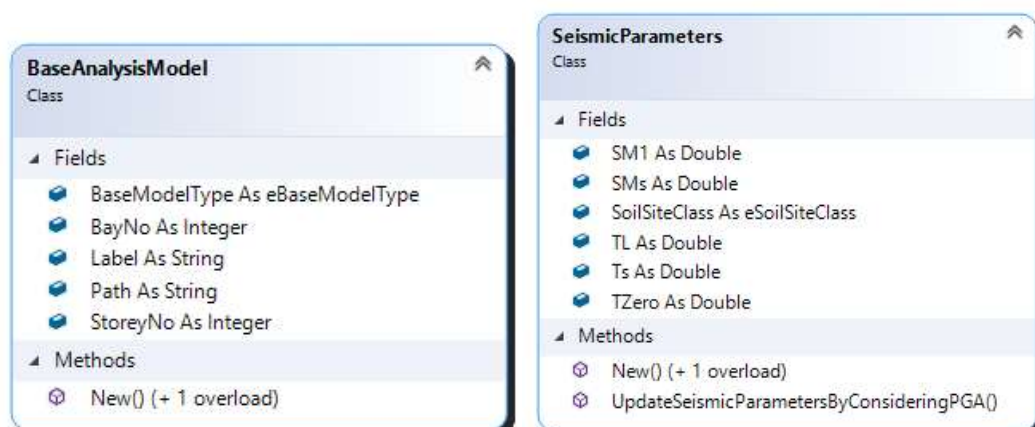


Figure 2.15. Class Diagrams of BaseAnalysisModel (left) and SeismicParameters (right)

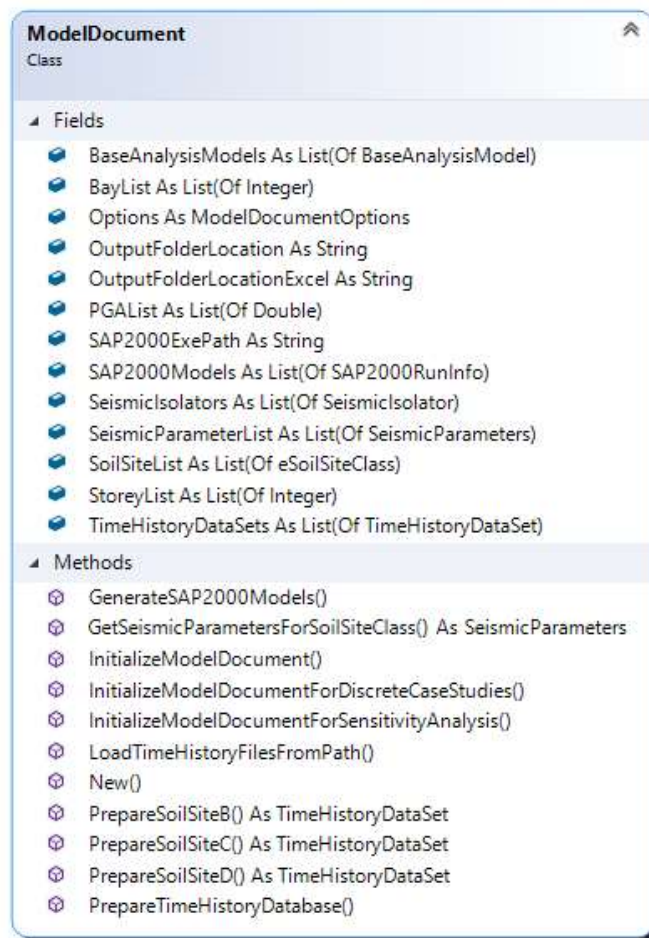


Figure 2.16. Class Diagram of ModelDocument

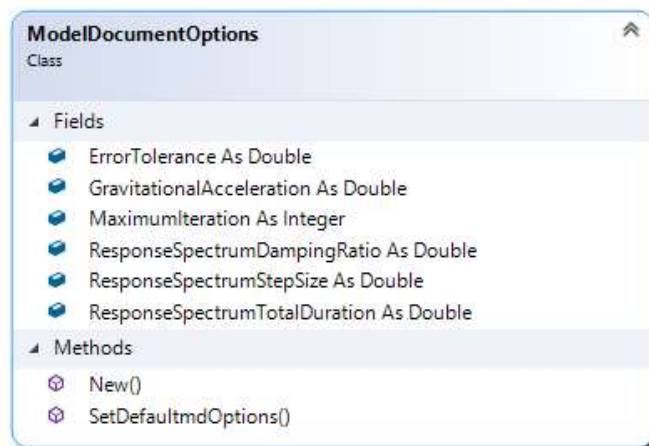


Figure 2.17. Class Diagram of ModelDocumentOptions

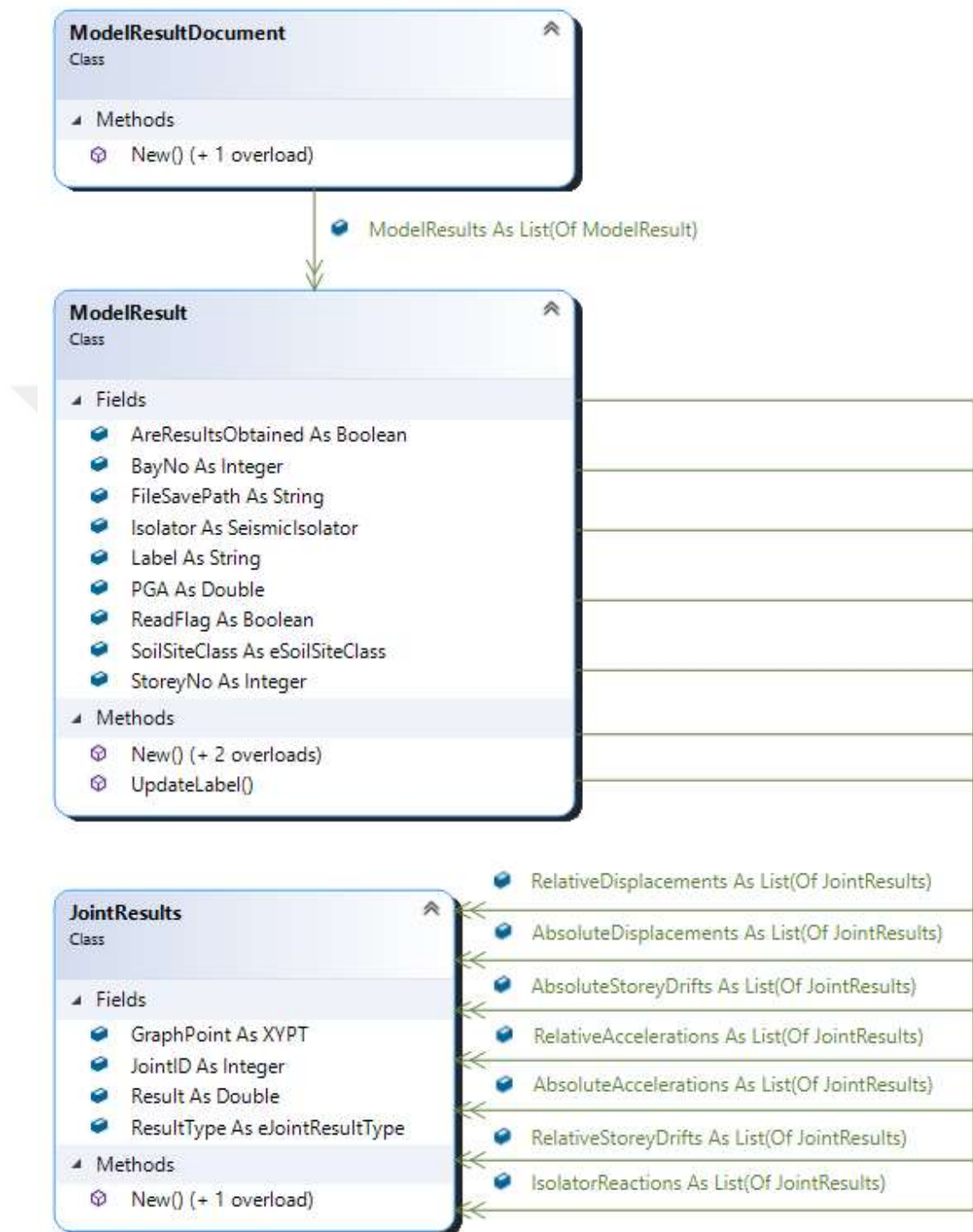


Figure 2.18. Class Diagrams of ModelResultDocument, ModelResult, and JointResults

Firstly, Base Analysis models are prepared manually. Secondly, the Modeling Tool prepares EL analysis models by using prefabricated base analysis models. After that, iterative analyses are done for the equivalent linear analysis approach. The effective periods of the structures are obtained from the results of the EL analysis. Ground motion scaling is conducted using the MS Excel goal seek algorithm through EXCEL API. After scaling is completed, scale factors are obtained, and nonlinear analysis models are prepared by using developed libraries. Nonlinear analyses are also triggered through the developed tool. After each nonlinear analysis, corresponded analysis results are obtained through API. The outline of the modeling, scaling, and post-processing procedure is presented in Figure 2.19.

For post-processing, the Analysis Model Viewer is developed. Custom user-controls are prepared for the visualization of the analysis results. The SAP2000 Modeling Tool presents the data and allows modifying all the data used in this study. The user interface of the SAP2000 Modeling Tool and post-processing tool are presented in Figure 2.20, Figure 2.21, Figure 2.22, Figure 2.23, Figure 2.24, and Figure 2.25.

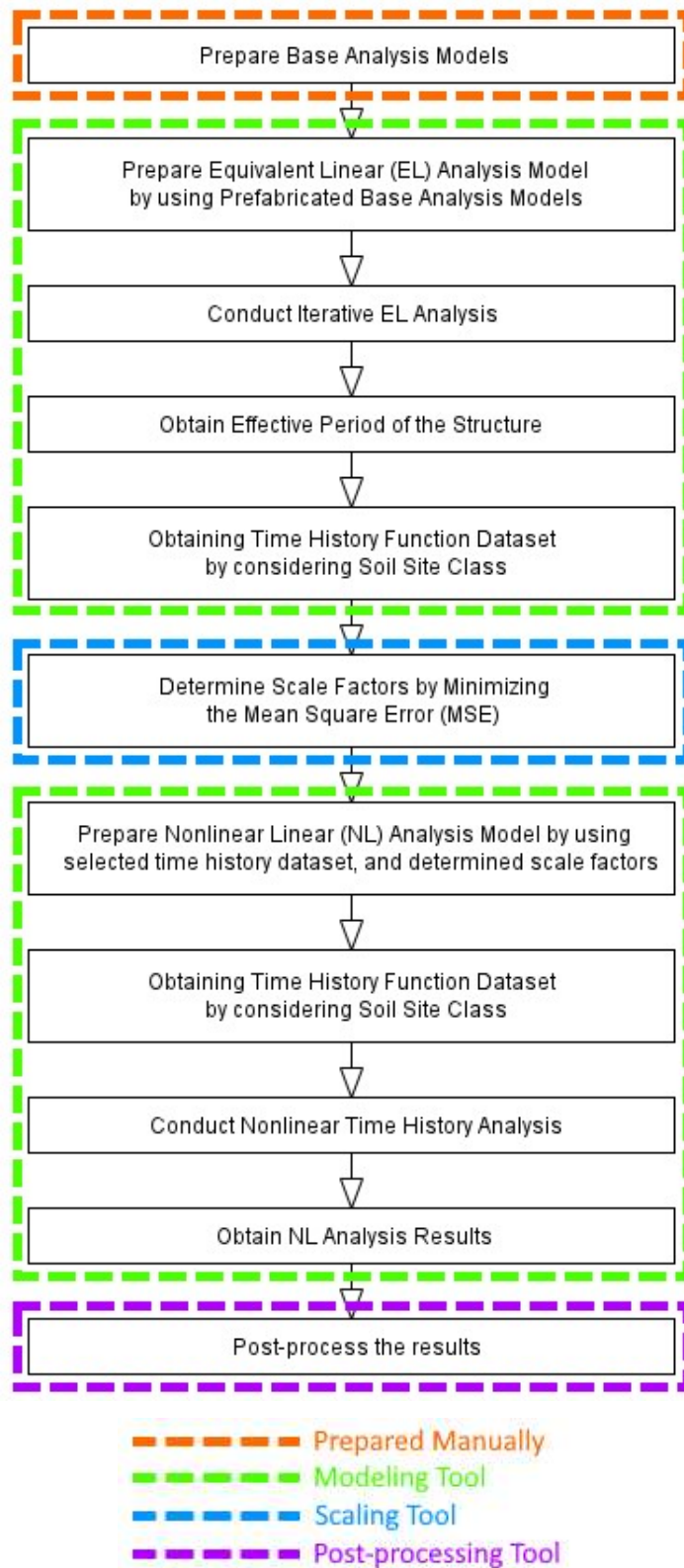


Figure 2.19. Modeling, Scaling, and Post-processing Procedure

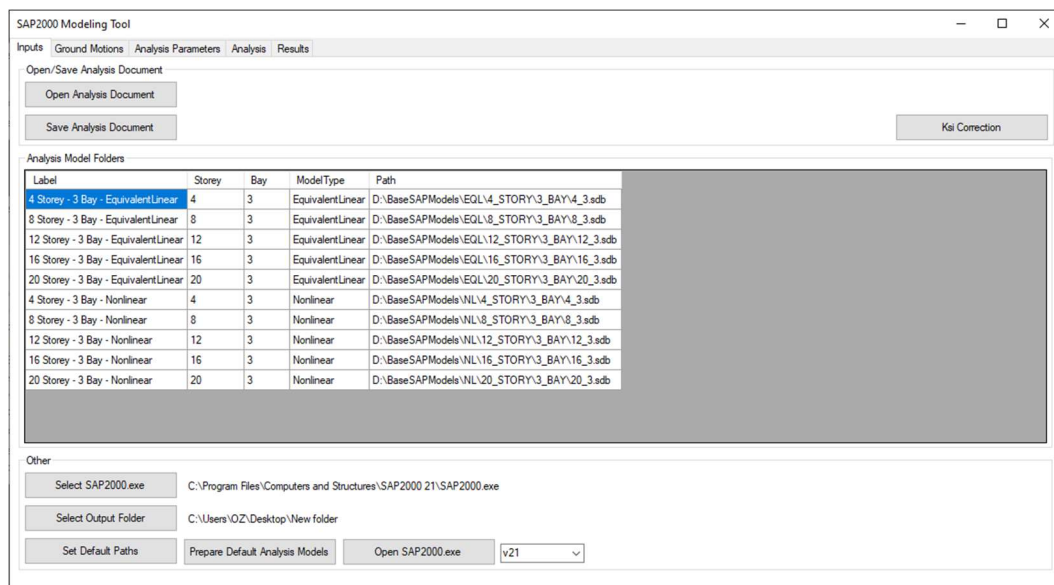


Figure 2.20. Input Tab of the SAP2000 Modeling Tool

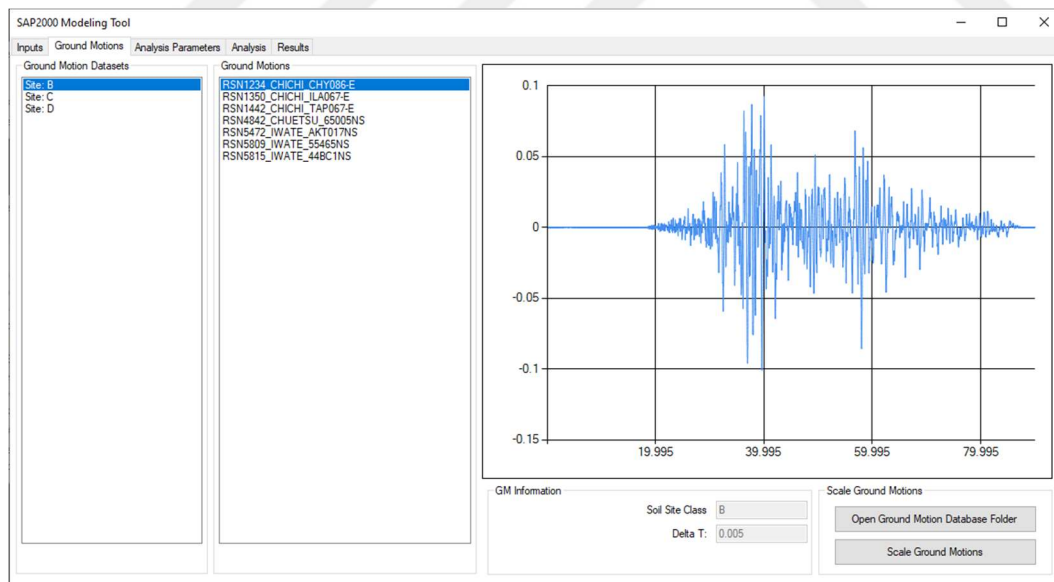


Figure 2.21. Ground Motions Tab of the SAP2000 Modeling Tool

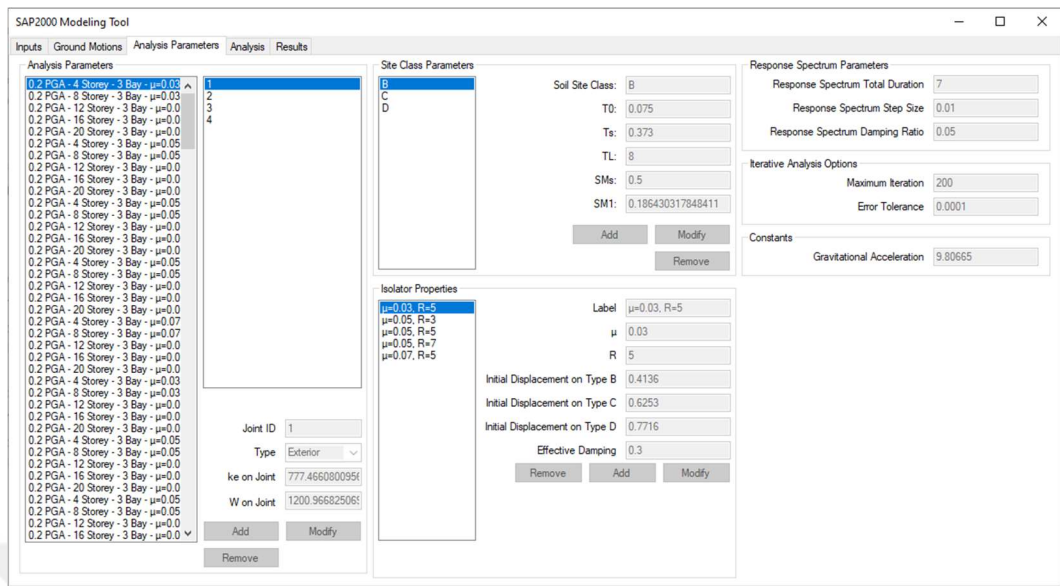


Figure 2.22. Analysis Parameters Tab of the SAP2000 Modeling Tool

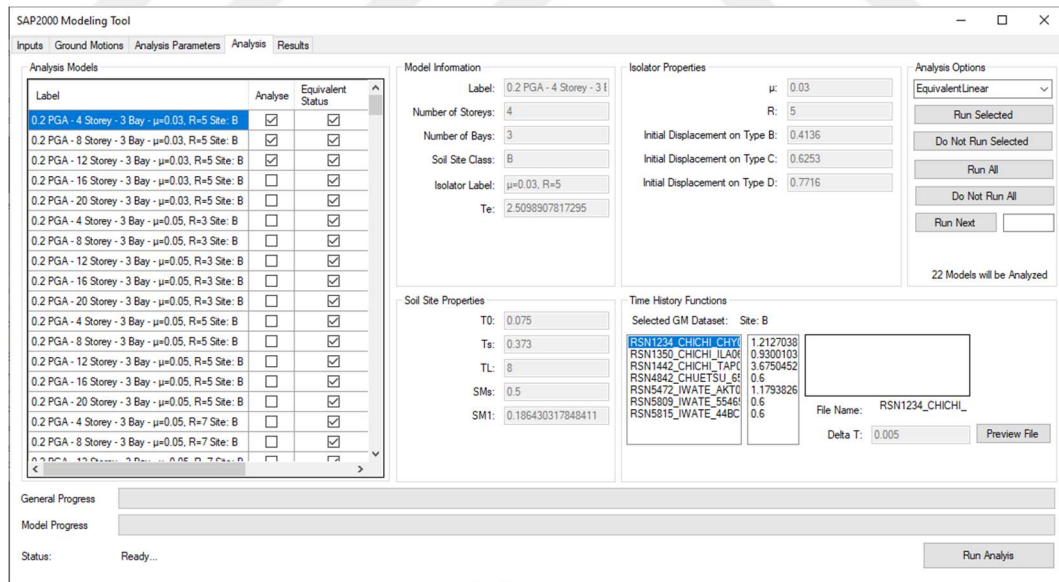


Figure 2.23. Analysis Tab of the SAP2000 Modeling Tool

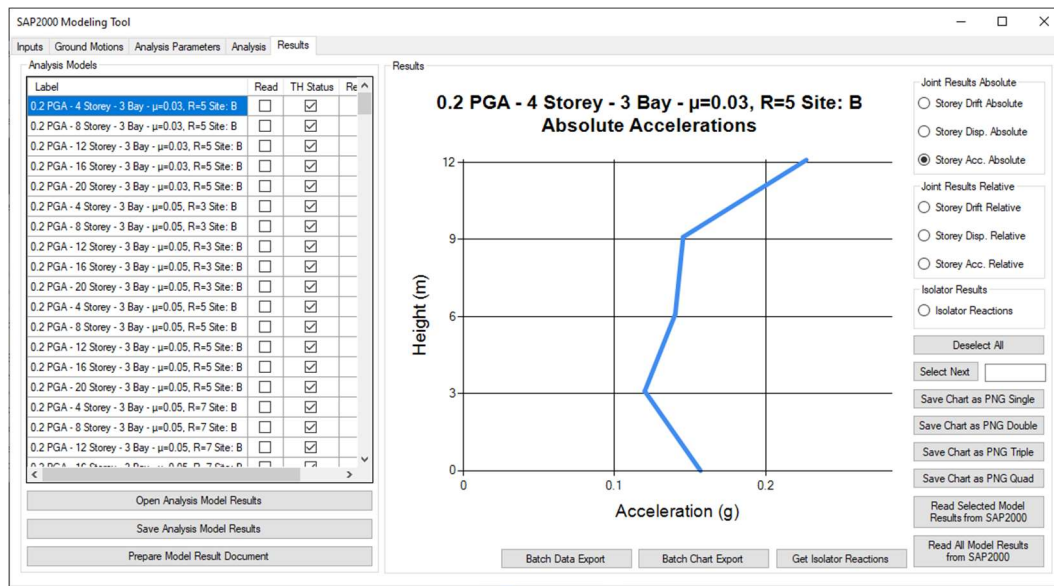


Figure 2.24. Results Tab of the SAP2000 Modeling Tool

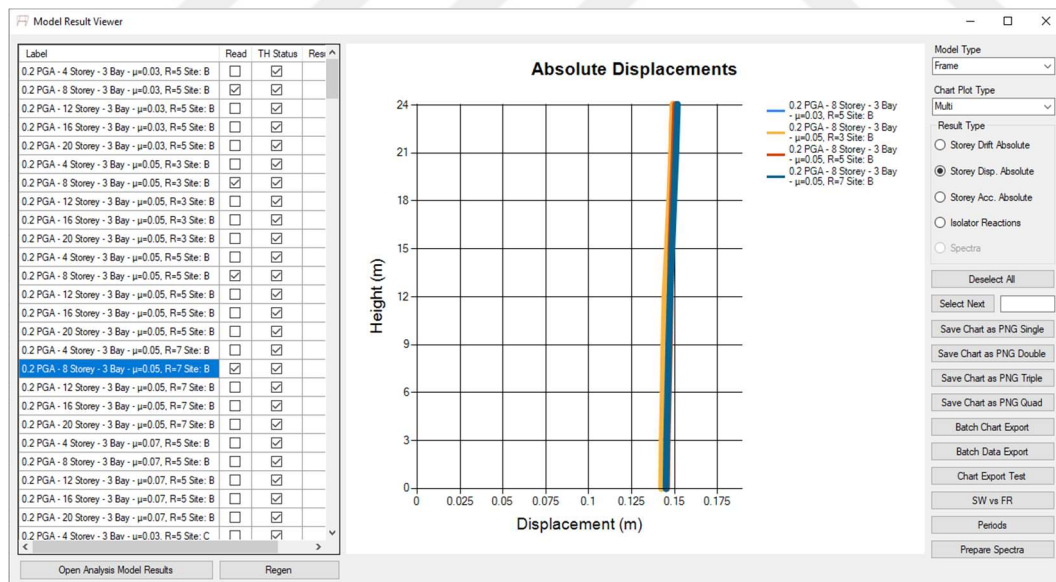


Figure 2.25. User Interface of the Model Result Viewer

CHAPTER 3

EQUIVALENT LINEAR ANALYSIS

In order to scale the ground motions, the effective period of the structure must be determined. The effective stiffness for friction isolators is determined by following an iterative procedure. Dicleli & Buddaram (2007) give an outline of the iterative procedure of the equivalent linear (EL) analysis for seismic isolated structures, as shown in Figure 3.1. During the iterative procedure, effective damping (ξ_e) and effective period (T_e) values are calculated as follows:

$$\xi_e = \frac{4Fyi(U_d - U_y)}{2\pi k_e U_d^2} \quad (3.1)$$

$$T_e = 2\pi \sqrt{\frac{m}{k_e}} \quad (3.2)$$

As mentioned earlier, the seismic isolation system is modeled as a spring and roller support for conducting the EL analysis. At each iteration of the EL analysis, stiffness values of the spring elements are calculated and reassigned, effective damping is calculated, the effective period of the base-isolated structure is calculated, response spectrum function is defined considering damping reduction and effective period, and new design displacement is obtained. If the difference between old and new design displacements is smaller than the tolerance, then stop the iteration. In this study, error tolerance and the maximum number of iterations for EL are selected as 0.0001 and 200, respectively. Effective seismic mass is determined by following ASCE 7-16 Ch. 12.7.2.

In total, 80 EL analyses for the sensitivity analysis and 360 EL analyses for the parametric study are conducted. Results of the EL analyses for both the sensitivity analysis and the parametric study are shown in Figure 3.2 and Figure 3.3. The results of the EL analyses are given in Appendix A.

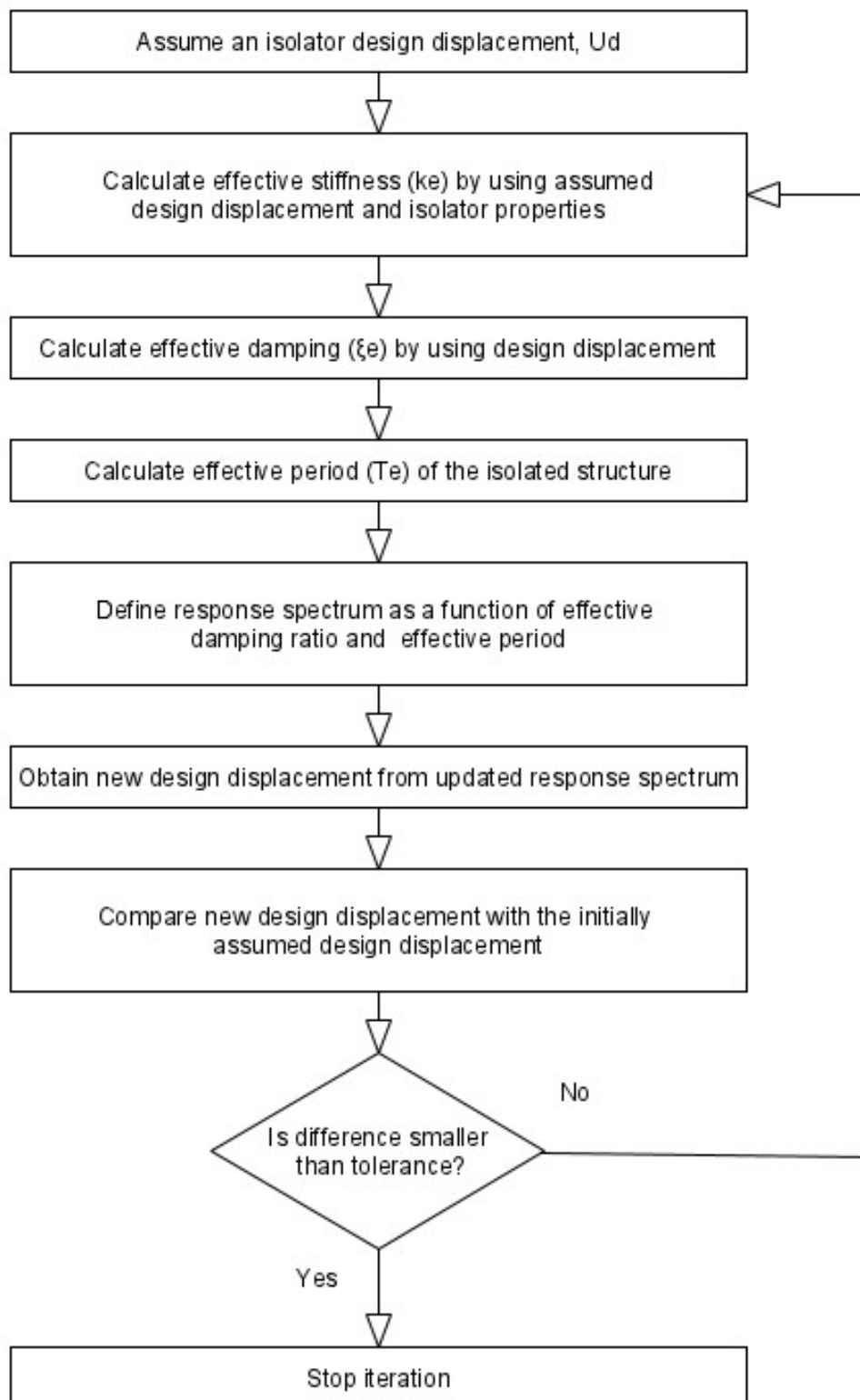


Figure 3.1. Equivalent Linear Analysis Procedure

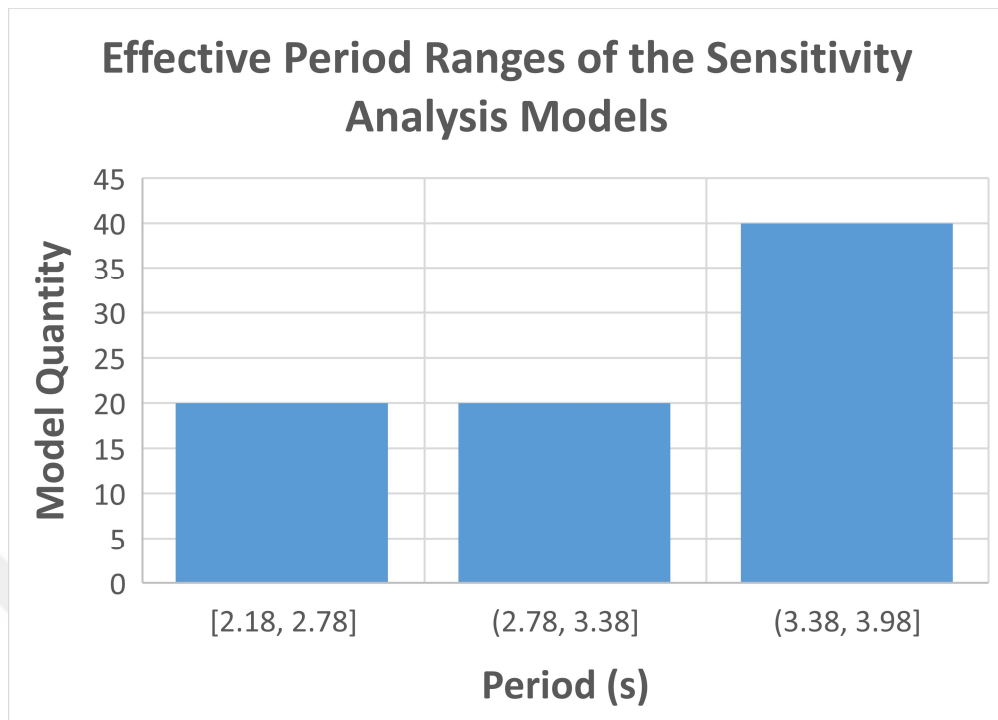


Figure 3.2. Effective Period Ranges of Sensitivity Analysis Models

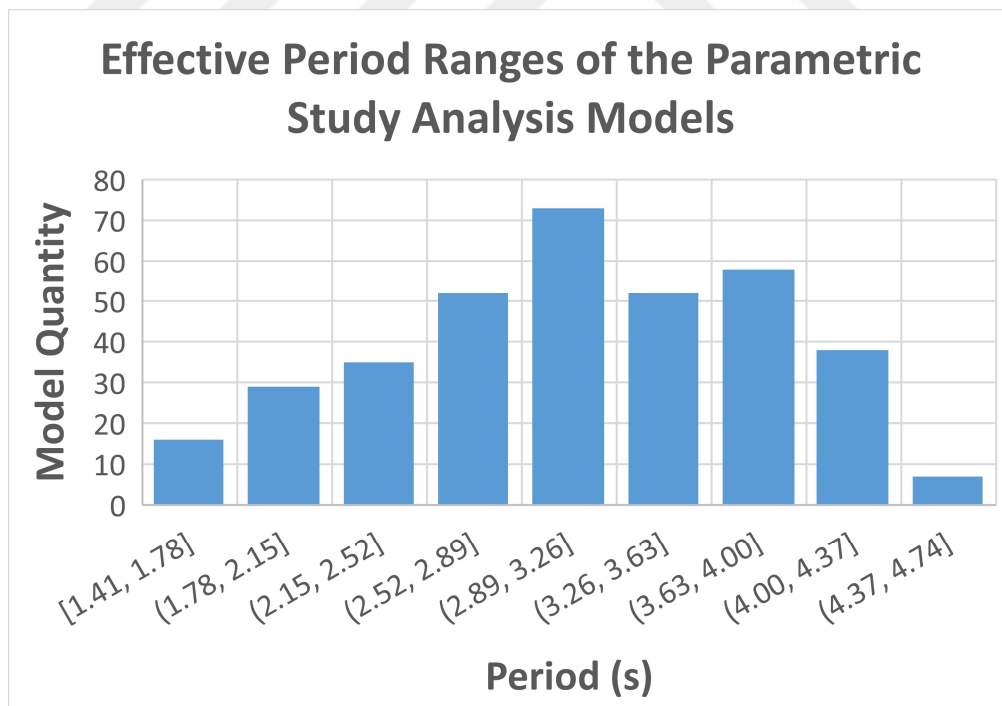


Figure 3.3. Effective Period Ranges of the Parametric Study Analysis Models

CHAPTER 4

GROUND MOTION SELECTION AND SCALING

4.1 Ground Motion Selection

Effective period intervals are determined to select the ground motion sets by using the calculated effective periods of the structures. Then, ground motion sets are obtained for each effective period interval and different soil site classes. After establishing the effective periods and effective period intervals of the analysis model domain, ground motions are selected from the PEER database by using the mid-point of the intervals, as shown in Figure 4.1. Finally, the scaling algorithm is prepared for obtaining the best fit for each analysis model.

The main concern of the selection is to keep scale factors between 0.2 and 5. The Minimize Mean Square Error (MSE) algorithm of the PEER is used to improve the fit quality of the selected dataset. Selected ground datasets for each soil site class are presented in Table 4.1, Table 4.2, and Table 4.3.

Table 4.1 Ground Motions Selected for the Soil Site Class B

GM ID	Earthquake	Station Name	Magnitude	R _{rup} (km)
1	Chi-Chi_Taiwan	CHY086	7.62	28.42
2	Chi-Chi_Taiwan	ILA067	7.62	38.82
3	Chi-Chi_Taiwan	TAP067	7.62	97.39
4	Chuetsu- oki Japan	Joetsu Uragawaraku Kamabucchi	6.8	22.74
5	Iwate_Japan	AKT017	6.9	33.76
6	Iwate_Japan	Minase Yuzawa	6.9	21.25
7	Iwate_Japan	Yuzawa	6.9	25.56

Table 4.2 Ground Motions Selected for the Soil Site Class C

GM ID	Earthquake	Station Name	Magnitude	R _{rup} (km)
1	Loma Prieta	APEEL 9 – Crystal Springs Res	6.93	41.03
2	Northridge-01	Castaic – Old Ridge Route	6.69	20.72
3	Chi-Chi_Taiwan	TCU042	7.62	26.31
4	Cape Mendocino	Loleta Fire Station	7.01	25.91
5	Chuetsu-oki_Japan	Sawa Mizuguti Tokamachi	6.8	27.3
6	Iwate_Japan	Yuzawa Town	6.9	25.56
7	Darfield_New Zealand	Heathcote Valley Primary School	7	24.47

Table 4.3 Ground Motions Selected for the Soil Site Class D

GM ID	Earthquake	Station Name	Magnitude	R _{rup} (km)
1	Coalinga-01	Parkfield – Fault Zone 7	6.36	31.21
2	Loma Prieta	Hollister City Hall	6.93	27.6
3	Kobe_Japan	Tadoka	6.9	31.69
4	Chi-Chi_Taiwan	TCU117	7.62	25.42
5	Chi-Chi_Taiwan-03	CHY101	6.2	25.3
6	Chuetsu-oki_Japan	Niigata Nishi Kaba District	6.8	29.91
7	El Mayor - Cucapah Mexico	El Centro Array #10	7.2	20.05

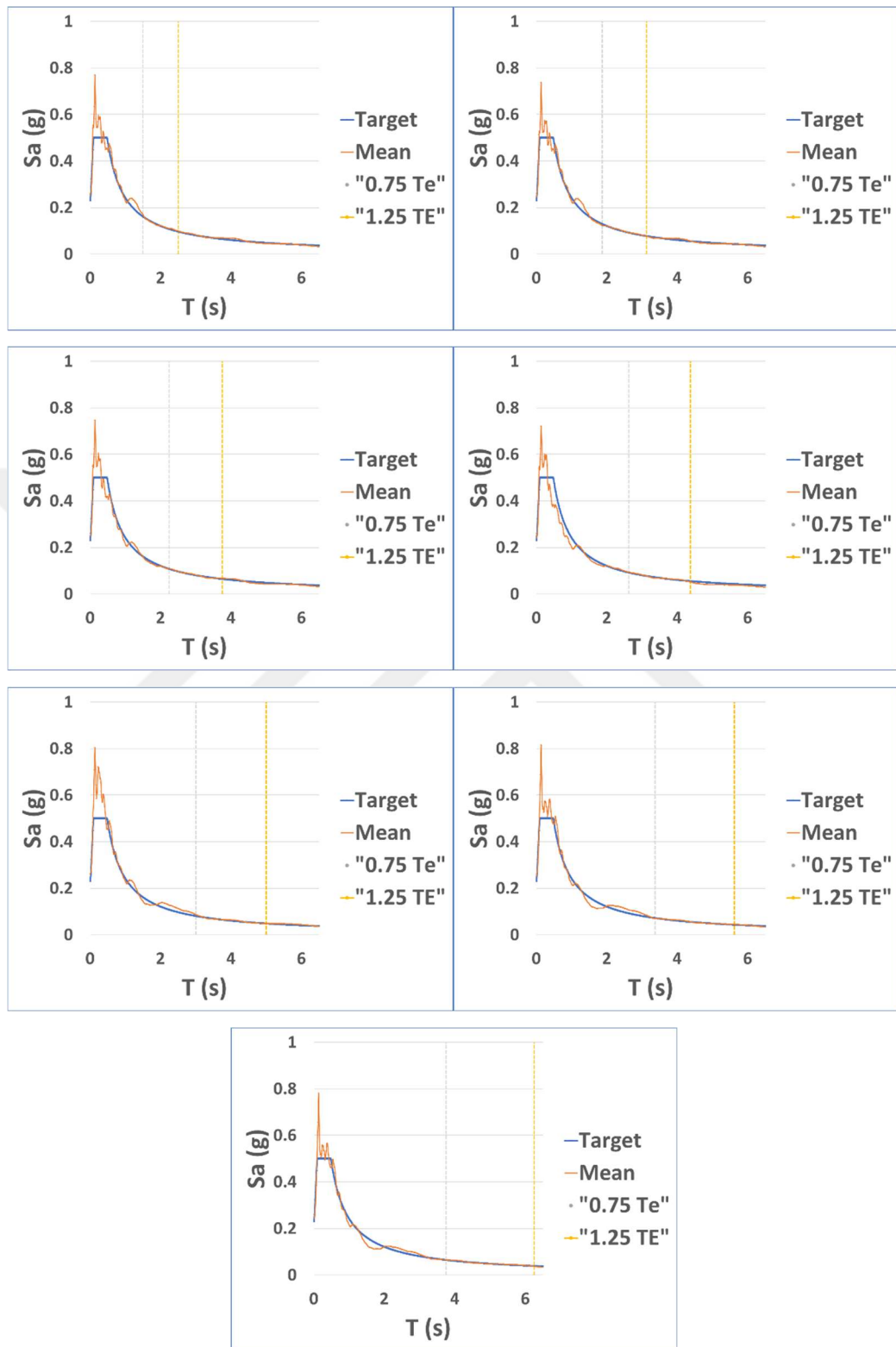


Figure 4.1. Ground motion dataset selection procedure by considering intervals

4.2 Ground Motion Scaling

Since selection is made for predefined intervals, and it's not feasible to perform the selection of scaled ground motions through PEERs interface for each analysis model of the parametric study, a scaling algorithm is developed. In order to conduct the scaling, Newmark's Step by Step Integration algorithm is used for preparing the acceleration spectra of the selected ground motions. After the acceleration spectra preparation procedure, MS Excel's goal-seek solver is used for scaling. Scale factor limits, 0.2 as the minimum and 5 as the maximum, are given as constraints to the solver. The goal of the solver is determined as the decreasing mean square error between average acceleration spectra and target response spectrum at an interval of $0.75 T_e$ and $1.25 T_e$. The scaling procedure is presented in Figure 4.2.

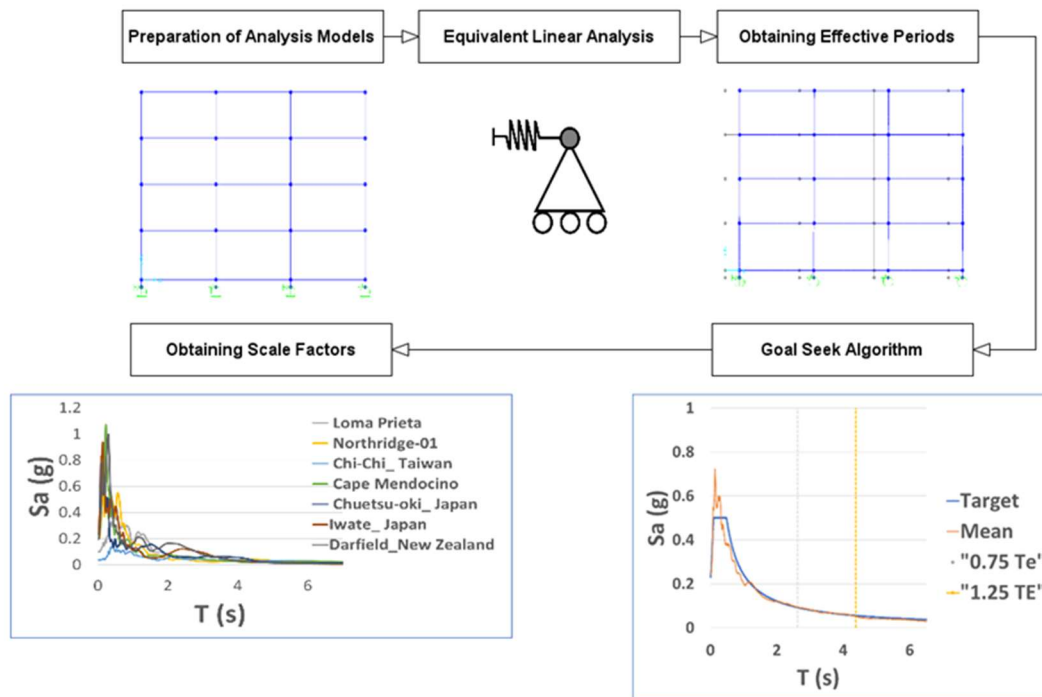


Figure 4.2. Scaling Procedure

CHAPTER 5

METHODOLOGY

In this chapter of the thesis, performance objectives selected to assess the feasibility of the seismic base-isolated structures and followed methodology are explained. Performance objectives can be classified as structural and non-structural.

5.1 Metric Calculation for Performance Objectives

5.1.1 Structural Performance Objectives

5.1.1.1 Uplift Limit State

In general, seismic isolators have no ability to resist tensile forces. The occurrence of uplift potentially causes harmful effects on the base isolation systems as well as the isolated building. It may cause overturning. Furthermore, damage to the base isolation may occur during the reengagement. However, local uplift of individual seismic isolation elements is permitted (ASCE 7-16, Ch. 17.2.4.7). As mentioned earlier, the design approach of the Mills-Peninsula Hospital, which is located at Burlingame, California, also permits the local uplift on friction pendulum bearings (Parisi et al., 2010). Results of the analytical and experimental results of this study show that friction pendulum bearings can stay functional under 1'' (2.54 cm). In this study, local uplift up to 2.5 cm is allowed. UPL is used as an abbreviation for the uplift limit state.

5.1.1.2 Drift Ratio Limit State

The drift ratio is an important parameter that controls the damage demand of the structures under lateral loads. In order to keep the structural deformation in the elastic region and to prevent damage on drift-sensitive non-structural components, the drift ratio must be checked. The effective response modification coefficient must be calculated to determine the drift ratio limit of the base-isolated structures. In this study, the force-resisting system of the superstructure is selected as an intermediate reinforced concrete moment frame. The response modification coefficient (R) is determined as five by considering the force-resisting system (ASCE 7-16 Table 12.2-1).

The effective reduction factor (R_I) is determined (ASCE 7-16 Ch. 17.5.4.2) as follows:

$$R_I = \frac{3R}{8} \text{ (Not greater than 2.0 and not less than 1.0)} \quad (5.1)$$

Since the response modification coefficient (R) is taken as 5 for the structures used in this study, R_I is determined as 1.875.

The drift ratio of seismic isolated structures is limited by $0.010 / R_I$ (ASCE 7-16 Ch. 17.6.4.4). By using the given formulation drift ratio limit is determined as 0.0053. DR is used as an abbreviation for the drift ratio limit state.

5.1.2 Non-Structural Performance Objectives

5.1.2.1 Overturning of Narrow and Wide Cabinets Limit State

Since some of the medical treatment equipment and medicines are stored in the cabinets, reducing the quake-induced damage on the cabinets is a very important performance objective to keep hospitals functional after an earthquake. Furthermore, the overturning of the cabinets may injure the staff or patients during an earthquake. Limit states of the overturning of narrow cabinets (2 m x 0.4 m) and wide cabinets (2 m x 0.6 m) are determined by using overturning calculations as follows:

$$m * a_{limit} * y = m * g * x \quad (5.2)$$

e.g., $m * a_{limit} * 1 = m * g * 0.2$

$$a_{limit} = 0.2 g$$

Floor accelerations must be lower than 0.2 g and 0.3 g, respectively. Illustrations of the overturning of narrow and wide cabinets are shown in Figure 5.1. OWC and ONC are used as abbreviations for the overturning of wide and narrow cabinets limit states, respectively.

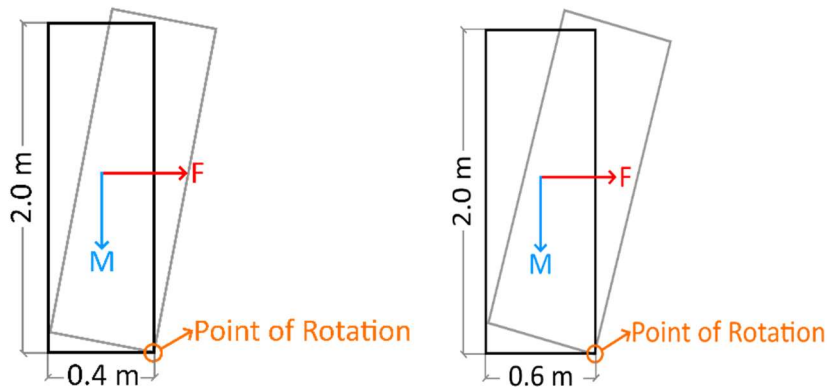


Figure 5.1. Overturning of Narrow and Wide Cabinets

5.2 Methodology

The seismic performance of the selected structure is assessed for each limit state as follows:

- For the UPL limit state, displacements of all isolators are checked by considering the results of all time-history analysis cases.
- For the DR limit state, inter-storey drift ratios are checked by considering the average envelope results of all time-history analysis cases.
- For the ONC and OWC limit states, Maximum absolute storey accelerations of the structure under the roof level are obtained and compared with 0.2 g and 0.3 g storey acceleration limits, respectively.

Typical absolute storey acceleration and inter-storey drift ratio plots are shown in Figure 5.2.

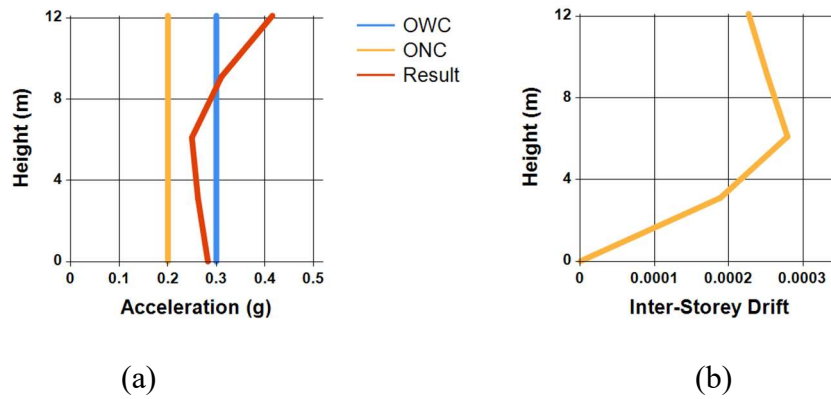


Figure 5.2. Typical Plots of (a) Absolute Storey Acceleration, (b) Inter-Storey Drift Ratio

Analysis models of the parametric study can be identified as a function of all selected parameters (Isolator friction, surface curvature radius, peak ground acceleration (PGA), soil site class (SSC), storey number, and bay number) as follows:

$$AnlModel_i = f(\mu, R, PGA, SSC, StoreyNo, BayNo) \quad (5.3)$$

$$List(Of AnlModel) = f(Selected Parameter) \quad (5.4)$$

$$AnlModelRes_{i,Aspect} = Max(Selected Aspect Through Storeys) \quad (5.5)$$

$$MeanRes_{Aspect,Parameter} = \frac{\sum_{i=0}^n AnlModelRes_{i,Aspect}}{n} \quad (5.6)$$

The effect of specific parameter on the selected aspect (Absolute acceleration or absolute displacement or inter-storey drift ratio) is calculated as follows:

- Obtain all analysis models prepared by using the specific parameter
e.g. $List(Of AnalysisModel) = f(0.03, R, PGA, SSC, StoreyNo, BayNo)$
- Get maximum values through storeys for each analysis model considering the selected aspect
e.g. $AnalysisModelRes_{i,Acc} = Max(Absolute Storey Accelerations)$
- Obtain the mean value of the selected aspect by considering the obtained analysis models
e.g.

$$MeanRes_{Acc,\mu = 0.03} = \frac{\sum_{i=0}^n AnalysisModelRes_{i,Acc}}{n}$$

The effect of a specific parameter on the selected aspect can be determined by using the procedure given above, as shown in Figure 5.3.

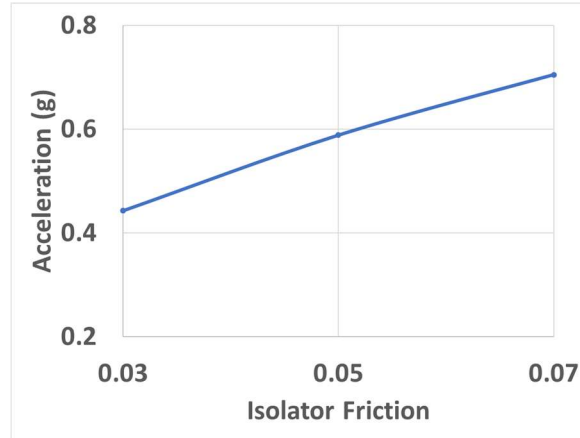


Figure 5.3. A Typical Plot for the Effect of Specific Parameter on the Selected Aspect

The feasibility of the selected structure is determined by using the below formulation:

$$Feasibility, i (\%) = \frac{Total\ Number\ of\ Satisfied\ Limit\ States}{Total\ Number\ of\ Limit\ States} \times 100 \quad (5.7)$$

$$MeanFeasibilityRes_{parameter} = \frac{\sum_{i=0}^n Feasibility, i}{n} \quad (5.8)$$

The effect of specific parameter on the feasibility of the structure is calculated as follows:

- Obtain all analysis models prepared by using the specific parameter

e.g.,

$$List(Of\ AnalysisModel) = f(0.03, R, PGA, SSC, StoreyNo, BayNo)$$

- Determine the feasibility of each analysis model

e.g.,

$$Feasibility, i (\%) = \frac{Total\ Number\ of\ Satisfied\ Limit\ States}{Total\ Number\ of\ Limit\ States} \times 100$$

- Obtain the mean value of the selected aspect by considering the obtained analysis models

e.g.,

$$MeanFeasibilityRes_{\mu = 0.03} = \frac{\sum_{i=0}^n Feasibility, i}{n}$$

The effect of a specific parameter on the feasibility of the structure can be determined by using the procedure given above, as shown in Figure 5.4.



Figure 5.4. A Typical Plot for the Effect of Specific Parameter on the Feasibility of the Structure

CHAPTER 6

SENSITIVITY ANALYSES

In this chapter, the effect of the bay number on seismic behavior and the effectiveness of the sensitive equipment isolation are evaluated.

6.1 Evaluation of the Effect of Bay Number on Seismic Behavior

In order to understand the effect of the bay number on inter-storey drifts, storey acceleration, absolute displacements, and local uplift, 80 nonlinear time-history analyses are conducted. We select friction (μ) and surface curvature (R) of the friction pendulum bearing as 0.05 and 5 m, respectively. Soil Class is selected as Class C. For earthquake intensity, 0.2, 0.4, 0.6, and 0.8 (g) PGA values are used. The average values of the maximum absolute accelerations, displacements, and inter-storey drifts are presented in Figure 6.1. The effect of bay number on local uplift is presented in Figure 6.2.

According to the analysis results, absolute accelerations slightly increase as bay numbers increase while absolute displacements slightly decrease. It is obvious that bay number has no significant effect on storey absolute accelerations and displacement of the structure. On the other hand, the bay number has a more significant effect on inter-storey drifts comparing with absolute accelerations and displacements. The maximum differences between absolute acceleration, displacement, and inter-storey drift values of all bay numbers are 1.695%, 0.762%, and 9.198 %, respectively. Relative differences and detailed values are presented in Table 6.1. Analysis results show that an increase in the bay number leads to a

decrease in the local uplift. All nonlinear time-history analysis results of the sensitivity analysis are presented in Appendix B, C, and D.

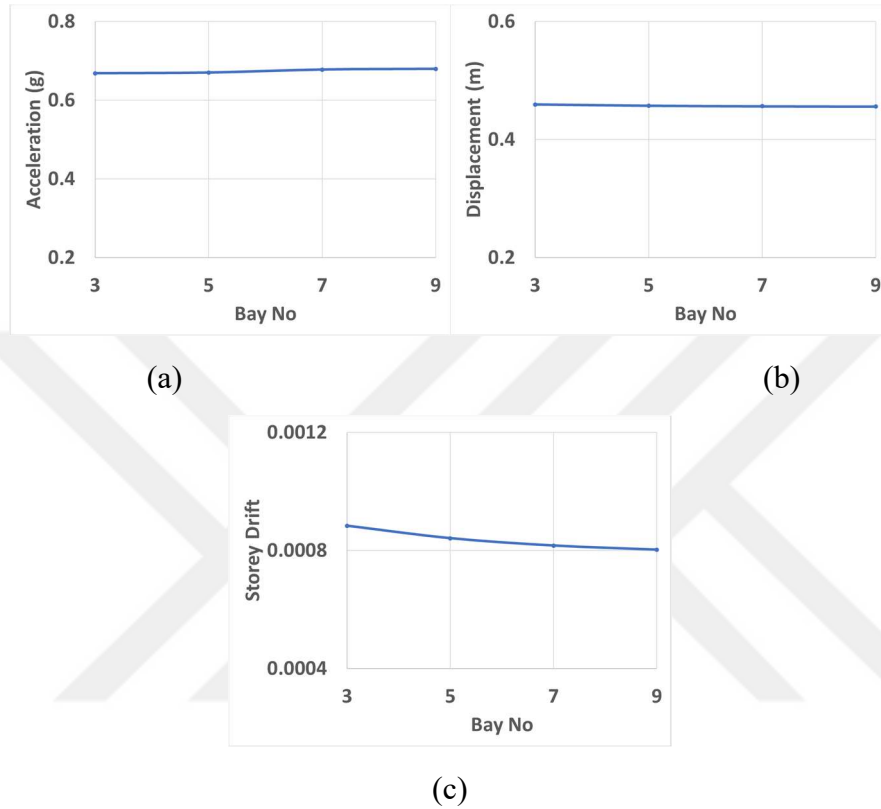


Figure 6.1. Effect of Bay Number on (a) Acceleration, (b) Displacement, and (c) Inter-Storey Drifts

Table 6.1 Results of the Sensitivity Analysis on the Effect of Bay Number

Bay No	Abs. Acc (m/s ²)	Relative Diff. (%)	Absolute Disp. (m)	Relative Diff. (%)	Inter-Storey Drift	Relative Diff (%)
3	0.668	0.265	0.459	0.442	0.000883	4.791
5	0.670	1.160	0.457	0.221	0.000841	2.960
7	0.678	0.263	0.456	0.101	0.000816	1.720
9	0.679	-	0.456	-	0.000802	-

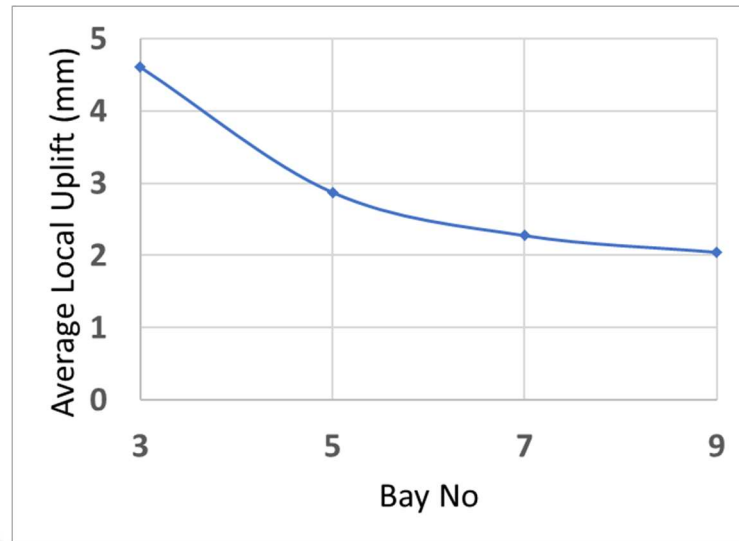


Figure 6.2. Effect of Bay Number on Local Uplift

6.2 Evaluation of the Effect of Sensitive Equipment Isolation on Acceleration

As mentioned before, hospitals have higher significance during hazards. If a hospital contains sensitive non-structural equipment like MRI machines or CT scanners, additional performance goals must be satisfied to reduce the quake-induced damage on the sensitive equipment. In order to accomplish higher performance goals, additional seismic isolation can be installed under sensitive equipment. In this chapter, the effect of the sensitive equipment isolation on acceleration is evaluated.

Heavy medical equipment is mainly installed in the lower storeys of hospitals. For this purpose, an MRI machine that weighs 3.5 t is modeled to the first floor, as shown in Figure 6.3. Sensitive equipment must undergo lower accelerations during an earthquake. Acceleration limits for sensitive equipment are determined as 0.1 g by considering the products on the market (Siemens, etc.).

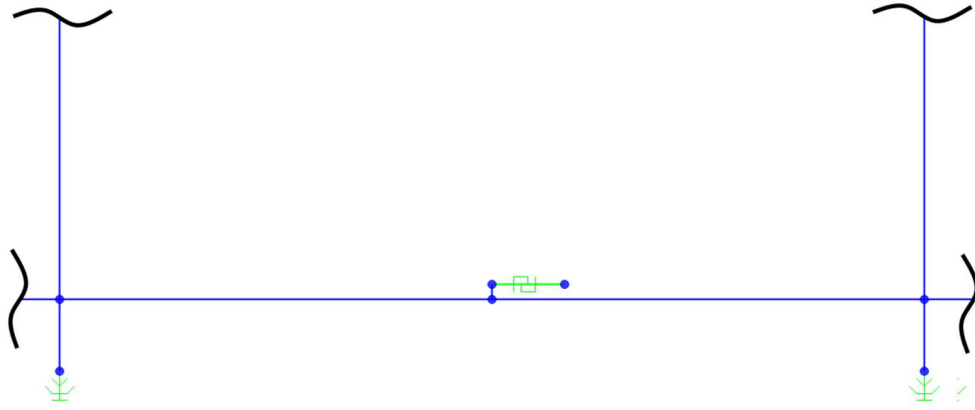


Figure 6.3. Analytical Model of the Isolated MRI Machine at the First Floor

In order to evaluate the effect of the sensitive equipment isolation on acceleration, 90 nonlinear time-history analyses are conducted. We select storey number, peak ground acceleration (PGA), hysteretic strength (Q_d), and yielded stiffness (K_d) as parameters of the sensitivity analysis. The bay number of the selected structures is selected as three. The base-isolation system of the selected structures has isolation friction and surface curvature values, 0.03 and 5 m, respectively. The soil site class of the selected structures is selected as B. For earthquake intensity, 0.4 and 0.6 (g) PGA values are used. For storey numbers, 8, 12, and 16 are used. For hysteretic strength (Q_d), 0.7, 1.05, and 1.4 (kN) are used. For yielded stiffness (K_d), 4, 5, 6, 7, and 8 (kN/m) are used. The average of the maximum absolute accelerations with or without isolation on the sensitive equipment is presented in Figure 6.4.

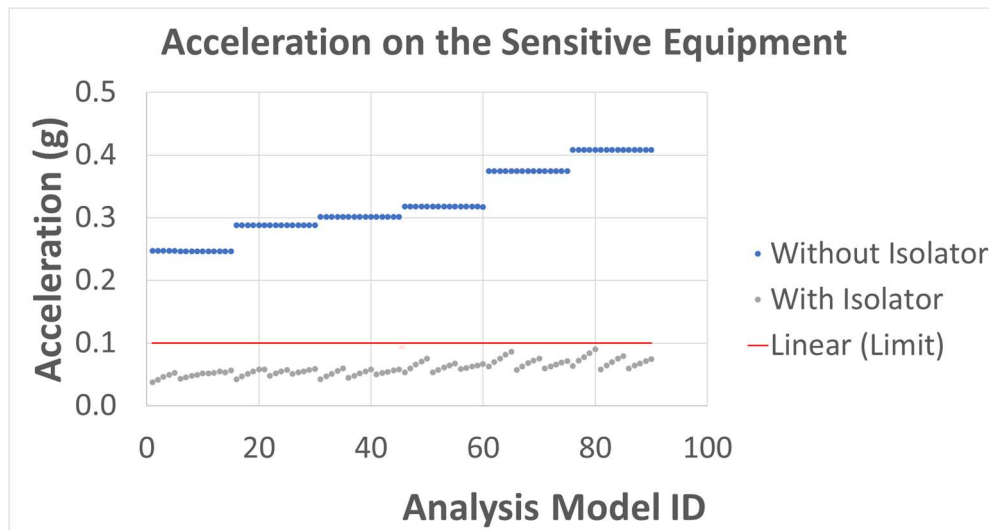


Figure 6.4. The Average of the Maximum Absolute Accelerations on the Sensitive Equipment

According to the analysis results, absolute accelerations on the sensitive equipment decrease dramatically when seismic isolation is installed. All of the case studies satisfy the acceleration performance goal. All nonlinear time-history analysis results of the sensitivity analysis are presented in Appendix E.

CHAPTER 7

PARAMETRIC STUDY AND EVALUATION OF ANALYSIS RESULTS

7.1 Introduction

In this chapter, the evaluation of how selected parameters affect the seismic behavior of the structure is discussed. Moreover, the effect of the selected parameters on the feasibility of the seismic isolated structures is checked. Peak ground acceleration (PGA), isolator friction (μ), surface curvature radius (R), aspect ratio (H/B) of the building, and soil site class are selected as the parameters of the parametric study. In the light of sensitivity analysis results, the bay number is excluded from the parameters of the study. Since buildings with three bays are the most critical case considering the uplift, 3 bay is selected as the bay number of the analysis models. A total of 360 (6 (St No) x 1 (Bay No) x 5 (Friction Isolator) x 4 (PGA) x 3 (Soil Class)) nonlinear time-history analyses are conducted.

7.2 Evaluation of the Results

7.2.1 The Effect of Selected Parameters on the Feasibility of Base-Isolated Structures

The feasibility of the selected buildings is determined by using the performance objectives presented in Chapter 6. The effect of selected parameters on the feasibility of the seismic base-isolated structures is presented in Figure 7.1.

As observed from the figures, an increase in the surface curvature radius increases the feasibility of the base-isolated structure, whereas an increase in all other parameters decreases the feasibility of the base-isolated structure. Peak ground acceleration has the most significant effect, and soil site class has the least significant effect on the feasibility. After peak ground acceleration, the parameter that has the most significant impact on the feasibility is the aspect ratio of the structure. Detailed results and relative differences between parameters are presented in Table 7.1, Table 7.2, Table 7.3, Table 7.4, and Table 7.5.

Table 7.1 Effect of Surface Curvature Radius on the Feasibility of the Base-Isolated Structures

Surface Curvature Radius (m)	Feasibility (%)	Relative Difference (%)
3	57.639	6.797
5	61.557	0.968
7	62.153	-

Table 7.2 Effect of Isolator Friction on the Feasibility of the Base-Isolated Structures

Isolator Friction	Feasibility (%)	Relative Difference (%)
0.03	67.014	10.535
0.05	59.954	14.517
0.07	51.250	-

Table 7.3 Effect of Soil Site Class on the Feasibility of the Base-Isolated Structures

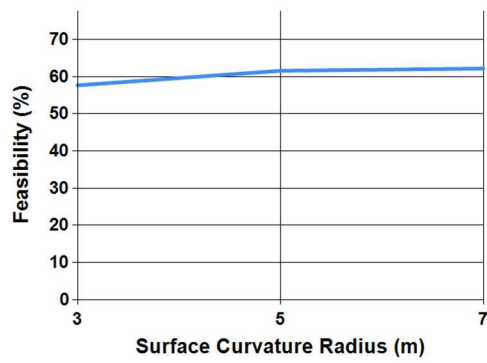
Soil Site Class	Feasibility (%)	Relative Difference (%)
B	61.458	1.356
C	60.625	1.031
D	60.000	-

Table 7.4 Effect of Aspect Ratio on the Feasibility of the Base-Isolated Structures

Aspect Ratio	Feasibility (%)	Relative Difference (%)
0.33	89.583	24.651
0.67	67.500	16.049
1.33	56.667	8.824
2	51.667	1.613
2.67	50.833	5.738
3.33	47.917	-

Table 7.5 Effect of Peak Ground Acceleration on the Feasibility of the Base-Isolated Structures

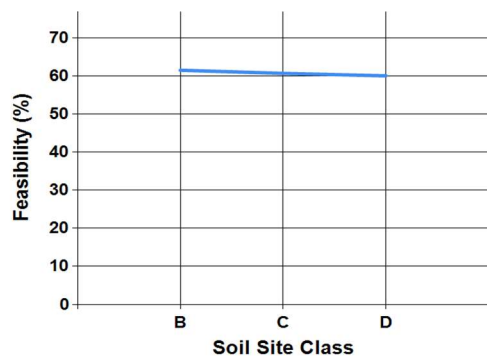
PGA (g)	Feasibility (%)	Relative Difference (%)
0.2	70.278	11.462
0.4	62.222	9.375
0.6	56.389	4.433
0.8	53.889	-



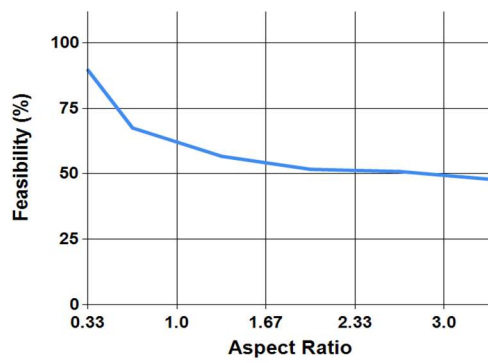
(a)



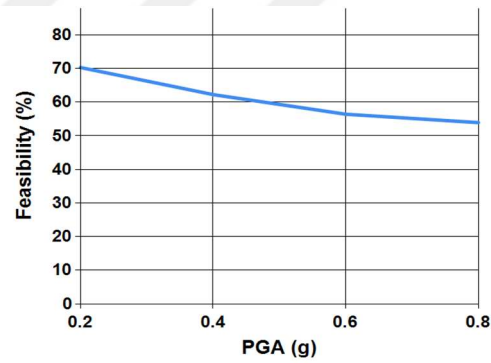
(b)



(c)



(d)



(e)

Figure 7.1. Effect of Selected Parameters on the Feasibility of the Base-Isolated Structures [(a) Surface Curvature Radius, (b) Isolator Friction, (c) Soil Site Class, (d) Aspect Ratio, and (e) Peak Ground Acceleration]

The results of the feasibility assessment are classified by considering the selected PGA values and presented in Figure 7.2, Figure 7.3, Figure 7.4, Figure 7.5, and Table 7.6. Results of the detailed feasibility assessment results are presented in Appendix F. For the uplift limit state, 100.00 %, 100.00 %, 97.33 %, and 93.33 % of the structures in the domain satisfy the requirements for 0.2, 0.4, 0.6, and 0.8 PGA, respectively. All of the structures in the domain satisfy the drift ratio limit state. Demand capacity ratios (DCR) are calculated by taking the limits presented in Chapter 6 as capacity values. Maximum storey acceleration and maximum inter-storey drift values through storeys are used as demand values of the limit states.

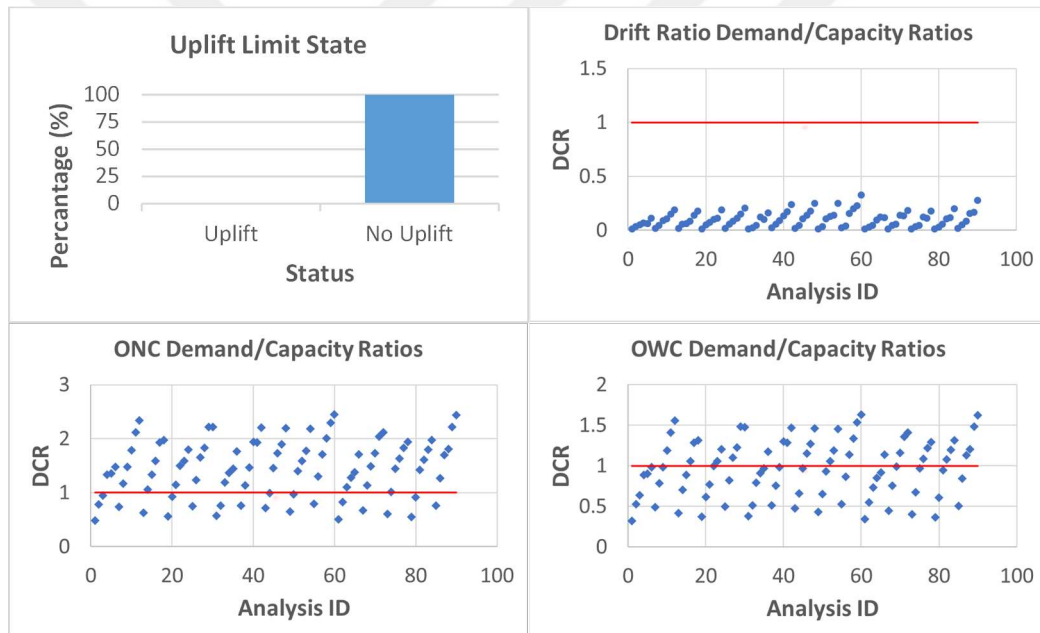


Figure 7.2. Demand Capacity Ratios of Performance Objectives for 0.2 PGA

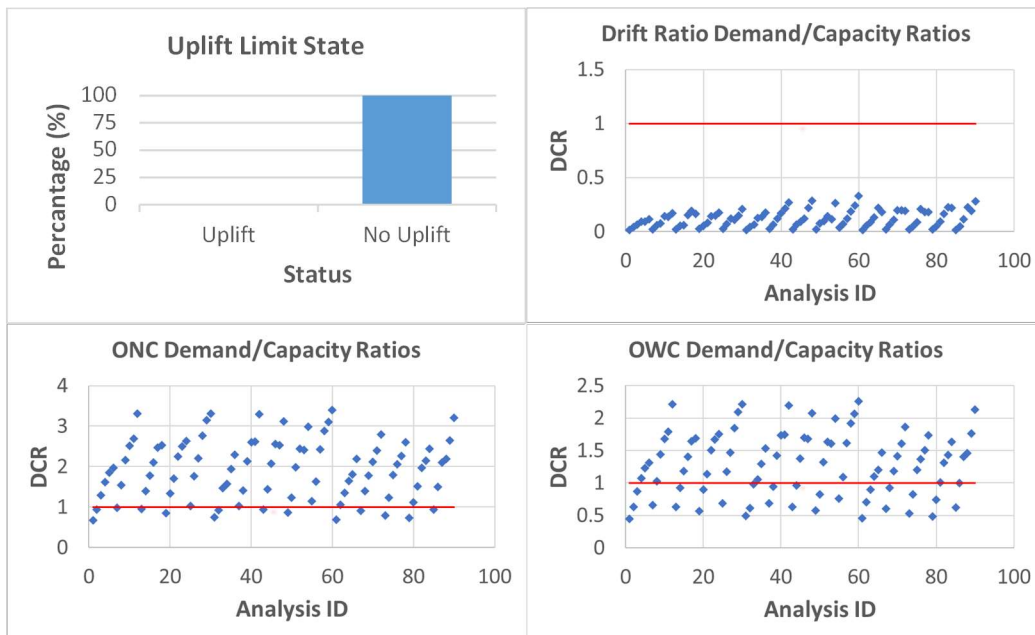


Figure 7.3. Demand Capacity Ratios of Performance Objectives for 0.4 PGA

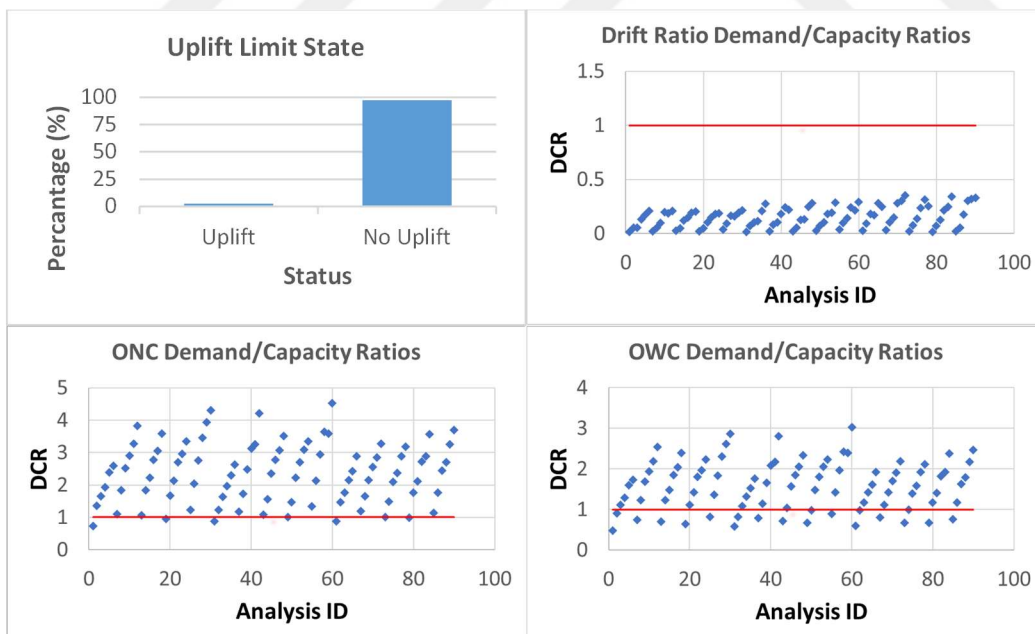


Figure 7.4. Demand Capacity Ratios of Performance Objectives for 0.6 PGA

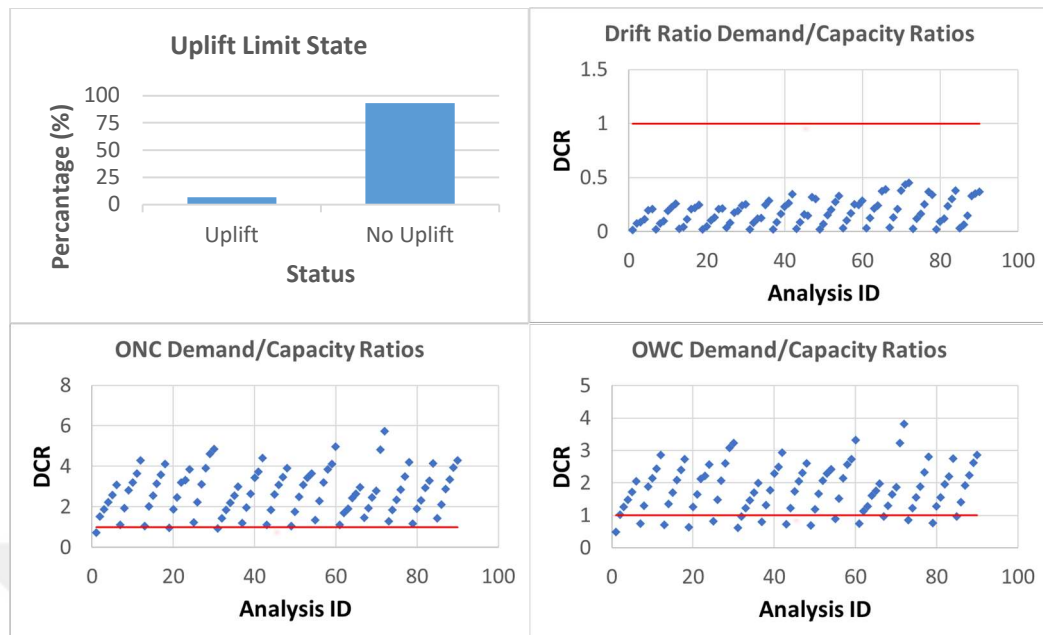


Figure 7.5. Demand Capacity Ratios of Performance Objectives for 0.8 PGA

Table 7.6 Feasibility Assessment Results for All PGA Values

Limit State	0.2 PGA	0.4 PGA	0.6 PGA	0.8 PGA
UPL (%)	100.00	100.00	97.78	94.44
DR (%)	100.00	100.00	100.00	100.00
ONC (%)	25.56	15.56	5.56	3.33
OWC (%)	55.56	33.33	22.22	17.78

We should note that the feasibility assessment is conducted on structures isolated with seismic isolation systems prepared with the selected parameters, not with seismic isolation systems specifically designed for the structures. Therefore, these low feasibility percentages do not indicate that seismic isolators are not feasible in general. The feasibility assessment is made to understand the effects of parameters on the feasibility of the base-isolated structure. Furthermore, the feasibility assessment shows that most of the base-isolated structures in the domain satisfy the structural limit states, and some of the base-isolated structures in the domain satisfy

the non-structural limit states even using base-isolation systems prepared with selected parameters.

The maximum number of storeys that can be reached by satisfying the selected performance objective for each soil site class under different earthquake intensities are presented in Figure 7.6, Figure 7.7, Figure 7.8, and Figure 7.9. Furthermore, this evaluation is also done by using combinations of the performance objectives, as shown in Figure 7.10, Figure 7.11, and Figure 7.12.

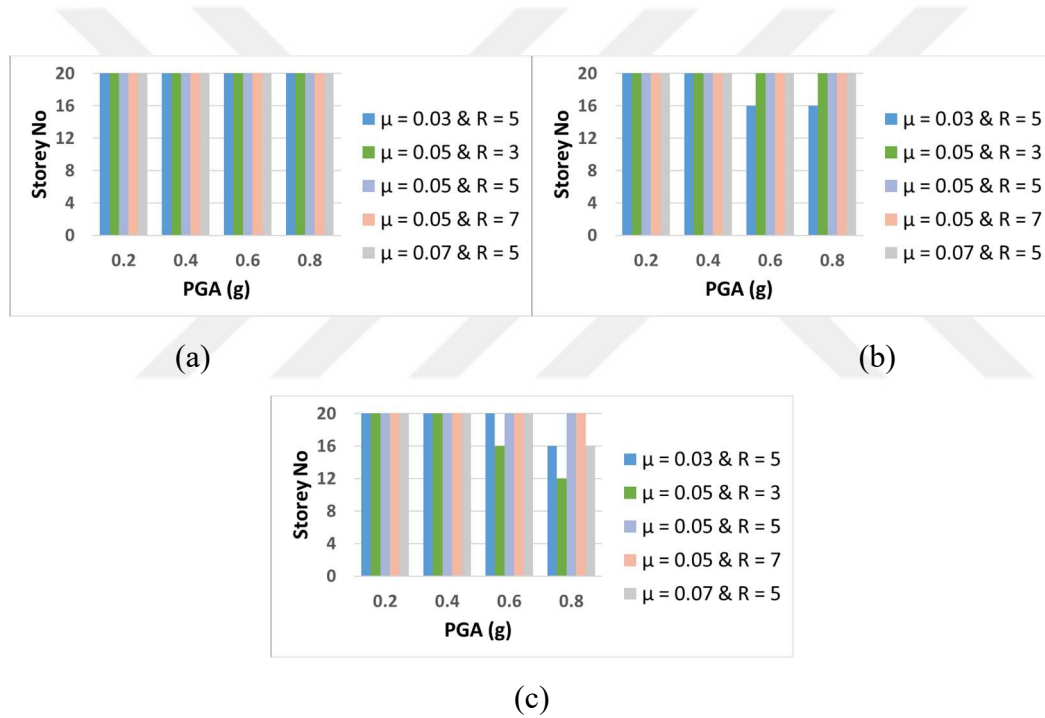
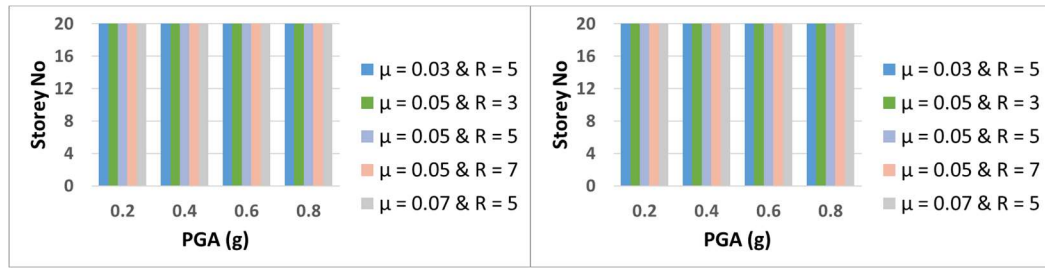
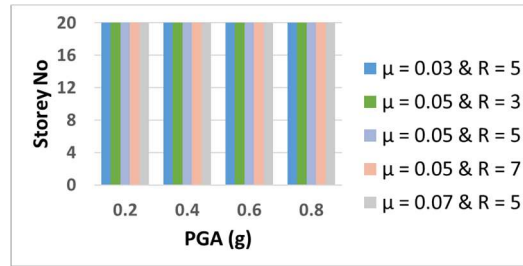


Figure 7.6. Maximum Feasible Storey Number (a) Soil Site Class B, (b) Soil Site Class C, and (c) Soil Site Class D for Uplift Limit State



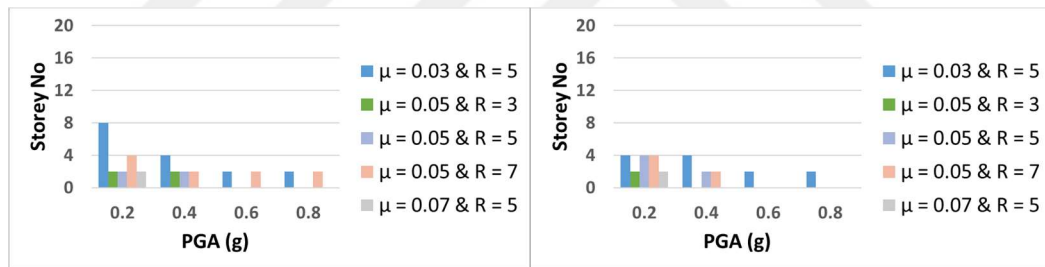
(a)

(b)



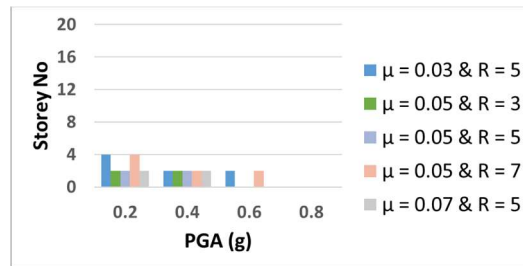
(c)

Figure 7.7. Maximum Feasible Storey Number (a) Soil Site Class B, (b) Soil Site Class C, and (c) Soil Site Class D for Inter-Storey Drift Ratio Limit State



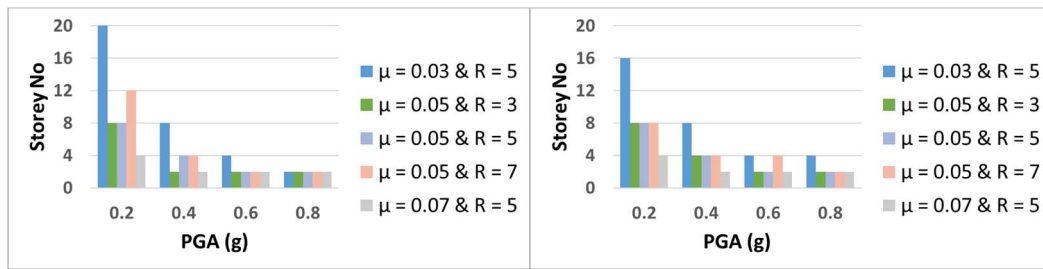
(a)

(b)



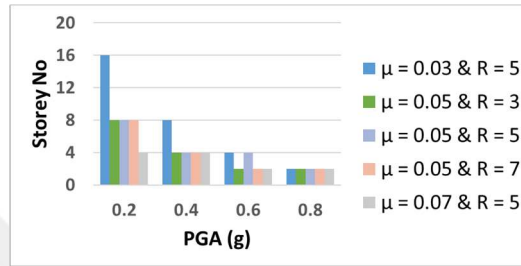
(c)

Figure 7.8. Maximum Feasible Storey Number (a) Soil Site Class B, (b) Soil Site Class C, and (c) Soil Site Class D for Overturning of Narrow Cabinets Limit State



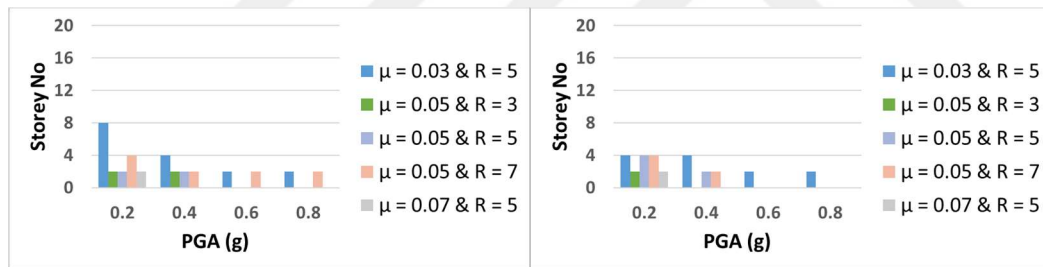
(a)

(b)



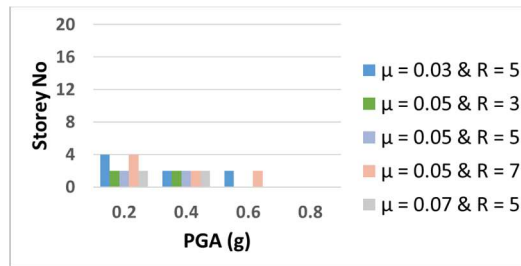
(c)

Figure 7.9. Maximum Feasible Storey Number (a) Soil Site Class B, (b) Soil Site Class C, and (c) Soil Site Class D for Overturning of Wide Cabinets Limit State



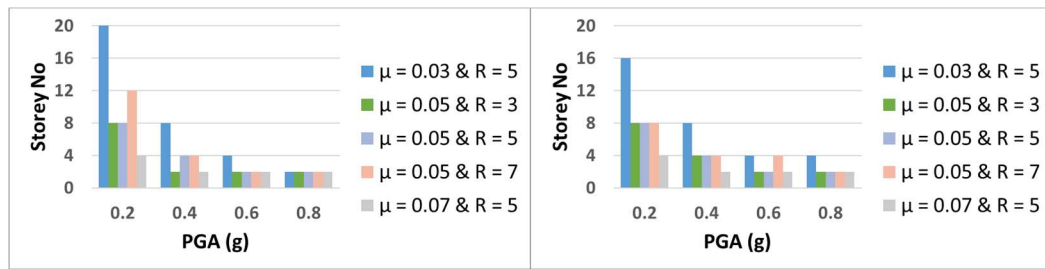
(a)

(b)



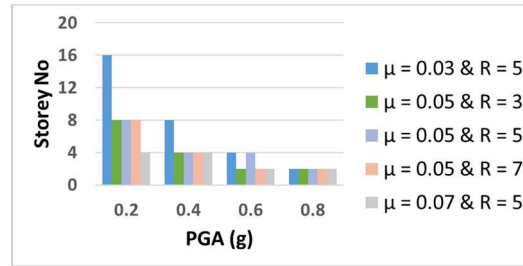
(c)

Figure 7.10. Maximum Feasible Storey Number (a) Soil Site Class B, (b) Soil Site Class C, and (c) Soil Site Class D for All Limit States



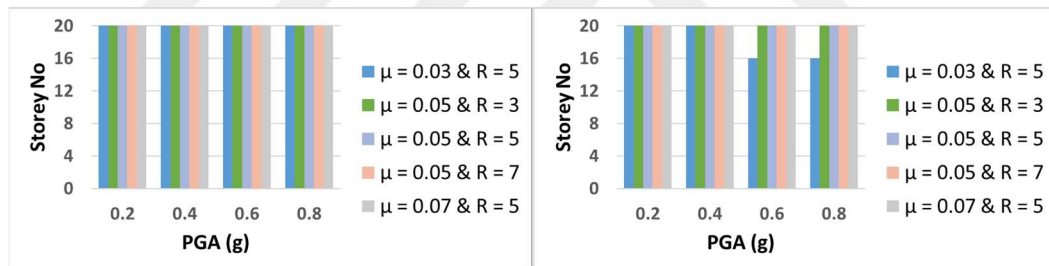
(a)

(b)



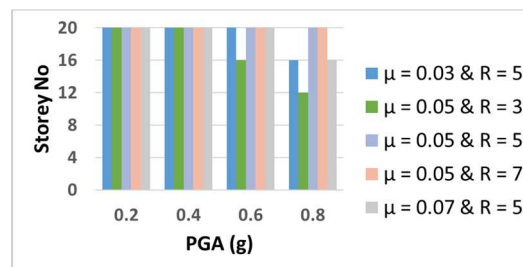
(c)

Figure 7.11. Maximum Feasible Storey Number (a) Soil Site Class B, (b) Soil Site Class C, and (c) Soil Site Class D for Uplift, Inter-Storey Drift Ratio, and Overturning of Wide Cabinets Limit States



(a)

(b)



(c)

Figure 7.12. Maximum Feasible Storey Number (a) Soil Site Class B, (b) Soil Site Class C, and (c) Soil Site Class D for Uplift, and Inter-storey Drift Ratio Limit States

7.2.2 The Effect of Selected Parameters on the Seismic Behavior of Base-Isolated Structures

The effect of surface curvature radius on absolute accelerations, absolute displacements, and inter-storey drift ratios are presented in Figure 7.13. Relative differences and detailed values are presented in Table 7.7.

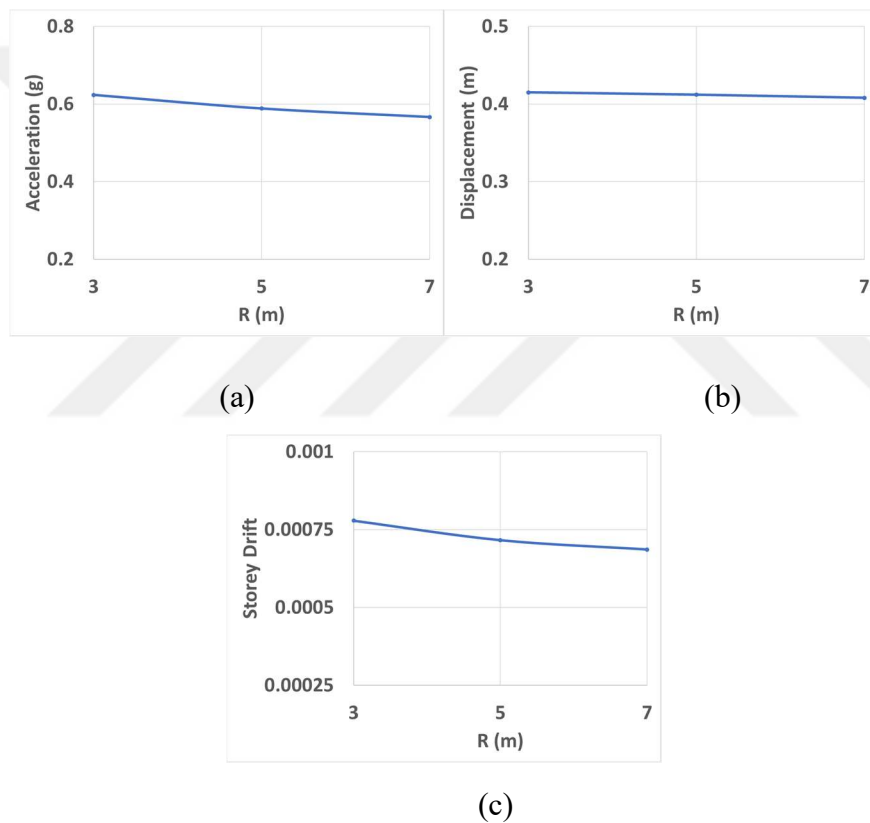
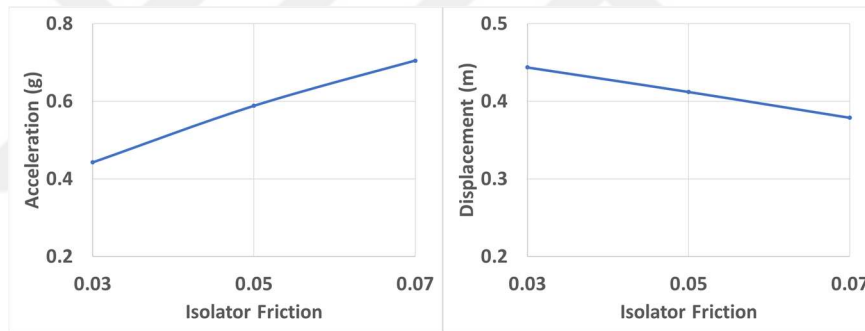


Figure 7.13. Effect of Surface Curvature Radius on (a) Absolute Accelerations, (b) Absolute Displacements, and (c) Inter-Storey Drifts

Table 7.7 Effect of Surface Curvature Radius on the Seismic Behavior of the Base-Isolated Structures

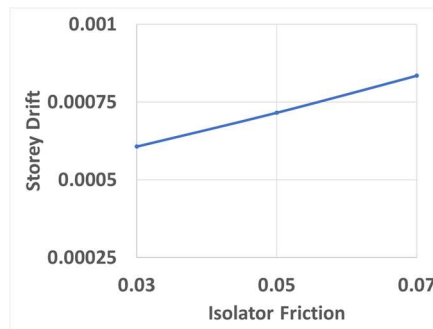
Surface Curvature Radius (m)	Abs. Acc (m/s ²)	Relative Diff. (%)	Absolute Disp. (m)	Relative Diff. (%)	Inter-Storey Drift	Relative Diff (%)
3	0.623	5.611	0.415	0.736	0.00078	8.081
5	0.588	3.719	0.412	0.985	0.00072	4.195
7	0.566	-	0.408	-	0.00069	-

The effect of isolator friction on absolute accelerations, absolute displacements, and inter-storey drift ratios are presented in Figure 7.14. Relative differences and detailed values are presented in Table 7.8.



(a)

(b)



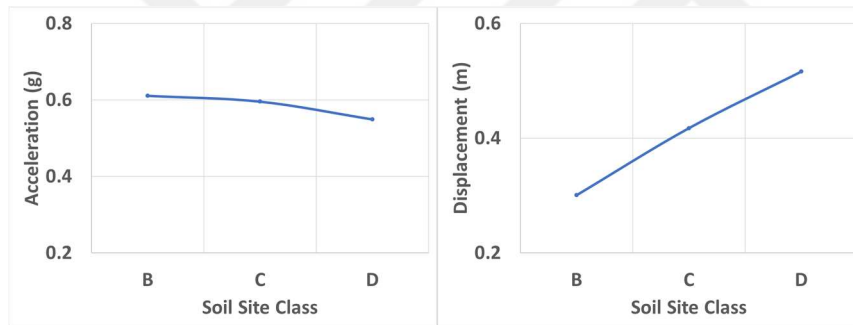
(c)

Figure 7.14. Effect of Isolator Friction on (a) Absolute Accelerations, (b) Absolute Displacements, and (c) Inter-Storey Drifts

Table 7.8 Effect of Isolator Friction on the Seismic Behavior of the Base-Isolated Structures

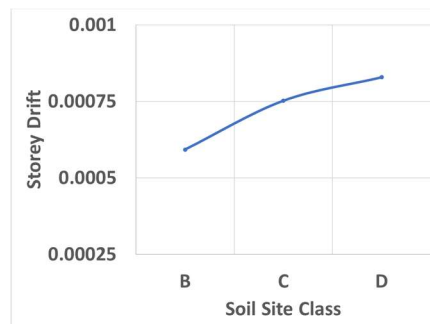
Isolator Friction	Abs. Acc (m/s ²)	Relative Diff. (%)	Absolute Disp. (m)	Relative Diff. (%)	Inter-Storey Drift	Relative Diff (%)
0.03	0.443	32.873	0.444	7.129	0.000607	17.909
0.05	0.588	19.805	0.412	8.077	0.000716	16.602
0.07	0.705	-	0.379	-	0.000834	-

The effect of soil site class on absolute accelerations, absolute displacements, and inter-storey drift ratios are presented in Figure 7.15. Relative differences and detailed values are presented in Table 7.9.



(a)

(b)



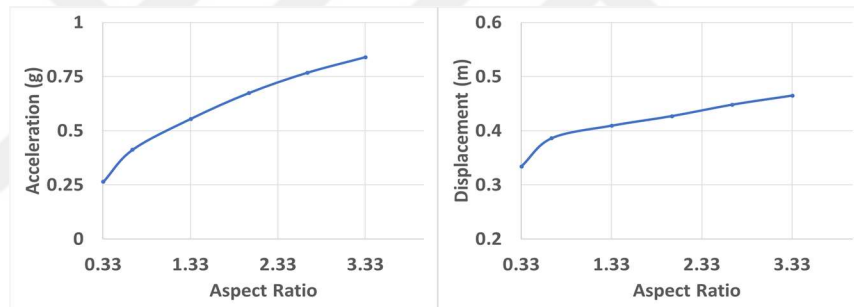
(c)

Figure 7.15. Effect of Soil Site Class on (a) Absolute Accelerations, (b) Absolute Displacements, and (c) Inter-Storey Drifts

Table 7.9 Effect of Soil Site Class on the Seismic Behavior of the Base-Isolated Structures

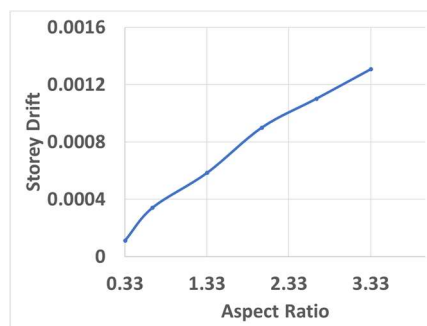
Soil Site Class	Abs. Acc (m/s ²)	Relative Diff. (%)	Absolute Disp. (m)	Relative Diff. (%)	Inter-Storey Drift	Relative Diff (%)
B	0.611	2.497	0.301	38.852	0.000592	26.988
C	0.595	7.833	0.418	23.594	0.000752	10.227
D	0.549	-	0.516	-	0.000829	-

The effect of aspect ratio on absolute accelerations, absolute displacements, and inter-storey drift ratios are presented in Figure 7.16. Relative differences and detailed values are presented in Table 7.10.



(a)

(b)



(c)

Figure 7.16. Effect of Aspect Ratio on (a) Absolute Accelerations, (b) Absolute Displacements, and (c) Inter-Storey Drifts

Table 7.10 Effect of Aspect Ratio on the Seismic Behavior of the Base-Isolated Structures

Aspect Ratio	Abs. Acc (m/s ²)	Relative Diff. (%)	Absolute Disp. (m)	Relative Diff. (%)	Inter-Storey Drift	Relative Diff (%)
0.33	0.264	56.012	0.334	15.522	0.000113	202.226
0.67	0.412	34.745	0.386	6.028	0.000341	71.500
1.33	0.554	21.534	0.409	4.307	0.000584	53.939
2	0.674	13.844	0.427	4.922	0.000899	22.433
2.67	0.767	9.370	0.448	3.744	0.001101	18.737
3.33	0.839	-	0.465	-	0.001307	-

The effect of peak ground accelerations on absolute accelerations, absolute displacements, and inter-storey drift ratios are presented in Figure 7.17. Relative differences and detailed values are presented in Table 7.11.

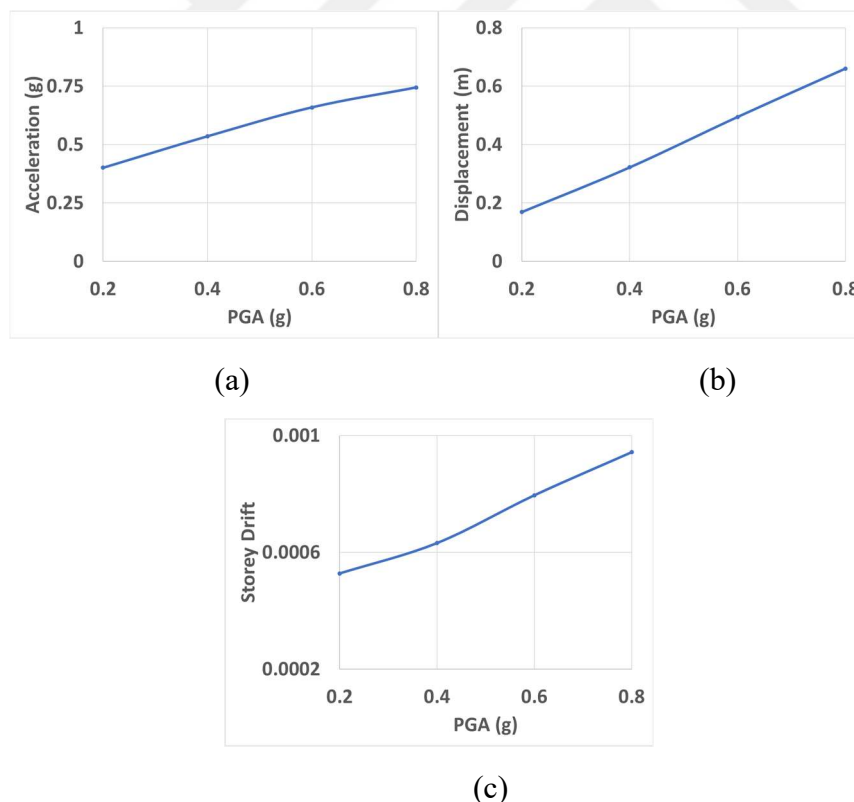


Figure 7.17. Effect of Peak Ground Acceleration on (a) Absolute Accelerations, (b) Absolute Displacements, and (c) Inter-Storey Drifts

Table 7.11 Effect of Peak Ground Acceleration on the Seismic Behavior of the Base-Isolated Structures

PGA (g)	Abs. Acc (m/s ²)	Relative Diff. (%)	Absolute Disp. (m)	Relative Diff. (%)	Inter-Storey Drift	Relative Diff (%)
0.2	0.401	33.472	0.169	90.519	0.000527	19.733
0.4	0.536	23.041	0.322	53.655	0.000631	25.939
0.6	0.659	12.891	0.495	33.505	0.000795	18.557
0.8	0.744	-	0.660	-	0.000943	-

The effect of selected parameters on absolute accelerations, absolute displacements, and inter-storey drifts are obtained from the results of the parametric study as follows:

- When surface curvature radius is increased, absolute accelerations, absolute displacements, and inter-storey drifts are decreased
- When isolator friction is increased, absolute accelerations and inter-storey drifts are increased while absolute displacements are decreased.
- When soil stiffness is decreased (from Soil Site Class B to D), absolute accelerations are decreased while absolute displacements and inter-storey drifts are increased.
- When aspect ratio and peak ground acceleration values are increased, absolute accelerations, absolute displacements, and inter-storey drifts are increased.

As observed from the figures and tables, the aspect ratio has the most significant effect on absolute accelerations and inter-storey drifts, while peak ground acceleration has the most significant effect on inter-storey drifts. After the aspect ratio, the parameter that has the greatest impact on the absolute accelerations and inter-storey drifts is the peak ground acceleration.

CHAPTER 8

CONCLUSION

In this thesis, a parametric study is conducted to understand (i) the feasibility of seismic base-isolated structures and (ii) the seismic behavior of the base-isolated structures. Peak ground acceleration (PGA), isolator friction, isolator surface curvature radius, soil site class, and building width-height aspect ratios are selected as the main parameters of this study. A total of 440 equivalent linear analyses are conducted. Moreover, 80 nonlinear time-history analyses are conducted to evaluate the effect of the bay number on seismic behavior. Additionally, 90 nonlinear time-history analyses are carried out to evaluate the effectiveness of sensitive equipment isolation. Furthermore, 360 nonlinear time-history analyses for parametric study are conducted to evaluate the effect of selected parameters on the feasibility of the base-isolated structure and the seismic behavior of the structures.

The results of the first sensitivity analyses show that the bay number of the structure has no significant effect on absolute accelerations and absolute displacements. The maximum differences between absolute acceleration, displacement, and inter-storey drift values of all bay numbers are determined as 1.695%, 0.762%, and 9.198 %, respectively. The results of the second sensitivity analyses show that if a hospital contains sensitive equipment like MRI machines, installing isolation for the equipment prevents the quake-induced damage and helps to satisfy the higher performance goals.

Conclusions of the parametric study are drawn as follows:

- Peak ground acceleration has the most significant effect, and soil site class has the least significant effect on the feasibility. After peak ground acceleration, the parameter that has the greatest impact on the feasibility is the aspect ratio of the structure.
- All of the analysis models satisfy the drift ratio limit state. For 0.2 and 0.4 PGA, all analysis models satisfy the uplift limit state. For 0.6 and 0.8 PGA, 97.78 % and 94.44 % of the analysis models satisfy the uplift limit state, respectively.
- The most effective parameter on absolute storey accelerations is determined as the aspect ratio of the structure. After aspect ratio, peak ground acceleration has the most significant effect on absolute storey accelerations.
- The most effective parameter on absolute displacements is determined as peak ground acceleration. After peak ground acceleration, soil site class has the most significant effect on absolute displacements.
- The most effective parameter on inter-storey drifts is determined as the aspect ratio of the structure. After the aspect ratio of the structure, soil site class has the most significant effect on inter-storey drifts.
- The surface curvature radius of the friction pendulum bearings has the least significant effect on the seismic behavior of the structure in every respect. But, an increase in the surface curvature radius of the friction pendulum bearings leads to a decrease in all inspected parameters (Absolute storey accelerations, absolute displacements, and inter-storey drifts).
- An increase in the soil stiffness mainly leads to an increase in the maximum feasible storey number. In contrast, an increase in the peak ground acceleration leads to a decrease in maximum feasible storey numbers.
- A decrease in the isolator friction leads to an increase in the maximum feasible number of storeys. In contrast, a decrease in the surface curvature mainly leads to a decrease in the maximum feasible storey number.

- The feasibility assessment reveals some storeys had absolute acceleration values lower than the limit of the ONC and OWC when the upper floors had values higher than the limit. For cases like this, anchoring the cabinets increases the total feasibility and maximum feasible storey number of a seismic base-isolated structure.
- In contrast to all other parameters, for soil stiffness, a slightly increasing trend of the absolute accelerations is not the governing parameter on the overall feasibility. An increase in the soil stiffness leads to a decrease in the occurrence of the uplift. That is the reason for the diverse relationships between feasibility and absolute acceleration.
- Maximum feasible storey numbers are determined as follows by considering all limit states:
 - For soil site class B, maximum feasible storey numbers are determined as 8, 4, 2, and 2 for 0.2, 0.4, 0.6, and 0.8 PGA, respectively.
 - For soil site class C, maximum feasible storey numbers are determined as 4, 4, 2, and 2 for 0.2, 0.4, 0.6, and 0.8 PGA, respectively.
 - For soil site class D, maximum feasible storey numbers are determined as 4, 2, and 2 for 0.2, 0.4, and 0.6 PGA, respectively.
 - For soil site class D, there is no feasible configuration for 0.8 PGA.
- Maximum feasible storey numbers are determined as follows by considering the UPL, DR, and OWC limit states (Narrow cabinets are anchored):
 - For soil site class B, maximum feasible storey numbers are determined as 20, 8, 4, and 2 for 0.2, 0.4, 0.6, and 0.8 PGA, respectively.
 - For soil site class C, maximum feasible storey numbers are determined as 16, 8, 4, and 4 for 0.2, 0.4, 0.6, and 0.8 PGA, respectively.

- For soil site class D, maximum feasible storey numbers are determined as 16, 8, 4, and 2 for 0.2, 0.4, 0.6, and 0.8 PGA, respectively.
- For all soil site classes, 20 storeys can be reached feasibly with proper isolator configuration selection by considering the only UPL and DR limit states (All cabinets are anchored).



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APPENDICES

A. Results of the Equivalent Linear Analysis

Table A.1: Results of the Equivalent Linear Analysis for Sensitivity Analysis

Analysis ID	PGA	Storey	Bay No	μ	R (m)	Soil Site Class	Effective Period (s)
1	0.2	4	3	0.05	5	C	2.18
2	0.2	4	5	0.05	5	C	2.18
3	0.2	4	7	0.05	5	C	2.18
4	0.2	4	9	0.05	5	C	2.18
5	0.2	8	3	0.05	5	C	2.19
6	0.2	8	5	0.05	5	C	2.19
7	0.2	8	7	0.05	5	C	2.19
8	0.2	8	9	0.05	5	C	2.19
9	0.2	12	3	0.05	5	C	2.21
10	0.2	12	5	0.05	5	C	2.21
11	0.2	12	7	0.05	5	C	2.21
12	0.2	12	9	0.05	5	C	2.21
13	0.2	16	3	0.05	5	C	2.22
14	0.2	16	5	0.05	5	C	2.22
15	0.2	16	7	0.05	5	C	2.22
16	0.2	16	9	0.05	5	C	2.22
17	0.2	20	3	0.05	5	C	2.25
18	0.2	20	5	0.05	5	C	2.24
19	0.2	20	7	0.05	5	C	2.24
20	0.2	20	9	0.05	5	C	2.24
21	0.4	4	3	0.05	5	C	3.06
22	0.4	4	5	0.05	5	C	3.06
23	0.4	4	7	0.05	5	C	3.06
24	0.4	4	9	0.05	5	C	3.06
25	0.4	8	3	0.05	5	C	3.07
26	0.4	8	5	0.05	5	C	3.07
27	0.4	8	7	0.05	5	C	3.07
28	0.4	8	9	0.05	5	C	3.07
29	0.4	12	3	0.05	5	C	3.10
30	0.4	12	5	0.05	5	C	3.10
31	0.4	12	7	0.05	5	C	3.10
32	0.4	12	9	0.05	5	C	3.10

Table A.1 (cont'd)

33	0.4	16	3	0.05	5	C	3.12
34	0.4	16	5	0.05	5	C	3.12
35	0.4	16	7	0.05	5	C	3.12
36	0.4	16	9	0.05	5	C	3.12
37	0.4	20	3	0.05	5	C	3.15
38	0.4	20	5	0.05	5	C	3.14
39	0.4	20	7	0.05	5	C	3.14
40	0.4	20	9	0.05	5	C	3.14
41	0.6	4	3	0.05	5	C	3.51
42	0.6	4	5	0.05	5	C	3.51
43	0.6	4	7	0.05	5	C	3.51
44	0.6	4	9	0.05	5	C	3.51
45	0.6	8	3	0.05	5	C	3.53
46	0.6	8	5	0.05	5	C	3.53
47	0.6	8	7	0.05	5	C	3.53
48	0.6	8	9	0.05	5	C	3.53
49	0.6	12	3	0.05	5	C	3.55
50	0.6	12	5	0.05	5	C	3.55
51	0.6	12	7	0.05	5	C	3.55
52	0.6	12	9	0.05	5	C	3.55
53	0.6	16	3	0.05	5	C	3.57
54	0.6	16	5	0.05	5	C	3.57
55	0.6	16	7	0.05	5	C	3.57
56	0.6	16	9	0.05	5	C	3.57
57	0.6	20	3	0.05	5	C	3.60
58	0.6	20	5	0.05	5	C	3.60
59	0.6	20	7	0.05	5	C	3.59
60	0.6	20	9	0.05	5	C	3.59
61	0.8	4	3	0.05	5	C	3.79
62	0.8	4	5	0.05	5	C	3.79
63	0.8	4	7	0.05	5	C	3.79
64	0.8	4	9	0.05	5	C	3.79
65	0.8	8	3	0.05	5	C	3.81
66	0.8	8	5	0.05	5	C	3.81
67	0.8	8	7	0.05	5	C	3.81
68	0.8	8	9	0.05	5	C	3.81
69	0.8	12	3	0.05	5	C	3.83
70	0.8	12	5	0.05	5	C	3.83

Table A.1 (cont'd)

71	0.8	12	7	0.05	5	C	3.83
72	0.8	12	9	0.05	5	C	3.83
73	0.8	16	3	0.05	5	C	3.86
74	0.8	16	5	0.05	5	C	3.85
75	0.8	16	7	0.05	5	C	3.85
76	0.8	16	9	0.05	5	C	3.85
77	0.8	20	3	0.05	5	C	3.89
78	0.8	20	5	0.05	5	C	3.88
79	0.8	20	7	0.05	5	C	3.88
80	0.8	20	9	0.05	5	C	3.88

Table A.2: Results of the Equivalent Linear Analysis for Parametric Study

Analysis ID	PGA	Storey	Bay No	μ	R (m)	Soil Site Class	Effective Period (s)
1	0.2	2	3	0.03	5	B	2.50
2	0.2	2	3	0.03	5	C	2.84
3	0.2	2	3	0.03	5	D	3.01
4	0.2	4	3	0.03	5	B	2.51
5	0.2	4	3	0.03	5	C	2.84
6	0.2	4	3	0.03	5	D	3.01
7	0.2	8	3	0.03	5	B	2.52
8	0.2	8	3	0.03	5	C	2.86
9	0.2	8	3	0.03	5	D	3.03
10	0.2	12	3	0.03	5	B	2.55
11	0.2	12	3	0.03	5	C	2.88
12	0.2	12	3	0.03	5	D	3.05
13	0.2	16	3	0.03	5	B	2.57
14	0.2	16	3	0.03	5	C	2.91
15	0.2	16	3	0.03	5	D	3.08
16	0.2	20	3	0.03	5	B	2.59
17	0.2	20	3	0.03	5	C	2.93
18	0.2	20	3	0.03	5	D	3.11
19	0.2	2	3	0.05	3	B	1.68
20	0.2	2	3	0.05	5	B	1.82
21	0.2	2	3	0.05	7	B	1.90
22	0.2	2	3	0.05	3	C	1.95

Table A.2 (cont'd)

23	0.2	2	3	0.05	5	C	2.17
24	0.2	2	3	0.05	7	C	2.30
25	0.2	2	3	0.05	3	D	2.09
26	0.2	2	3	0.05	5	D	2.37
27	0.2	2	3	0.05	7	D	2.53
28	0.2	4	3	0.05	3	B	1.68
29	0.2	4	3	0.05	5	B	1.83
30	0.2	4	3	0.05	7	B	1.91
31	0.2	4	3	0.05	3	C	1.95
32	0.2	4	3	0.05	5	C	2.18
33	0.2	4	3	0.05	7	C	2.31
34	0.2	4	3	0.05	3	D	2.10
35	0.2	4	3	0.05	5	D	2.37
36	0.2	4	3	0.05	7	D	2.54
37	0.2	8	3	0.05	3	B	1.70
38	0.2	8	3	0.05	5	B	1.84
39	0.2	8	3	0.05	7	B	1.91
40	0.2	8	3	0.05	3	C	1.97
41	0.2	8	3	0.05	5	C	2.19
42	0.2	8	3	0.05	7	C	2.32
43	0.2	8	3	0.05	3	D	2.12
44	0.2	8	3	0.05	5	D	2.38
45	0.2	8	3	0.05	7	D	2.55
46	0.2	12	3	0.05	3	B	1.72
47	0.2	12	3	0.05	5	B	1.85
48	0.2	12	3	0.05	7	B	1.92
49	0.2	12	3	0.05	3	C	2.00
50	0.2	12	3	0.05	5	C	2.21
51	0.2	12	3	0.05	7	C	2.33
52	0.2	12	3	0.05	3	D	2.15
53	0.2	12	3	0.05	5	D	2.40
54	0.2	12	3	0.05	7	D	2.56
55	0.2	16	3	0.05	3	B	1.74
56	0.2	16	3	0.05	5	B	1.86
57	0.2	16	3	0.05	7	B	1.93
58	0.2	16	3	0.05	3	C	2.03
59	0.2	16	3	0.05	5	C	2.22

Table A.2 (cont'd)

60	0.2	16	3	0.05	7	C	2.34
61	0.2	16	3	0.05	3	D	2.18
62	0.2	16	3	0.05	5	D	2.43
63	0.2	16	3	0.05	7	D	2.58
64	0.2	20	3	0.05	3	B	1.78
65	0.2	20	3	0.05	5	B	1.88
66	0.2	20	3	0.05	7	B	1.94
67	0.2	20	3	0.05	3	C	2.06
68	0.2	20	3	0.05	5	C	2.25
69	0.2	20	3	0.05	7	C	2.35
70	0.2	20	3	0.05	3	D	2.21
71	0.2	20	3	0.05	5	D	2.45
72	0.2	20	3	0.05	7	D	2.59
73	0.2	2	3	0.07	5	B	1.41
74	0.2	2	3	0.07	5	C	1.73
75	0.2	2	3	0.07	5	D	1.91
76	0.2	4	3	0.07	5	B	1.41
77	0.2	4	3	0.07	5	C	1.73
78	0.2	4	3	0.07	5	D	1.92
79	0.2	8	3	0.07	5	B	1.41
80	0.2	8	3	0.07	5	C	1.74
81	0.2	8	3	0.07	5	D	1.93
82	0.2	12	3	0.07	5	B	1.42
83	0.2	12	3	0.07	5	C	1.75
84	0.2	12	3	0.07	5	D	1.94
85	0.2	16	3	0.07	5	B	1.44
86	0.2	16	3	0.07	5	C	1.76
87	0.2	16	3	0.07	5	D	1.96
88	0.2	20	3	0.07	5	B	1.52
89	0.2	20	3	0.07	5	C	1.78
90	0.2	20	3	0.07	5	D	1.97
91	0.4	2	3	0.03	5	B	3.32
92	0.4	2	3	0.03	5	C	3.62
93	0.4	2	3	0.03	5	D	3.75
94	0.4	4	3	0.03	5	B	3.33
95	0.4	4	3	0.03	5	C	3.62
96	0.4	4	3	0.03	5	D	3.76

Table A.2 (cont'd)

97	0.4	8	3	0.03	5	B	3.34
98	0.4	8	3	0.03	5	C	3.64
99	0.4	8	3	0.03	5	D	3.77
100	0.4	12	3	0.03	5	B	3.37
101	0.4	12	3	0.03	5	C	3.66
102	0.4	12	3	0.03	5	D	3.80
103	0.4	16	3	0.03	5	B	3.39
104	0.4	16	3	0.03	5	C	3.69
105	0.4	16	3	0.03	5	D	3.82
106	0.4	20	3	0.03	5	B	3.42
107	0.4	20	3	0.03	5	C	3.72
108	0.4	20	3	0.03	5	D	3.85
109	0.4	2	3	0.05	3	B	2.36
110	0.4	2	3	0.05	5	B	2.74
111	0.4	2	3	0.05	7	B	2.98
112	0.4	2	3	0.05	3	C	2.58
113	0.4	2	3	0.05	5	C	3.05
114	0.4	2	3	0.05	7	C	3.38
115	0.4	2	3	0.05	3	D	2.71
116	0.4	2	3	0.05	5	D	3.21
117	0.4	2	3	0.05	7	D	3.58
118	0.4	4	3	0.05	3	B	2.37
119	0.4	4	3	0.05	5	B	2.74
120	0.4	4	3	0.05	7	B	2.99
121	0.4	4	3	0.05	3	C	2.59
122	0.4	4	3	0.05	5	C	3.06
123	0.4	4	3	0.05	7	C	3.38
124	0.4	4	3	0.05	3	D	2.72
125	0.4	4	3	0.05	5	D	3.21
126	0.4	4	3	0.05	7	D	3.58
127	0.4	8	3	0.05	3	B	2.39
128	0.4	8	3	0.05	5	B	2.76
129	0.4	8	3	0.05	7	B	3.00
130	0.4	8	3	0.05	3	C	2.61
131	0.4	8	3	0.05	5	C	3.07
132	0.4	8	3	0.05	7	C	3.39
133	0.4	8	3	0.05	3	D	2.74

Table A.2 (cont'd)

134	0.4	8	3	0.05	5	D	3.23
135	0.4	8	3	0.05	7	D	3.59
136	0.4	12	3	0.05	3	B	2.42
137	0.4	12	3	0.05	5	B	2.78
138	0.4	12	3	0.05	7	B	3.02
139	0.4	12	3	0.05	3	C	2.64
140	0.4	12	3	0.05	5	C	3.10
141	0.4	12	3	0.05	7	C	3.41
142	0.4	12	3	0.05	3	D	2.77
143	0.4	12	3	0.05	5	D	3.25
144	0.4	12	3	0.05	7	D	3.62
145	0.4	16	3	0.05	3	B	2.45
146	0.4	16	3	0.05	5	B	2.81
147	0.4	16	3	0.05	7	B	3.04
148	0.4	16	3	0.05	3	C	2.67
149	0.4	16	3	0.05	5	C	3.12
150	0.4	16	3	0.05	7	C	3.43
151	0.4	16	3	0.05	3	D	2.80
152	0.4	16	3	0.05	5	D	3.28
153	0.4	16	3	0.05	7	D	3.64
154	0.4	20	3	0.05	3	B	2.49
155	0.4	20	3	0.05	5	B	2.83
156	0.4	20	3	0.05	7	B	3.06
157	0.4	20	3	0.05	3	C	2.71
158	0.4	20	3	0.05	5	C	3.15
159	0.4	20	3	0.05	7	C	3.46
160	0.4	20	3	0.05	3	D	2.84
161	0.4	20	3	0.05	5	D	3.31
162	0.4	20	3	0.05	7	D	3.66
163	0.4	2	3	0.07	5	B	2.30
164	0.4	2	3	0.07	5	C	2.64
165	0.4	2	3	0.07	5	D	2.82
166	0.4	4	3	0.07	5	B	2.30
167	0.4	4	3	0.07	5	C	2.65
168	0.4	4	3	0.07	5	D	2.83
169	0.4	8	3	0.07	5	B	2.32
170	0.4	8	3	0.07	5	C	2.66

Table A.2 (cont'd)

171	0.4	8	3	0.07	5	D	2.85
172	0.4	12	3	0.07	5	B	2.34
173	0.4	12	3	0.07	5	C	2.69
174	0.4	12	3	0.07	5	D	2.87
175	0.4	16	3	0.07	5	B	2.36
176	0.4	16	3	0.07	5	C	2.71
177	0.4	16	3	0.07	5	D	2.89
178	0.4	20	3	0.07	5	B	2.38
179	0.4	20	3	0.07	5	C	2.74
180	0.4	20	3	0.07	5	D	2.92
181	0.6	2	3	0.03	5	B	3.75
182	0.6	2	3	0.03	5	C	3.96
183	0.6	2	3	0.03	5	D	4.05
184	0.6	4	3	0.03	5	B	3.76
185	0.6	4	3	0.03	5	C	3.96
186	0.6	4	3	0.03	5	D	4.05
187	0.6	8	3	0.03	5	B	3.77
188	0.6	8	3	0.03	5	C	3.98
189	0.6	8	3	0.03	5	D	4.07
190	0.6	12	3	0.03	5	B	3.80
191	0.6	12	3	0.03	5	C	4.00
192	0.6	12	3	0.03	5	D	4.09
193	0.6	16	3	0.03	5	B	3.82
194	0.6	16	3	0.03	5	C	4.03
195	0.6	16	3	0.03	5	D	4.12
196	0.6	20	3	0.03	5	B	3.85
197	0.6	20	3	0.03	5	C	4.06
198	0.6	20	3	0.03	5	D	4.15
199	0.6	2	3	0.05	3	B	2.71
200	0.6	2	3	0.05	5	B	3.21
201	0.6	2	3	0.05	7	B	3.58
202	0.6	2	3	0.05	3	C	2.91
203	0.6	2	3	0.05	5	C	3.51
204	0.6	2	3	0.05	7	C	3.92
205	0.6	2	3	0.05	3	D	3.00
206	0.6	2	3	0.05	5	D	3.66
207	0.6	2	3	0.05	7	D	4.12

Table A.2 (cont'd)

208	0.6	4	3	0.05	3	B	2.72
209	0.6	4	3	0.05	5	B	3.21
210	0.6	4	3	0.05	7	B	3.58
211	0.6	4	3	0.05	3	C	2.92
212	0.6	4	3	0.05	5	C	3.51
213	0.6	4	3	0.05	7	C	3.92
214	0.6	4	3	0.05	3	D	3.01
215	0.6	4	3	0.05	5	D	3.66
216	0.6	4	3	0.05	7	D	4.12
217	0.6	8	3	0.05	3	B	2.74
218	0.6	8	3	0.05	5	B	3.23
219	0.6	8	3	0.05	7	B	3.59
220	0.6	8	3	0.05	3	C	2.94
221	0.6	8	3	0.05	5	C	3.53
222	0.6	8	3	0.05	7	C	3.93
223	0.6	8	3	0.05	3	D	3.03
224	0.6	8	3	0.05	5	D	3.68
225	0.6	8	3	0.05	7	D	4.13
226	0.6	12	3	0.05	3	B	2.77
227	0.6	12	3	0.05	5	B	3.25
228	0.6	12	3	0.05	7	B	3.61
229	0.6	12	3	0.05	3	C	2.97
230	0.6	12	3	0.05	5	C	3.55
231	0.6	12	3	0.05	7	C	3.95
232	0.6	12	3	0.05	3	D	3.06
233	0.6	12	3	0.05	5	D	3.70
234	0.6	12	3	0.05	7	D	4.15
235	0.6	16	3	0.05	3	B	2.80
236	0.6	16	3	0.05	5	B	3.28
237	0.6	16	3	0.05	7	B	3.64
238	0.6	16	3	0.05	3	C	3.00
239	0.6	16	3	0.05	5	C	3.57
240	0.6	16	3	0.05	7	C	3.97
241	0.6	16	3	0.05	3	D	3.10
242	0.6	16	3	0.05	5	D	3.73
243	0.6	16	3	0.05	7	D	4.17
244	0.6	20	3	0.05	3	B	2.83

Table A.2 (cont'd)

245	0.6	20	3	0.05	5	B	3.31
246	0.6	20	3	0.05	7	B	3.66
247	0.6	20	3	0.05	3	C	3.04
248	0.6	20	3	0.05	5	C	3.60
249	0.6	20	3	0.05	7	C	3.99
250	0.6	20	3	0.05	3	D	3.14
251	0.6	20	3	0.05	5	D	3.75
252	0.6	20	3	0.05	7	D	4.20
253	0.6	2	3	0.07	5	B	2.82
254	0.6	2	3	0.07	5	C	3.13
255	0.6	2	3	0.07	5	D	3.28
256	0.6	4	3	0.07	5	B	2.83
257	0.6	4	3	0.07	5	C	3.13
258	0.6	4	3	0.07	5	D	3.29
259	0.6	8	3	0.07	5	B	2.84
260	0.6	8	3	0.07	5	C	3.15
261	0.6	8	3	0.07	5	D	3.30
262	0.6	12	3	0.07	5	B	2.87
263	0.6	12	3	0.07	5	C	3.17
264	0.6	12	3	0.07	5	D	3.32
265	0.6	16	3	0.07	5	B	2.89
266	0.6	16	3	0.07	5	C	3.20
267	0.6	16	3	0.07	5	D	3.35
268	0.6	20	3	0.07	5	B	2.92
269	0.6	20	3	0.07	5	C	3.23
270	0.6	20	3	0.07	5	D	3.38
271	0.8	2	3	0.03	5	B	3.97
272	0.8	2	3	0.03	5	C	4.12
273	0.8	2	3	0.03	5	D	4.19
274	0.8	4	3	0.03	5	B	3.98
275	0.8	4	3	0.03	5	C	4.13
276	0.8	4	3	0.03	5	D	4.19
277	0.8	8	3	0.03	5	B	3.99
278	0.8	8	3	0.03	5	C	4.14
279	0.8	8	3	0.03	5	D	4.21
280	0.8	12	3	0.03	5	B	4.02
281	0.8	12	3	0.03	5	C	4.17

Table A.2 (cont'd)

282	0.8	12	3	0.03	5	D	4.23
283	0.8	16	3	0.03	5	B	4.05
284	0.8	16	3	0.03	5	C	4.20
285	0.8	16	3	0.03	5	D	4.26
286	0.8	20	3	0.03	5	B	4.08
287	0.8	20	3	0.03	5	C	4.23
288	0.8	20	3	0.03	5	D	4.29
289	0.8	2	3	0.05	3	B	2.93
290	0.8	2	3	0.05	5	B	3.53
291	0.8	2	3	0.05	7	B	3.95
292	0.8	2	3	0.05	3	C	3.08
293	0.8	2	3	0.05	5	C	3.79
294	0.8	2	3	0.05	7	C	4.30
295	0.8	2	3	0.05	3	D	3.15
296	0.8	2	3	0.05	5	D	3.90
297	0.8	2	3	0.05	7	D	4.45
298	0.8	4	3	0.05	3	B	2.94
299	0.8	4	3	0.05	5	B	3.54
300	0.8	4	3	0.05	7	B	3.96
301	0.8	4	3	0.05	3	C	3.09
302	0.8	4	3	0.05	5	C	3.79
303	0.8	4	3	0.05	7	C	4.30
304	0.8	4	3	0.05	3	D	3.16
305	0.8	4	3	0.05	5	D	3.91
306	0.8	4	3	0.05	7	D	4.46
307	0.8	8	3	0.05	3	B	2.96
308	0.8	8	3	0.05	5	B	3.55
309	0.8	8	3	0.05	7	B	3.97
310	0.8	8	3	0.05	3	C	3.11
311	0.8	8	3	0.05	5	C	3.81
312	0.8	8	3	0.05	7	C	4.31
313	0.8	8	3	0.05	3	D	3.18
314	0.8	8	3	0.05	5	D	3.92
315	0.8	8	3	0.05	7	D	4.47
316	0.8	12	3	0.05	3	B	2.99
317	0.8	12	3	0.05	5	B	3.58
318	0.8	12	3	0.05	7	B	3.99

Table A.2 (cont'd)

319	0.8	12	3	0.05	3	C	3.14
320	0.8	12	3	0.05	5	C	3.83
321	0.8	12	3	0.05	7	C	4.33
322	0.8	12	3	0.05	3	D	3.21
323	0.8	12	3	0.05	5	D	3.95
324	0.8	12	3	0.05	7	D	4.49
325	0.8	16	3	0.05	3	B	3.02
326	0.8	16	3	0.05	5	B	3.60
327	0.8	16	3	0.05	7	B	4.01
328	0.8	16	3	0.05	3	C	3.18
329	0.8	16	3	0.05	5	C	3.86
330	0.8	16	3	0.05	7	C	4.36
331	0.8	16	3	0.05	3	D	3.25
332	0.8	16	3	0.05	5	D	3.97
333	0.8	16	3	0.05	7	D	4.52
334	0.8	20	3	0.05	3	B	3.06
335	0.8	20	3	0.05	5	B	3.63
336	0.8	20	3	0.05	7	B	4.03
337	0.8	20	3	0.05	3	C	3.22
338	0.8	20	3	0.05	5	C	3.89
339	0.8	20	3	0.05	7	C	4.38
340	0.8	20	3	0.05	3	D	3.29
341	0.8	20	3	0.05	5	D	4.00
342	0.8	20	3	0.05	7	D	4.54
343	0.8	2	3	0.07	5	B	3.15
344	0.8	2	3	0.07	5	C	3.45
345	0.8	2	3	0.07	5	D	3.61
346	0.8	4	3	0.07	5	B	3.16
347	0.8	4	3	0.07	5	C	3.46
348	0.8	4	3	0.07	5	D	3.61
349	0.8	8	3	0.07	5	B	3.18
350	0.8	8	3	0.07	5	C	3.47
351	0.8	8	3	0.07	5	D	3.63
352	0.8	12	3	0.07	5	B	3.20
353	0.8	12	3	0.07	5	C	3.49
354	0.8	12	3	0.07	5	D	3.65
355	0.8	16	3	0.07	5	B	3.23

Table A.2 (cont'd)

356	0.8	16	3	0.07	5	C	3.52
357	0.8	16	3	0.07	5	D	3.68
358	0.8	20	3	0.07	5	B	3.26
359	0.8	20	3	0.07	5	C	3.55
360	0.8	20	3	0.07	5	D	3.71



B. Results of Sensitivity Analysis – The Effect of Bay Number on Storey Acceleration

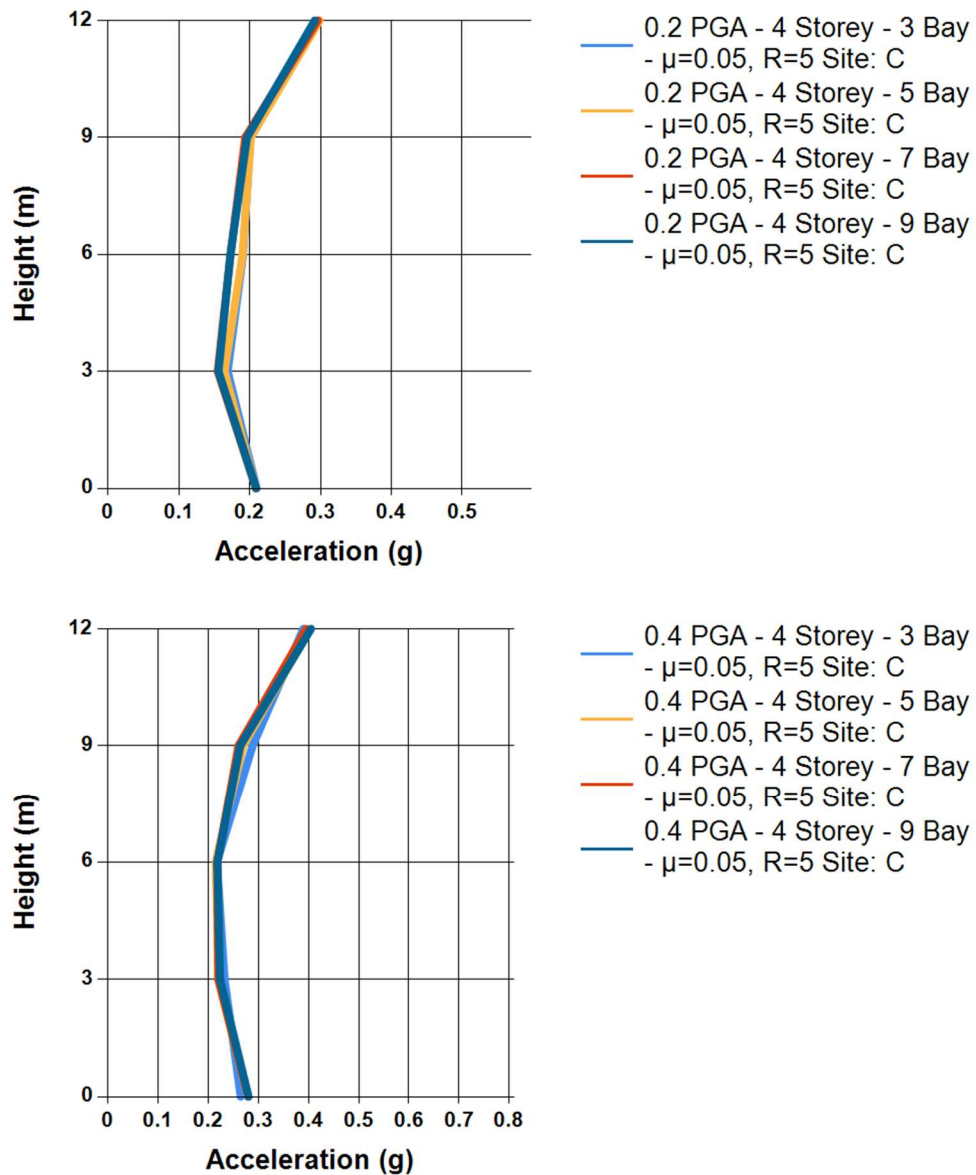


Figure 8.1. Effect of Bay Number on Absolute Accelerations for 4 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

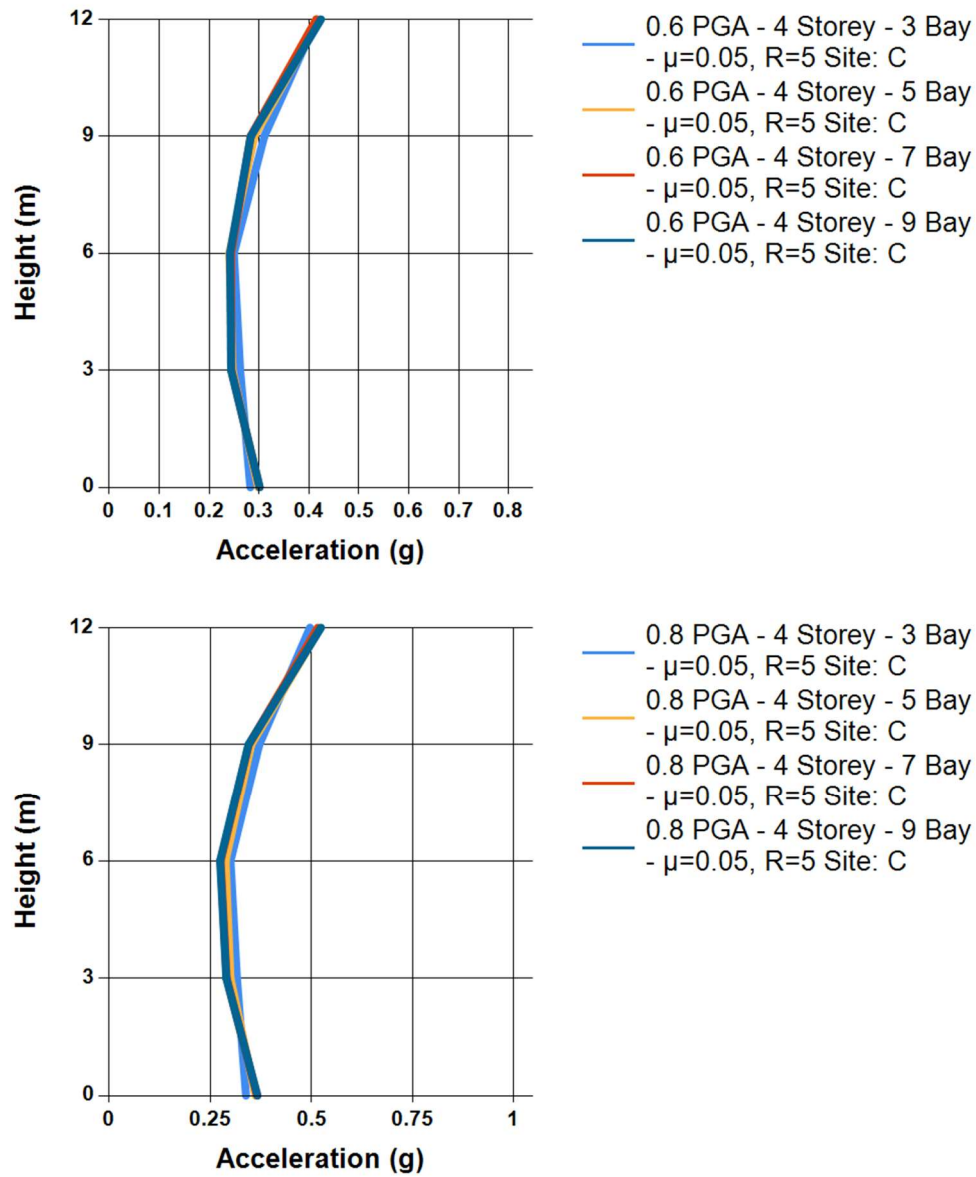


Figure 8.2. Effect of Bay Number on Absolute Accelerations for 4 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

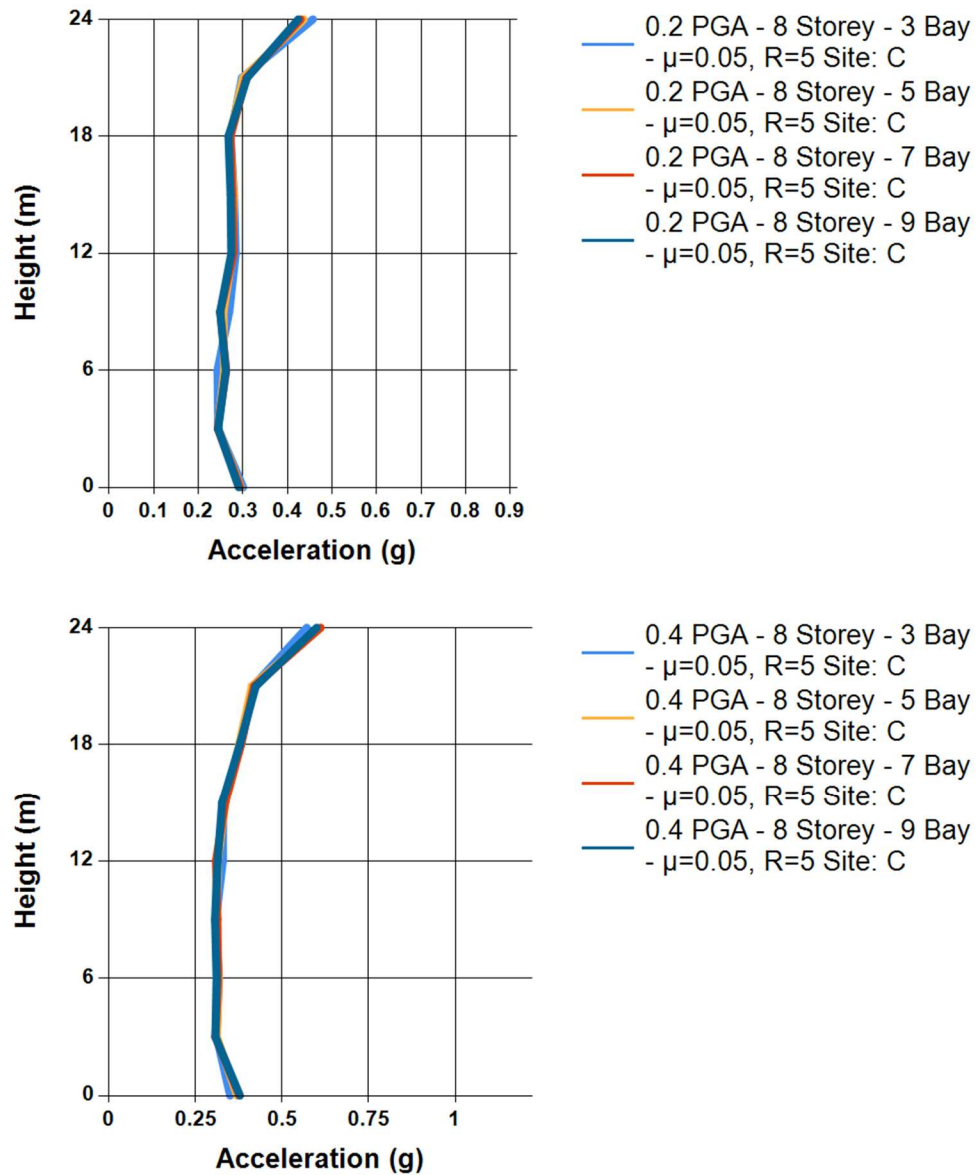


Figure 8.3. Effect of Bay Number on Absolute Accelerations for 8 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

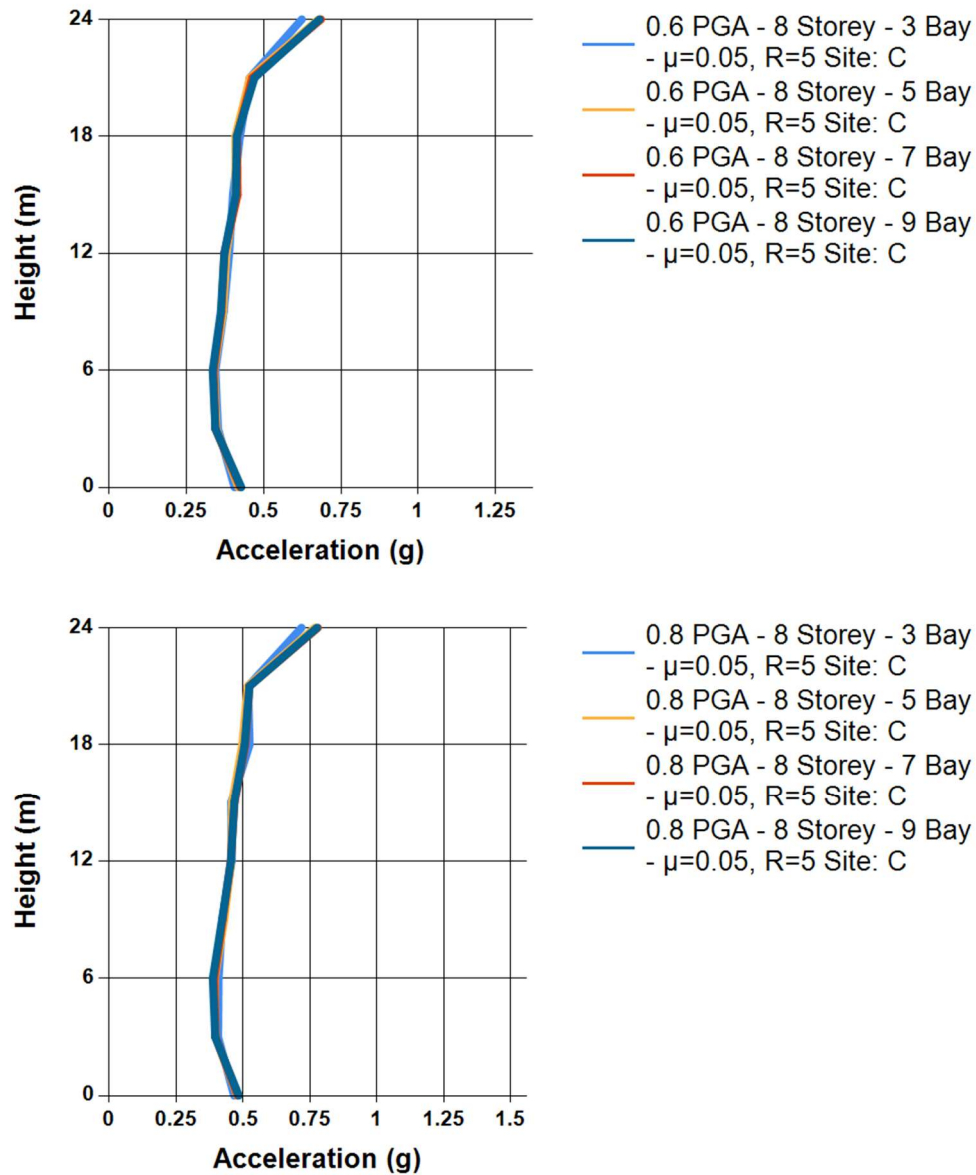


Figure 8.4. Effect of Bay Number on Absolute Accelerations for 8 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

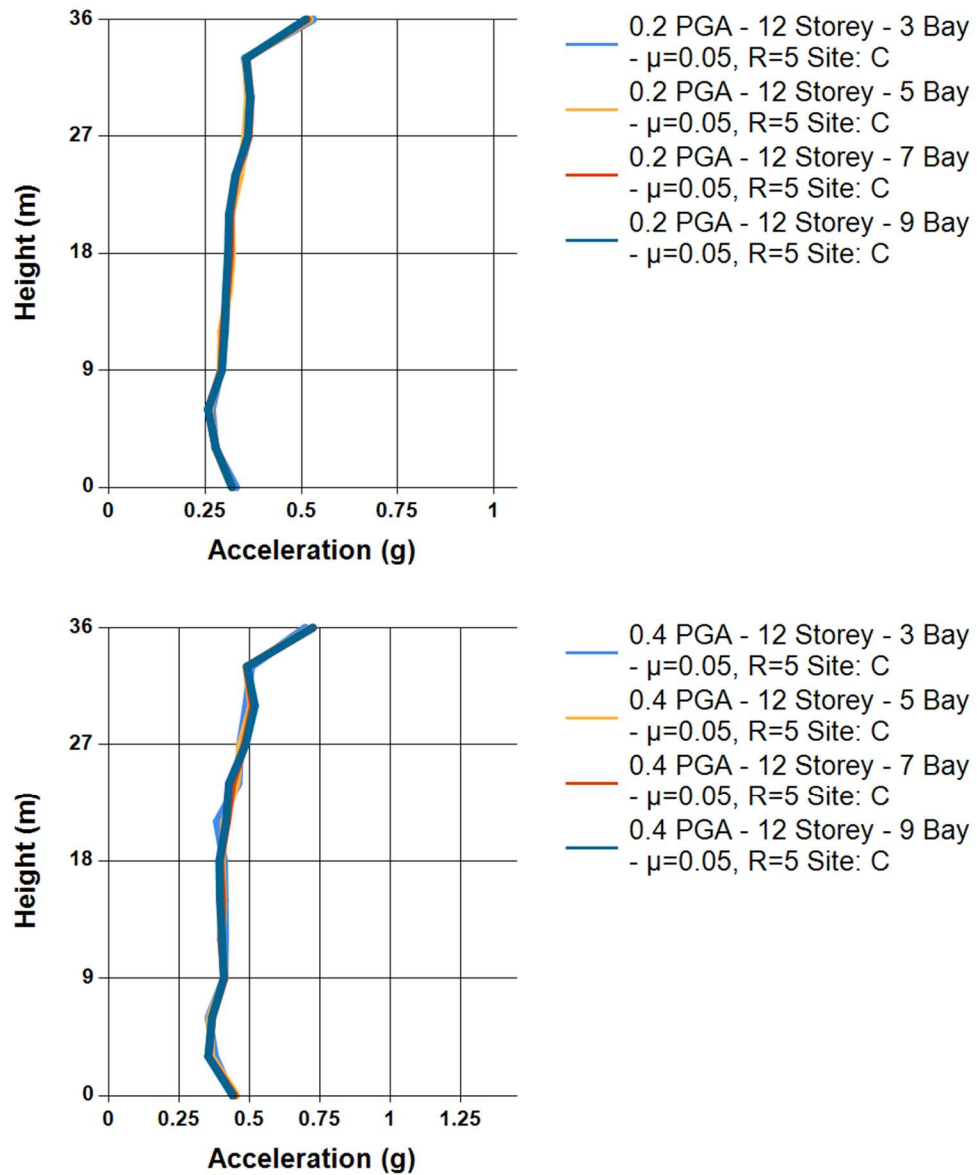


Figure 8.5. Effect of Bay Number on Absolute Accelerations for 12 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

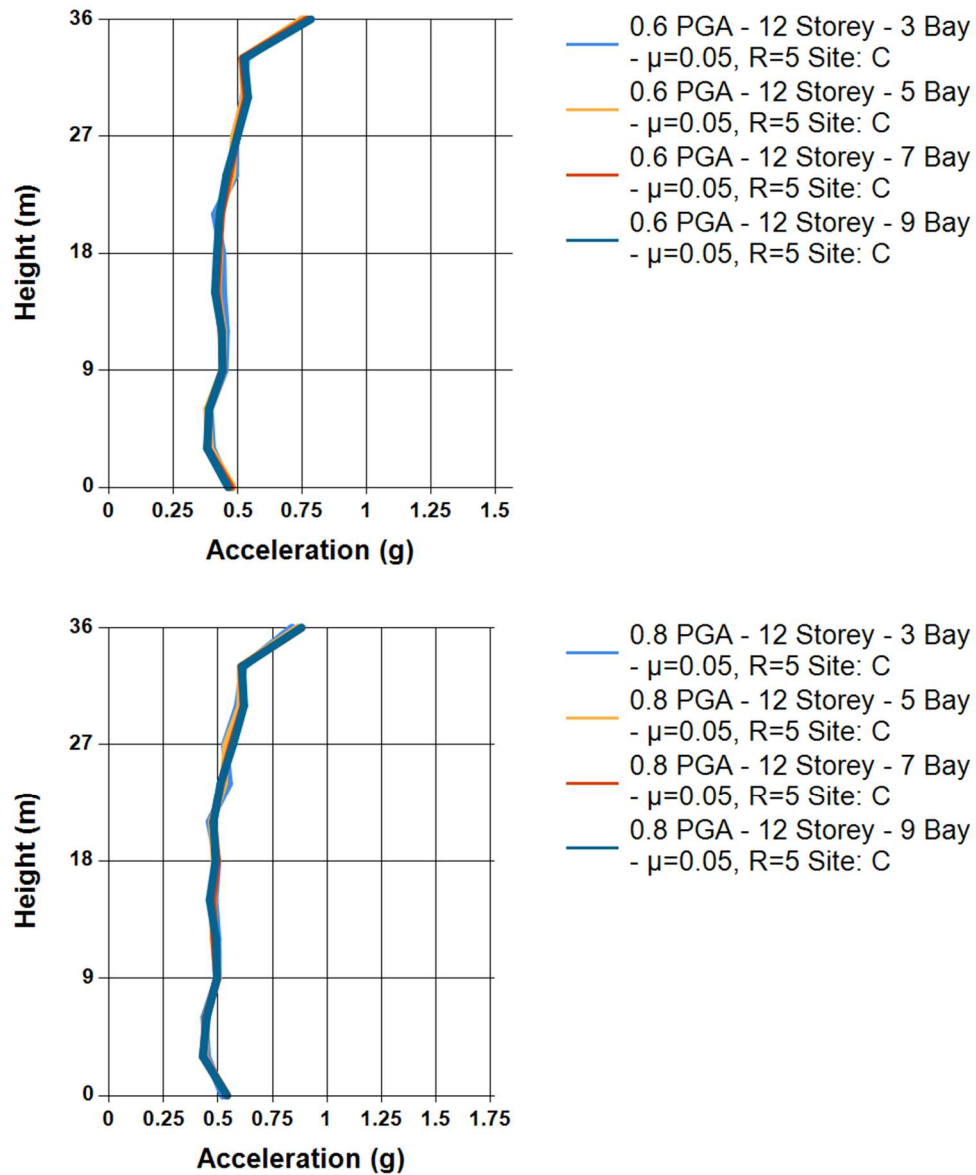


Figure 8.6. Effect of Bay Number on Absolute Accelerations for 12 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

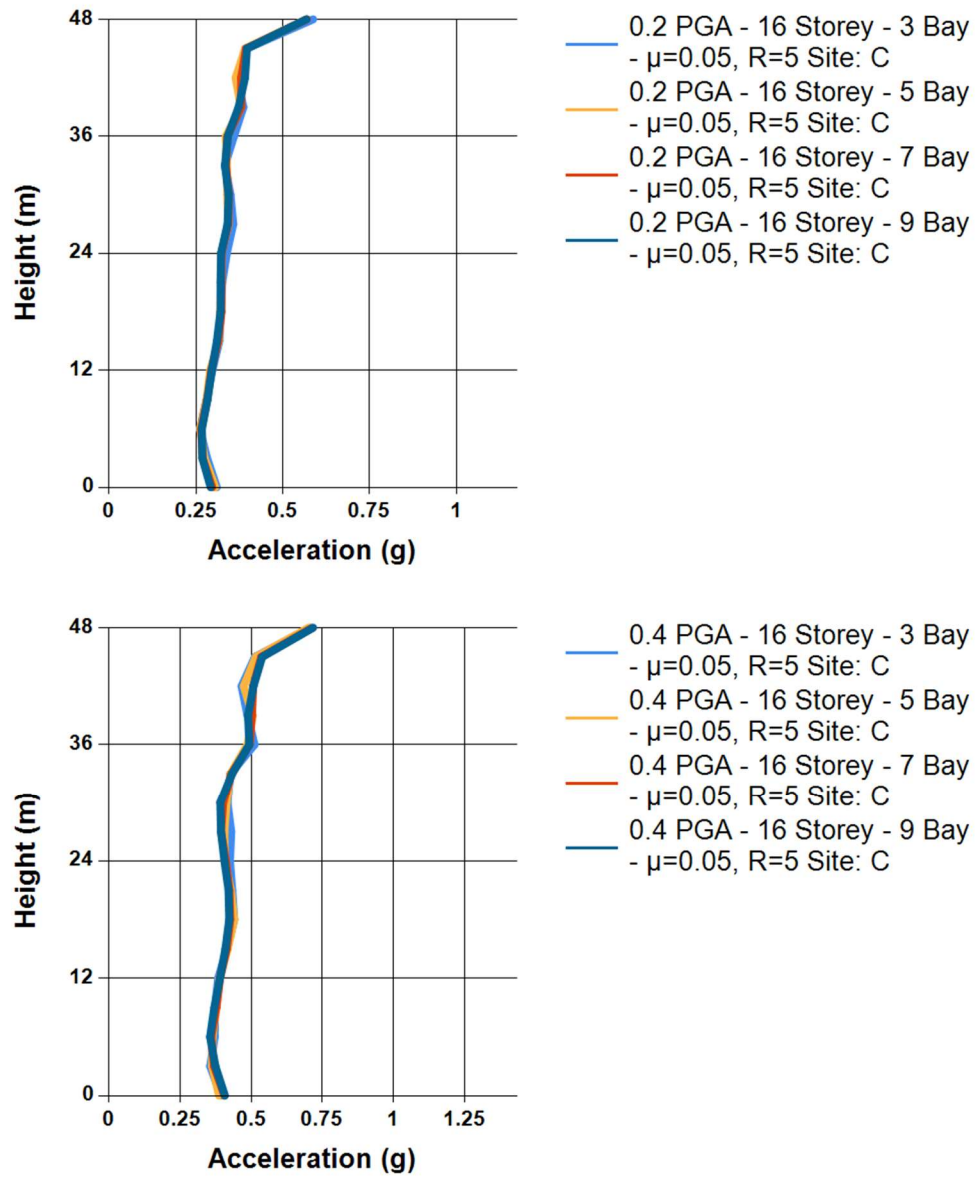


Figure 8.7. Effect of Bay Number on Absolute Accelerations for 16 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

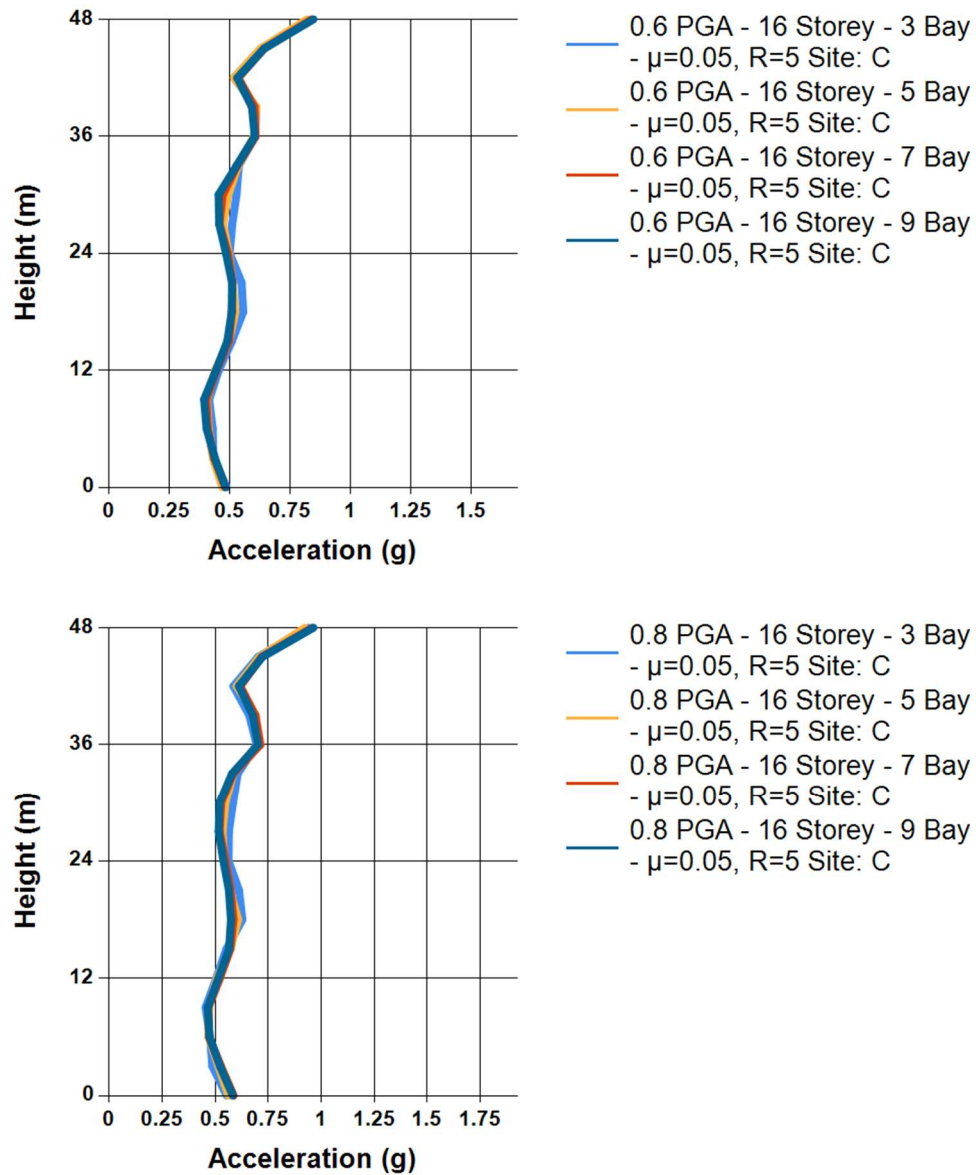


Figure 8.8. Effect of Bay Number on Absolute Accelerations for 16 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

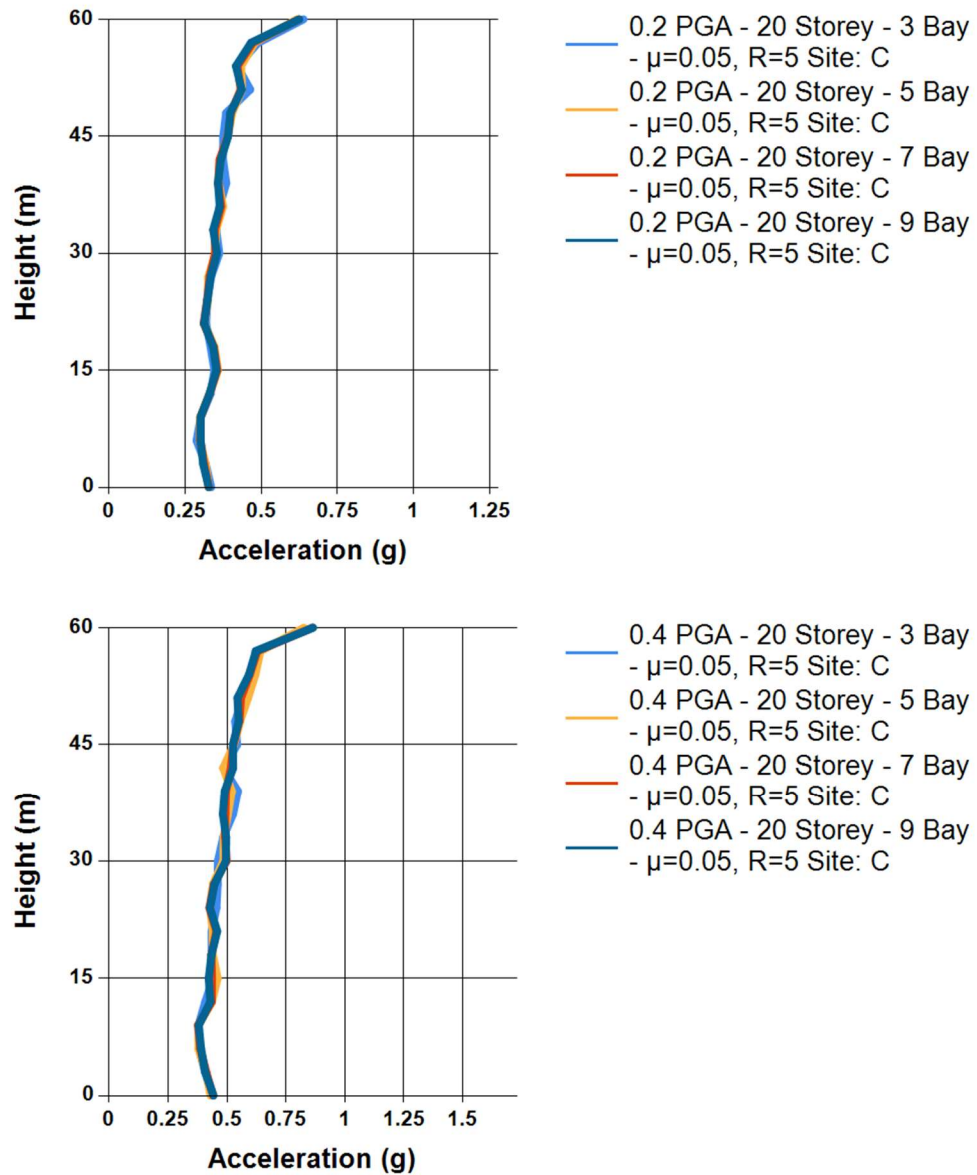


Figure 8.9. Effect of Bay Number on Absolute Accelerations for 20 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

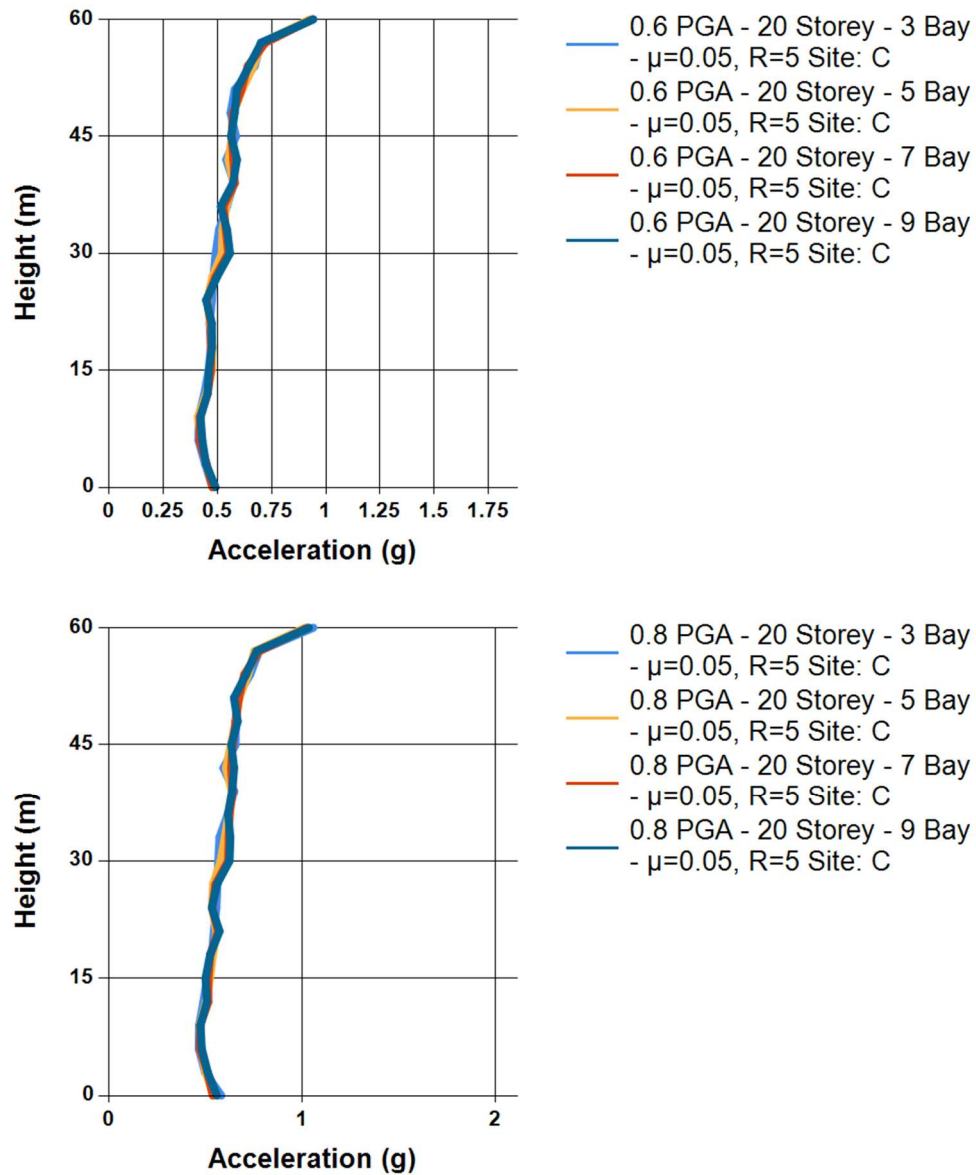


Figure 8.10. Effect of Bay Number on Absolute Accelerations for 20 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

C. Results of Sensitivity Analysis – The Effect of Bay Number on Absolute Displacement

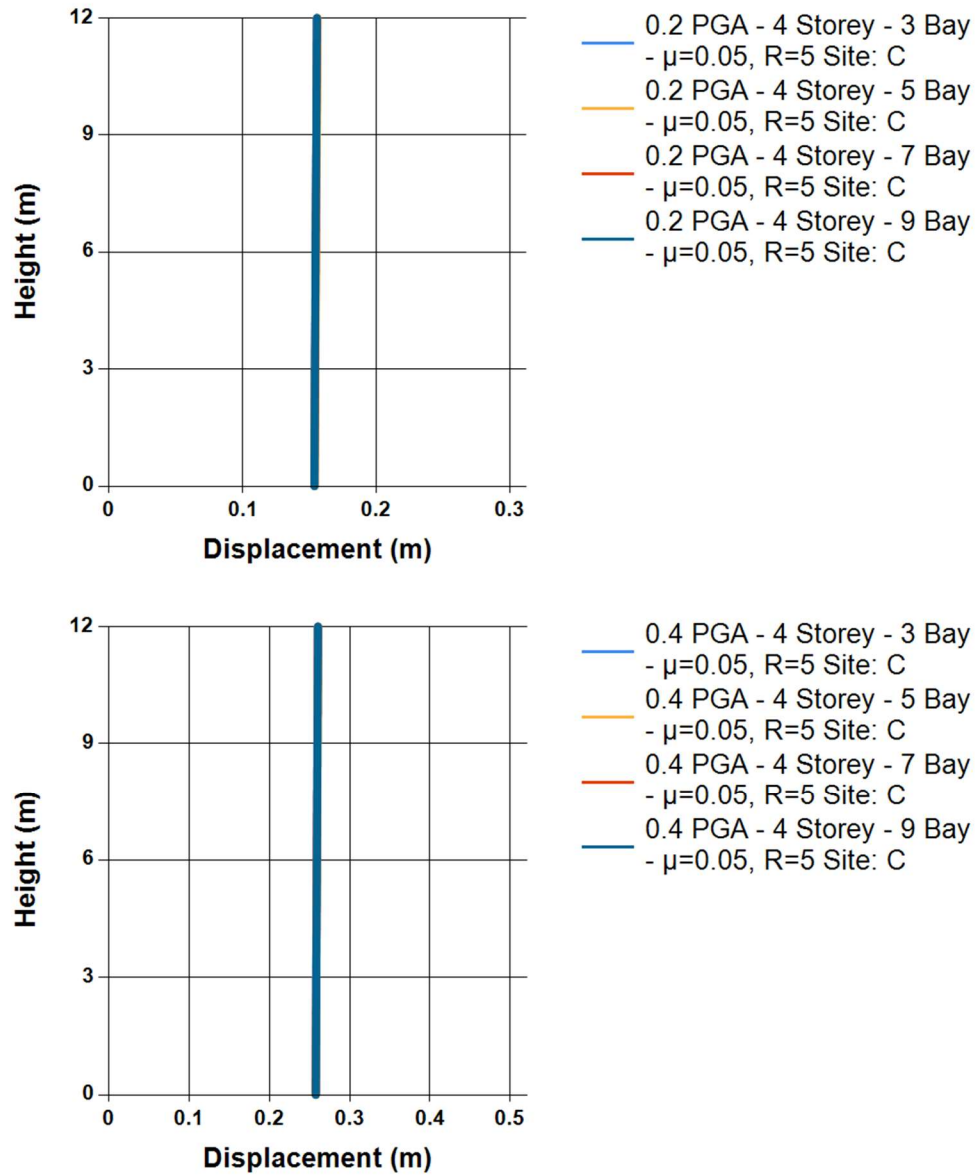


Figure 8.11. Effect of Bay Number on Absolute Displacements for 4 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

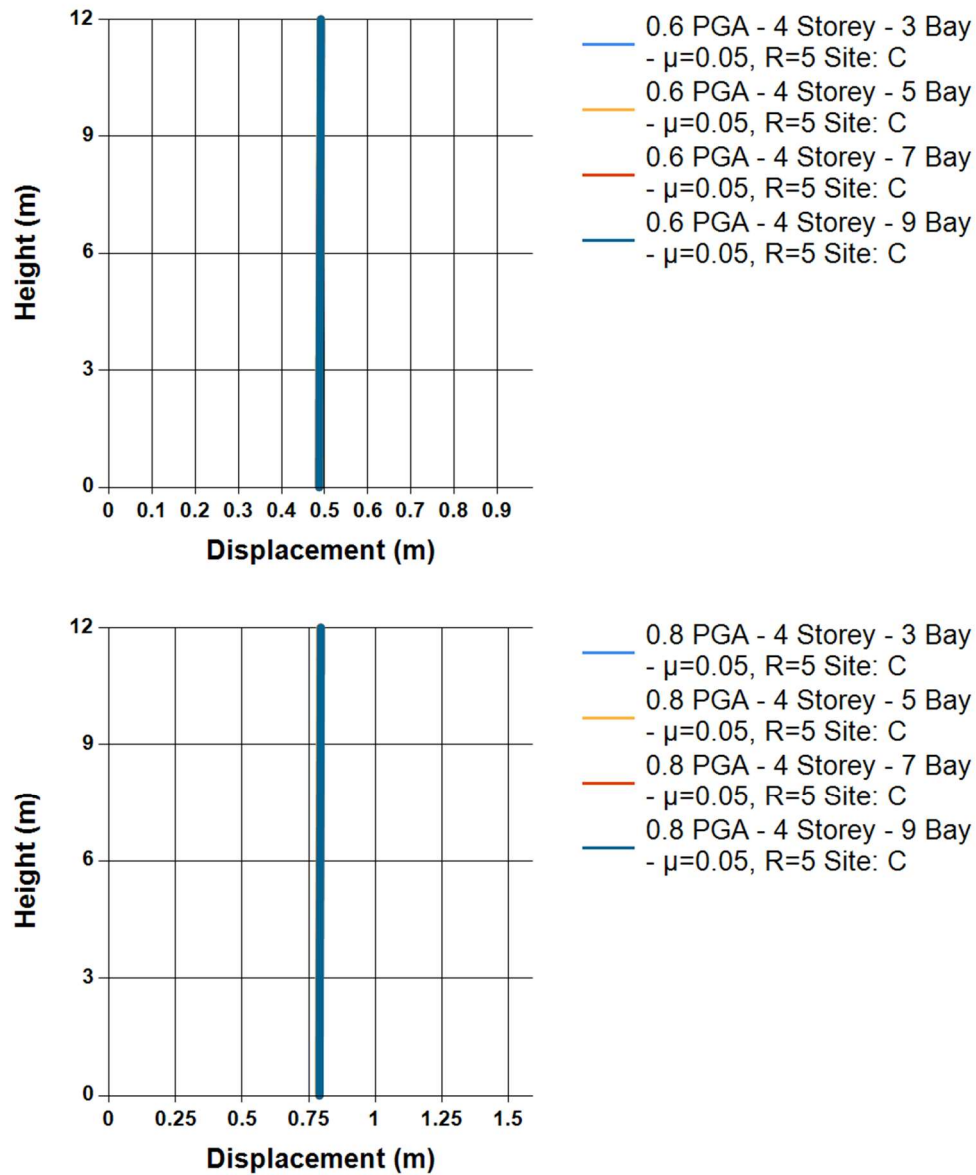


Figure 8.12. Effect of Bay Number on Absolute Displacements for 4 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

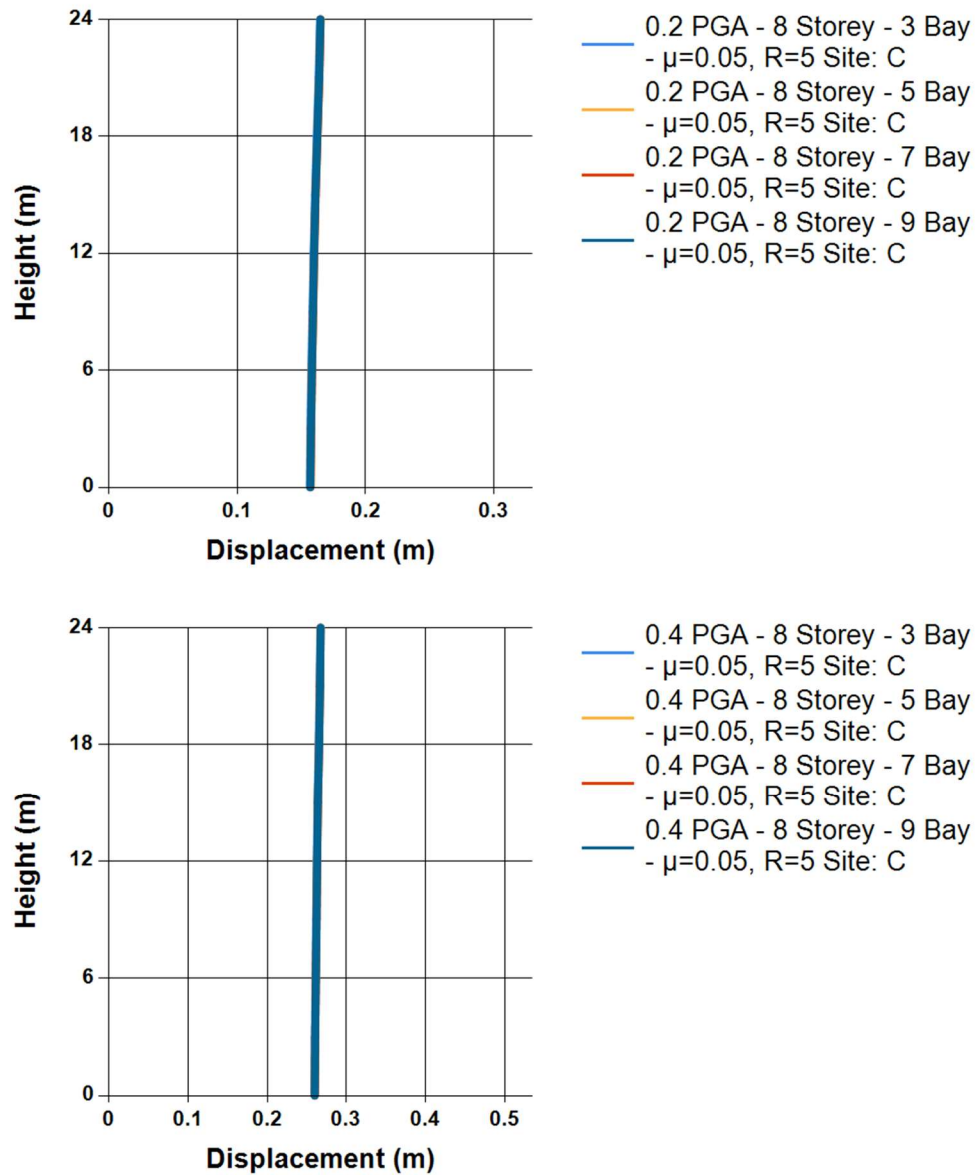


Figure 8.13. Effect of Bay Number on Absolute Displacements for 8 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

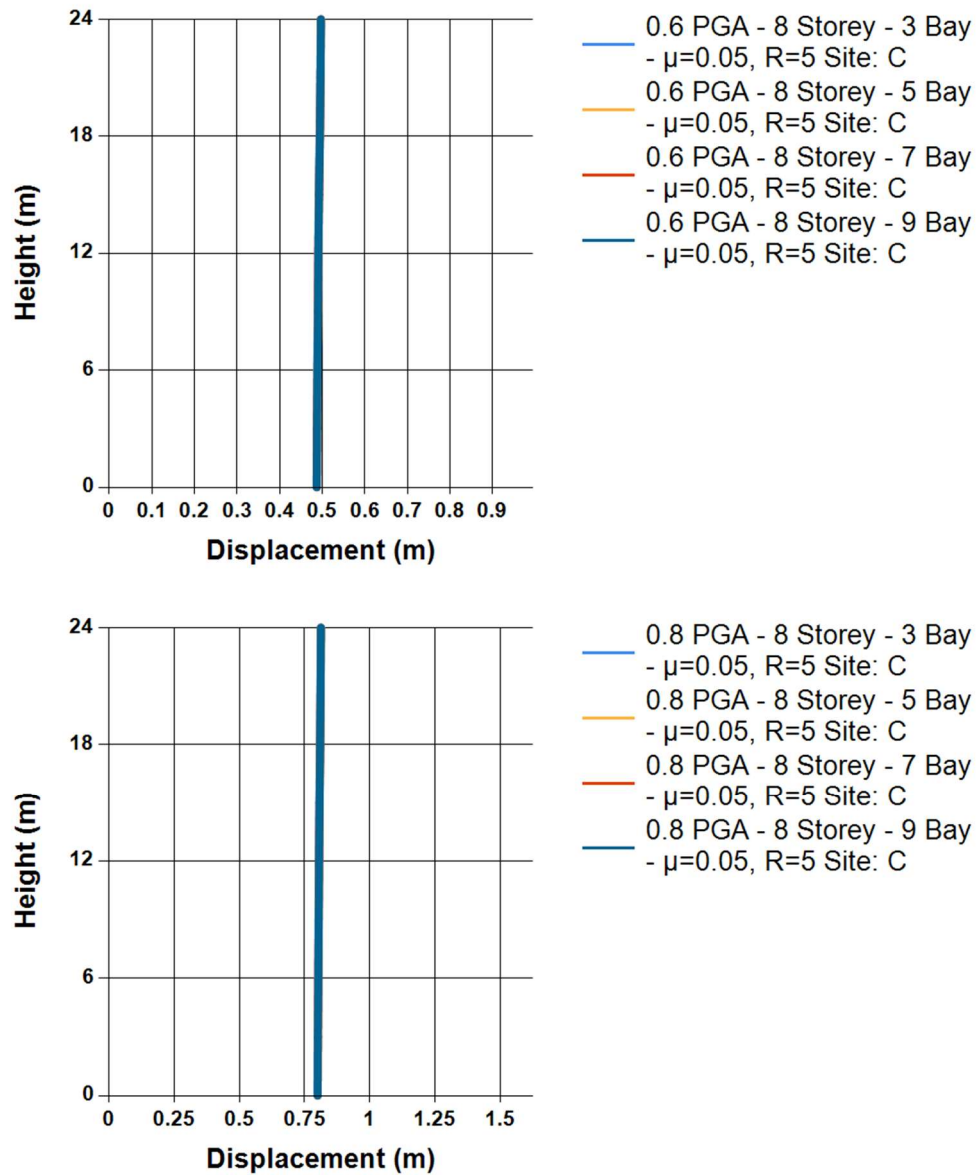


Figure 8.14. Effect of Bay Number on Absolute Displacements for 8 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

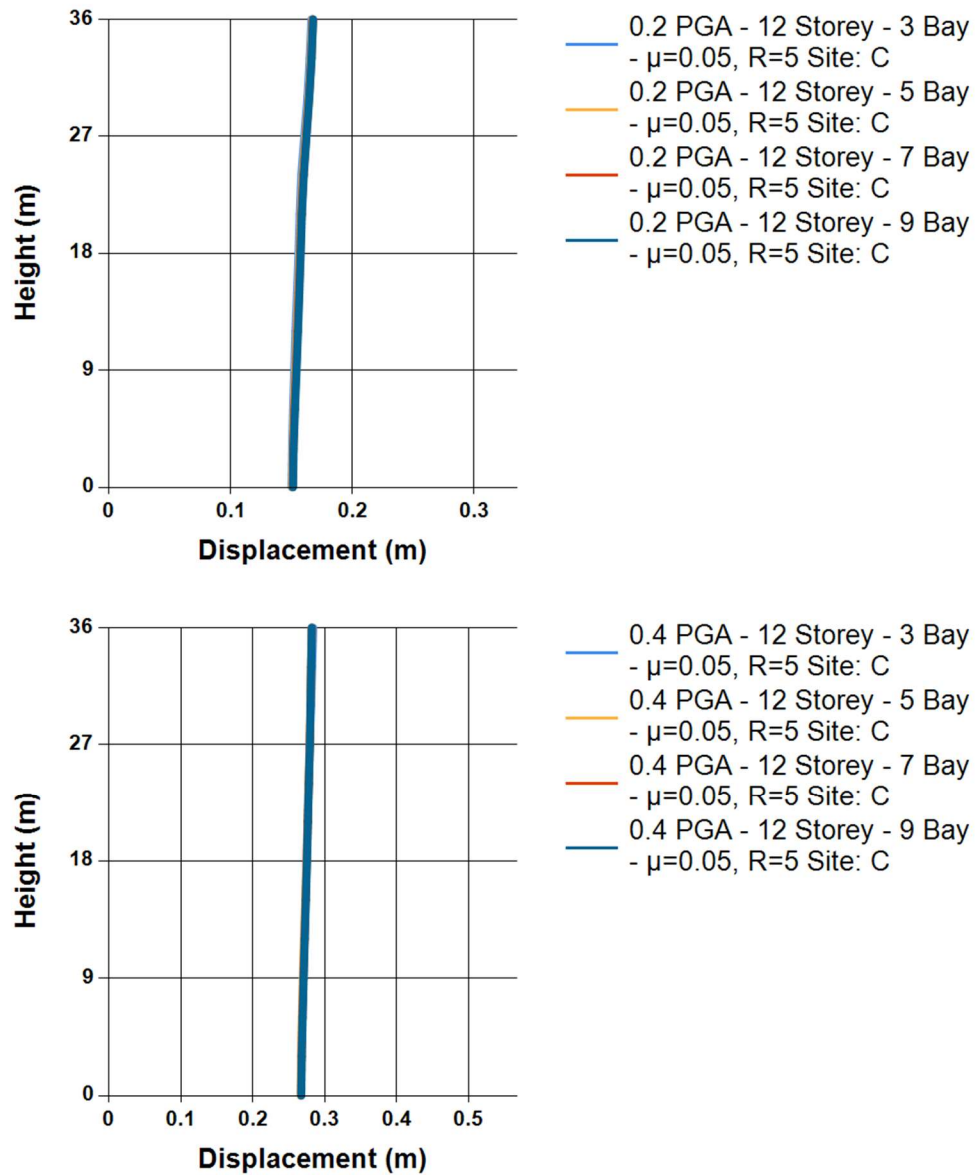


Figure 8.15. Effect of Bay Number on Absolute Displacements for 12 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

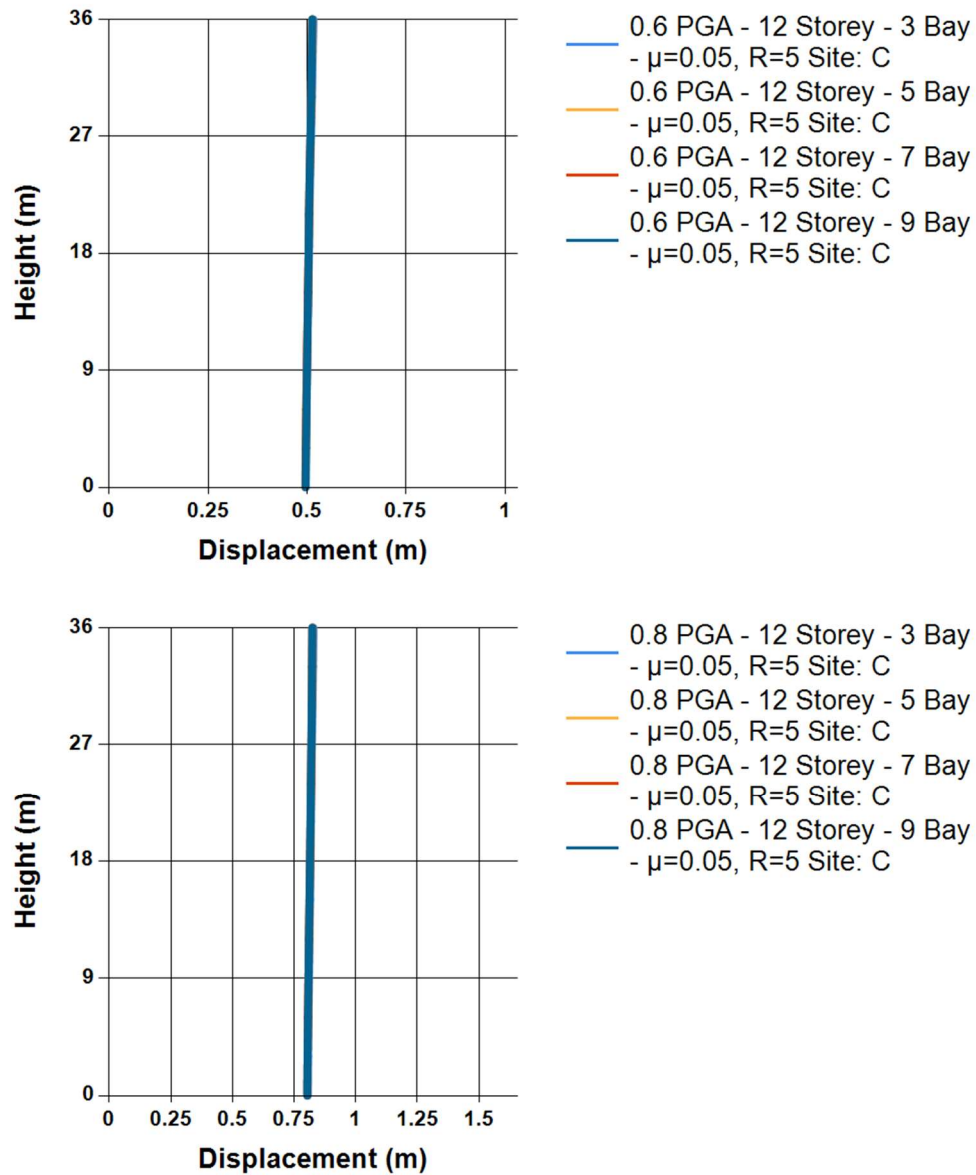


Figure 8.16. Effect of Bay Number on Absolute Displacements for 12 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

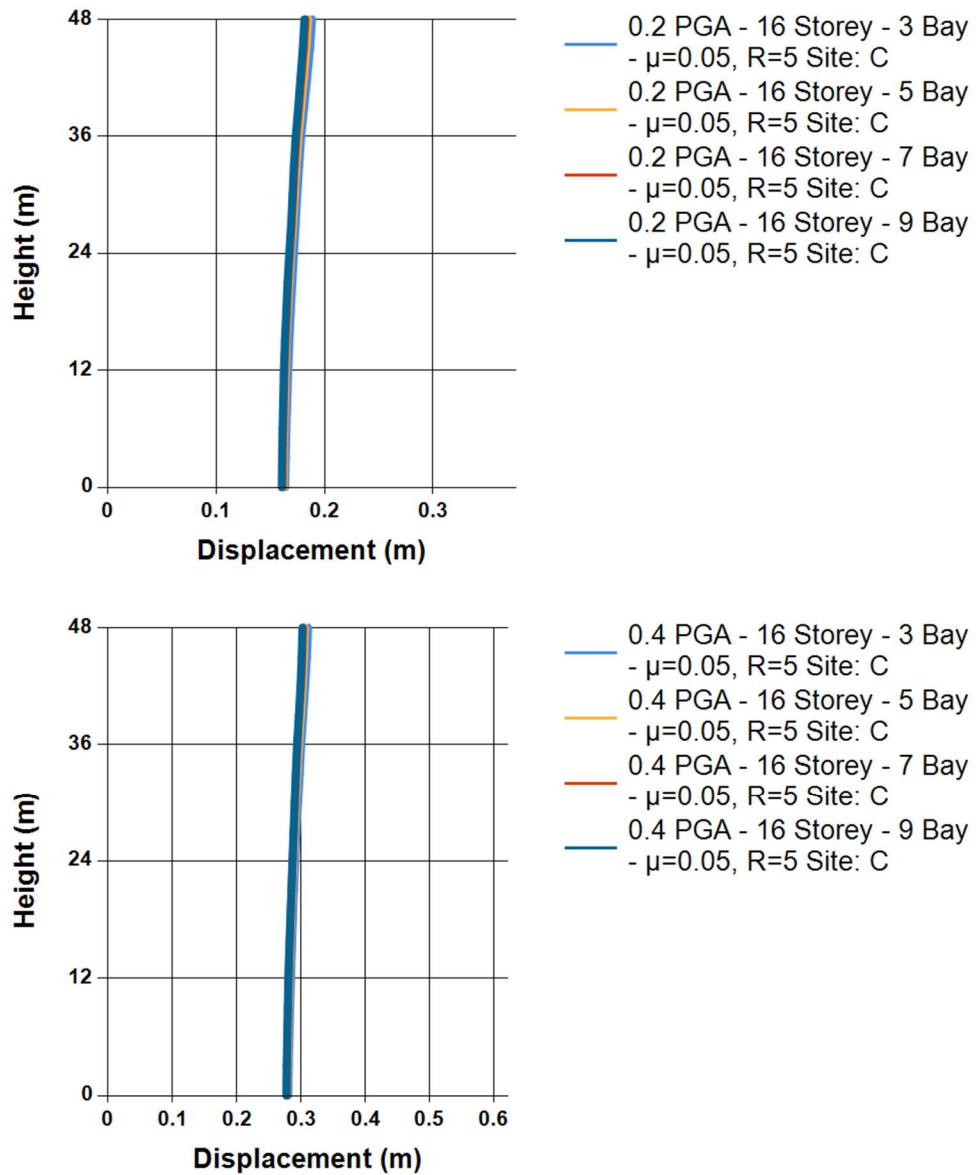


Figure 8.17. Effect of Bay Number on Absolute Displacements for 16 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

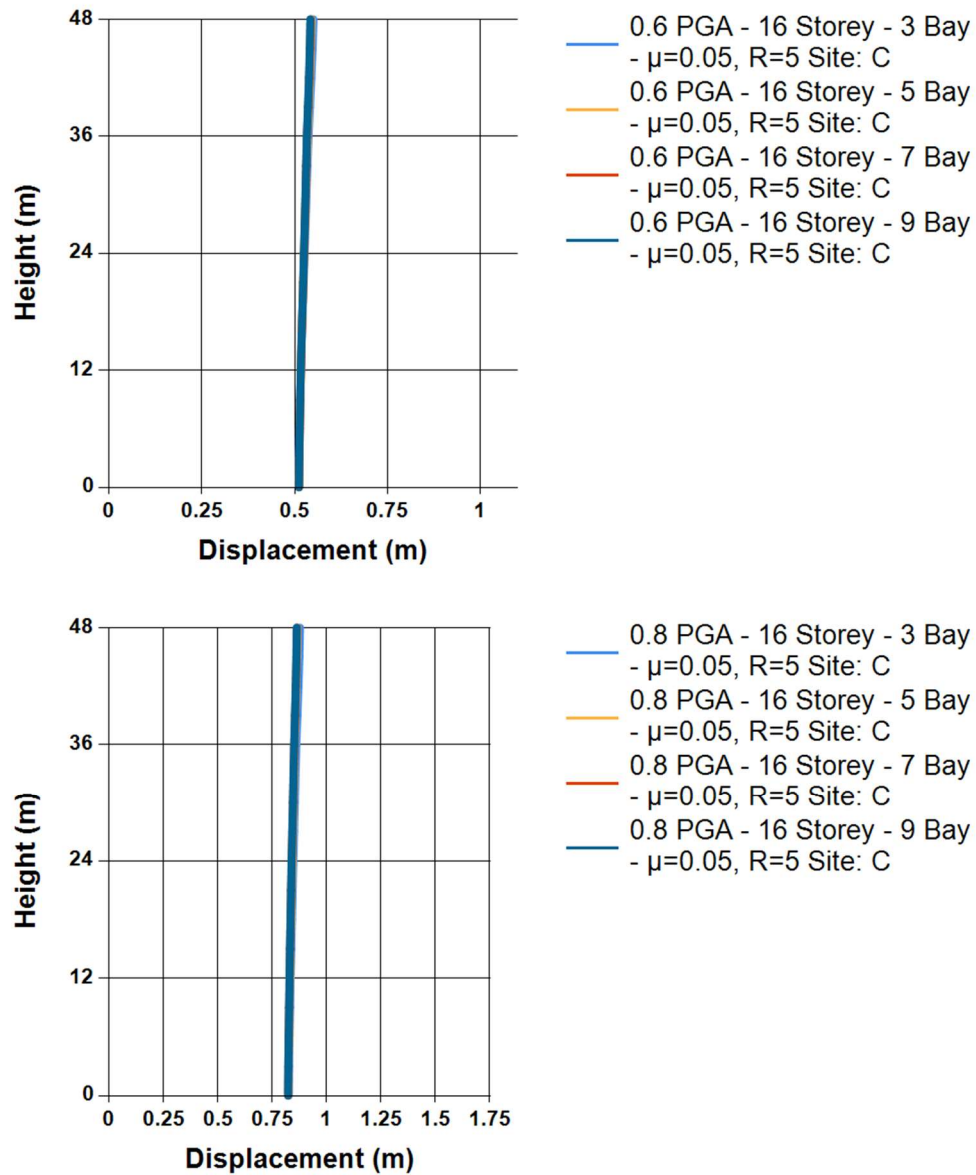


Figure 8.18. Effect of Bay Number on Absolute Displacements for 16 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

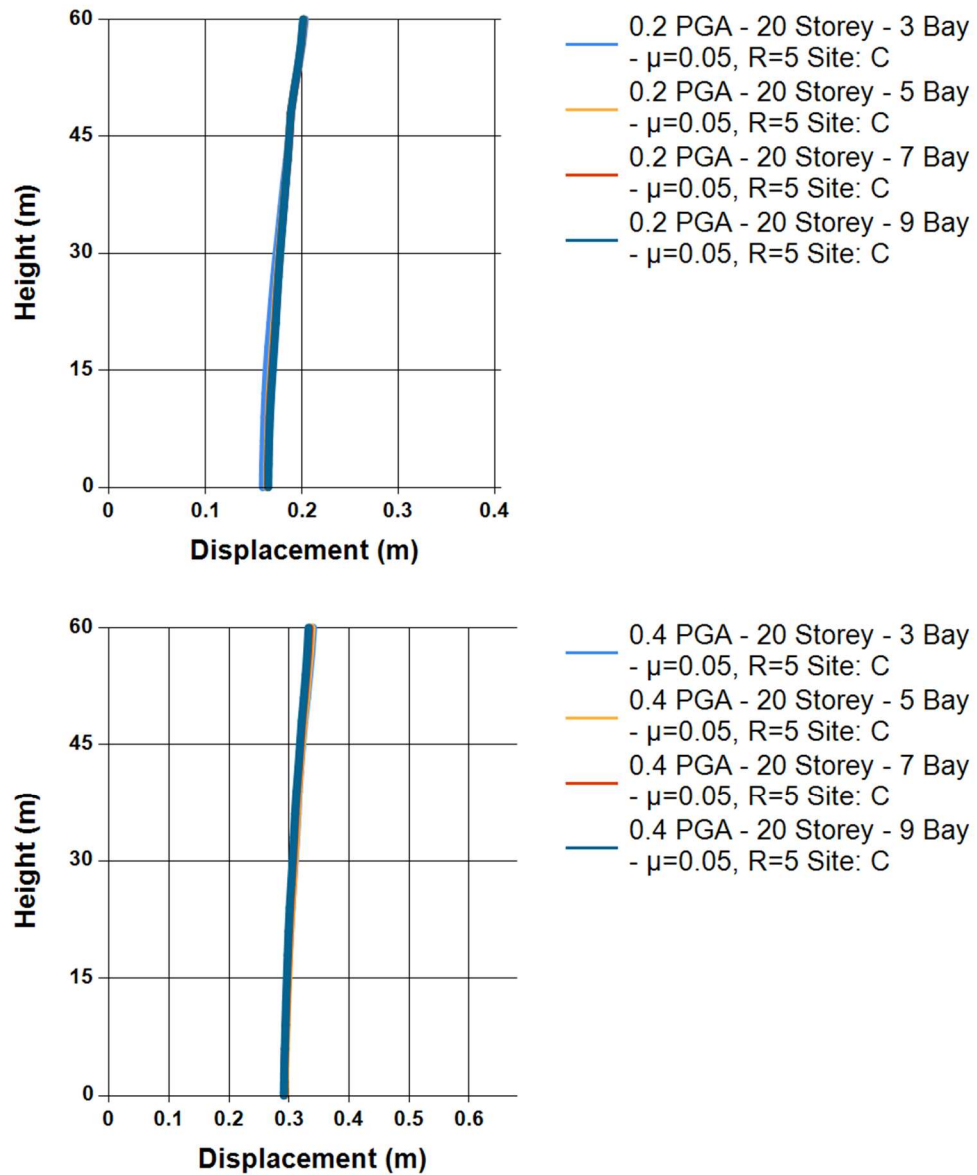


Figure 8.19. Effect of Bay Number on Absolute Displacements for 20 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

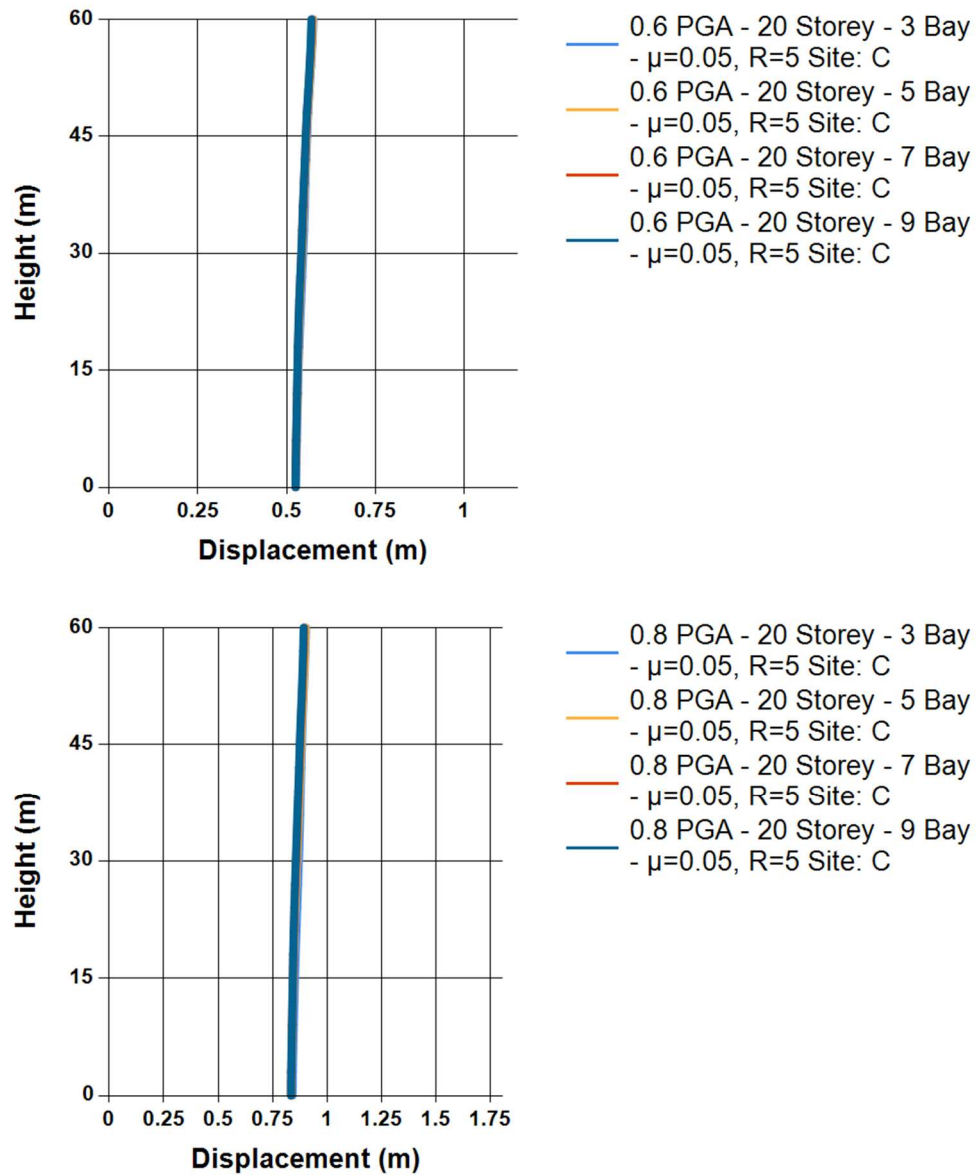


Figure 8.20. Effect of Bay Number on Absolute Displacements for 20 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA Values

D. Results of Sensitivity Analysis – The Effect of Bay Number on Inter-Storey Drift

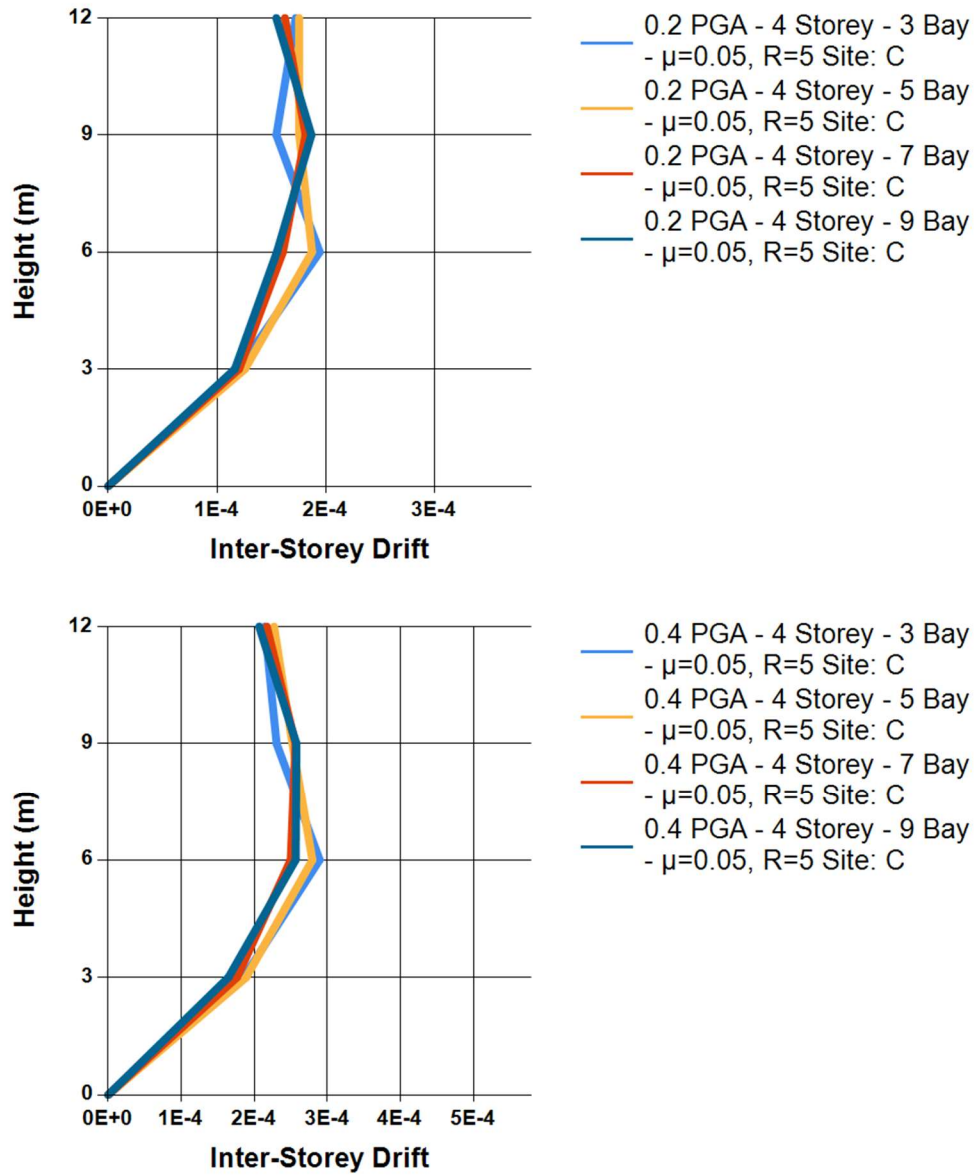


Figure 8.21. Effect of Bay Number on Inter-Storey Drifts for 4 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

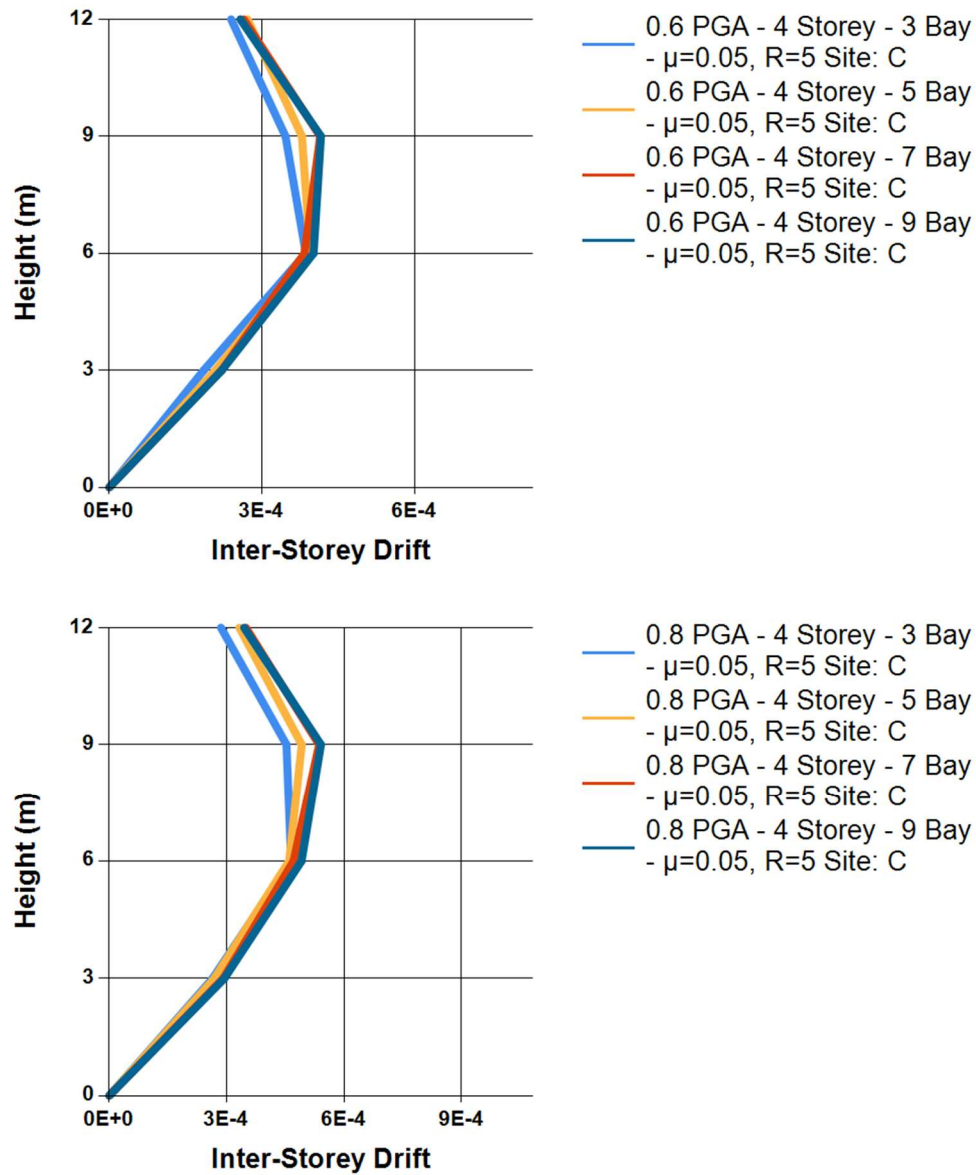


Figure 8.22. Effect of Bay Number on Inter-Storey Drifts for 4 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

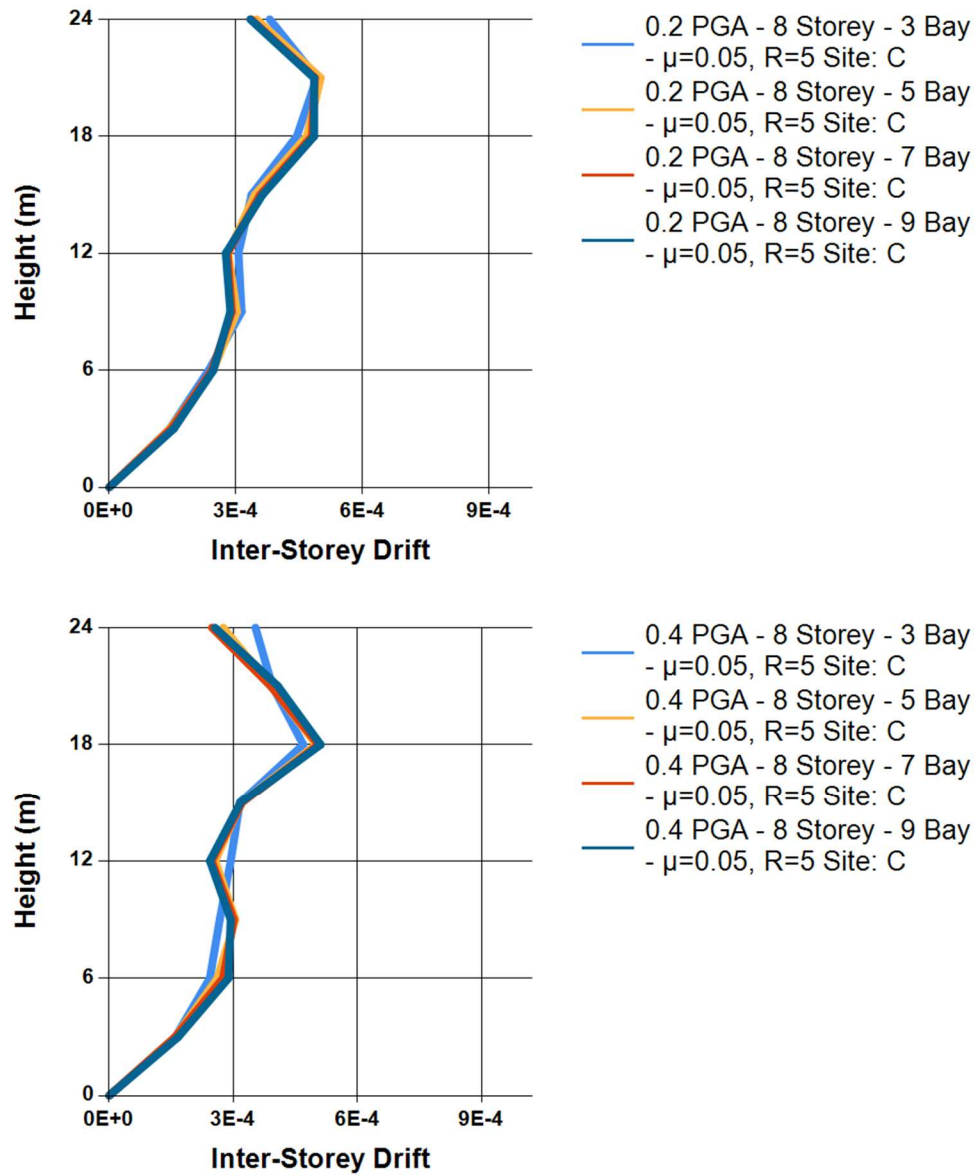


Figure 8.23. Effect of Bay Number on Inter-Storey Drifts for 8 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

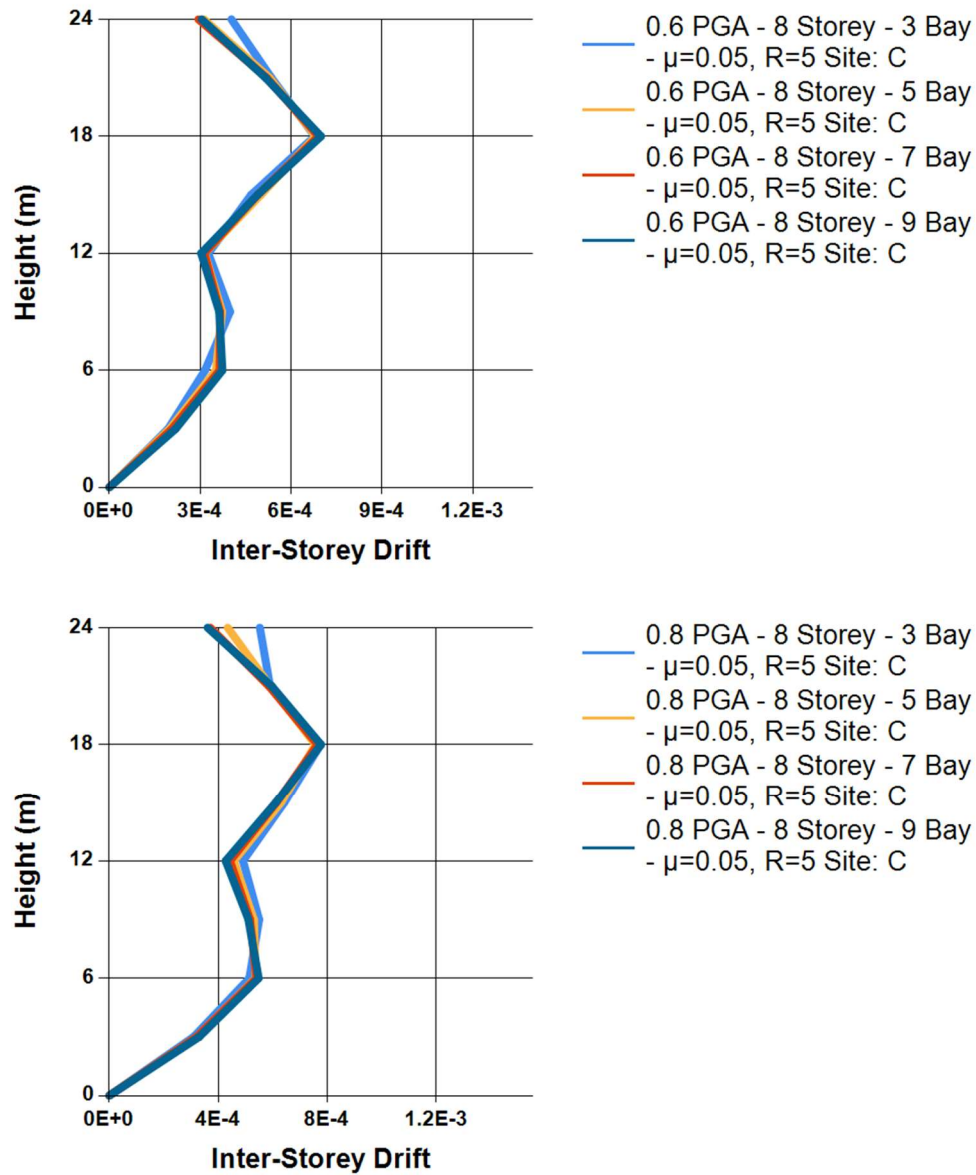


Figure 8.24. Effect of Bay Number on Inter-Storey Drifts for 8 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

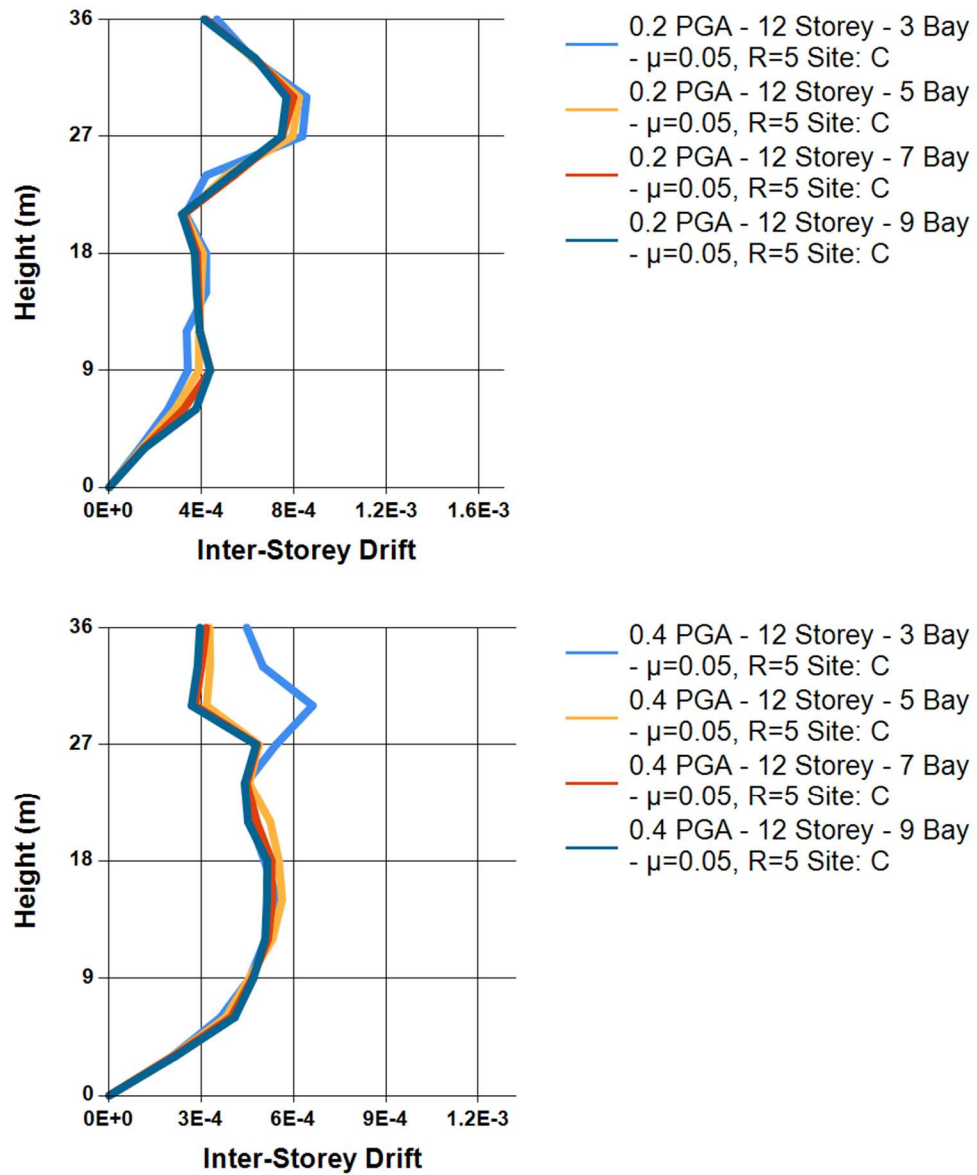


Figure 8.25. Effect of Bay Number on Inter-Storey Drifts for 12 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

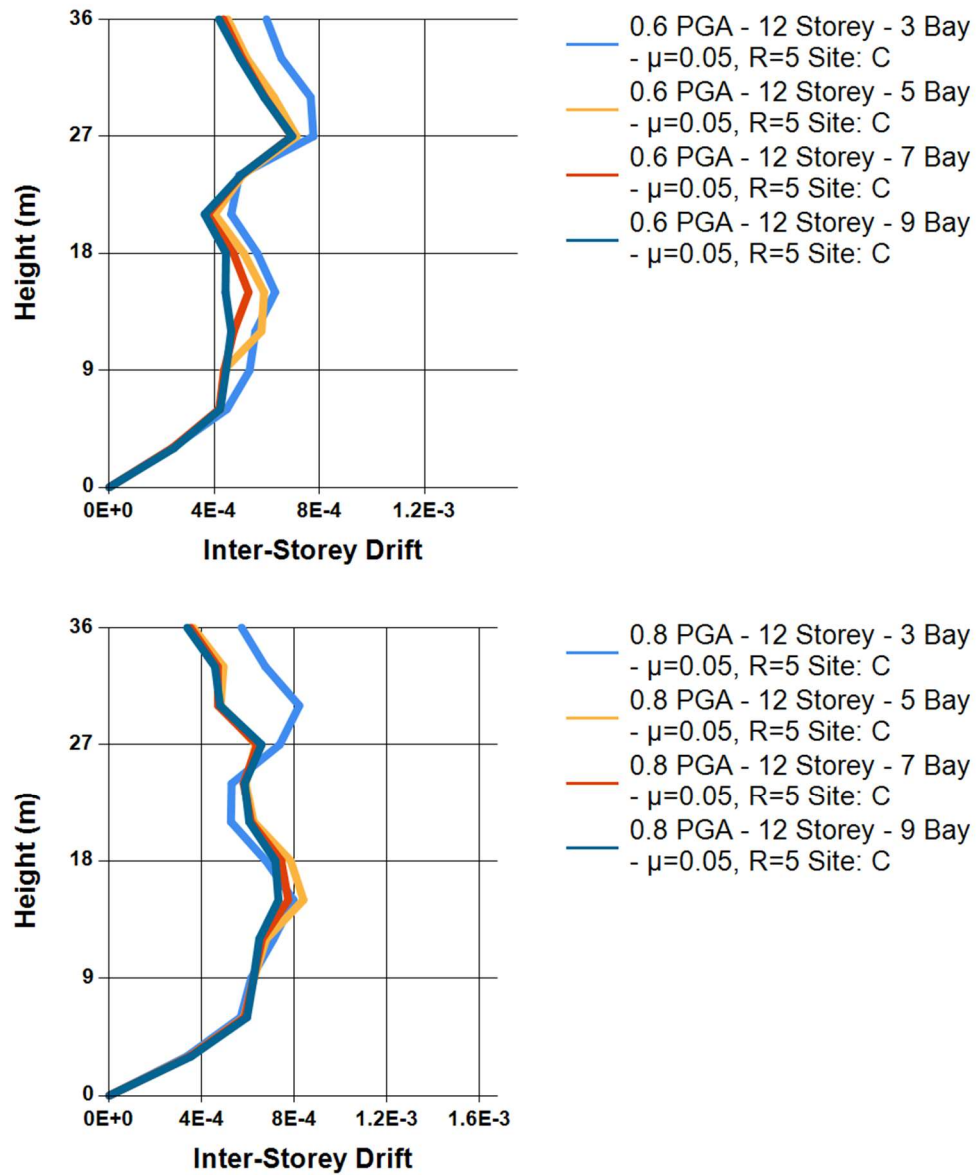


Figure 8.26. Effect of Bay Number on Inter-Storey Drifts for 12 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

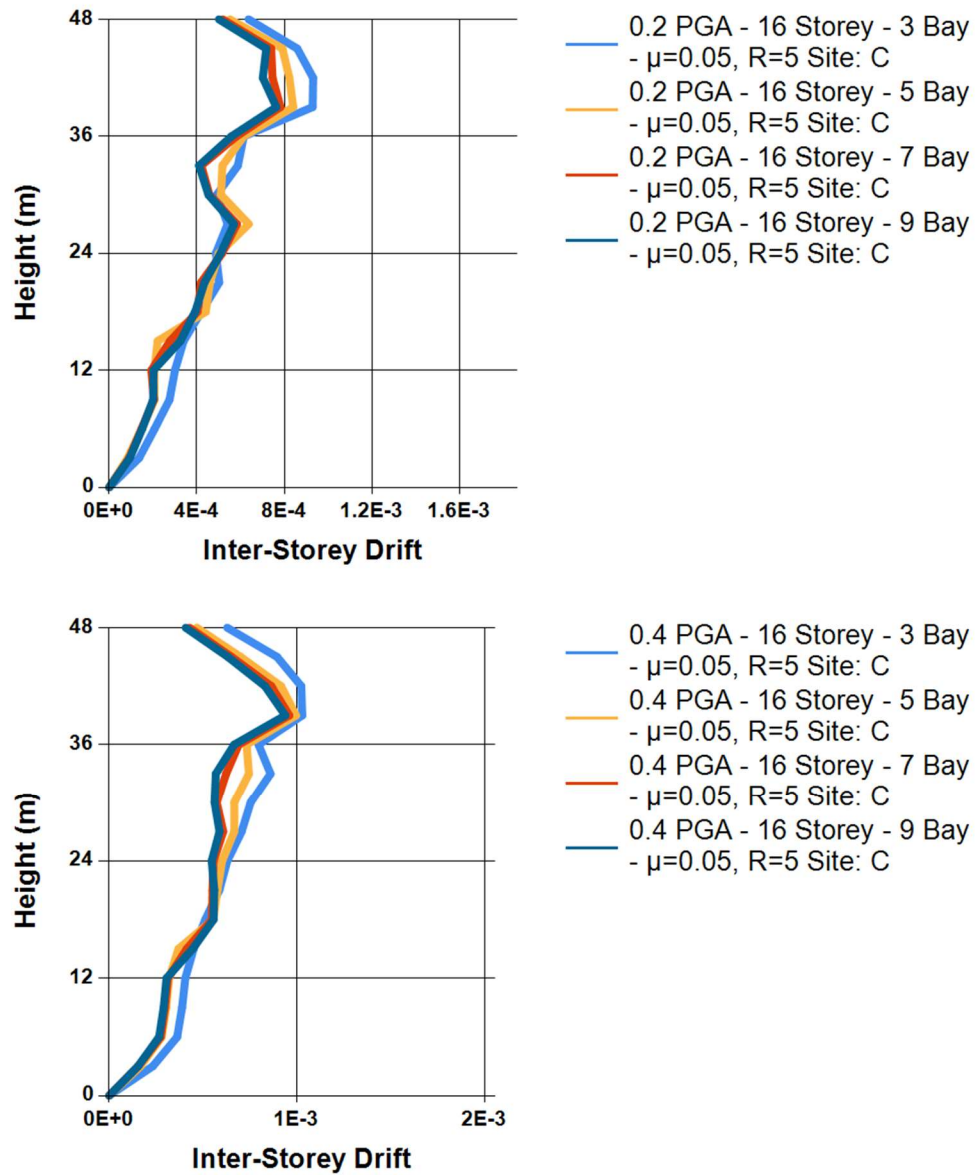


Figure 8.27. Effect of Bay Number on Inter-Storey Drifts for 16 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

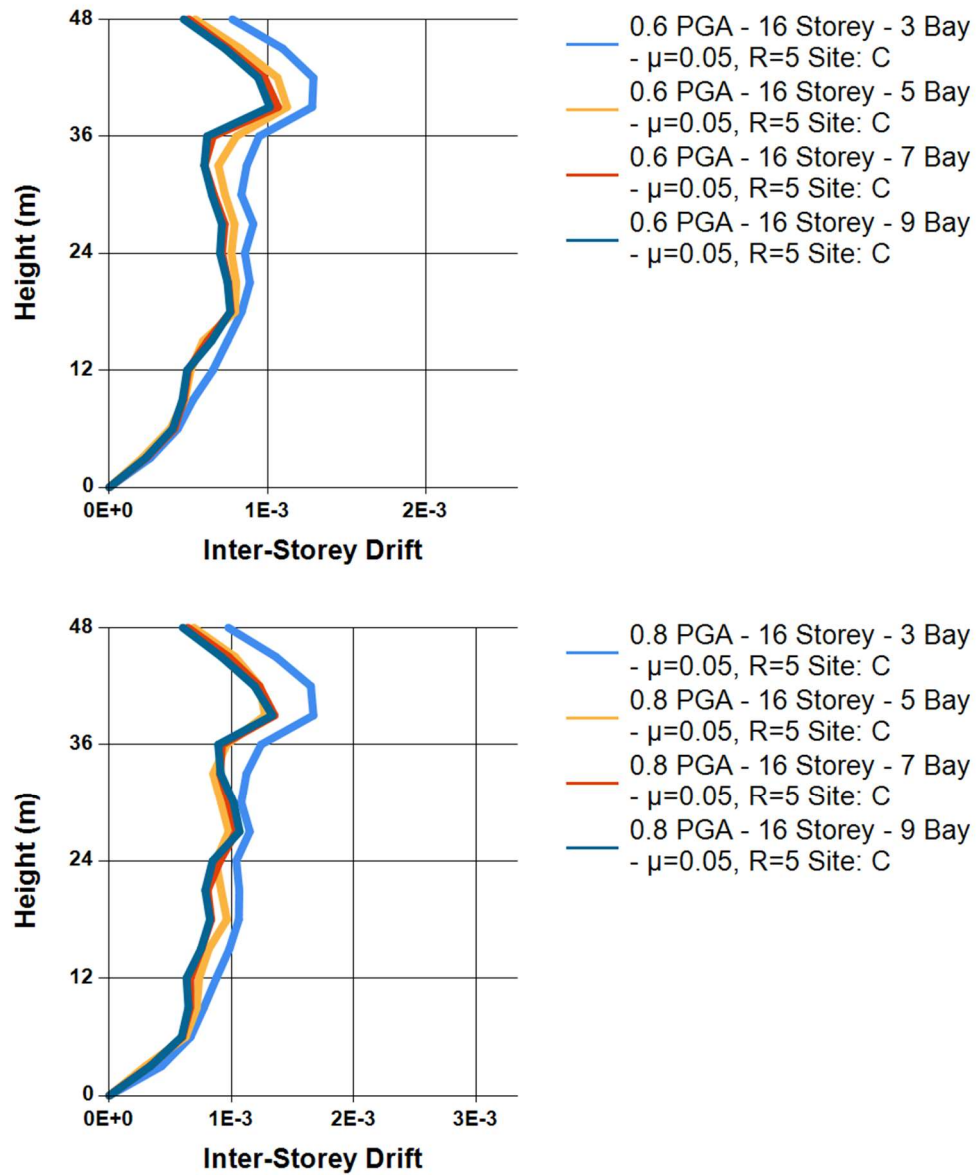


Figure 8.28. Effect of Bay Number on Inter-Storey Drifts for 16 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

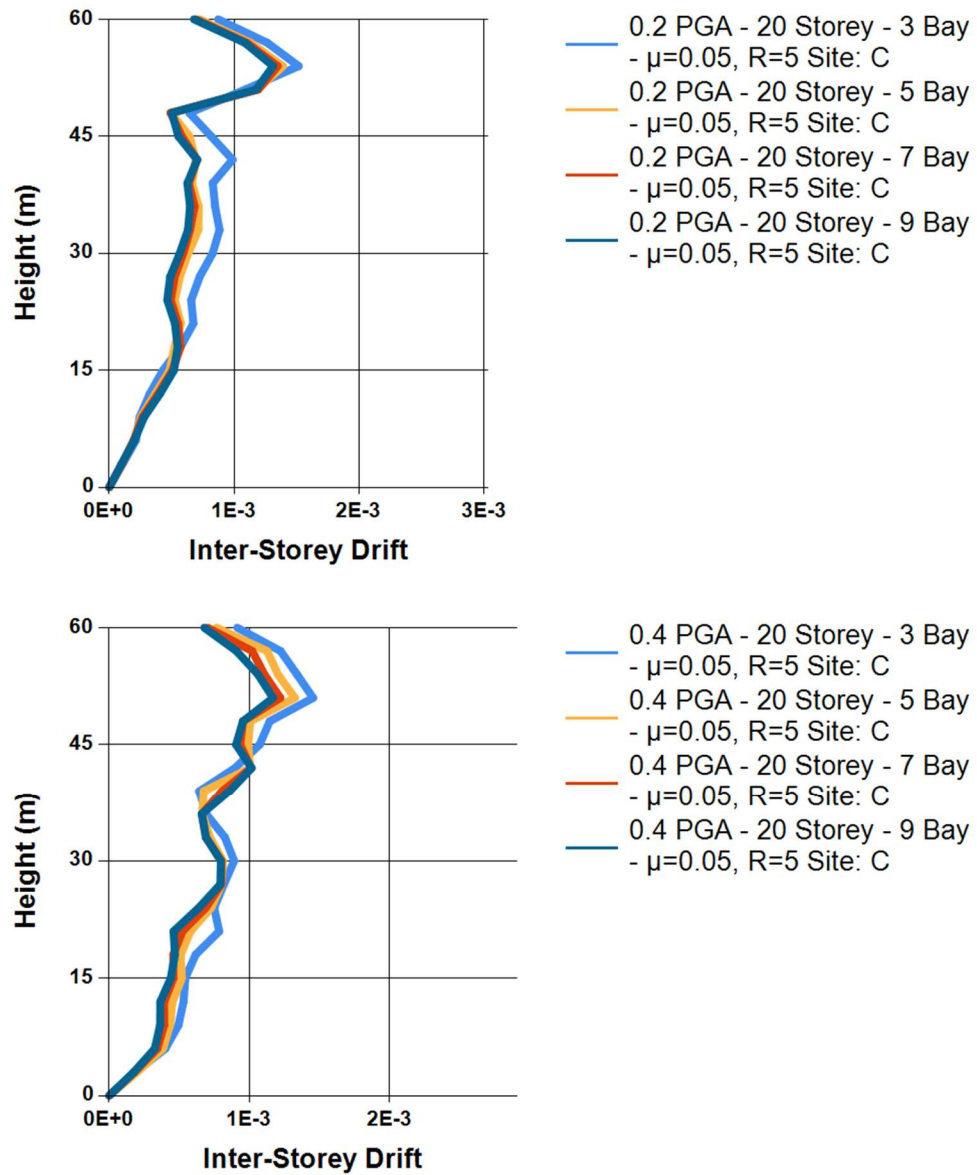


Figure 8.29. Effect of Bay Number on Inter-Storey Drifts for 20 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.2 and 0.4 PGA

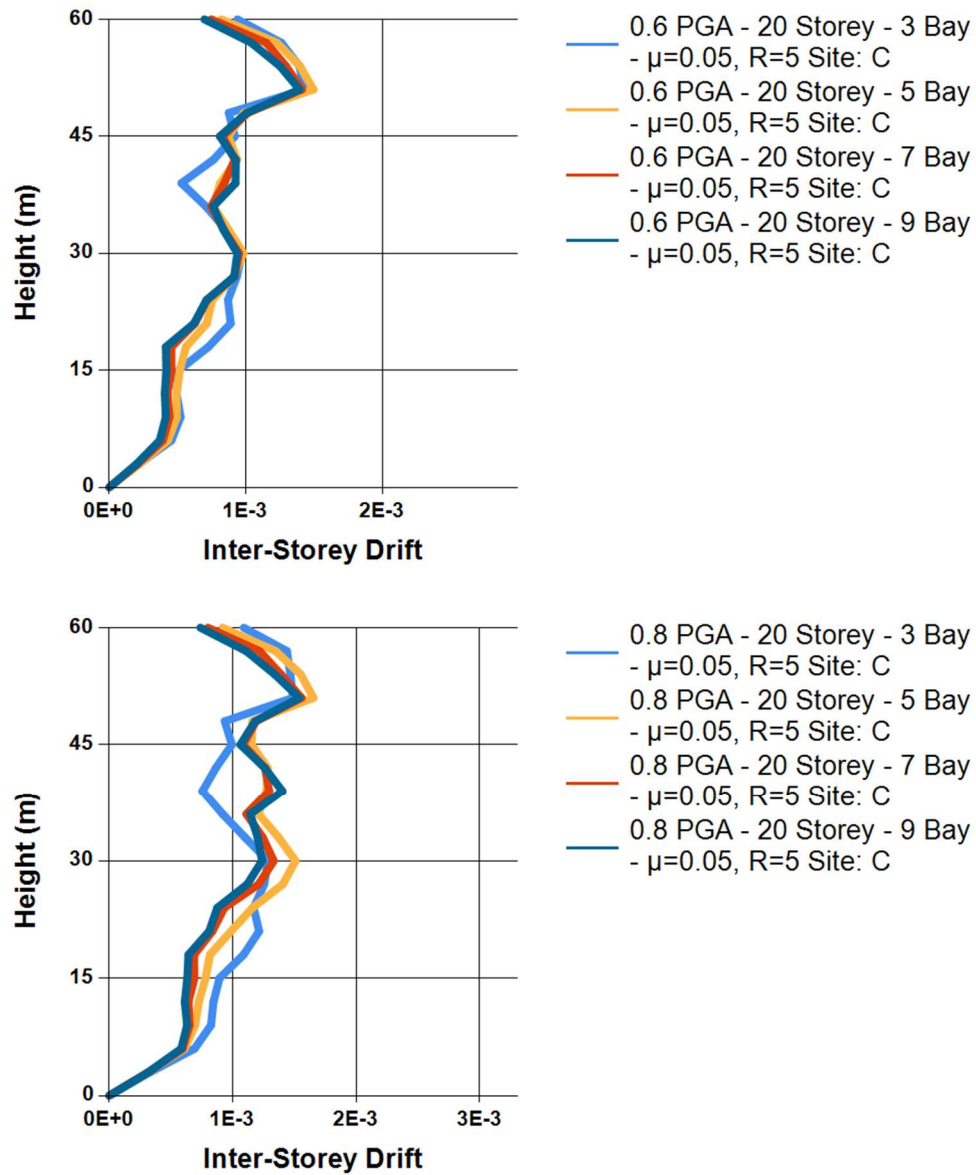


Figure 8.30. Effect of Bay Number on Inter-Storey Drifts for 20 Storey Buildings with Selected Isolator and Soil Site Class Configuration for 0.6 and 0.8 PGA

E. Results of Sensitivity Analysis – The Effect of the Sensitive Equipment Isolation on Acceleration

Table A.3: The Effect of Sensitive Equipment Isolation on Acceleration

Analysis Model Properties			Isolator Properties		Accelerations (g)	
ID	St No	PGA (g)	Q _d (kN)	K _d (kN/m)	Without Isolator	With Isolator
1	8	0.4	0.7	4	0.2469	0.0375
2	8	0.4	0.7	5	0.2470	0.0417
3	8	0.4	0.7	6	0.2471	0.0463
4	8	0.4	0.7	7	0.2470	0.0496
5	8	0.4	0.7	8	0.2469	0.0523
6	8	0.4	1.05	4	0.2466	0.0435
7	8	0.4	1.05	5	0.2466	0.0455
8	8	0.4	1.05	6	0.2466	0.0475
9	8	0.4	1.05	7	0.2465	0.0494
10	8	0.4	1.05	8	0.2465	0.0518
11	8	0.4	1.4	4	0.2464	0.0516
12	8	0.4	1.4	5	0.2463	0.0522
13	8	0.4	1.4	6	0.2463	0.0548
14	8	0.4	1.4	7	0.2463	0.0535
15	8	0.4	1.4	8	0.2463	0.0562
16	12	0.4	0.7	4	0.2879	0.0427
17	12	0.4	0.7	5	0.2880	0.0473
18	12	0.4	0.7	6	0.2879	0.0511
19	12	0.4	0.7	7	0.2880	0.0548
20	12	0.4	0.7	8	0.2879	0.0584
21	12	0.4	1.05	4	0.2879	0.0584
22	12	0.4	1.05	5	0.2879	0.0480
23	12	0.4	1.05	6	0.2880	0.0516
24	12	0.4	1.05	7	0.2879	0.0546
25	12	0.4	1.05	8	0.2879	0.0574
26	12	0.4	1.4	4	0.2879	0.0513
27	12	0.4	1.4	5	0.2879	0.0532
28	12	0.4	1.4	6	0.2879	0.0551
29	12	0.4	1.4	7	0.2880	0.0570
30	12	0.4	1.4	8	0.2879	0.0588
31	16	0.4	0.7	4	0.3014	0.0422

Table A.3 (cont'd)

32	16	0.4	0.7	5	0.3014	0.0471
33	16	0.4	0.7	6	0.3013	0.0512
34	16	0.4	0.7	7	0.3013	0.0553
35	16	0.4	0.7	8	0.3014	0.0596
36	16	0.4	1.05	4	0.3015	0.0445
37	16	0.4	1.05	5	0.3015	0.0478
38	16	0.4	1.05	6	0.3015	0.0514
39	16	0.4	1.05	7	0.3014	0.0551
40	16	0.4	1.05	8	0.3014	0.0581
41	16	0.4	1.4	4	0.3015	0.0502
42	16	0.4	1.4	5	0.3015	0.0525
43	16	0.4	1.4	6	0.3015	0.0545
44	16	0.4	1.4	7	0.3015	0.0563
45	16	0.4	1.4	8	0.3014	0.0582
46	8	0.6	0.7	4	0.3181	0.0534
47	8	0.6	0.7	5	0.3181	0.0599
48	8	0.6	0.7	6	0.3180	0.0656
49	8	0.6	0.7	7	0.3179	0.0704
50	8	0.6	0.7	8	0.3179	0.0756
51	8	0.6	1.05	4	0.3179	0.0536
52	8	0.6	1.05	5	0.3178	0.0572
53	8	0.6	1.05	6	0.3177	0.0613
54	8	0.6	1.05	7	0.3178	0.0644
55	8	0.6	1.05	8	0.3177	0.0674
56	8	0.6	1.4	4	0.3179	0.0591
57	8	0.6	1.4	5	0.3177	0.0603
58	8	0.6	1.4	6	0.3176	0.0624
59	8	0.6	1.4	7	0.3176	0.0645
60	8	0.6	1.4	8	0.3176	0.0665
61	12	0.6	0.7	4	0.3742	0.0625
62	12	0.6	0.7	5	0.3742	0.0699
63	12	0.6	0.7	6	0.3743	0.0755
64	12	0.6	0.7	7	0.3743	0.0817
65	12	0.6	0.7	8	0.3743	0.0867
66	12	0.6	1.05	4	0.3742	0.0576
67	12	0.6	1.05	5	0.3742	0.0630
68	12	0.6	1.05	6	0.3742	0.0682
69	12	0.6	1.05	7	0.3742	0.0719

Table A.3 (cont'd)

70	12	0.6	1.05	8	0.3742	0.0749
71	12	0.6	1.4	4	0.3743	0.0594
72	12	0.6	1.4	5	0.3742	0.0627
73	12	0.6	1.4	6	0.3743	0.0658
74	12	0.6	1.4	7	0.3742	0.0689
75	12	0.6	1.4	8	0.3742	0.0713
76	16	0.6	0.7	4	0.4081	0.0639
77	16	0.6	0.7	5	0.4081	0.0722
78	16	0.6	0.7	6	0.4081	0.0776
79	16	0.6	0.7	7	0.4081	0.0840
80	16	0.6	0.7	8	0.4081	0.0899
81	16	0.6	1.05	4	0.4081	0.0578
82	16	0.6	1.05	5	0.4081	0.0644
83	16	0.6	1.05	6	0.4081	0.0701
84	16	0.6	1.05	7	0.4081	0.0750
85	16	0.6	1.05	8	0.4081	0.0793
86	16	0.6	1.4	4	0.4080	0.0598
87	16	0.6	1.4	5	0.4081	0.0641
88	16	0.6	1.4	6	0.4081	0.0677
89	16	0.6	1.4	7	0.4081	0.0710
90	16	0.6	1.4	8	0.4081	0.0743

F. Results of Parametric Study – Feasibility Assessment Results

Table A.4: Feasibility Assessment Results for 0.2 PGA

Analysis ID	Label	UPL	DR	ONC	OWC
1	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	✓	✓
2	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	✓	✓
3	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	✓	✓
4	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	✓
5	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	✓
6	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	✓
7	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	✓	✓
8	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	✓
9	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	✓
10	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
11	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
12	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
13	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	✓	✓
14	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	✓
15	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	✓
16	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
17	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
18	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
19	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	✓	✓
20	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	✓	✓
21	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	✓
22	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	✓
23	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
24	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
25	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	✓	✓
26	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	✓
27	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
28	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
29	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
30	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
31	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	✓	✓
32	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	✓	✓
33	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	✓

Table A.4 (cont'd)

34	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	✓
35	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	✓
36	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	X
37	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	✓	✓
38	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	✓
39	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	✓
40	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
41	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
42	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
43	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	✓	✓
44	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	✓	✓
45	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	✓
46	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
47	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
48	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
49	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	✓	✓
50	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	✓	✓
51	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	✓
52	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
53	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
54	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
55	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	✓	✓
56	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	✓
57	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
58	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
59	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
60	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
61	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	✓	✓
62	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	✓	✓
63	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	✓
64	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	✓
65	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	✓
66	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
67	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	✓	✓
68	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	✓
69	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	✓
70	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X

Table A.4 (cont'd)

71	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
72	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
73	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	✓	✓
74	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	✓
75	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	✓
76	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
77	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
78	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
79	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	✓	✓
80	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	✓	✓
81	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	✓
82	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
83	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
84	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
85	0.2 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	✓	✓
86	0.2 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	✓
87	0.2 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
88	0.2 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
89	0.2 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
90	0.2 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X

Table A.5: Feasibility Assessment Results for 0.4 PGA

Analysis ID	Label	UPL	DR	ONC	OWC
1	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	✓	✓
2	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	✓	✓
3	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	✓
4	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
5	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
6	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
7	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	✓	✓
8	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
9	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
10	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
11	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
12	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
13	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	✓	✓
14	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	✓
15	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
16	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
17	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
18	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
19	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	✓	✓
20	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	✓
21	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
22	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
23	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
24	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
25	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	✓
26	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
27	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
28	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
29	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
30	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
31	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	✓	✓
32	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	✓	✓
33	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	✓
34	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	X
35	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	X
36	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	X

Table A.5 (cont'd)

37	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	✓
38	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	✓
39	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
40	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
41	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
42	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
43	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	✓	✓
44	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	✓
45	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
46	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
47	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
48	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
49	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	✓	✓
50	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	✓
51	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
52	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
53	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
54	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
55	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	✓
56	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
57	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
58	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
59	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
60	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
61	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	✓	✓
62	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	✓
63	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	✓
64	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
65	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
66	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
67	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	✓	✓
68	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	✓
69	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
70	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
71	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
72	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
73	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	✓	✓

Table A.5 (cont'd)

74	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	✓
75	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
76	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
77	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
78	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
79	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	✓	✓
80	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	✓
81	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
82	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
83	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
84	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
85	0.4 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	✓	✓
86	0.4 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	✓
87	0.4 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
88	0.4 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
89	0.4 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
90	0.4 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X

Table A.6: Feasibility Assessment Results for 0.6 PGA

Analysis ID	Label	UPL	DR	ONC	OWC
1	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	✓	✓
2	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	✓
3	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
4	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
5	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
6	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
7	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	✓
8	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
9	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
10	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
11	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
12	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
13	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	✓
14	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
15	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
16	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
17	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
18	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
19	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	✓	✓
20	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
21	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
22	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
23	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
24	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
25	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	✓
26	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
27	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
28	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
29	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
30	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
31	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	✓	✓
32	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	✓
33	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	X
34	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	X
35	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	X
36	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	X	✓	X	X

Table A.6 (cont'd)

37	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	✓
38	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
39	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
40	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
41	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
42	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
43	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	✓
44	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
45	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
46	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
47	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
48	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
49	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	✓
50	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	✓
51	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
52	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
53	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
54	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
55	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	✓
56	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
57	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
58	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
59	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
60	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
61	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	✓	✓
62	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	✓
63	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
64	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
65	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
66	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
67	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	✓
68	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
69	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
70	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
71	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
72	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	X	✓	X	X
73	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	✓

Table A.6 (cont'd)

74	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	✓
75	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
76	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
77	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
78	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
79	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	✓	✓
80	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
81	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
82	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
83	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
84	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
85	0.6 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	✓
86	0.6 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
87	0.6 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
88	0.6 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
89	0.6 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
90	0.6 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X

Table A.7: Feasibility Assessment Results for 0.8 PGA

Analysis ID	Label	UPL	DR	ONC	OWC
1	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	✓	✓
2	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
3	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
4	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
5	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
6	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: B	✓	✓	X	X
7	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	✓
8	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
9	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
10	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
11	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
12	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: B	✓	✓	X	X
13	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	✓
14	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
15	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
16	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
17	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
18	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: B	✓	✓	X	X
19	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	✓	✓
20	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
21	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
22	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
23	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
24	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: B	✓	✓	X	X
25	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	✓
26	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
27	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
28	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
29	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
30	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: B	✓	✓	X	X
31	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	✓	✓
32	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	✓
33	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	X
34	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	X
35	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	✓	✓	X	X
36	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: C	X	✓	X	X

Table A.7 (cont'd)

37	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	✓
38	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
39	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
40	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
41	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
42	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: C	✓	✓	X	X
43	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	✓
44	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
45	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
46	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
47	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
48	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: C	✓	✓	X	X
49	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	✓
50	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
51	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
52	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
53	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
54	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: C	✓	✓	X	X
55	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	✓
56	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
57	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
58	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
59	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
60	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: C	✓	✓	X	X
61	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	✓
62	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
63	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
64	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
65	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	✓	✓	X	X
66	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.03$, R=5 Site: D	X	✓	X	X
67	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	✓
68	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
69	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
70	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	✓	✓	X	X
71	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	X	✓	X	X
72	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=3 Site: D	X	✓	X	X
73	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	✓

Table A.7 (cont'd)

74	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
75	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
76	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
77	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
78	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=5 Site: D	✓	✓	X	X
79	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	✓
80	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
81	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
82	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
83	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
84	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.05$, R=7 Site: D	✓	✓	X	X
85	0.8 PGA - 2 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	✓
86	0.8 PGA - 4 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
87	0.8 PGA - 8 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
88	0.8 PGA - 12 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
89	0.8 PGA - 16 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	✓	✓	X	X
90	0.8 PGA - 20 Storey - 3 Bay - $\mu=0.07$, R=5 Site: D	X	✓	X	X