

SEISMIC PERFORMANCE EVALUATION OF REINFORCED CONCRETE
STRUCTURES CONSIDERING THE INFLUENCE OF VARIATION OF GROUND
MOTION



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Furkan Zeki Gürsan

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MOTION

APPROVED BY:

Assist. Prof. Dr. Özden Saygılı
(Thesis Supervisor)
(Yeditepe University)

Prof. Dr. Nesrin Yardımcı Tiryakioğlu
(Yeditepe University)

Assist. Prof. Dr. Adlen Altunbaş
(Medipol University)

DATE OF APPROVAL:/....../2021

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Name, Last name: Furkan Zeki Gürsan

Signature:

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ABSTRACT

SEISMIC PERFORMANCE EVALUATION OF REINFORCED CONCRETE STRUCTURES CONSIDERING THE INFLUENCE OF VARIATION OF GROUND MOTION

Turkey is a seismically active region that has suffered significant damages from past earthquakes. The aim of this study is to evaluate the structural performance of reinforced concrete structures according to the Turkish Building Seismic Code 2018 using different ground motion data sets. In this study, the seismic behavior of an existing reinforced concrete structure located in the east of Turkey is evaluated. The case study of the existing reinforced concrete structure is used as an exhibition center. According to the Turkish Building Seismic Code 2018, the structure is considered as a “Building where people are short-term and concentrated”. According to the Turkish Building Seismic Code 2018, the existing bearing system should provide the Controlled Damage (KH) performance level, which is considered as a minimum performance level determined, under the expected earthquake loads. The non-linear structural performance of the reinforced concrete structure is evaluated under simulated, artificial, synthetic and real excitations in accordance with the ground motion level given in the Turkish Building Seismic Code 2018. Earthquake ground motion level with a return period of 475 years and a probability of exceeding 10 percent in 50 years is used. Damage distributions, base shear forces and relative floor displacements are discussed considering the influence of variation of ground motion.

ÖZET

FARKLI DEPREM YER HAREKETİ SETLERİ ETKİSİ ALTINDA BETONARME YAPILARIN DEPREM PERFORMANSININ DEĞERLENDİRİLMESİ

Türkiye, geçmiş depremlerden önemli ölçüde zarar görmüş, sismik olarak aktif bir bölgedir. Bu çalışma, Türkiye Bina Deprem Yönetmeliği 2018'e göre betonarme yapıların farklı deprem kayıt setleri etkisi altında yapısal performansını değerlendirmeyi amaçlamaktadır. Bu çalışmada, Türkiye'nin doğusunda bulunan mevcut bir betonarme yapının deprem yükleri etkisi altındaki davranışı incelenmiştir. İncelemeye esas olan mevcut yapının döşeme sistemi kirişli plak olup deprem yüklerinin tamamı betonarme çerçeveler ile karşılanmaktadır. Mevcut yapı fuar merkezi olarak kullanılmaktadır. Türkiye Bina Deprem Yönetmeliği 2018'e göre "İnsanların kısa süreli ve yoğun olarak bulunduğu binalar" kategorisindedir. Olası deprem yükleri etkisinde mevcut taşıyıcı sistemin Türkiye Bina Deprem Yönetmeliği'nde belirlenen minimum performans seviyesi olan Kontrollü Hasar performans seviyesini sağlaması gerekmektedir. Betonarme yapının yapısal davranışı, Türkiye Bina Deprem Yönetmeliği 2018'de verilen yer hareketi seviyeleri ile uyumlu yapay, sentetik ve gerçek depremler altında simule edilerek, performansı değerlendirilmiştir. Türkiye Bina Deprem Yönetmeliği'nde, 475 yıllık bir geri dönüş periyoduna sahip, 50 yılda aşılma olasılığı yüzde 10 olan DD-2 deprem yer hareketi düzeyi için değerlendirmeler yapılmıştır. Mevcut betonarme yapının yapısal davranışının belirlenmesi için hazırlanan sonlu eleman esaslı hesap modelleri, zaman tanım alanında doğrusal olmayan hesap yöntemi kullanılarak farklı yer hareketi veri setleri için çözülmüştür. Hazırlanan tüm matematiksel modeller; taşıyıcı sistem elemanlarının hasar dağılımları, taban kesme kuvvetleri ve görelî kat ötelemeleri açısından karşılaştırılmıştır.

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LIST OF SYMBOLS/ABBREVIATIONS

AFAD	Disaster and Emergency Management Presidency
AGM	Artificial ground motion
ASCE	American Society of Civil Engineers
ATC	Applied Technology Council
BHB	Visible damage zone
BKS	Building usage class
D/C	Demand/Capacity
d_b	Longitudinal reinforcement diameter
DD-1	Earthquake ground motion level-1
DD-2	Earthquake ground motion level-2
DD-3	Earthquake ground motion level-3
DD-4	Earthquake ground motion level-4
DTS	Seismic design category
EC	The European Committee Standardization
E_c	Concrete modulus of elasticity
EI	Effective stiffness of the uncracked section
EI_e	Effective stiffness of the cracked section
E_s	Rebar modulus of elasticity
EXW	Exponential envelope function
F_1	Local soil effect coefficient for 1.0 period zone
FEMA	Federal Emergency Management
FFSM, FF	Far field synthetic ground motion
F_s	Local soil effect coefficient for short period zone
GB	Collapse zone
GÖ	Collapse prevention
H_N	Building height
I	Building importance factor
İHB	Significant damage zone
KH	Controlled damage
L_p	Plastic hinge length

L_s	Shear span
m	Mass
M_e	Maximum bending moment that the section can meet linearly
M_p	Maximum bending moment
M_y	Effective yield moment
n	Live load participation factor
NEHRP	National Earthquake Hazard Reduction Program
NFSM, NF	Near field synthetic ground motion
P_B	Buckling load
P_{cr}	Critical load
P_G	Collapse load
PEER	Pacific Earthquake Engineering Research Center
PGA	Peak ground acceleration
P_i	Proportionally increasing external loads
P_L	Limit load
P_{L1}	First order limit load
P_{L2}	Second order limit load
$P-\Delta$	Load parameter-displacement relations
R_a	Earthquake load reduction coefficient
RC	Reinforced concrete
SRGM	Scaled real ground motion
S_1	Map acceleration coefficient for a period of 1.0 second
S_{D1}	Design spectral acceleration coefficient for a period of 1.0 second coefficient
S_{DS}	Short period design spectral acceleration coefficient
SGM	Synthetic ground motion
SH	Limited damage
SHB	Limited damage zone
SHW	Saragoni & Hart envelope function
S_s	Short period map spectral acceleration coefficient
T_A, T_B	Spectrum characteristic periods
TBSC	Turkish Building Seismic Code
TEC	Turkish Earthquake Code

w	Weight
ε	Strain
ε_{co}	Strain limit where the plastic deformations begin in concrete
ε_{cu}	Ultimate compression strain in confined concrete
ε_{su}	Ultimate rebar strain
$\varepsilon_c^{(SH)}$	Confined concrete strain allowed for limited damage performance level
$\varepsilon_c^{(KH)}$	Confined concrete strain allowed for controlled damage performance level
$\varepsilon_c^{(G\ddot{O})}$	Confined concrete strain allowed for collapse prevention performance level
θ_p	Plastic rotation demand
θ_y	Displaced axis rotation for yield condition
$\theta_p^{(SH)}$	Plastic rotation demand for limited damage
$\theta_p^{(KH)}$	Plastic rotation demand for controlled damage
$\theta_p^{(G\ddot{O})}$	Plastic rotation demand for collapse prevention
$\sigma\text{-}\varepsilon$	Stress-Strain relations
φ_p	Plastic rotation
φ_{pmax}	Rotational capacity

1. INTRODUCTION

1.1. GLOBAL CONTEXT

In recent years, numerous lives and property losses have occurred in human life because of the structures affected by earthquakes. There have been significant earthquakes in Turkey and many other countries. Specifically, serious damage and numerous losses occurred after the earthquakes of Erzincan in 1992, Marmara and Duzce in 1999 and Van in 2011 in Turkey, Kobe in 1995 in Japan, Loma Prieta in 1989 and Northridge in 1994 in United States of America. [1]

Within the introduction of performance-based design and evaluation approach in recent years, studies on calculation methods that take into account non-linear behavior of structures have become more important. In the performance-based design and evaluation approach, it is foreseen to determine the plastic deformation demand of the structure under the earthquake loads and to control the damage level of structural elements by considering this demand. Thus, under the influence of different earthquakes, a building with the targeted performance level can be designed or the performance level of existing building can be evaluated. [2]

1.2. OUTLINE OF THESIS

The purpose of this study is to apply the Nonlinear Calculation Time History Method and evaluate the numerical results obtained under the effect of different earthquake data sets of an existing reinforced concrete building located in the city of Van.

The stages to be followed in the study are listed as follows.

- i. Influence of design and material parameters in the static and dynamic analysis of reinforce concrete structures Review of performance-based design and evaluation methods according to TBSC-2018.
- ii. Seismic hazard analysis and preparation of strong ground motion data sets.
- iii. Numerical modelling and Non-linear time history analysis
- iv. Determination of cross-sectional damage zones, relative story drifts and base shear forces

- v. Seismic response evaluation considering the influence of artificial, synthetic near and far field ground motion and scaled real ground motion
- vi. Explanation of research findings.

1.3. LITERATURE REVIEW

Structural design and evaluation concept on the basis of performance criteria based on deformation and displacement was introduced and developed during the studies of more realistic determination of the earthquake performances of existing structures in the earthquake zones of the United States and the retrofitting of structures that are not sufficiently safe.

The major damage caused by the 1989 Loma Prieta and 1994 Northridge earthquakes in the state of California of the United States of America has revealed the need to develop methods based on more realistic performance criteria based on deformation and displacement as an alternative to performance criteria predicting a sufficient strength under the influence of earthquakes. To meet this requirement, Guidelines and Commentary for Seismic Rehabilitation of Buildings- ATC 40 by the Applied Technology Council (ATC), NEHRP Guidelines for Seismic Rehabilitation of Building- FEMA 273,274 report by Federal Emergency Management (FEMA) and FEMA 356 pre-standard by the American Society of Civil Engineers (ASCE) has been prepared. [40, 41, 42] The ATC 55 project was initiated in order to examine and develop the results of the researches conducted and the FEMA 440 report containing the findings of the project was published. [43] This research and the results of the studies are included in the ASCE 41-06 standard. [46] On the other hand in Europe, in the Design of Structures for Earthquake Resistance – Assessment and Retrofitting of Buildings Eurocode 8-3 standard, which is among the European Union standards, there are approaches including the results of researches to determine the earthquake performance of existing structures. [4, 44]

In Turkey, performance-based seismic design or damage assessment of RC structures are an active research subject especially since 2007 earthquake regulation (TEC-2007). [45] Turkish Building Seismic Code has been revised and has officially come into force since 1 January 2019. The regulation brings important changes to the seismic hazard map prepared by Ministry of Interior Disaster and Emergency Management Presidency (AFAD), which is

used throughout the country, and also includes important changes in the structural modelling and analysis of new buildings, the definition of earthquake performance targets and the evaluation of the earthquake performance of existing buildings.



2. THEORICAL PRINCIPLES OF PERFORMANCED BASED SEISMIC ENGINEERING (STATIC AND DYNAMIC NON-LINEAR ANALYSIS)

2.1. NON-LINEAR BEHAVIOR OF STRUCTURAL ELEMENTS

Structural design is the methodical analysis of a structure's stability, strength, and rigidity. The fundamental goal of structural analysis and design is to create a system that can withstand all loads imposed in its expected lifetime without loss. Except for certain special circumstances, structural systems usually show linear behavior under service loads. Systems other than this generalization are slender structures, systems resting on elastic ground and structures containing regional weaknesses and stability deficiencies. [4]

In the analysis methods based on linear system behavior, the stress-strain relations of the material are taken as linear-elastic and the displacements are assumed to be very small. On the other hand, as the external impacts reaches the ultimate load carrying capacity of the structure by exceeding the service load limit, the stresses exceed the linear-elastic limit and the corresponding displacements are not very small that cannot be neglected. [4]

Considering the bearing capacity of building materials beyond the linear-elastic boundary and taking into account the effects of not too small displacements on the equilibrium equations and, where necessary, on geometric conformity conditions, it is possible to closely monitor the behavior of building systems under external effects. This allows for more realistic and cost-effective options to be obtained. [4]

Generally, there are two situations in the development and application of calculation methods based on the non-linear behavior of the system. The first is the determination of the factors that cause the structure system to be nonlinear, and the creation of a numerical model that represents the system behavior in a realistic way, and the other is the effective solution of the nonlinear equation system obtained as a result of the analysis of this numerical model. [4]

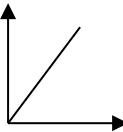
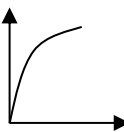
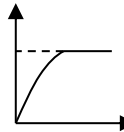
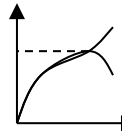
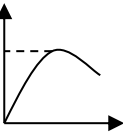
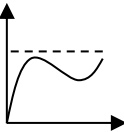
2.1.1. Structural Nonlinearity

The non-linear behavior of a structural system under external loads is generally due to two main reasons. [4]

- 1) Material is not linear-elastic, the internal force-deformation relations (constitutive laws) are not linear,
- 2) Nonlinear equilibrium equations (and in some cases geometric continuity equations) due to changes in geometry.

The factors that cause nonlinear structural systems and the theories that take these factors into account are summarized in Table 2.1. [4]

Table 2.1. Causes of non-linearity of structural systems

Conditions Required by the Solution	Linear Systems	Nonlinear Systems				
		Material Nonlinearity (1)	Geometric Nonlinearity (2)		Geometric and material nonlinearity (1+2)	
			Second Order Theory	Finite Displacement Theory	Second Order Theory	Finite Displacement Theory
Constitutive laws (Stress-strain relations)	Linear Elastic	Non- Linear Elastic	Linear Elastic	Linear Elastic	Non-linear Elastic	Non-linear Elastic
Displacement in Equilibrium Equations	Small	Small	Not Small	Not Small	Not Small	Not Small
Displacements in Geometric Conformity Conditions	Small	Small	Small	Not Small	Small	Not Small
P- δ						

2.1.2. Non-Linear Behavior of Structural Systems Under External Loads

The load parameter - displacement ($P-\Delta$) relations obtained by calculating a structural system under the effect of vertical and horizontal loads according to linear and nonlinear theories are shown schematically in Figure 2.1. [4]

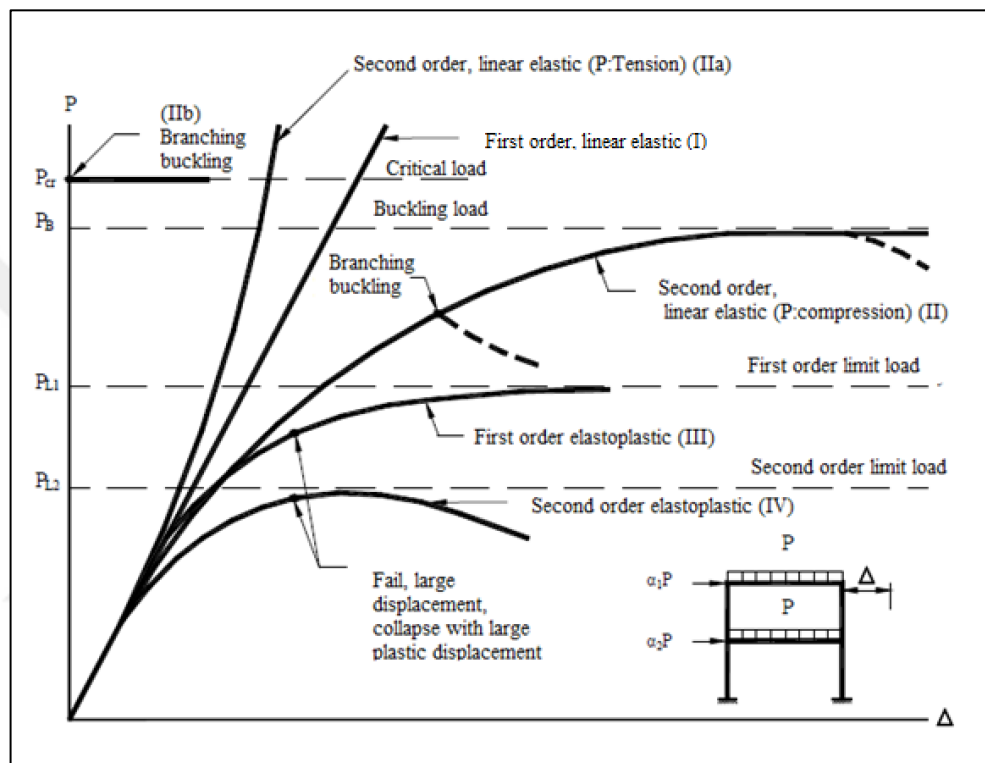


Figure 2.1. Load parameter-displacement ($P-\Delta$) relations obtained according to various theories [4]

2.2. FORMULATIONS AND SOLUTION PROCEDURES FOR MATERIAL NONLINEAR STRUCTURAL ANALYSIS

The calculation of nonlinear reinforced concrete systems in terms of material is examined with the assumption that nonlinear deformations are spread over the system and collected in certain sections called plastic cross sections.

2.2.1. Distributed Non-Linearity Models

Considering that nonlinear deformations distributed over the system in nonlinear structure systems in terms of materials, successive approximation methods or load increment methods can be used to determine the load parameter-displacement relations (capacity curves) and to calculate the collapse loads. [4]

2.2.2. Concentrated Non-Linearity Models

It can be assumed that nonlinear deformations are concentrated in certain sections called plastic hinges (or plastic section in general), and other parts of the system behave linear-elastic in structural systems that are not linear in terms of material and exhibit adequate ductile behavior. [4]

Plastic Hinge Hypothesis

In systems where the ductility ratio defined as the ratio of total deformations to linear deformations is large and nonlinear deformations are spread over a small region, it can be assumed that nonlinear bending deformations are concentrated in certain sections called plastic hinges, and the system behaves linear-elastic in other regions. This hypothesis is called the plastic hinge (plastic section) hypothesis. [4]

Real bending moment - curvature relation, the bending moment diagram of a certain region of a plane frame element given in Figure 2.2, total bending shape changes and nonlinear changes are shown in Figure 2.3. [4]

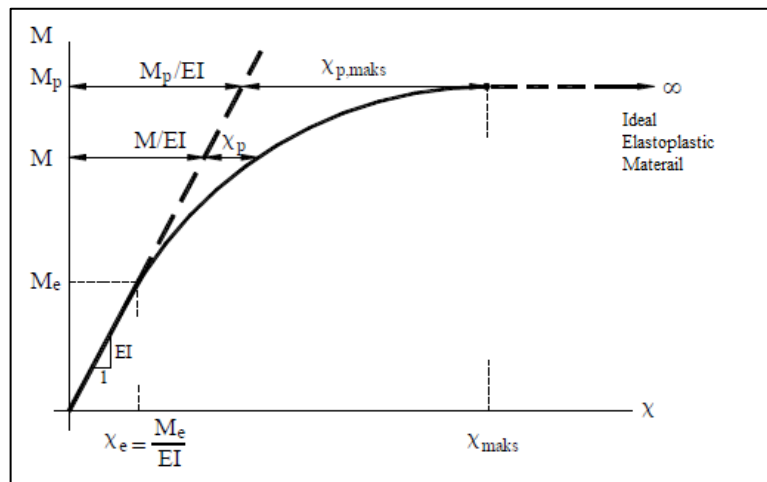


Figure 2.2. Moment-curvature diagram

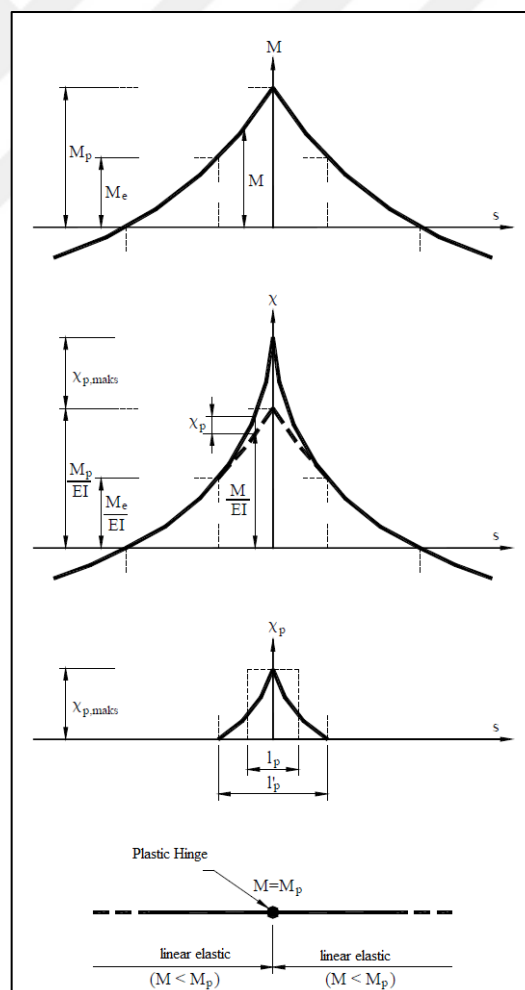


Figure 2.3. Nonlinear deformations

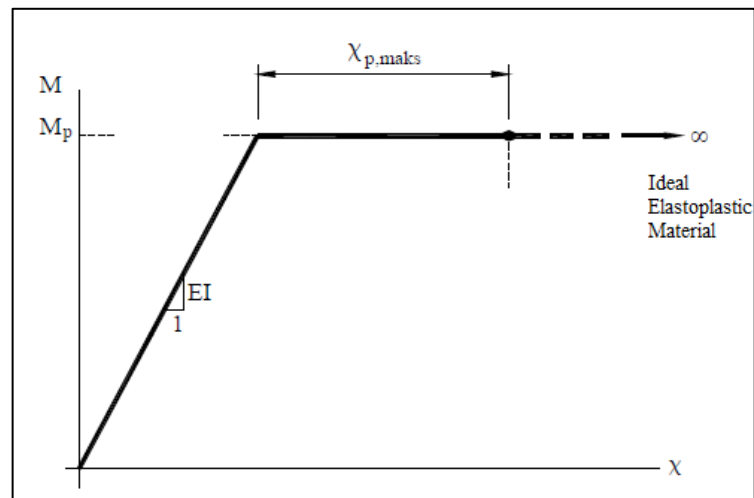


Figure 2.4. Idealized moment-curvature diagram

Under increasing external loads, when the rotation of the plastic hinges reaches a limit value called rotational capacity, the cross section may become unusable due to the large plastic deformations that occur. If the rotations of plastic hinges in one or more sections of the building system reach their rotational capacity, they cause the entire structure to become unusable (out of operation), in other words, to collapse.

Rotational capacity in reinforced concrete building systems depends on various factors, some of which are listed below:

- i. limit unit length changes (ϵ_{cu} and ϵ_{su}) that determine σ - ϵ diagrams of concrete and reinforcement steel,
- ii. the amount, shape and placement of the confinement reinforcement that affects the unit length change of the concrete (ϵ_{cu}),
- iii. Cross-sectional dimensions influencing the length of the plastic zone,
- iv. The shape of the moment diagram,
- v. normal force acting on the cross section.

Furthermore, in performance-based design and evaluation methods, the expected level of performance of the building is also a factor that determines rotational capacity.

In summary, the plastic hinge hypothesis is explained as following;

- a) When the bending moment (M) in a section increases and becomes equal to the plastic moment (M_p), a plastic hinge is formed at that section. Then, the bending moment ($M = M_p$) in the section remains constant and the section rotates freely. Thus, the bending moment in the cross section is kept constant at $M = M_p$. When the plastic rotation (ϕ_p) in the plastic joint increases and reaches the rotational capacity ($\max \phi_p$), power depletion occurs in the cross section.
- b) The system behaves linear-elastic between plastic hinges.
- c) In plane systems, if the normal force affects the cross section with the bending moment, instead of the plastic moment (M_p), the reduced plastic moment (M_p) value obtained from the yield condition depending on the normal force N in the section is used. [4]

2.3. BEHAVIOR OF BUILDINGS UNDER EARTHQUAKE LOADS

The earthquake, which is one of the force effects on the construction system, causes the formation of inertia forces proportional to the mass of the building and therefore strains in the structures. The basic principle of earthquake resistant building design is that the structure can meet frequent small-intensity earthquakes within elastic limits, moderate earthquakes with repairable damages in the bearing system beyond the elastic limits, and very rare and severe earthquakes with major damage but without complete collapse and loss of life. In buildings designed with this understanding, earthquake forces that may affect the building in a severe earthquake are reduced and applied. The reduction made depends on the ductility of the structure and the ability of the elements to cooperate with each other. For this reason, the inelastic behavior of the structures gains importance. [9]

2.3.1. Structural Damping

The most important effect of the damping is the removal of the energy loaded into the system due to earthquakes and similar reasons. Energy absorption in vibrating systems can be achieved by many mechanisms. Internal friction in building elements, friction between structural elements and non-structural elements can be given as examples of these mechanisms. Since it is not possible to consider all of these damping mechanisms for the

structure, a single damping coefficient (c) is used by idealizing the damping that will occur in the structure due to all the mechanisms. However, given that it is not practical to create the structure damping matrix by calculating the damping factor for each structural element, the damping is usually calculated numerically depending on the modal damping ratios. Generally, it is assumed that the damping in structures is around 5 percent of the critical viscous damping for each natural vibration period. [10]

2.3.2. Structural Ductility

Ductility can be defined as the ability of a structure, an element or a section to change significantly without a significant reduction in its bearing capacity. This definition includes the ability to consume energy with hysterical cycles along with the ability to change shape. The energy consumed in the sections where plastic hinges are formed plays a very important role in the resistance of a building to earthquake loads. The consumption of sufficient energy depends on the ductility of the sections where the plastic hinges are formed.

The importance of ductility in building systems;

- The absorption and damping of the dynamic effect of the earthquake by transforming it into elastic and non-reversible energy type,
- prevention of major damage to the structure and complete collapse,
- considering inelastic behavior in the bearing system with the seismic load reduction factor (R_a). [11]

2.3.3. Importance of Confinement

The confinement reinforcement in a reinforced concrete section, increases the strength of the concrete in the core and significantly increases the ductility. Under possible earthquake loads, the cross sections in reinforced concrete buildings are generally expected to remain within elastic limits. It is possible for the reinforcement at the ends of the beams and columns to yield, and therefore to form plastic hinges in these zones. Since the consumption of energy remains very low with deformations within elastic limits, the energy should be consumed in plastic hinges that are formed to a major extent. Energy consumption in a plastic hinge

depends on the rotational capacity of the plastic hinge, in other words, the ductility of the cross section. Therefore, confinement reinforcement is required, which significantly increases the ductility of the section. [12]

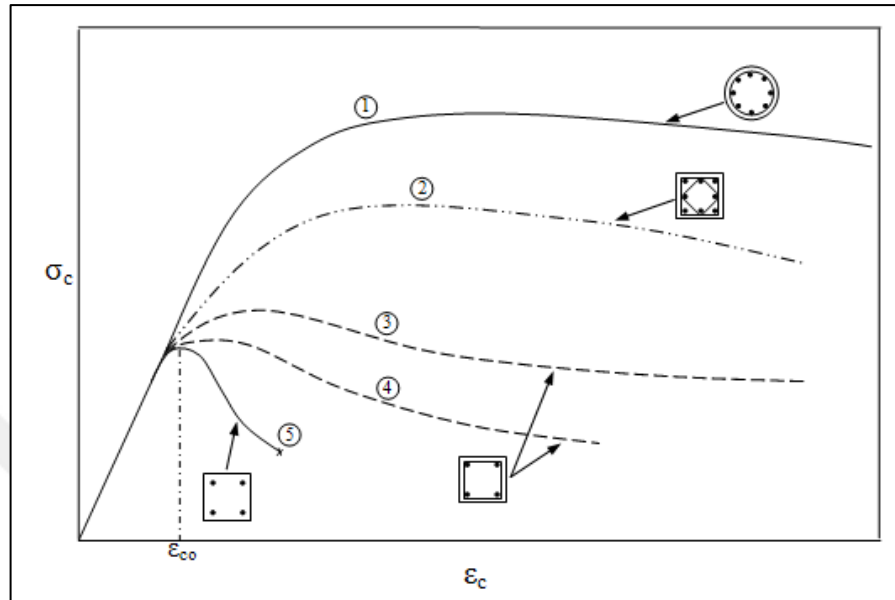


Figure 2.5. Confined and unconfined concrete σ - ϵ relations

Figure 2.5 shows the stress-strain (σ - ϵ) relations of confined and unconfined concretes. Curve number 5 for unconfined, others for confined concrete. Curves 3 and 4 are for sections with a single rectangular stirrup in its cross section. The only difference between curves 3 and 4 is that the stirrup spacing in structural member number 3 is less. As can be seen, the rectangular stirrup significantly increases the ductility compared to the non-stirrup case, but the strength increase is less. In the section indicated by 2, double stirrups are placed and the stirrup spacing is reduced by half compared to 3 and 4. As can be seen from curve number 1, the most effective type of winding is the circular fret where the deformations depend on axial stiffness. [13]

2.3.4. Mander Concrete Model

The flexural capacity of the columns is more dependent on the stress distribution of the concrete under compression, because the neutral axis depth of the cross section under the effect of high axial force is large. For this reason, in the analysis models used to determine

the performance of the structure, concrete models should be used to define the realistic moment-curvature relationships, taking into account the confinement effect. Unconfined model is taken as basis for shell concrete and confined model for core concrete. [14]

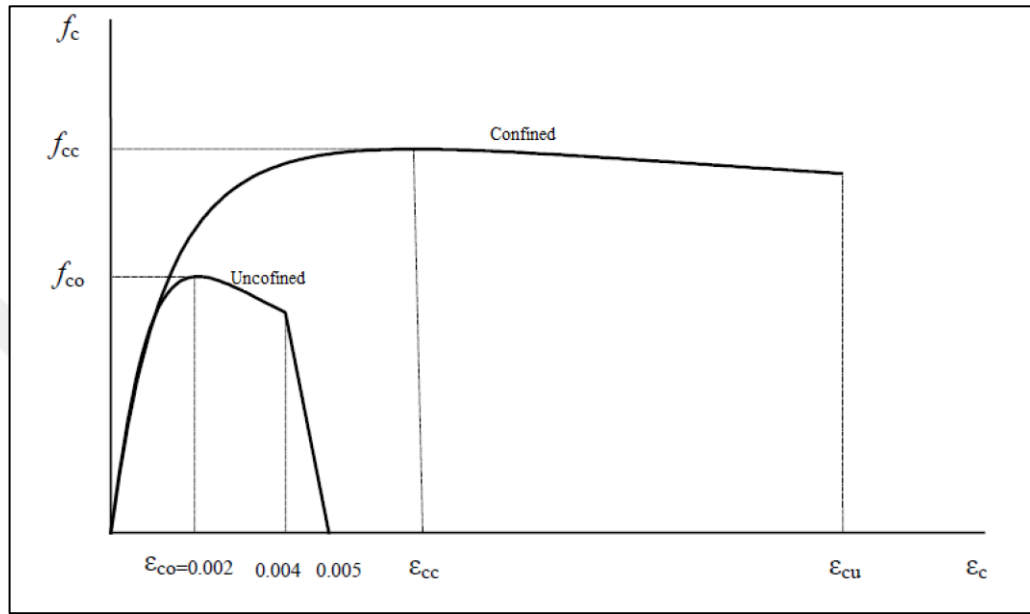


Figure 2.6. Mander concrete model

3. PERFORMANCE BASED SEISMIC DESIGN AND ASSESMENT ACCORDING TO THE TBSC-2018

Following sections include, basic principles, formulations and solution procedures to evaluate the earthquake performance of existing reinforced concrete buildings according to the TBSC 2018.

3.1. EARTHQUAKE GROUND MOTIONS LEVELS FOR PERFORMANCE BASED EVALUATION

- DD-1 (Earthquake ground motion level-1), is very rare earthquake ground motion in which the probability of exceedance of spectral parameters in 50 years is 2 percent and the corresponding recurrence period is 2475 years. This earthquake ground motion is also called the major earthquake ground motion.
- DD-2 (Earthquake ground motion level-2), characterizes the infrequent earthquake ground motion in which the probability of exceedance of spectral parameters in 50 years is 10 percent and the corresponding recurrence period is 475 years. This earthquake ground motion is also called standard design earthquake ground motion.
- DD-3 (Earthquake ground motion level-3), describes the frequent earthquake ground motion in which the probability of exceedance of spectral parameters in 50 years is 50 percent and the corresponding recurrence period is 72 years.
- DD-4 (Earthquake ground motion level-4), DD-4 characterizes the very frequent earthquake ground motion in which the probability of exceedance of spectral parameters in 50 years is 68 percent (probability of exceedance in 30 years is 50 percent) and the corresponding recurrence period is 43 years. This earthquake ground motion is also called service earthquake ground motion.

3.2. BUILDING USAGE CLASSIFICATION AND IMPORTANCE FACTOR

Building usage class (BKS) is determined according to the purpose of occupancy or type of building (Table 3.1). Building importance factor (I) is determined according to the selected building usage class.

Table 3.1. Building usage classes and importance factor

Building Usage Class	Purpose of Occupancy or Type of Building	Building Importance Factor (I)
BKS = 1	Buildings to be utilized after the earthquake and buildings where people are long-term and dense, buildings where valuable goods are stored and buildings containing dangerous substances a) Buildings required to be utilized immediately after the earthquake (Hospitals, dispensaries, health wards, firefighting buildings and facilities, PTT and other telecommunication facilities, transportation stations and terminals, power generation and distribution facilities; governorate, county and municipality administration buildings, first aid and emergency planning stations) b) Schools, other educational buildings and facilities, dormitories, military barracks, prisons, etc. c) Museums d) Buildings containing of storing (toxics, explosive, flammable materials, etc.)	1.5
BKS = 2	Intensively but short-term occupied buildings shopping malls, sports facilities, cinema, theatre, concert halls, sanctuary, etc.	1.2
BKS = 3	Other buildings BKS=1 and BKS=2 (Residential and office buildings, hotels, building-like industrial structures, etc.)	1.0

3.3. SEISMIC DESIGN CATEGORY

Seismic Design Category (DTS) is determined using Table 3.2, depending on the building usage classes (BKS) and the short-period design spectral acceleration coefficient determined for the DD-2 earthquake ground motion level. In the scope of this thesis, the case study is

for an existing reinforced concrete building. Therefore, required tables are given for the existing reinforced concrete building.

Table 3.2. Seismic design category

DD-2 Short Period Design Spectral Acceleration Coefficient at Earthquake Ground Motion Level-2 (S_{DS})	Building Usage Class	
	BKS = 1	BKS = 2, 3
$S_{DS} < 0.33$	DTS = 4a	DTS = 4
$0.33 \leq S_{DS} < 0.50$	DTS = 3a	DTS = 3
$0.50 \leq S_{DS} < 0.75$	DTS = 2a	DTS = 2
$S_{DS} \geq 0.75$	DTS = 1a	DTS = 1

3.4. BUILDING HEIGHT CLASS

Building height classes (BYS) are determined from the Table 3.3 according to the seismic design category (DTS) and the height of the building (H_N).

Table 3.3. Building height classes

Building Height Class	DTS = 1, 1a, 2, 2a	DTS = 3, 3a	DTS = 4, 4a
BYS = 1	$H_N > 70$	$H_N > 91$	$H_N > 105$
BYS = 2	$56 < H_N \leq 70$	$70 < H_N \leq 91$	$91 < H_N \leq 105$
BYS = 3	$42 < H_N \leq 56$	$56 < H_N \leq 70$	$56 < H_N \leq 91$
BYS = 4	$28 < H_N \leq 42$	$42 < H_N \leq 56$	$42 < H_N \leq 56$
BYS = 5	$17.5 < H_N \leq 28$	$28 < H_N \leq 42$	$28 < H_N \leq 42$
BYS = 6	$10.5 < H_N \leq 17.5$	$17.5 < H_N \leq 28$	$17.5 < H_N \leq 28$
BYS = 7	$7 < H_N \leq 10.5$	$10.5 < H_N \leq 17.5$	$10.5 < H_N \leq 17.5$
BYS = 8	$H_N \leq 7$	$H_N \leq 10.5$	$H_N \leq 10.5$

3.5. BUILDING PERFORMANCE TARGET

The Standard Performance Targets defined for DTS = 1, 2, 3, 3a, 4, 4a and Advanced Performance Targets defined for DTS = 1a, 2a for four earthquake ground motion levels are given in the Table 3.4.

Table 3.4. Performance objectives for reinforced concrete structures (Expect for high-rise buildings $BYS \geq 2$)

Earthquake Ground Motion Level	DTS = 1, 2, 3, 3a, 4, 4a		DTS = 1a, 2a	
	Standard Performance Target	Design/Evaluation Approach	Advanced Performance Target	Design/Evaluation Approach
DD-3	—	—	SH	ŞGDT
DD-2	KH	ŞGDT	—	—
DD-1	—	—	KH	ŞGDT

3.6. GATHERING INFORMATION FOR EXISTING BUILDINGS

Information on the element details and dimensions to be used in determining the capacities of the structural system elements of the existing buildings and evaluating the earthquake resistance and the information about the bearing system geometry and material properties are obtained from projects of the building, the observations and measurements to be made in building and the experiments applied to the material samples (core, steel coupon sample, etc.) to be taken from the building. [3]

3.6.1. Limited Level of Knowledge in RC Buildings

Building Geometry: The field work, will make it possible obtain a survey of the construction system plan. Architectural projects are used to assist with survey work, if required. The obtained information required to include the location and material of all reinforced concrete elements and partition walls on each floor, axle distances, heights and dimensions, and should be sufficient to create a numerical model of the building. The foundation system shall

be determined by a sufficient number of foundation pits to be opened inside or outside the building. Adverse aspects of the building will be documented in the floor plan and sections. The relationship of the building with the neighboring buildings shall be determined.

Element Details: The amount and details of reinforcement in reinforced concrete elements are assumed to meet the minimum reinforcement conditions at the time the building was built. In order to verify this assumption or to determine the realization rate, at least one per floor, 5 percent of the wall and columns shall be stripped of the concrete cover and the reinforcement will be determined. Stripping shall be carried out within the middle third of the span of the length of the columns and beams. The stripped surfaces will then be covered with high strength repair mortar. In addition, the number and placement of transverse and longitudinal reinforcement in 20 percent of the walls and columns whose concrete cover is not stripped will be determined by reinforcement detection devices.

Material Properties: At least three concrete core samples shall be taken from the columns or walls on each floor in accordance with the conditions specified in TS EN 12504-1. The strength values found by testing the cores whose length and nominal diameter are equal to each other and 100 mm can be used to determine the current strength of concrete without applying any coefficient. In converting the test results obtained from cores with different length / diameter ratios, appropriate conversion coefficients should be taken as basis. If the total number of core samples is three, the lowest compression strength obtained from the samples will be taken as the actual strength of the concrete without statistical assessment. If the number of samples is more than three, the greater of the (mean-standard deviation) value obtained from the samples and (0.85 times the average) value are taken as the current concrete strength. It shall be checked whether the smallest value is a statistically deviating result by evaluating the difference between the smallest value and the average of the remaining results among the test results of a group of concrete samples. For this purpose, when evaluating the sample results in the group, if the lowest single value is lower than 75 percent of the average of the remaining results, this sample is not taken into consideration. The reinforcing class shall be determined by visual inspection, the characteristic elasticity stress of the steel of this class will be considered as the current strength of the steel. In this examination, the elements with corrosion in the reinforcement will be marked in the plan and this shall not be taken into account in calculating the capacity of the elements.

3.6.2. Comprehensive Level of Knowledge in RC Buildings

Building Geometry: If the building has reinforced concrete projects, the conformity of the existing geometry with the projects is verified with the measurements to be carried out. If there are significant differences between the projects and the measures, the project is ignored. If there is no project, the structural system survey of the building will be obtained through field work. The information obtained should include the location, openings, heights, dimensions and materials of all reinforced concrete elements and the partition walls of each story. Adverse aspects of the building will be documented in the floor plan and sections. The relationship of the building with the neighboring buildings will be determined. The information on the geometry of the building should contain the details required to accurately describe the weight of the building. The foundation system shall be determined by a sufficient number of inspection pits to be opened inside or outside the building.

Element Details: If the building has reinforced concrete detail projects, the procedures specified in the comprehensive knowledge level is applied to the same amount of reinforced concrete elements to check the suitability of the reinforcement to the project. In addition, the number and placement of the transverse and longitudinal reinforcement in 20 percent of the walls and columns and 10 percent of the frame beams whose concrete cover is not stripped shall be determined by reinforcement detection devices. In case of inconsistency between the project and the implementation, the reinforcement realization coefficient, which expresses the ratio of the existing reinforcement in reinforced concrete elements to the reinforcement envisaged in the project, shall be determined separately for walls, columns and beams. This coefficient used to determine the capabilities of the elements must not be greater than 1. This coefficient shall be applied to all other elements where the reinforcement has not been determined, and the possible reinforcement ratios shall be determined. If the projects or construction (an application) drawings are not available, the reinforcement is determined by stripping the concrete cover of 10 percent of the columns and walls, at least two on each floor. The stripped surfaces are then be covered with high strength repair mortar. In addition, the number and placement of transverse and longitudinal reinforcement in 30 percent of columns and walls and 15 percent of beams whose concrete cover is not stripped are be determined by reinforcement detection devices.

Material Properties: Experimental tests shall be conducted for 1 concrete core sample at each 400 m² for the columns or walls, not less than three on the ground floor and not less than two on the other floors and not less than 9 in total in the building, in accordance with the conditions specified in TS EN 12504-1. Rules that are used with limited knowledge are valid for determining existing concrete strength. The distribution of concrete strength in the building can be checked with Schmidt concrete test hammer readings or similar non-destructive inspection tools adapted with concrete samples test results. The reinforcement class is determined by the examination of the stripped surfaces as explained at a limited knowledge level, one sample is taken for each steel class (S220, S420, etc.), the yield stress, rupture strength and deformation properties of the steel is determined and the suitability for the project is determined. In this case, the characteristic yield stress of the steel used in the project shall be taken as the existing yield stress of the steel in the calculation of the element capacity. If it is not suitable for the project, at least three more samples shall be tested and the most unfavorable yield stress obtained is taken as the current steel yield stress in the element capacity calculations. Elements with corrosion in the reinforcement shall be marked in the plan for the element capacity calculations, as is the case with limited knowledge level.

Table 3.5. Knowledge level coefficients for buildings

Knowledge Level	Knowledge Level Coefficients
Limited	0.75
Comprehensive	1.00

3.7. CROSS-SECTIONAL DAMAGE LIMITS AND ZONES

3.7.1. Cross-Sectional Damage Limits

In the case of ductile elements, three damage states and damage limits are defined at the cross-section level. These are limited damage (SH), controlled damage (KH) and collapse prevention (GÖ) states and their limit values. Limited damage defines limited inelastic behavior in the relevant section, inelastic behavior where controlled damage section strength

can be safely provided, and collapse prevention damage state defines advanced inelastic behavior in the section. This classification cannot be applied to brittle structural members.

3.7.2. Cross-Sectional Damage Zones

Structural members whose critical cross-section damage does not reach SH are located in the Limited Damage Zone, the elements between SH and KH in the Visible Damage Zone (BHB), the elements between KH and GÖ are located in the Significant Damage Zone (İHB), and elements exceeding the GÖ are located in the Collapse Zone (GB).

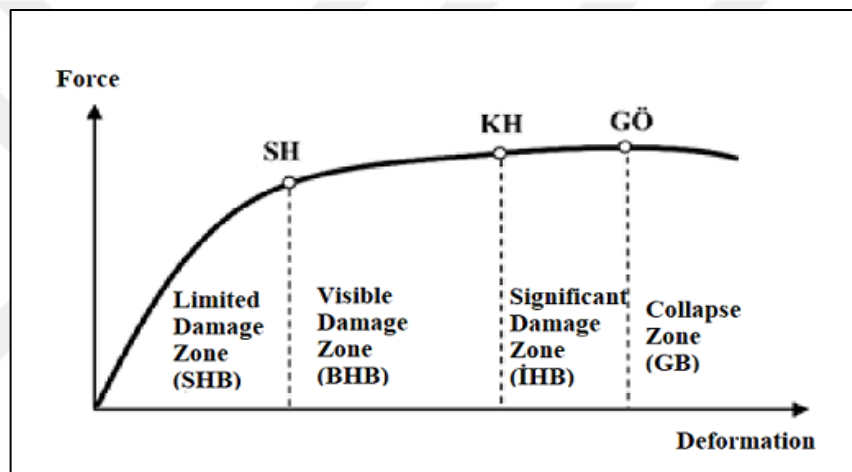


Figure 3.1. Damage limits and damage zones

3.8. STRUCTURAL PERFORMANCE LEVELS FOR EXISTING BUILDINGS

The earthquake ground motion levels to be taken as a basis in determining the earthquake performance of existing buildings and the minimum performance targets for buildings at these earthquake ground motion levels are given in Table 3.4. The earthquake performance of existing buildings is related to the condition of the expected damages in the building under the effect of the applied earthquake and it is defined on the basis of four different damage states.

3.8.1. Limited Damage (SH) Performance Level

As a result of the calculations made for each earthquake direction applied on any floor of reinforced concrete buildings, maximum 20 percent of the beams can pass into the *visible damage zone* (BHB), but all other bearing elements are in the *limited damage zone* (SHB). If any, provided that the brittle failure members are retrofitted, the buildings in this situation are considered to be in *Limited Damage Performance Level* (SH).

3.8.2. Controlled Damage (KH) Performance Level

The buildings that meet the following conditions are considered to be at the *Controlled Damage Performance Level*, provided that the brittle failure members, if any, are retrofitted:

- As a result of the calculations made for each earthquake direction applied on any floor of reinforced concrete buildings, excluding the secondary (not included in the horizontal load bearing system) beams, maximum 35 percent of the beams can pass into the Significant Damage Zone.
- It can pass into the area of advanced damage in the column and wall elements. However, the total contribution of the vertical elements in the Significant Damage Zone to the shear force carried by the vertical elements in each floor should be below 20 percent. The ratio of the total shear forces of the vertical elements in the Significant Damage Zone on the top floor to the total shear forces of all vertical elements on that floor may be at most 40 percent.
- All other bearing elements are in Limited Damage Zone or Visible Damage Zone. Although, the ratio of the shear forces carried by the vertical elements of which the visible damage limit is exceeded in both of the lower and upper sections of any floor to the shear force carried by all vertical elements in that floor should not exceed 30 percent.
- Columns that require stronger columns than beams at both the lower and upper nodes are not included in this calculation in the *linear* calculation.

3.8.3. Collapse Prevention (GÖ) Performance Level

Provided that all the brittle failure members elements are in the Collapse Zone, the buildings that meet the following conditions are considered to be at the *Collapse Prevention Performance Level*:

- As a result of the calculations made for each earthquake direction applied on any floor of reinforced concrete buildings, excluding the secondary (not included in the horizontal load bearing system) beams, at most 20 percent of the beams can pass into the Collapse Zone.
- All other bearing elements are in Limited Damage Zone, Visible Damage Zone or Significant Damage Zone. However, the ratio of the shear forces carried by the vertical elements of which the visible damage limit is exceeded in both of the lower and upper sections of any floor to the shear force carried by all vertical elements in that floor should not exceed 30 percent.
- Columns that require stronger columns than beams at both the lower and upper nodes are not included in this calculation in the *linear* calculation.
- Its use in the existing condition of the building is inconvenient for life safety.

3.8.4. Collapse (GB) Performance Level

If the building cannot provide the Collapse Prevention Performance Level, it is in Collapse Performance Level and its use is inconvenient in terms of life safety.

3.9. CALCULATION METHOD FOR STRUCTURAL PERFORMANCE DETERMINATION

3.9.1. Linear Methods

Linear calculation methods to be used to determine the earthquake performance of buildings are *Equivalent Earthquake Load Method* and *Mode Combination Method*. Additional rules are applied regarding these methods. $R_a = 1$ shall be taken in the calculation of the total

equivalent earthquake load (base shear force). With the Mode Combination Method, $R_a = 1$ is taken in the earthquake calculation. In the calculation of the element internal forces and capacities compatible with the applied earthquake direction and direction, the internal force directions obtained in the mode dominant in this direction is taken as basis.

3.9.2. Non-Linear Methods

The purpose of the non-linear calculation methods to be used for calculating the structural performance of existing buildings under the effect of earthquakes is to calculate the plastic deformation and plastic rotation demands for ductile behavior and the internal force demands for brittle behavior for a given earthquake. These demands are compared with deformation and internal force capacities and structural performance assessment are made at the cross-section and building level. Nonlinear calculation methods to be used in the evaluation of buildings are *Single-mode Pushover Method*, *Multi-Mode Pushover Method*, *Non-linear Time History Method*. In this thesis non-linear time history approach is adopted and the following chapters comprise the formulations and calculations.

Non-linear Time History Method

Nonlinear time history calculation corresponds to the step-by-step direct integration of the differential equation set expressing the motion equations of the bearing system under the earthquake loads.

Special rules to consider in non-linear calculation:

- i. Except for the energy consumption related to nonlinear behavior in the bearing system elements, the dynamic energy loss occurring in linear operating structural and non-structural elements are represented by the viscous damping matrix in the motion equations. Viscous damping matrix is created as *Rayleigh Damping Matrix* or *Modal Damping Matrix*.
- ii. As in all nonlinear methods, nonlinear incremental static calculation is made in the initial step of the calculation, excluding earthquake loadings. Internal forces and nonlinear deformations obtained from this calculation are taken into account as initial values in the earthquake calculation.

- iii. The time increment to be used in the calculation is chosen in such a way that all vibration modes that contribute to the dynamic behavior are adequately represented.

3.9.3. Effective Section Rigidity of RC Bearing System Elements

Effective section rigidity factors regarding in-plane and out-of-plane behavior of linearly modelled walls and floors are determined according to the Table 3.6.

Table 3.6. Effective rigidity factors for reinforced concrete members

Reinforced Concrete Bearing System Elements	Effective Rigidity Factor	
Wall – Slab (in-plane)	<i>Axial</i>	<i>Sliding</i>
Shear Wall	0.50	0.50
Basement Wall	0.80	0.50
Slab	0.25	0.25
Wall – Slab (out-of-plane)	<i>Bending</i>	<i>Shear</i>
Shear Wall	0.25	1.00
Basement Wall	0.50	1.00
Slab	0.25	1.00
Frame	<i>Bending</i>	<i>Shear</i>
Coupling Beam	0.15	1.00
Beam	0.35	1.00
Column	0.70	1.00
Shear Wall (equivalent frame)	0.50	0.50

The effective cross-section rigidity of columns, beams, coupling beams and walls modelled according to the piled plastic behavior are determined according to Equation (3.1).

$$(EI)_e = \frac{M_y L_s}{\theta_y} \frac{1}{3} \quad (3.1)$$

Where, M_y and θ_y show the average of the effective yield moments and yield rotation of the plastic hinges at the ends of the plastic hinges. L_s is the shear span (ratio of moment / shear force in cross section); it can be taken as approximately half the span in columns and beams.

θ_y is calculated using Equation (3.2):

$$\theta_y = \frac{\phi_y L_s}{3} + 0.0015\eta \left(1 + 1.5 \frac{h}{L_s}\right) + \frac{\phi_y d_b f_{ye}}{8\sqrt{f_{ce}}} \quad (3.2)$$

Where ϕ_y shows the effective curvature flow in the plastic hinge section. It is taken $\eta = 1$ for beams and columns and $\eta = 0.5$ for shear walls and h is the section height.

3.10. GENERAL PRINCIPLES FOR THE DESIGN OR ASSESSMENT OF RC BUILDINGS FOR EARTHQUAKE RESISTANCE

General principles for the design or assessment of reinforced concrete building for earthquake resistance are explained below.

- In the definition of the earthquake effect, the horizontal elastic design spectrum is used for the determined earthquake ground motion levels. Building Importance Factor is not used in earthquake calculation ($I = 1.0$).
- The earthquake performance of the buildings is evaluated under the combined effects of the vertical loads and earthquake loads on the building. In the earthquake calculation, the masses are determined according to Equation 3.3.

$$w_j^{(S)} = w_{G,j}^{(S)} + n w_{Q,j}^{(S)} \quad ; \quad m_j^{(S)} = \frac{w_j^{(S)}}{g} \quad (3.3)$$

- Where n represents the live load participation factor and determined according to Table 3.7.

Table 3.7. Live load participation factor

Purpose of Usage of The Building	n
Warehouse, etc.	0.80
School, dormitory, sports facility, cinema, theatre, concert hall, place of worship, restaurant, store, etc.	0.60
Residential, office, hotel, hospital, parking lot, etc.	0.30

- Earthquake loads are applied on the building in each of the orthogonal directions
Numerical model of the structural bearing system is created with sufficient accuracy

to calculate the internal forces, displacements and deformations that occur in the structural elements under the common effects of earthquake loads and vertical loads.

- In buildings where floors behave as rigid horizontal diaphragms, two lateral displacement components and the rotation around the vertical axis shall be taken into account at each floor as independent static displacement components. Uncertainties in the bearing systems of the existing buildings shall be given in the calculation methods through the knowledge level coefficients according to the scope of the data collected from the building.
- Short columns may be developed due to structural arrangements or due to openings provided in infill walls between columns. In these cases where short columns are located, columns are modelled with existing heights.
- The conditions for the definition of the interaction diagrams of reinforced concrete sections under the effect of uniaxial or biaxial bending and axial force are given below:
 - i) Quality classes of concrete and reinforcing steel to be used in the numerical model of the building shall be determined based on the knowledge level basis defined in earthquake calculations.
 - ii) The maximum compressive strain in concrete can be taken as 0.0035, and the maximum strain hardening of steel can be taken as 0.01.
 - iii) Interaction diagrams can be modelled like multiline or multiplane diagrams by linearizing them correctly.
- In defining the member dimensions of reinforced concrete systems, joints may be considered rigid end regions.
- Effective section rigidity factor of the cracked section is used in reinforced concrete elements under the effect of bending. The effective section rigidity shall be calculated according to section 3.9.3.
- In the calculation of the positive and negative plastic moments of the beams, the flange concrete and the reinforcement can be taken into calculation.
- In the case of insufficient clamping or overlap length in reinforced concrete elements, the yield stress of the relevant reinforcement in the calculation of the section capacity moment shall be reduced in proportion to the clamping or lacking length of the overlap.

- In case where any damage in the superstructure due to underlying soils, such as settlement or differential settlement during earthquake is expected, it shall be considered in the analysis performed on the bases of principles of soil mechanics and foundation engineering.



4. GROUND MOTION DATA SETS

4.1. SEISMICITY OF THE REGION

The city of Van is under the influence of the 40 km long Bitlis fault zone which passes about 20 km north of the city and the South Anatolian fault. The region of Van is under the influence of the north-south compression and contraction zone as a result of the proximity of the Arabian plate to the north towards the Eurasian plate. [48] There are three different categories of faults falling in the Van region; strike-slip, thrust to reverse and oblique-slip normal. [15] According to the historical earthquake database there are 40 earthquake records belonging to the historical period regarding the Van and surrounding. Most of these earthquakes were concentrated around Van, Erzurum Muş and Bitlis-Adilcevaz. According to these historical earthquake records, 14 severe earthquakes occurred during this period. The major earthquakes that occurred were the 1111 Van earthquake of IX magnitude and the 1852 Erzurum earthquake of IX-X intensity. Until 2021, there are 504 earthquakes with a magnitude of 4 and greater occurred in the Van region. According to the available records, most of the earthquakes that occurred during this period were concentrated around Erzurum, Karlıova-Varto, Çaldıran, Van and Hakkari. It is understood from the epicenter coordinates of the earthquakes that the North Anatolian Fault Zone was relatively more active in this period. In terms of seismic hazard, the region of Karlıova, Varto, Malazgirt, Patnos, Erciş, Muradiye, Çaldıran, north of Özalp and around Hakkari have highest seismic vulnerability. A simplified tectonic unit and seismic activity of Van and its surroundings is given in Figure 4.1. On October 23, 2011 the Van earthquake occurred approximately 20 km north of the province of Van with a magnitude of Mw 7.2 with a right-lateral strike-slip mechanism. Following the main earthquake, 111 aftershocks with a magnitude of 4.0 and above occurred. According to the Disasters and Emergency Situations Directorate of Turkey (AFAD), this earthquake resulted in the death of approximately 604 people, 4152 people were injured, and some 6017 buildings collapsed. [16] Another earthquake of Mw 5.7 took place on 9 November 2011. In addition to that, after October 23, 2011, 5527 earthquakes ranging in size from 1.4 to 5.7 occurred in the Van earthquake region for about 1 year. [17,18]

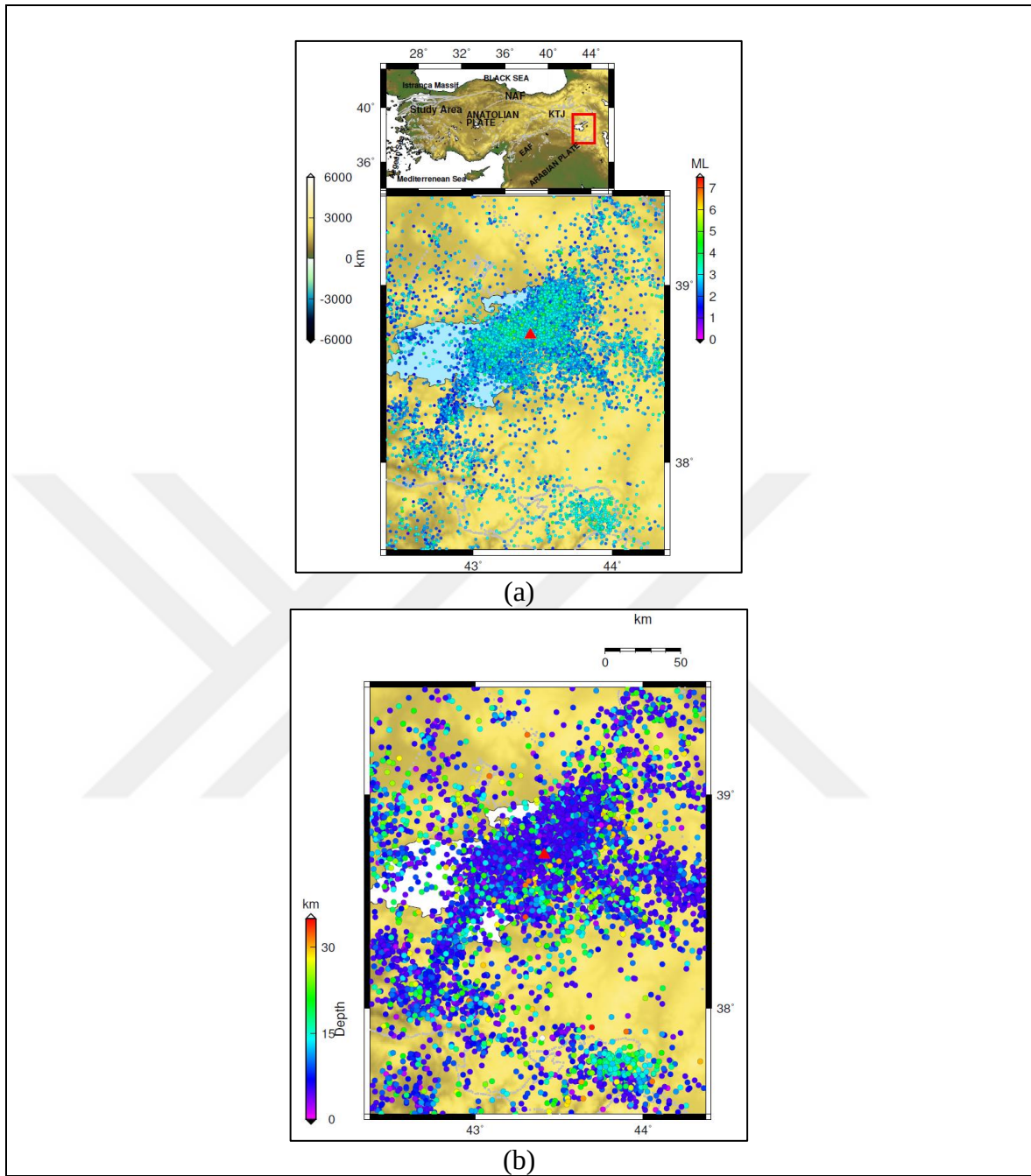


Figure 4.1. Simplified tectonic units and seismic activity of Van and surroundings. (a) Magnitudes of earthquakes, (b) Depths of earthquakes

A preliminary assessment of the background seismicity of the study area was obtained by earthquake sources capable of producing damaging ground motions. Earthquake catalog data from Kandilli Observatory and Earthquake Research Institute (KOERI) were used in this study. The compiled catalogue covers the region between 37.00° N– 40.00° N and 42.00° E– 45.00° E and the period spans from 1900 to 2021. The collected catalogues were filtered by

removing artifacts and duplicate events. Poisson distribution of the earthquake catalog was assumed. Declustering algorithm of Gardner and Knopoff (1974) method was used to remove clustering from the original catalog that based on space time windows (Figure 4.2). [49] Figure 4.3 shows the distribution of earthquakes according to their magnitudes and hypocenter depths. Figure 4.4 presents the time distribution of the cumulative moment release and cumulative number of events of magnitude 4 or more. They show a relatively steady rate of occurrence of strong events (with some time clustering) and a significant increase in the total number of recorded earthquakes as the number and sensitivity of seismographs has increased. The coefficient of “a” and “b” were calculated by interpolation of past aftershock zone extent and aftershock duration data. The “a” value represents the seismic activity and varies from 4 to 8 depending on the size of the deformation area, time span, number of earthquakes, and magnitude ranges. The b-value is a statistical parameter mainly depends on the nature of tectonic settings, crustal heterogeneity, pore fluids pressure, and stress state. [50,54] These coefficients provided implications on seismotectonic settings and potential seismic hazards in the selected region. The frequency-magnitude plot used to estimate the parameter 'b' in the period 1900 - 2021 is shown in Figure 4.5. For events with magnitude greater than 4.0, the 'b' value is 0.69 ± 0.01 which is within the expected range. According to the Figure 4.6 there is a band of high 'b' values trending west through the center of the area. In this thesis, the geological and tectonic situation of the region was examined and statistical information regarding the earthquakes that took place in the study area was compiled. As a result, the highest possible ground acceleration in the region was calculated as 0.7 g for the earthquake, which is likely to be exceeded with a 2 percent probability within 50 years. This acceleration level corresponds to an earthquake of 2475 years.

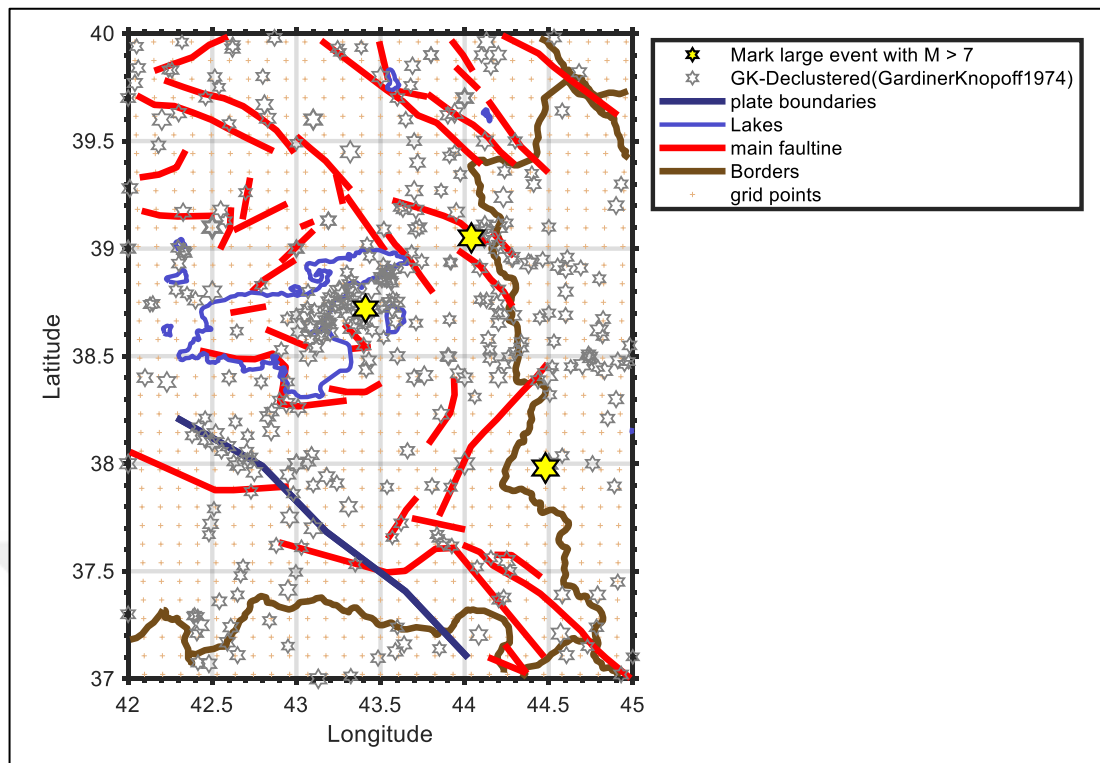


Figure 4.2. Spatial distribution of the study area seismicity from 1900 to 2021. Only events with magnitude equal or larger than 4 are shown.

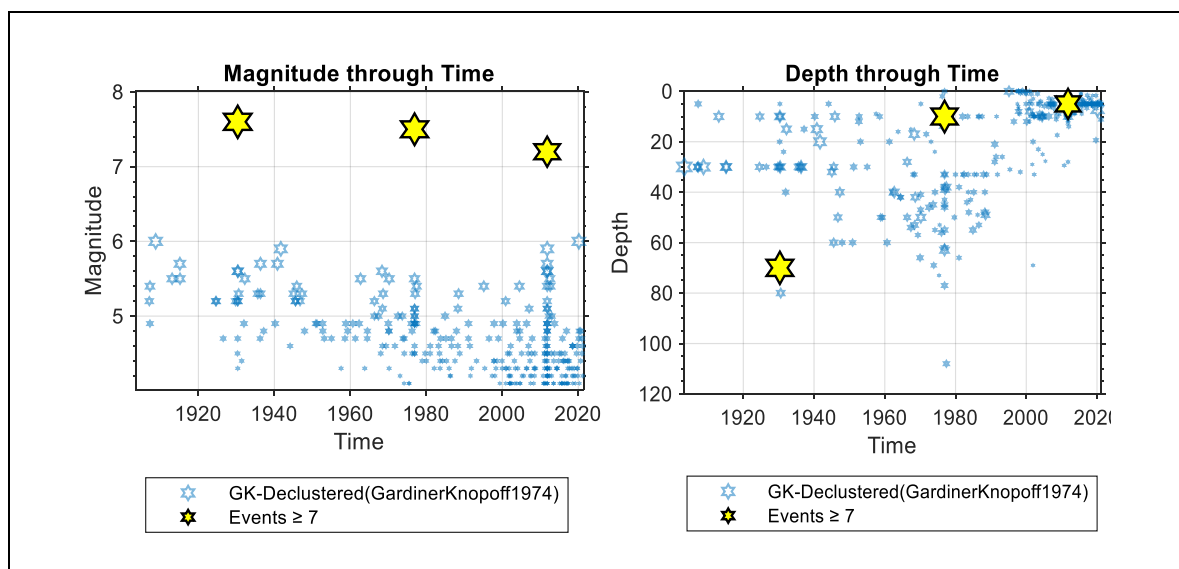


Figure 4.3. Distribution of earthquakes according to their magnitudes and hypocenter depths from 1900 to 2021

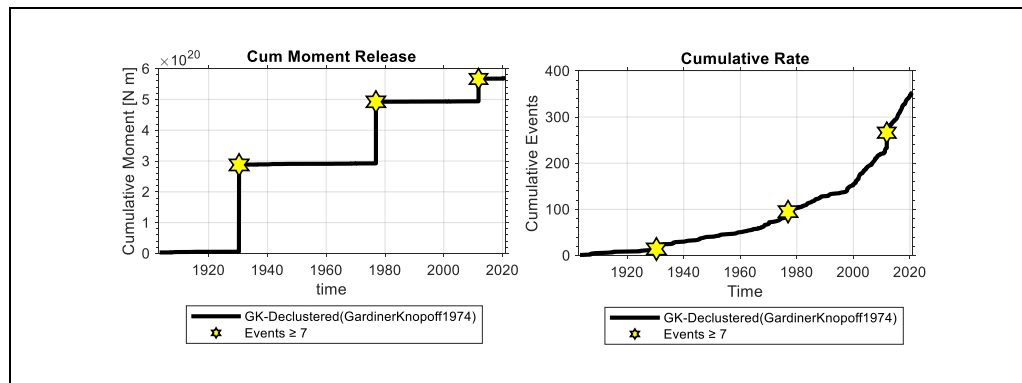


Figure 4.4. Cumulative moment and number of events as a function of time above Mw 4

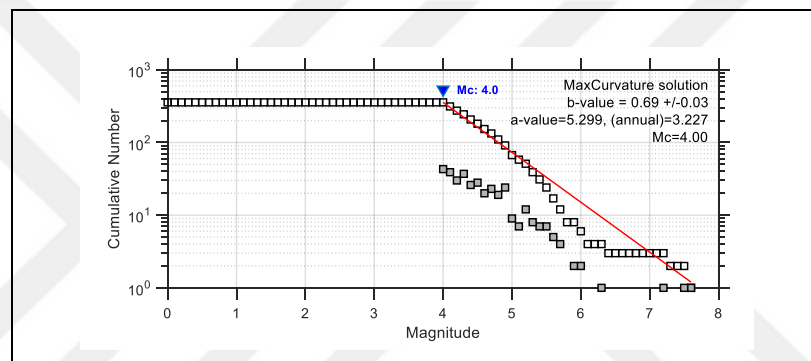


Figure 4.5. Illustration of discretization of a continuous magnitude distribution for a source with a truncated Gutenberg-Richter distribution, a minimum considered magnitude of 4, a maximum magnitude of 7.7

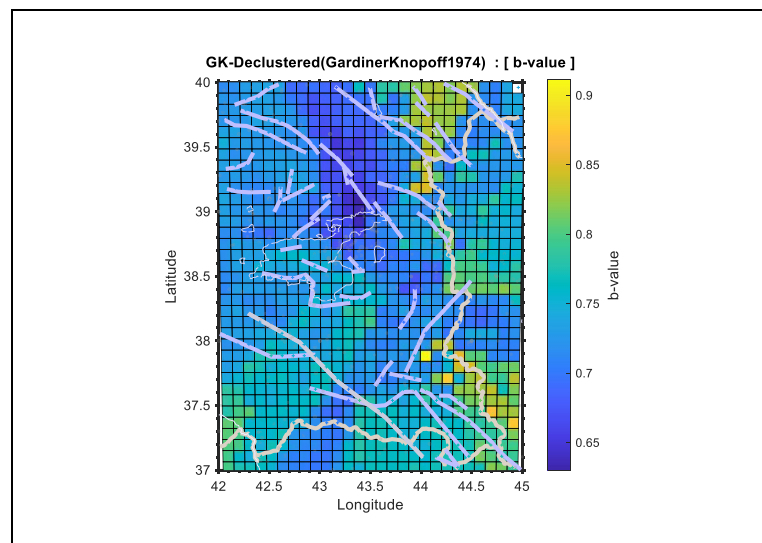


Figure 4.6. ' b ' value map of case study region for events with $M_w \geq 4$, 1900 to 2021

4.2. DEFINITION OF EARTHQUAKE GROUND MOTION

Real earthquake ground motion accelerograms, synthetic motions or artificial ground motions are used for the most part of the dynamic analyses during the evaluation of seismic response of a building. Although real strong ground motions reflect the seismic action at the site and the source characteristics, generally it is difficult to find a sufficient number of ground motion for seismic engineering application. In such circumstances synthetic or artificial ground motions can be used. Generation of synthetic ground motion requires source models account for rupture mechanisms, magnitude and seismicity of the region including source, path and site effects. These are demanding parameters since they are mostly determined according to specific earthquake scenarios. However, generation of artificial ground motion requires a target spectrum to match using supplementary information such as duration, fault distance or peak ground acceleration (PGA).

The number of time history input signals has a considerable effect on estimating the mean structural responses. For this reason, in this thesis synthetic, artificial, unscaled and scaled real records were used to predict an accurate structural response. In addition, it is thought to contribute this variability in input signal to the investigation of probability of collapse as well. Ground motion data set are all compatible with the selected ground shaking level given in Turkish Building Seismic Code 2018. TBSC-2018 provides regional variations in the shape of the response spectrum for site conditions, earthquake source and path. In this study for the target spectrum, a reduced design acceleration spectrum was created under a horizontal earthquake effect according to the TBSC-2018. The soil profile in the selected area is composed of thick, medium solid-hard silt and silt sand and gravel sand layers ranging from clay to medium tight-tight. The shear wave velocities obtained in the central districts of Van province according to SPT-N values vary between 261.3 m/s and 357.7 m/s. [19,37] Taking into account the site properties proposed by the National Earthquake Hazard Reduction Program (NEHRP), the site is medium tight-hard as class D. [20] Second earthquake ground motion level was taken into consideration for the generation of synthetic accelerograms. The ground motion level has a 10 percent probability to be exceeded in 50 years. Return period of this ground shaking is approximately 475 years. Ground motion data set comprised of artificial, synthetic and real excitations are depicted in Figure 4.7.

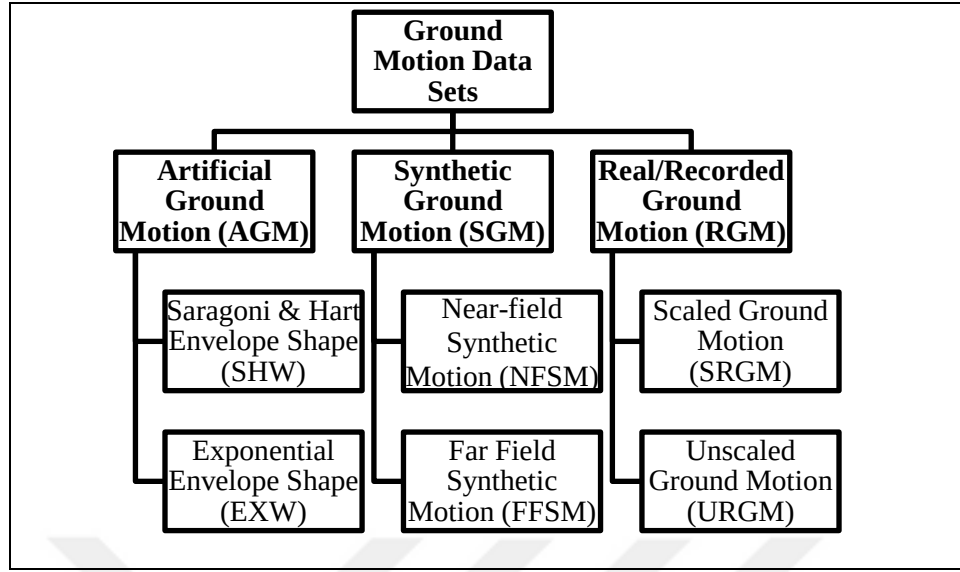


Figure 4.7. Ground motion data

4.2.1. Artificial Ground Motion

Artificial ground motion (AGM) was generated based on the adaptation of a random process to a target spectrum of the region using stochastic approach. Firstly, power spectral density function was calculated using a target response spectrum and consequently sinusoidal waves with random phase angles and amplitudes were obtained. Lastly sinusoidal motions were summed and an iterative procedure was applied to improve the match with the target response spectrum. [21,22] The accelerogram was defined using target spectrum and adapting its frequency content using the Fourier transform. The correction of the random process was performed for each iteration and Fourier transformation was applied to move from time domain to frequency domain using Equation 4.1. [23]

$$F(f)_{i+1} = F(f)_i \left[\frac{SRT(f)}{SR(f)_i} \right] \quad (4.1)$$

where,

$F(f)_{i+1}$, $F(f)_i$ are the data of the accelerogram in the frequency domain.

$SR(f)_i$ is the data response spectrum relative to the accelerogram of that iteration due to frequency f .

SRT(f): is the data of target spectrum relative to the accelerogram of that iteration due to frequency f .

In order to simulate the transient behavior for the artificial ground motions, the steady state motions were multiplied by two different envelope shapes as Saragoni & Hart envelope shape and exponential envelope shape. [24,25] Sinusoidal wave equation was used to generate the steady state motion:

$$W(t) = \sum_i A_i \sin (w_i t + \phi_i) \quad (4.2)$$

where,

A_i is the amplitude

ϕ_i is the phase angle of the i^{th} sinusoidal wave

For the first data set, to simulate the transient behavior for the artificial ground motions, steady state motions were multiplied by Saragoni and Hart (1974) envelope shape, $I(x)$ in which the phase angles are in the interval of $[0-2\Pi]$, with a uniform probability distribution by the following equation. [24]

$$GM(t) = I(x) \sum_i A_i \sin (w_i t + \phi_i) \quad (4.3)$$

For the second data set, steady state motions were multiplied by exponential envelope shape. [25] For each set of envelope shape eight artificial ground motions were generated. Considering the data set of Case Study, PGA of artificial ground motions varies between 0.26 g and 0.28 g. Artificial acceleration time histories that the steady state motion was multiplied by Saragoni & Hart envelope function (Saragoni and Hart, 1974) are given in Figure 4.8. Artificial acceleration time histories that the steady state motion was multiplied by exponential envelope function (Liu, 1969) are given in Figure 4.9. In addition, comparison of target spectrum and response spectrum of artificial ground motions are shown in Figure 4.10.

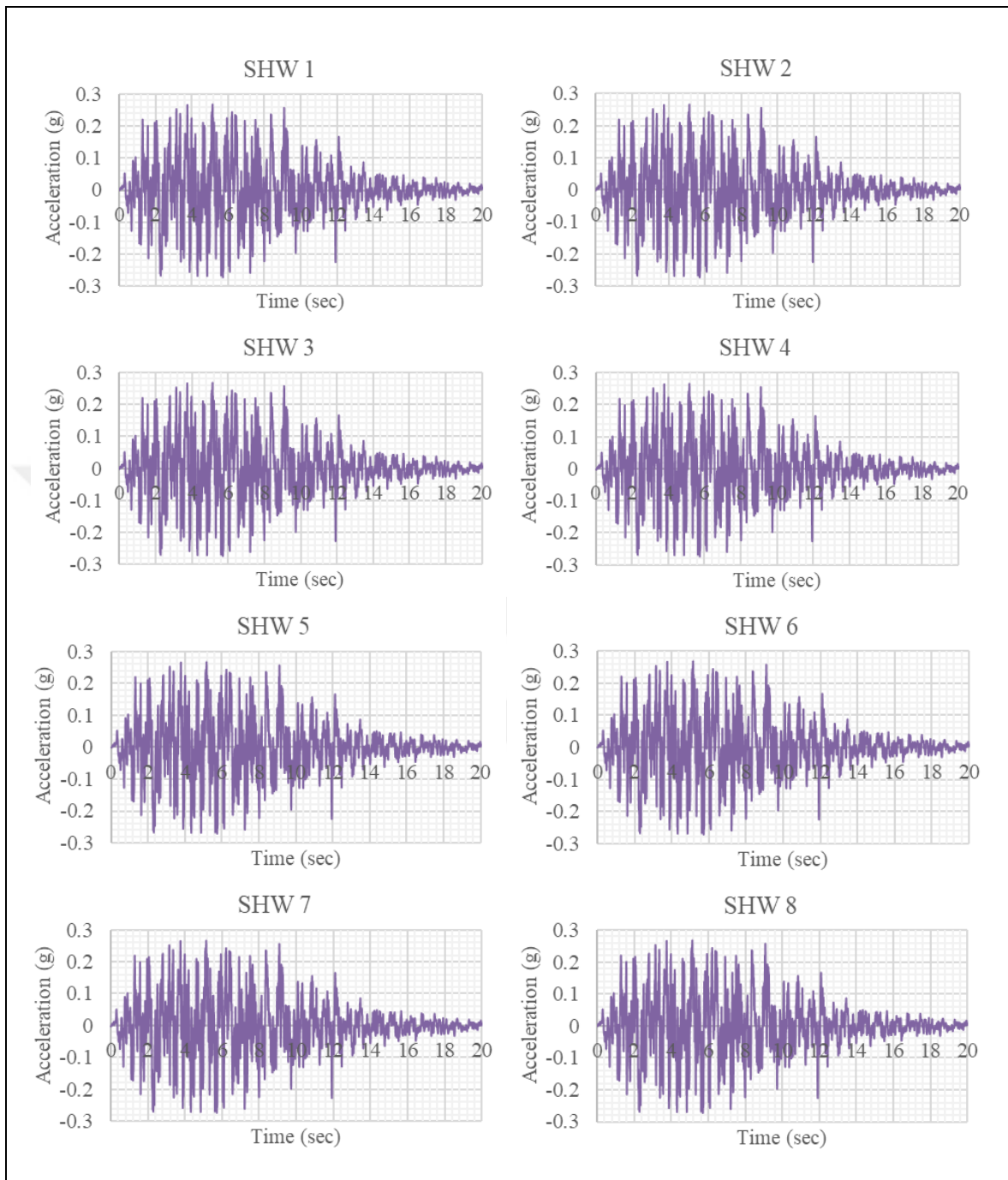


Figure 4.8. Artificial acceleration time histories for Saragoni & Hart envelope function (SHW) [24]

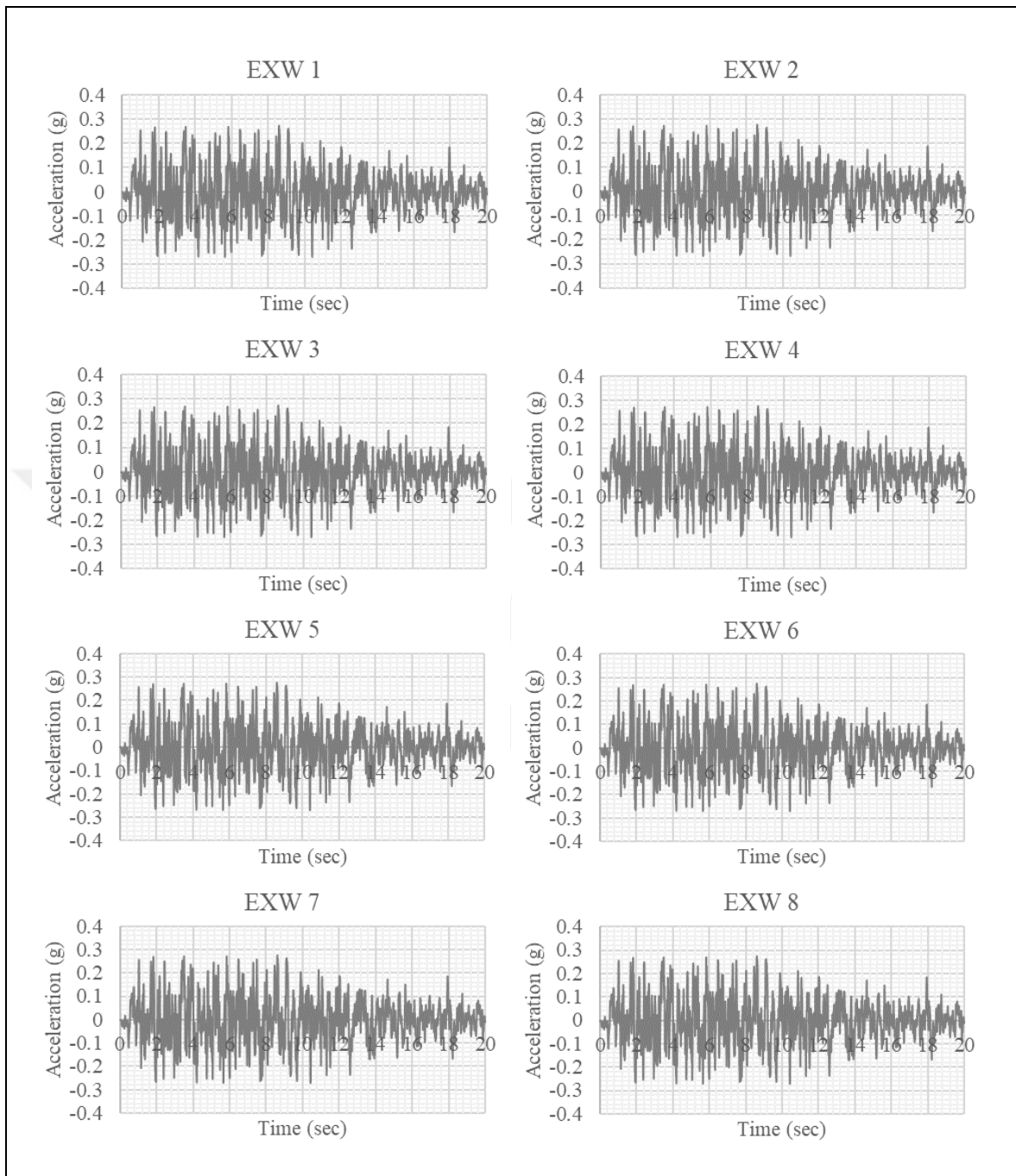


Figure 4.9. Artificial acceleration time histories for exponential envelope function (EXW)

[25]

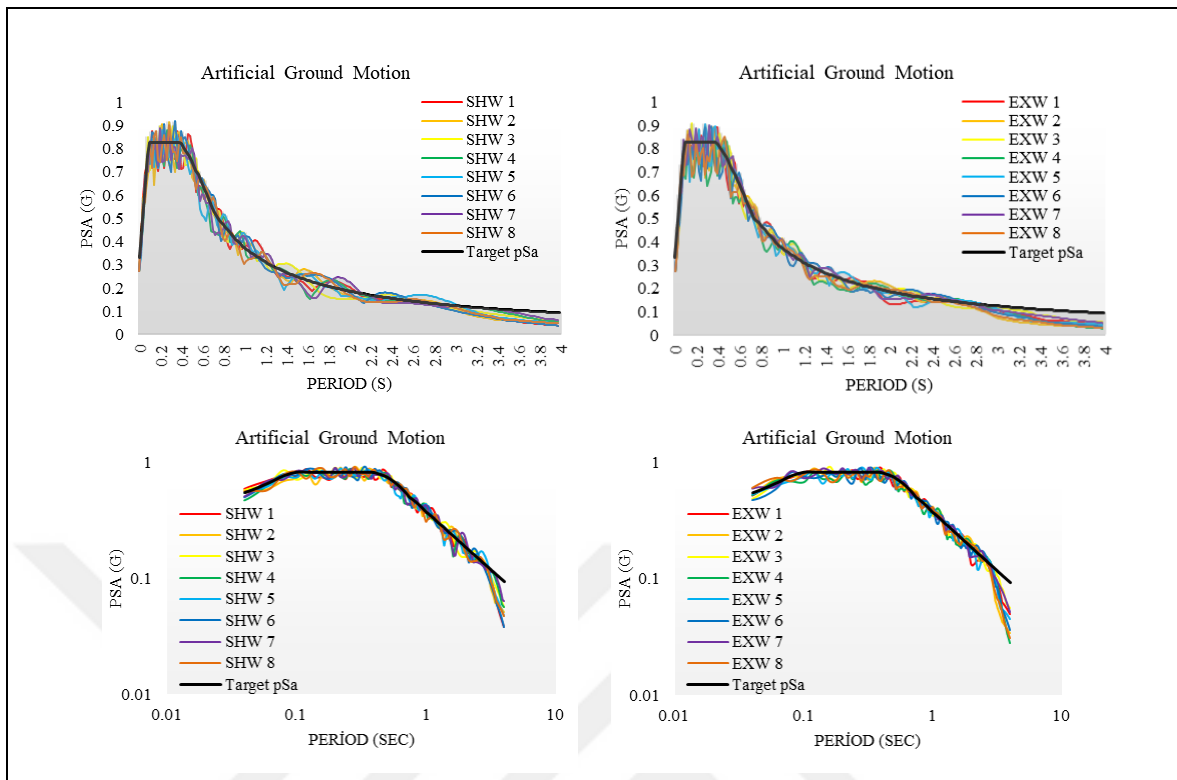


Figure 4.10. Comparison of target spectrum and response spectrum of artificial ground motion in linear and loglog plots

4.2.2. Synthetic Near-Field and Far Field Ground Motion

Due to the characteristics of earthquakes, near field ground motions have long period velocity pulses that are not shown in far field ground motions. Besides, the effect of ground motion of a moderate-large earthquake recorded in a near-field mostly differ from the effects recorded far from the earthquake source. [26] The ground motion recorded in field within a distance of about 20 km from the fault rupture is typically known as near-field ground motion. Although there is no clear definition for the distance range of near and far field, if the site is about 50 km around the fault, then the ground motion is considered as a far-field earthquake. Near-field ground motions distinctively have higher acceleration, more limited frequencies and different pulses in time histories as far as far field ground motion is concerned. In addition to that, forward directivity and fling step effects are common characteristics of near-field ground motions. These effects result from rupture mechanism, residual ground displacement and slip direction of rupture relative to the site. At the beginning of the record, large pulses are observed due to transfer of a major portion of the

fault's energy to the site when the rupture propagation of the fault towards a site with a velocity close to the shear wave velocity. Seismic waves observed at site with radiation pattern of the fault oriented in the fault-normal direction get close to each other and generate a large pulse which decrease the duration of the fault waves reaching the structure. [27,28] Although most of these pulses are observed from the radiation pattern of the fault oriented in the fault-normal direction, the fault parallel direction could result in strong pulses, too. [29,30] Fling-step effect is the relative slip between the hanging wall and footwall which produces a large amplitude unidirectional velocity pulse and a monotonic step in displacement time history. [31,32] These pulses result in the occurrence of static permanent ground displacements due to tectonic deformation associated with fault rupture. [33] As these near field effects can lead to higher seismic demands, it is important to take seismic design of structures located in the near-field zone into consideration. [51,52,53]

For each earthquake ground motion level, a total of eight near field, eight far field synthetic excitations were generated based on the adaptation of a random process to a target spectrum of the region. The accelerogram was defined using target spectrum and adapting its frequency content using the Fourier transform. Hallodorsen and Papageorgiou algorithm was used for the generation of synthetic motions applied both in the near-fault and in the far-field region. [34] The correction of the random process was performed for each iteration using the following equation. [23]

$$F(f)_{i+1} = F(f)_i \left[\frac{SRT(f)}{SR(f)_i} \right] \quad (4.4)$$

At each iteration, a Fourier transformation was applied to move from time domain to frequency domain. In order to generate the synthetic accelerogram, Gaussian white noise was multiplied by Saragoni & Hart (1974) envelope shape. Soil effects were considered as linear based on NERPH class D ($V_{s30} = 255$ m/s). The smallest and largest periods of the target response spectrum were used to determine the frequency range within the power spectral density function. In order to establish the elastic response spectra, linear dynamic analysis was performed using Newmark integration method to solve the single degree of freedom system of equations of motion. [35] For the ground motion level 2, peak ground acceleration (PGA) of near field and far field synthetic ground motions vary between 0.26g and 0.28g.

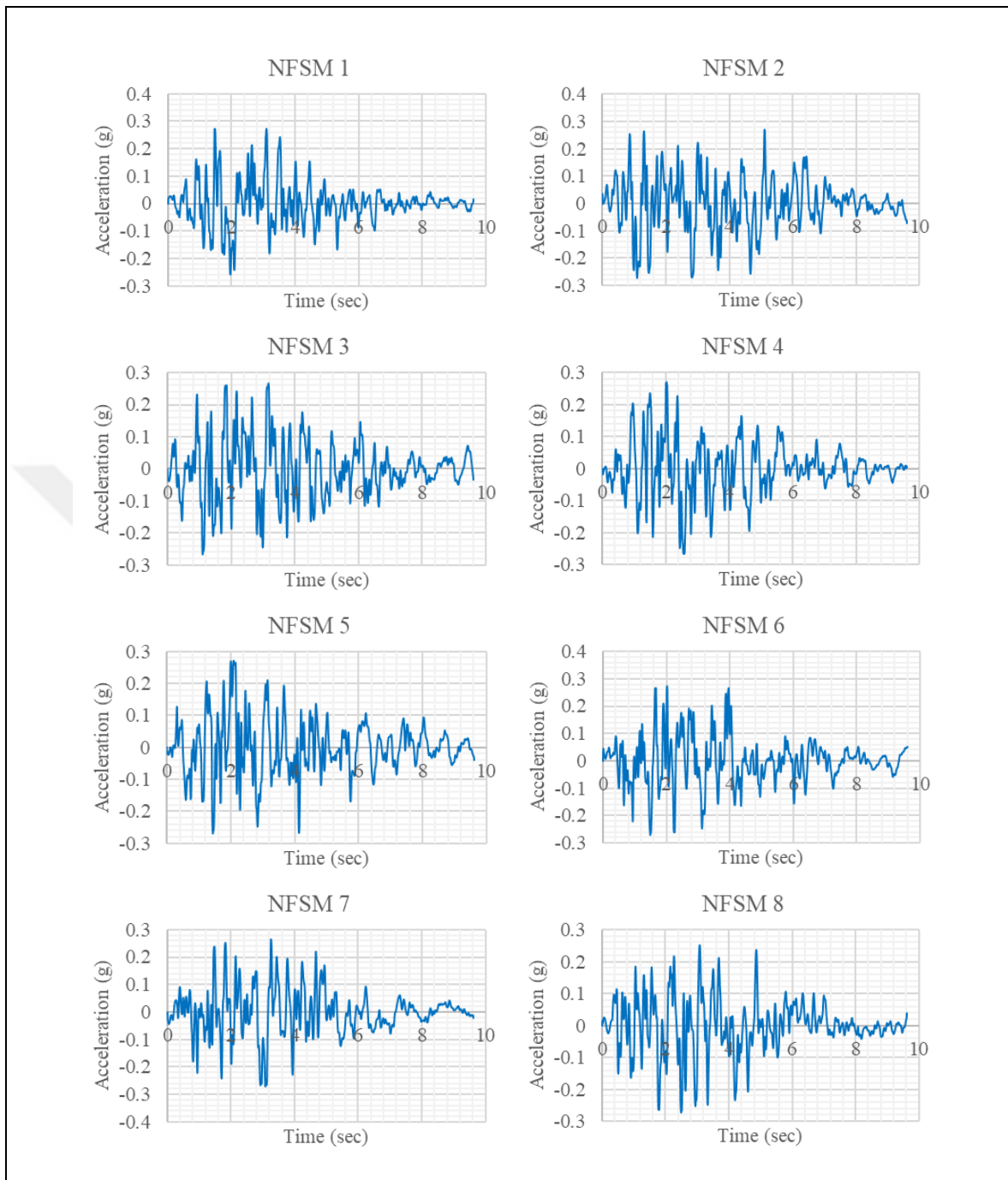


Figure 4.11. Acceleration time histories of near-field synthetic ground motion

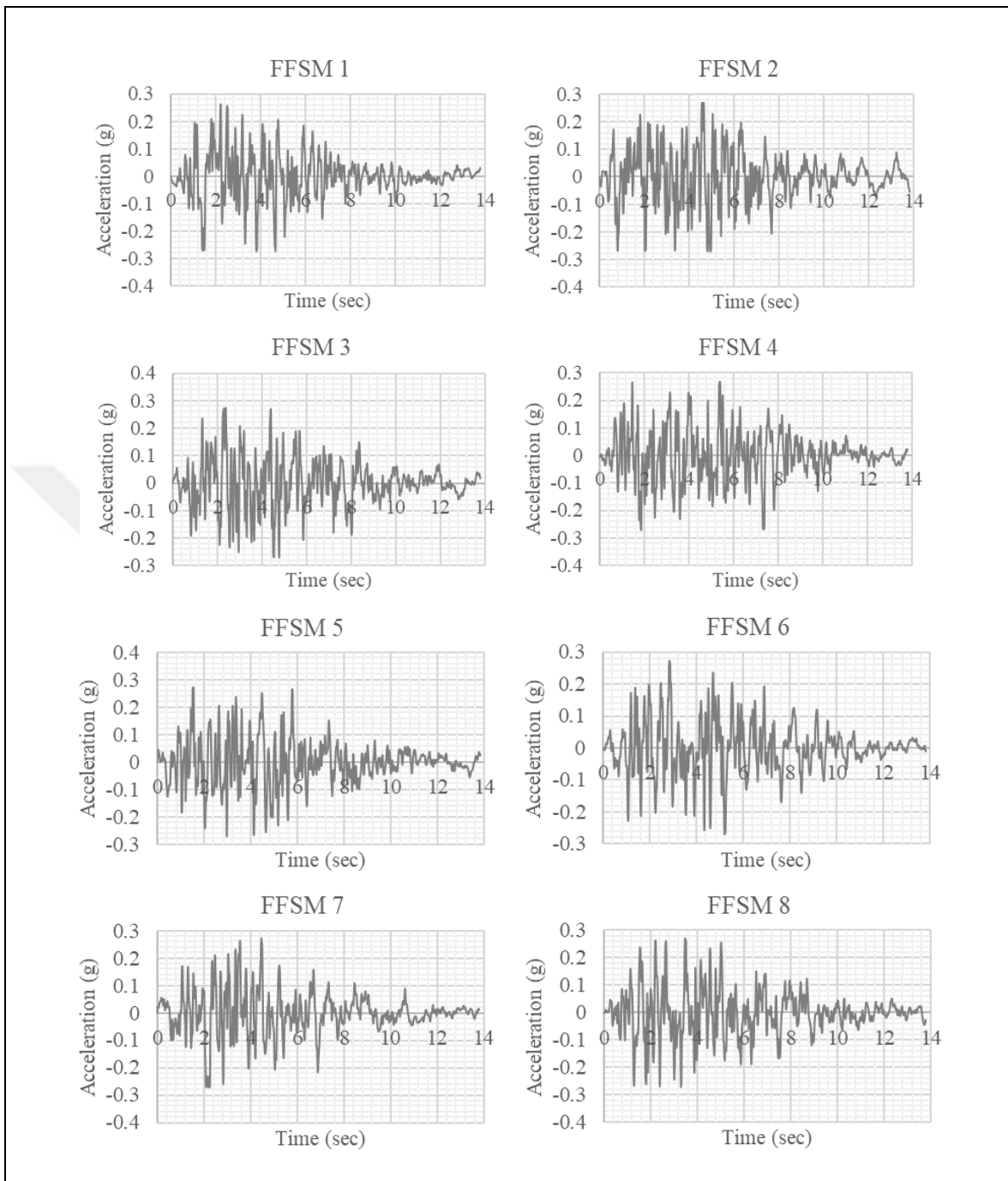


Figure 4.12. Acceleration time histories of far-field synthetic ground motion

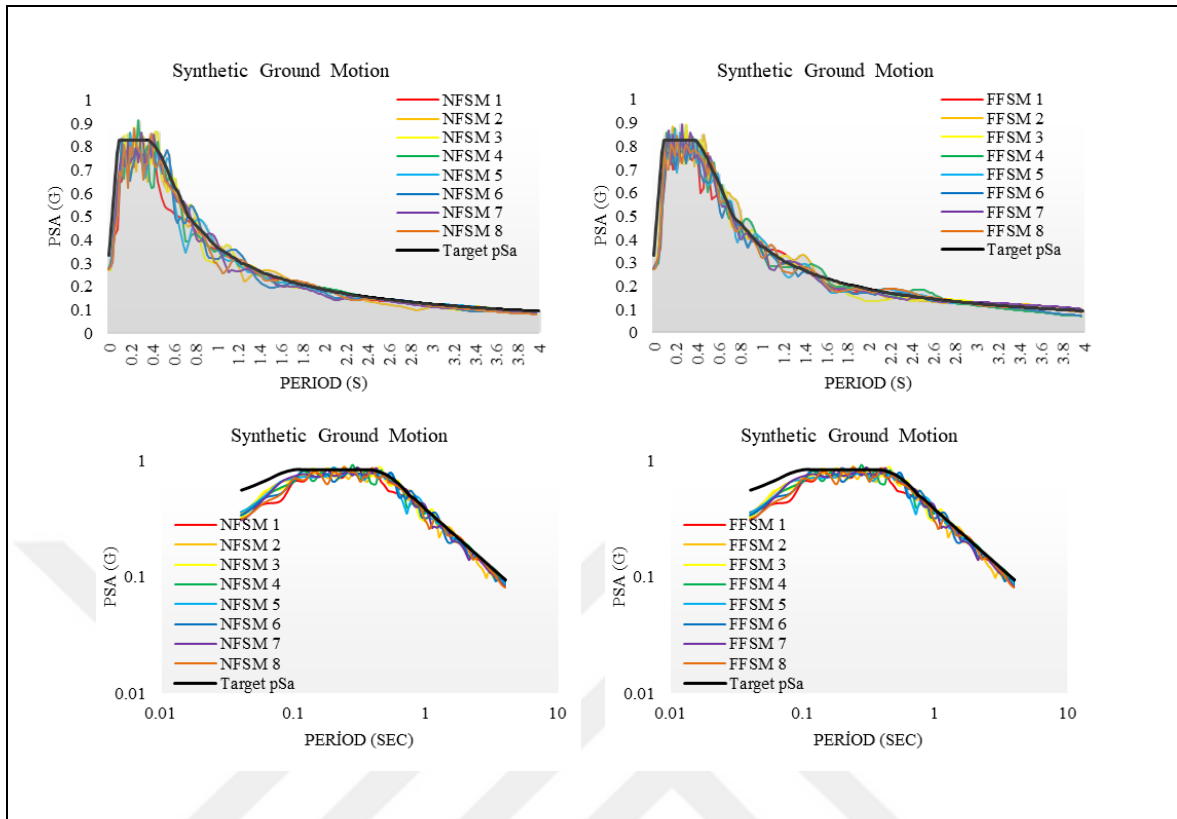


Figure 4.13. Comparison of target spectrum and response spectrum of synthetic ground motion data

4.2.3. Real Ground Motion

In addition to the AGM and SGM, natural accelerograms were also used as an input in response history analysis. The web-based Pacific Earthquake Engineering Research Center (PEER) ground motion database for shallow crustal earthquakes in active tectonic regimes was used for the unscaled real record. The database has one of the most comprehensive sets of meta-data, including different distance measure, various site characterizations, earthquake source data. [38] In the scope of this thesis, total of 11 real earthquake ground motion compatible with the target spectrum were downloaded. Furthermore, ground motion record of October 23, 2011 Van earthquake (M_L 6.7) was downloaded from the Disaster and Emergency Management Authority (AFAD) Strong Motion Database. The earthquake lasted for approximately 80 s. Acceleration time histories of Van Earthquake are given in Figure 4.14. Comparison of target spectrum and response spectrum of ground motions are shown in Figure 4.15.

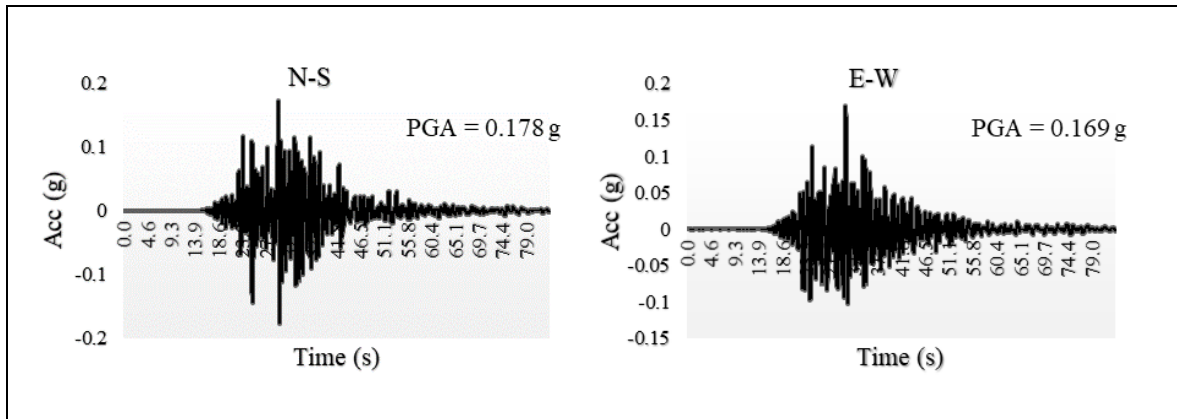


Figure 4.14. Acceleration time histories of October 23, 2011 Van earthquake

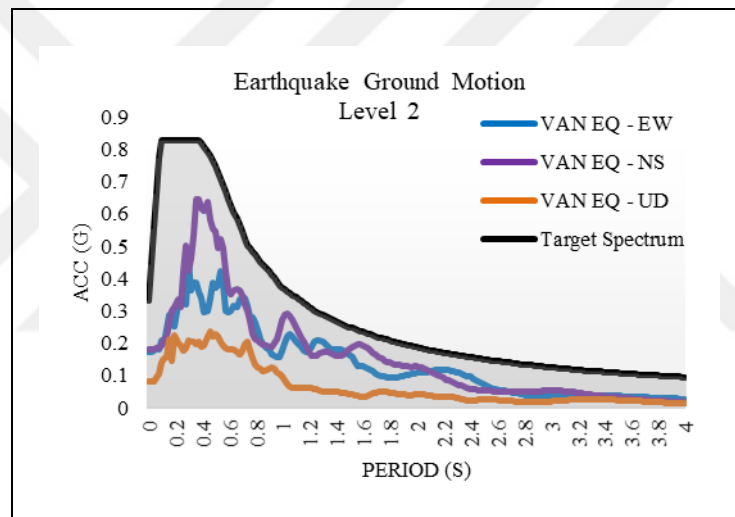


Figure 4.15. Comparison of target spectrum and response spectrum of recorded ground motion

In the meantime, real earthquake accelerograms were scaled to fit the target spectrum as it is difficult to find a sufficient number of real records reflect the site effect in terms of magnitude, distance, fault mechanism and soil condition. There are different ways of scaling the records depending on the seismic design codes that most of them reveal different methods for amplitude scaling. The European Committee Standardization recommends that the average spectrum of the scaled records should be always larger than 90 percent of the target spectrum in the periods between $0.2 T_1$ and $2.0 T_1$, where T_1 is the fundamental period of the structure in the direction where the excitation is applied. [36] The American Society of Civil Engineers, (2007) recommends that the average spectrum of the scaled records

should be equal to 1.3 times the target spectrum in the periods between $0.2 T_1$ and $1.5 T_1$. [46] According to the TBSC 2018, the amplitudes of earthquake ground motion components shall be scaled according to the rule that the ratio of the average of the resultant spectra of all selected records between the $0.2 T_p$ and $1.5 T_p$ periods and the amplitudes of the design spectrum in the same period range should not be less than 1.3 where T_p is the fundamental period of the structure in the direction where the excitation is applied. [3] In this study, amplitude scaling was applied by scaling the records to the target spectrum ordinate using minimizing the Mean Squared Error (MSE) method. This technique was applied in frequency domain over a specified period range according to the requirements given in TBSC 2018 without changing the frequency content. This iterative process was repeated until the variance in ground motions within the suite and desired matching was achieved. By means of this technique, response spectrum of the scaled data fits the target spectrum in a way that the function log was minimized in a least mean square sense over the periods between $0.2 T_p$ and $1.5 T_p$. Total of 11 real earthquake ground motion accelerograms were scaled by minimizing the MSE. Acceleration time histories of scaled real ground motion are given in Figure 4.16. Spectral comparison of scaled with respect to target spectra is given in Figure 4.17. In the study, firstly, ground motion records from PEER NGA West2 Data Bank were examined and ground motion records with desired properties were selected. [38] Then, 11 ground motion records meeting the above-mentioned conditions were scaled using the SeismoMatch program. [47] The list of ground motions used in the study is given in Table 4.1.

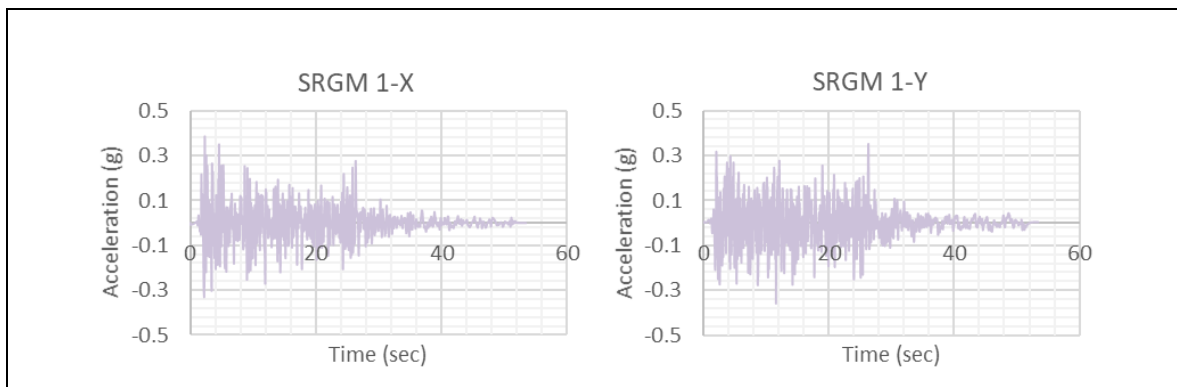


Figure 4.16. Acceleration time histories of scaled ground motion

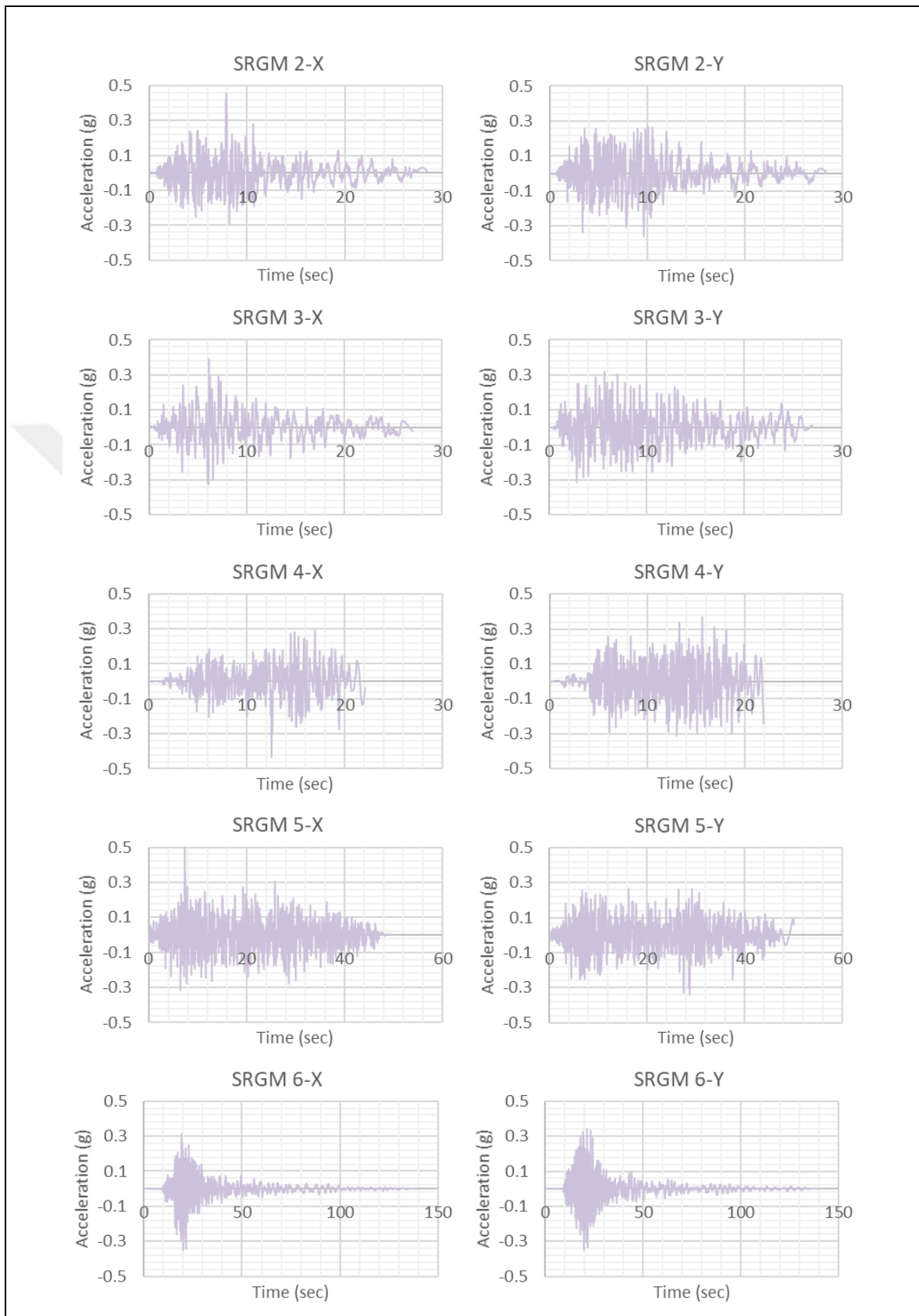


Figure 4.16. Acceleration time histories of scaled ground motion (Contd.)

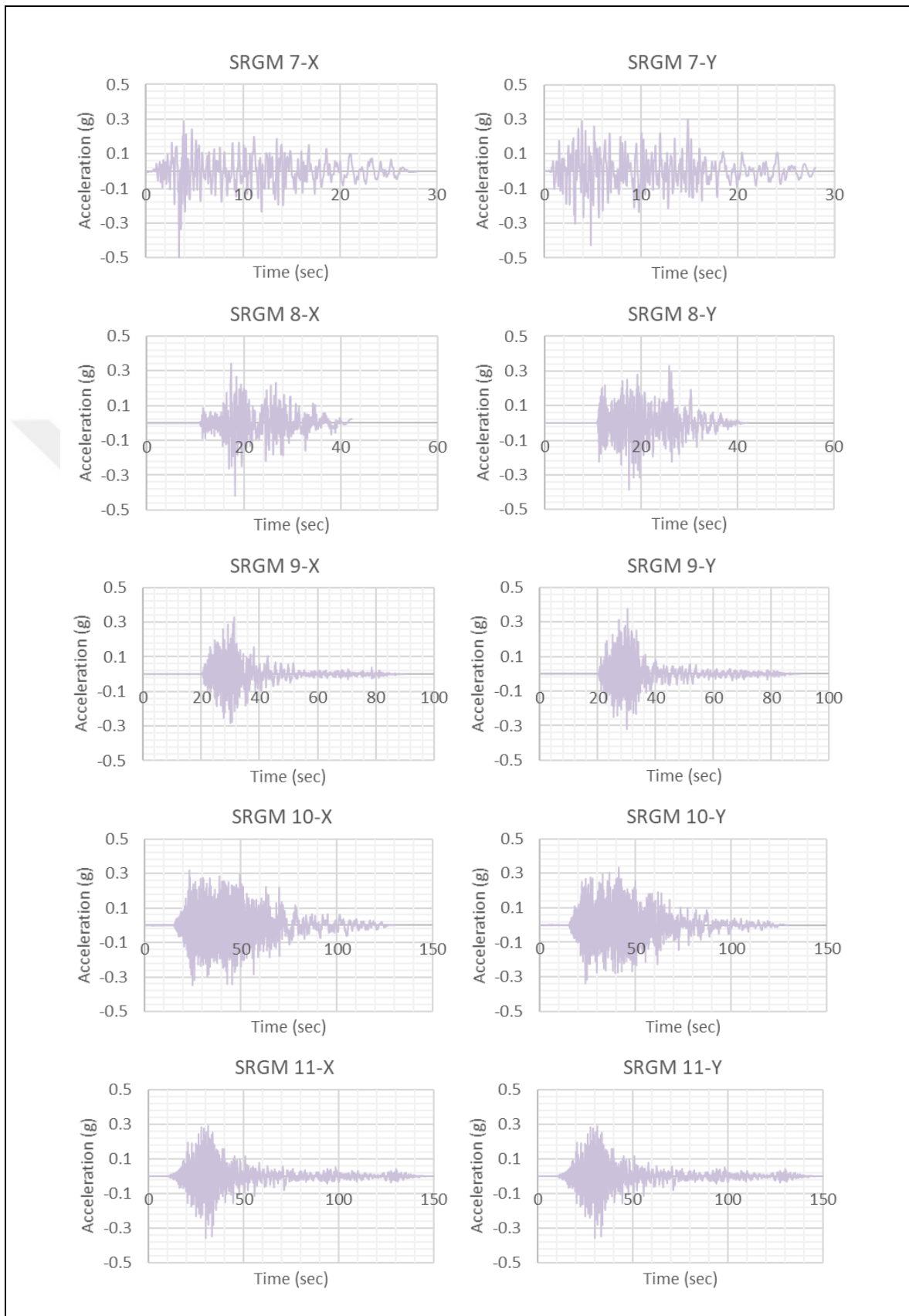


Figure 4.16. Acceleration time histories of scaled ground motion (Contd.)

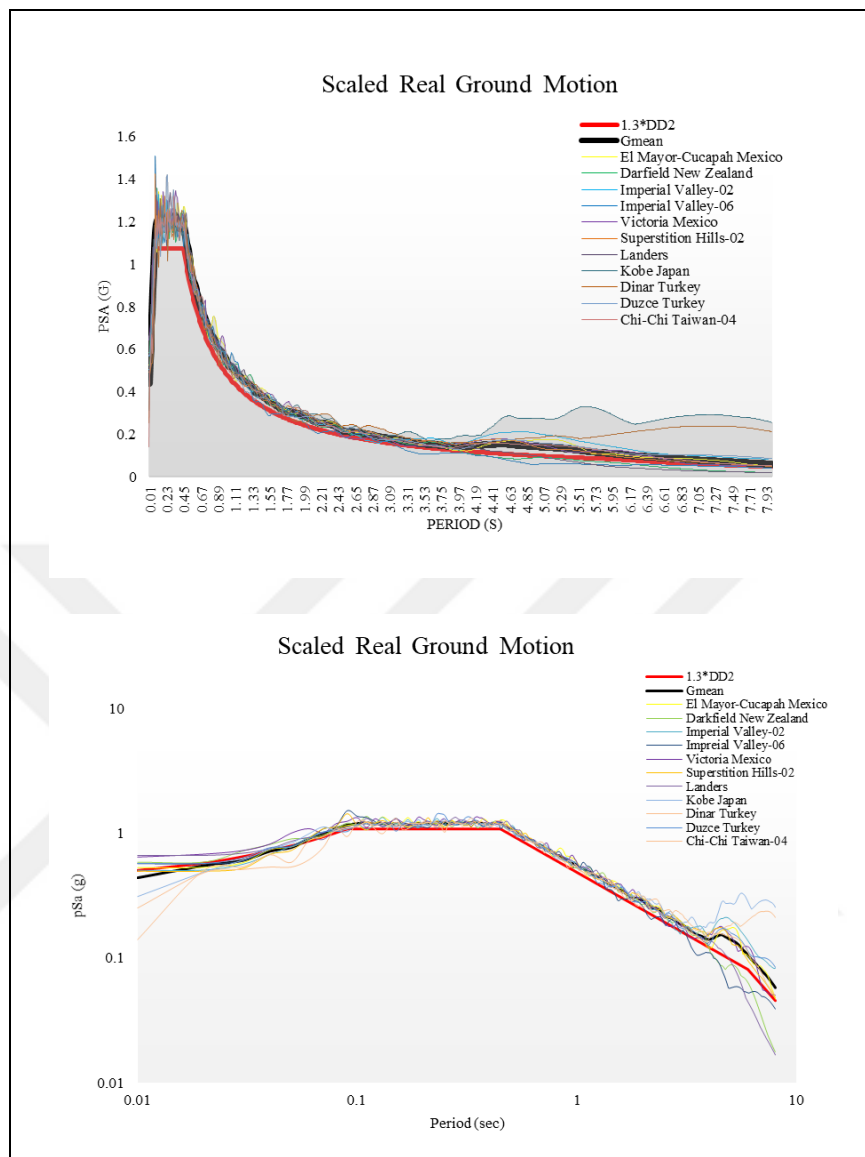


Figure 4.17. Comparison of target spectrum and response spectrum of scaled real ground motion in linear and loglog plots

Table 4.1. Earthquake records

No	Earthquake	Year	Magnitude (Mw)	Fault Mechanism	Station	Distance to Earthquake Center (km)	Vs30 (m/sn)	Scale Factor	Record Name (H1) (H2)
1	Imperial Valley-02	1940	6.95	Strike Slip	El Centro Array #9	6.09	213	0.89	RSN171 IMPVALL.H (H-EMO000)(H-EMO270)
2	Imperial Valley-06	1979	6.53	Strike Slip	Agrarias	0.65	242	1.09	RSN803 LOMAP (WVC000)(WVC270)
3	Victoria_Mexico	1980	6.33	Strike Slip	Chihuahua	18.96	242	1.32	RSN821 ERZINCAN (ERZ-NS)(ERZ-EW)
4	Superstition Hills-02	1987	6.54	Strike Slip	Brawley Airport	17.03	209	2.00	RSN949 NORTHR (ARL090)(ARL360)
5	Landers	1992	7.28	Strike Slip	Desert Hot Springs	21.78	359	1.55	RSN1114 KOBE (PRI000)(PRI090)
6	Kobe_Japan	1995	6.9	Strike Slip	Abeno	24.85	256	1.28	RSN1141 DINAR (DIN090)(DIN180)
7	Dinar_Turkey	1995	6.4	Normal	Dinar	3.36	220	0.76	RSN1176 KOCAELI (YPT060)(YPT150)
8	Duzce_Turkey	1999	7.14	Strike Slip	Lamont 1062	9.14	338	1.69	RSN1244 CHICHI (CHY101-E)(CHY101-N)
9	Chi-Chi-Taiwan-04	1999	6.2	Strike Slip	CHY101	21.67	259	1.23	RSN1605 DUZCE (DZC180)(DZC270)
10	El Mayor-Cucapah_	2010	7.2	Strike Slip	EJIDO SALTILLO	17.32	242	0.91	RSN2114 DENALI (PS10-047)(PS10-317)
11	Darfield_New Zealand	2010	7	Strike Slip	Christchurch Botanical	18.05	187	0.91	RSN6906 DARFIELD (GDLCN55W)(GDLC35W)

5. CASE STUDY: EVALUATION OF BUILDING PERFORMANCE AN EXISTING RC BUILDING

5.1. BUILDING GENERAL INFORMATION

The existing building to be assessment performance is located in Ipekyolu, Van. The location of building is given Figure 5.1. The building consists of 1 ground and 2 normal floors. Ground floor height is 4.50m, height of 1st floor is 3.60m, height of 2nd floor is 4.00m and the total height of the building is 12.10m. The building is used as an exhibition center. The building, which has an orthogonal axis system, has 6 axes in the X-X direction and 4 axes in the Y-Y direction. In the X-X direction, the first and the last of the axes span is 4.33 meters, and the middle axes span is 6 meters. The axes span in the Y-Y direction are 6.5 meters, but only ground floor has 5 axes in the Y-Y direction, and the axes spans respectively 3.65m, 2.85m and 2x6.5 meters. The length of the building in the X-X direction is 26.66 meters from the axle to the axle and 19.5 meters from the axle to the axis in the Y-Y direction. The bearing system of the existing reinforced concrete building consist only of frame and the earthquake loads are covered by the frames. The longitudinal section is given in Figure 5.3. The formwork plans showing the building geometry is shown in Figure 5.4, Figure 5.5, Figure 5.6.



Figure 5.1. The existing building location (Latitude:38.51112° Longitude:43.43977°) (I)



Figure 5.2. The existing building location (Latitude:38.51112⁰ Longitude:43.43977⁰) (II)

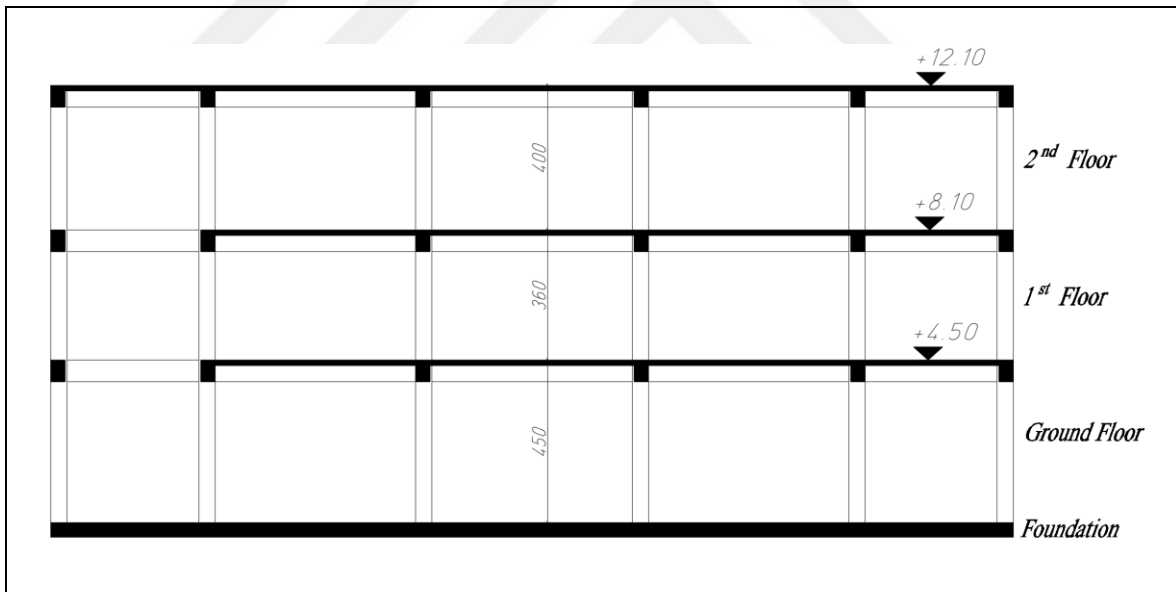


Figure 5.3. Longitudinal section

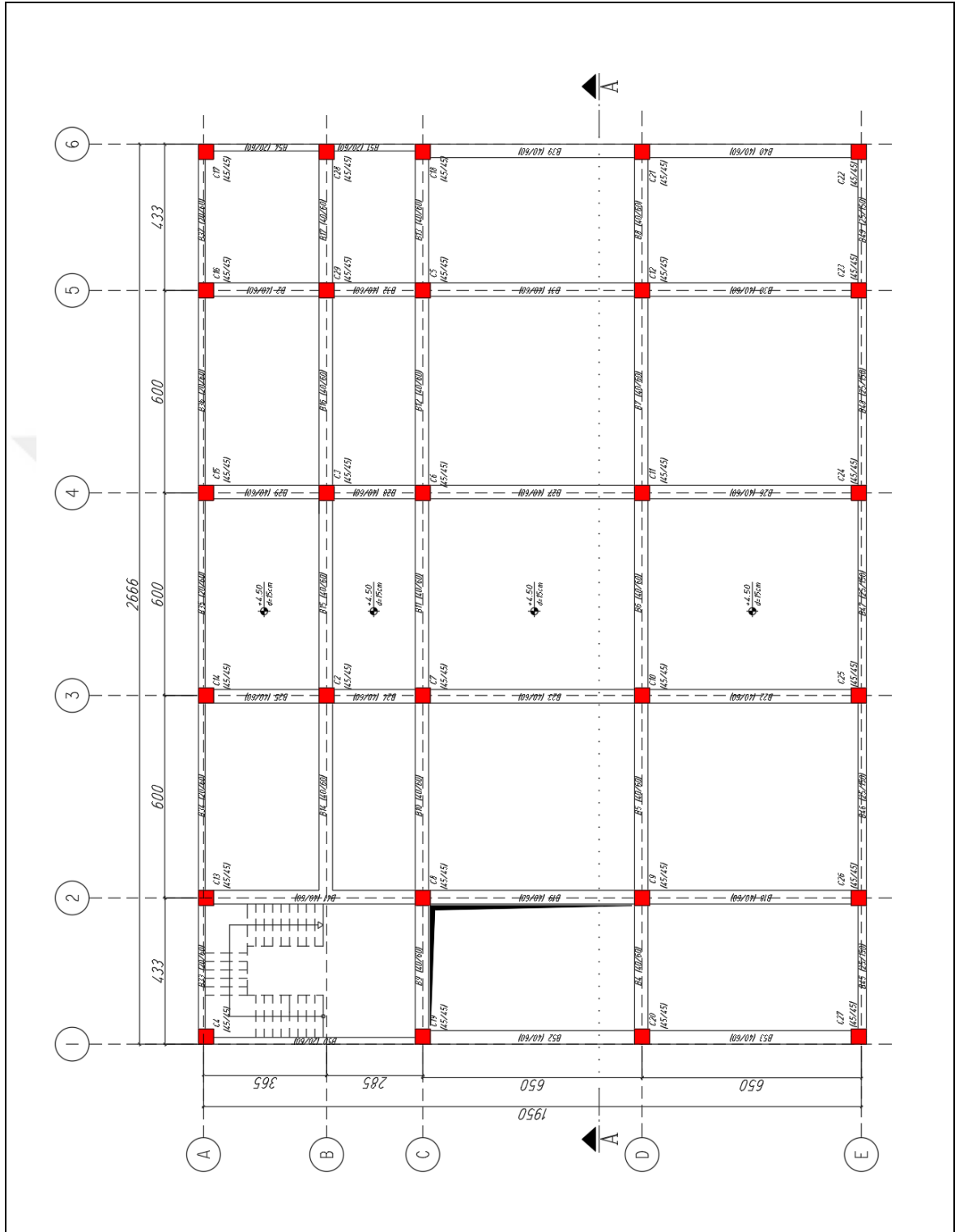


Figure 5.4. Ground floor formwork plan

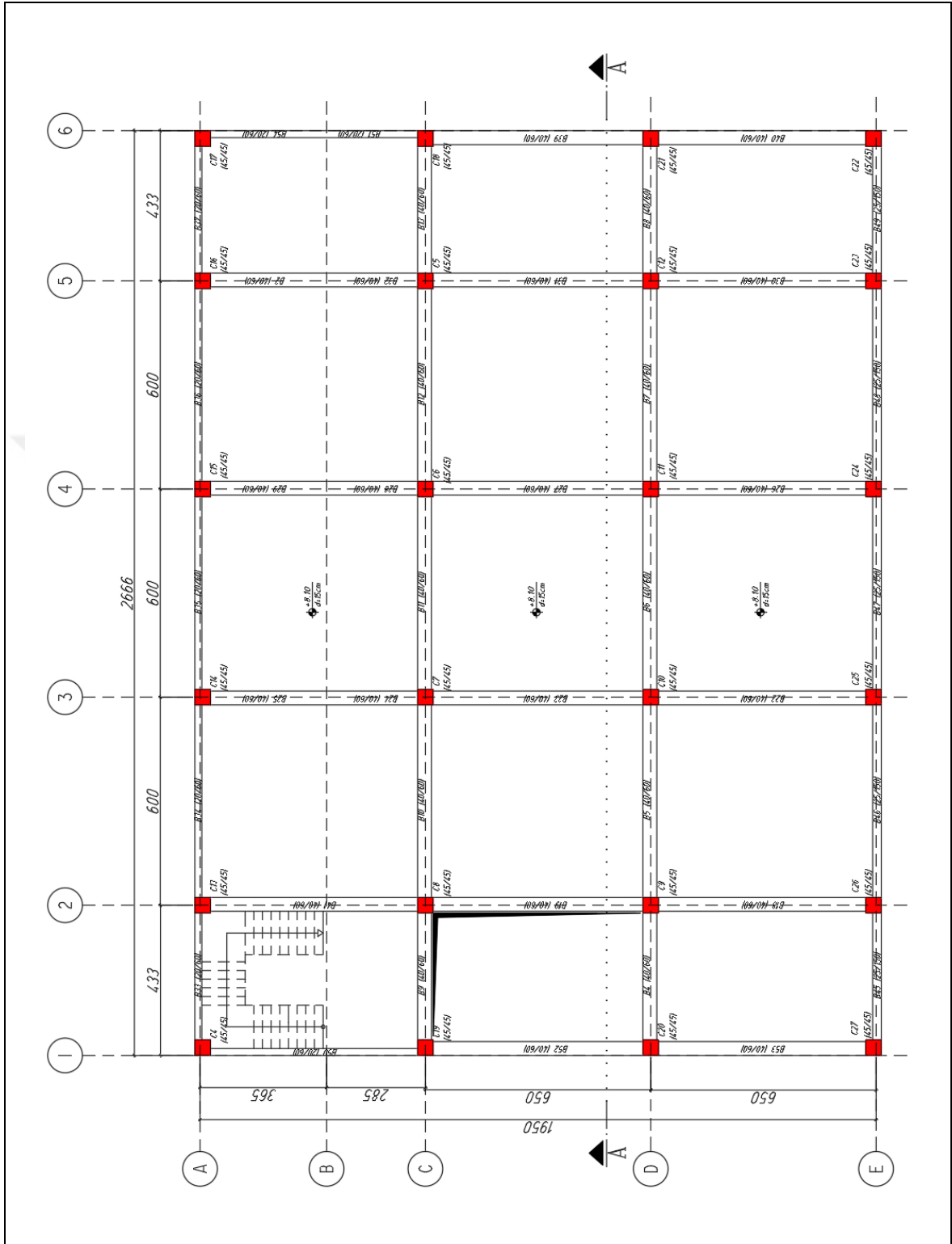


Figure 5.5. 1st floor formwork plan

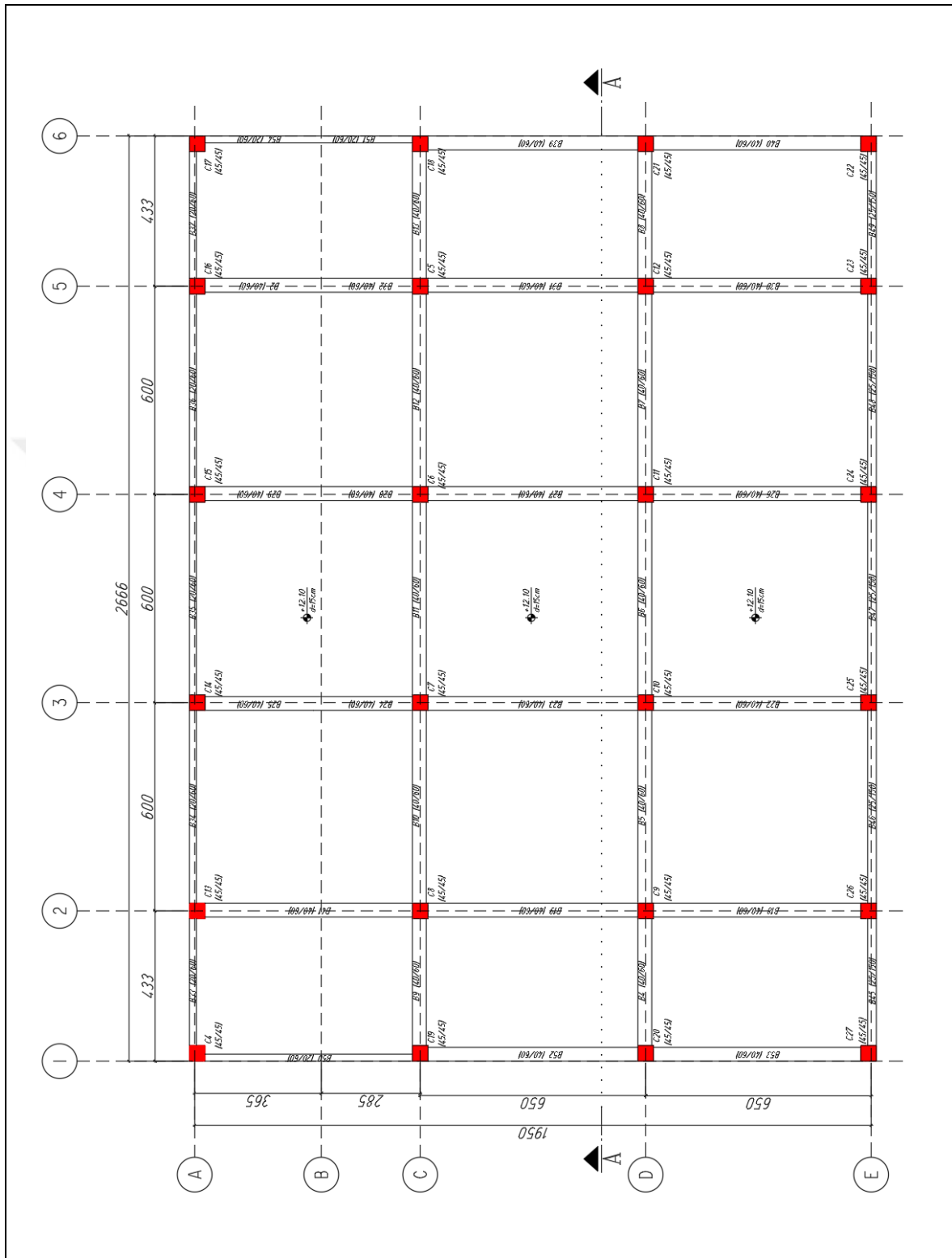


Figure 5.6. 2nd floor formwork plan

i. Building usage classification and importance factor:

The case study structure is an exhibition center, therefore building usage class (BKS) is 2, and importance factor (I) is 1.2.

Table 5.1. Building usage class and importance factor for the case study structure

Building Usage Class	Purpose of Occupancy or Type of Building	Building Importance Factor (I)
BKS = 2	Buildings where people are short-term and dense Shopping malls, sports facilities, cinema, theatre, concert halls, place of worship, etc.	1.2

ii. Seismic design category

Seismic design categories are described in Section 3.3. At DD-2 earthquake ground motion level, the short-period design spectral acceleration coefficient is $S_{DS} = 0.825$. $DTS = 1$ for $S_{DS} > 0.75$ and BKS = 2.

Table 5.2. Seismic design category for the case study structure

DD-2 Short Period Design Spectral Acceleration Coefficient at Earthquake Ground Motion Level-2 (S_{DS})	Building Usage Class	
	BKS = 1	BKS = 2, 3
$S_{DS} < 0.33$	DTS = 4a	DTS = 4
$0.33 \leq S_{DS} < 0.50$	DTS = 3a	DTS = 3
$0.50 \leq S_{DS} < 0.75$	DTS = 2a	DTS = 2
$S_{DS} = 0.825 \geq 0.75$	DTS = 1a	DTS = 1

iii. Building height class

There is no rigid basement floor in the building used in the study. Building height is $H_N = 12.10\text{m}$. Accordingly, for $DTS=1$, the building height class is determined as $BYS=6$.

Table 5.3. Building height classes for the case study structure

Building Height Class	DTS = 1, 1a, 2, 2a	DTS = 3, 3a	DTS = 4, 4a
BYS = 1	$H_N > 70$	$H_N > 91$	$H_N > 105$
BYS = 2	$56 < H_N \leq 70$	$70 < H_N \leq 91$	$91 < H_N \leq 105$
BYS = 3	$42 < H_N \leq 56$	$56 < H_N \leq 70$	$56 < H_N \leq 91$
BYS = 4	$28 < H_N \leq 42$	$42 < H_N \leq 56$	$42 < H_N \leq 56$
BYS = 5	$17.5 < H_N \leq 28$	$28 < H_N \leq 42$	$28 < H_N \leq 42$
BYS = 6	$10.5 < H_N \leq 17.5$	$17.5 < H_N \leq 28$	$17.5 < H_N \leq 28$
BYS = 7	$7 < H_N \leq 10.5$	$10.5 < H_N \leq 17.5$	$10.5 < H_N \leq 17.5$
BYS = 8	$H_N \leq 7$	$H_N \leq 10.5$	$H_N \leq 10.5$

iv. Building performance target

Within the scope of the performance-based earthquake safety determination of the existing building used in the study, the existing building (Building Height Class-BYS=6, $H_N=12.10\text{m}$) was evaluated as Building Usage Class (BKS)=2 (Exhibition Center) and Earthquake Design Class (DTS)=1. In this case, according to TBDY-2018, the minimum performance target for existing buildings is the earthquake level with 10 percent probability of exceeding in 50 years and the Controlled Damage performance for DD-2 earthquake ground motion level where the corresponding recurrence period is 475 years. As a performance approach, it should be done according to the deformation criteria.

Table 5.4. Performance objectives for case study structure

Earthquake Ground Motion Level	DTS = 1, 2, 3, 3a, 4, 4a		DTS = 1a, 2a	
	Standard Performance Target	Design/Evaluation Approach	Advanced Performance Target	Design/Evaluation Approach
DD-3	—	—	SH	ŞGDT
DD-2	KH	ŞGDT	—	—
DD-1	—	—	KH	ŞGDT

5.1.1. Material Properties

The concrete quality of the existing structure is determined as C15 (BS 15). Yield strength of longitudinal and transverse reinforcement is S420.

Concrete quality of C15 as given in TS-500 [8];

Characteristic compressive cylinder strength of concrete : $f_{ck} = 15 \text{ MPa}$

Modulus of elasticity : $E_c = 26587 \text{ MPa}$

Requirements for reinforcing steel with strength of S420 given in TS-500 [8];

Characteristic yield strength of longitudinal reinforcement : $f_{yk} = 420 \text{ MPa}$

Characteristic yield strength of transverse reinforcement : $f_{yk} = 420 \text{ MPa}$

Modulus of elasticity : $E_s = 200000 \text{ MPa}$

5.1.2. Soil Conditions

Soil groups and local site classes to be considered as the bases of determination of local soil conditions are given in Table 5.5. For the case study, available local information and observation results are used to identify the soil group and local site class. [55] The average V_{s30} (m/s) at the foundation level of the building is in the range of 180-360 m/s and the local site class is ZD.

Table 5.5. Local soil class for case study structure (TBSC-2018)

Local Site Classes	Description of Soil Class	Average in the top 30 meters		
		$(V_s)_{30}$ [m/s]	$(N_{60})_{30}$	$(c_u)_{30}$ [kPa]
ZA	Sound, stiff rocks	> 1500	-	-
ZB	Slightly weathered, medium sound rocks	760 – 1500	-	-
ZC	Very dense sand, gravel and stiff clay layers or soft rocks with planes of many cracks	360 – 760	> 50	> 250
ZD	Medium-dense sand, gravel or very stiff clay layers	180 – 360	15 - 50	70 - 250
ZE	Loose sand, gravel or very stiff layers of clay or Profiles containing a soft clay layer ($c_u < 25 \text{ kPa}$) thicker than 3 meters in total, meeting the conditions of $PI > 20$ and $w > 40\%$	< 180	< 15	< 70
ZF	Soils requiring site-specific research and evaluation: 1) Soils with a potential risk of subsidence under the effect of earthquakes (liquefiable, highly sensitive clays, collapsible, weakly cemented soils, etc., 2) Clays with a total thickness of more than 3 meters with high peat and/or organic content, 3) High plasticity ($PI > 50$) clays with a total thickness of more than 8 meters, 4) Very thick (> 35 m) soft or medium stiff clays			

5.1.3. Loads

Numerical model of the existing structure is created along with the requirements of seismic loads and other loads. Considering the other loads (such as floor thickness, floor covering types and thicknesses, partition walls etc.), reinforced structural system is modelled according to the requirements specified in TS -498 and to the requirements as well as material and load factors specified in TS-500.

5.1.3.1. Dead Loads and Live Loads

The self-weights of reinforced concrete building members (beams, columns, walls, floors) are calculated according to the cross-section and material properties of the element in the structural analysis program and are directly included in the calculations. In addition to the self-weights, the super dead loads, which are also included in the dead loads and may differ on each floor of the buildings, and the live load acceptance that the relevant floors may be exposed to according to the purpose of use are given in Table 5.6.

Table 5.6. Dead and live loads

Reinforced Concrete Slab			
	Ground Floor and 1st Floor	2nd Floor	
	Slab Thickness	Slab Thickness	
	b=15	b=15	cm
Slab (Self-weight)	3.75	3.75	kN/m ²
Super Dead Load	2.00	2.00	kN/m ²
Total Dead Loads:	5.75	5.75	kN/m²
Total Live Loads:	3.50	1.50	kN/m²

5.1.3.2. Seismic Loads

In order to evaluate the earthquake safety of the existing structure used in the study within the scope of performance-based evaluation methods, TBSC-2018 principles were used for earthquake loading data to be used in the analysis and Seismic Hazard Maps prepared by

AFAD were used. First of all, considering the latitude and longitude of the location of the building and soil class, acceleration magnitudes corresponding to the relevant earthquake ground motion level were obtained from seismic hazard maps and the earthquake design spectrum was defined. For the nonlinear time history method, the earthquake records are scaled according to the spectrum whose values are specified mentioned below. Detailed information on these earthquake records is given in section 4.

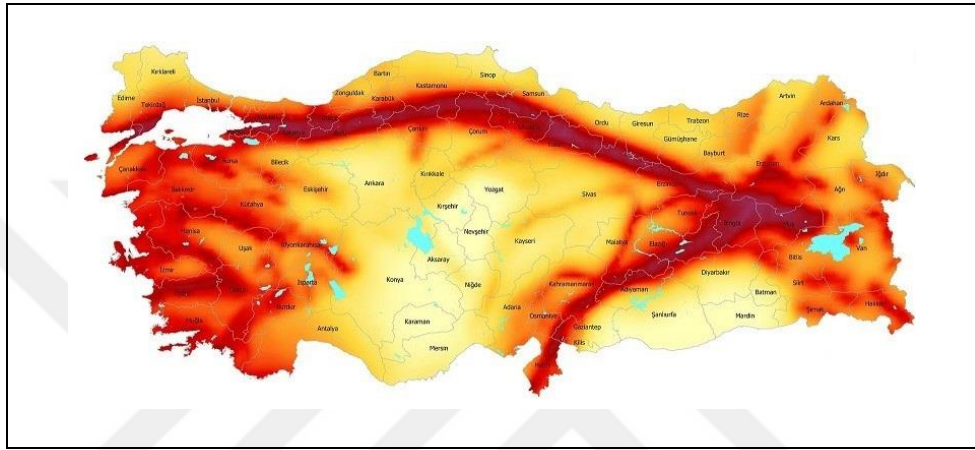


Figure 5.7. Seismic hazard map of Turkey

Spectrum and spectral acceleration coefficients for ground motion level 2 (DD-2) are given as;

Seismic Hazard Map:

- Short Period Spectral Acceleration Coefficient : $S_S = 1.013$
- Map Spectral Acceleration Coefficient for a Period of 1 Second : $S_1 = 0.275$
- Peak Ground Acceleration : $PGA = 0.414 \text{ g}$

F_S and F_1 :

- For Short Period Zone (ZD, S_S) : $F_S = 0.900$
- For 1 Second Period Zone (ZD, S_1) : $F_1 = 0.800$

Design Spectral Acceleration Coefficients (S_{DS} and S_{D1}) and Spectrum Characteristic Periods (T_A and T_B):

$$S_{DS} = S_S \times F_S = 1.013 \times 0.900 = 0.912$$

$$S_{D1} = S_1 \times F_1 = 0.275 \times 0.800 = 0.220$$

$$T_A = 0.048 \text{ s}, T_B = 0.241 \text{ s}$$

5.2. STRUCTURAL SYSTEM ANALYSIS

The three-dimensional (3D) numerical model of the buildings was created using, ETABS v19.0.2 (*Integrated Building Design Software*) structural analysis program.

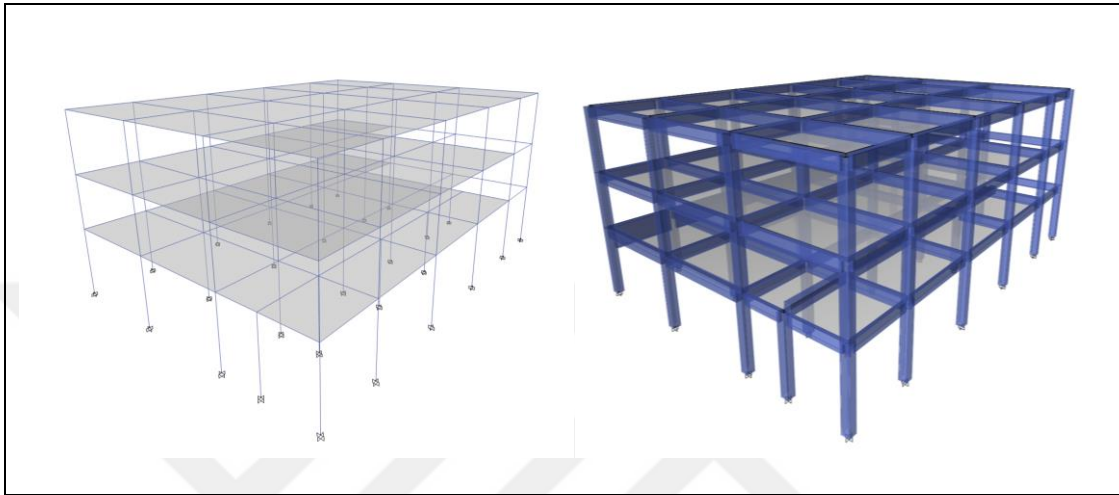


Figure 5.8. 3D numerical model of the existing building

In the nonlinear calculation model of the building's bearing system:

- a) Assuming that the floors work as a rigid diaphragm in the horizontal plane, two horizontal displacements and rotational degrees of freedom around the vertical axis are taken into consideration at each floor. The story degrees of freedom are defined at the center of mass of each floor, and additional eccentricity is not applied.
- b) Story masses to be taken into consideration in earthquake calculations are defined in accordance with the story weights.
- c) Beams and columns are represented by frame finite elements.
- d) Effective section rigidities are used for all sections.
- e) The structural system model of the building has been prepared with sufficient accuracy to calculate the internal forces, displacements and deformations that will occur in the structural elements under the common effects of earthquake effects and vertical loads.
- f) Lumped plasticity model was used in columns and beams as a nonlinear behavior model. Plastic hinges are generally placed at both ends of the frame members and a linear

behavior pattern is considered in the areas outside these two hinges. These types of hinges are defined as M3 or M2 hinges. Likewise, the relationship between axial force and bending moment can be modelled by defining the yield-surfaces. These types of hinges are defined as P-M-M hinges.

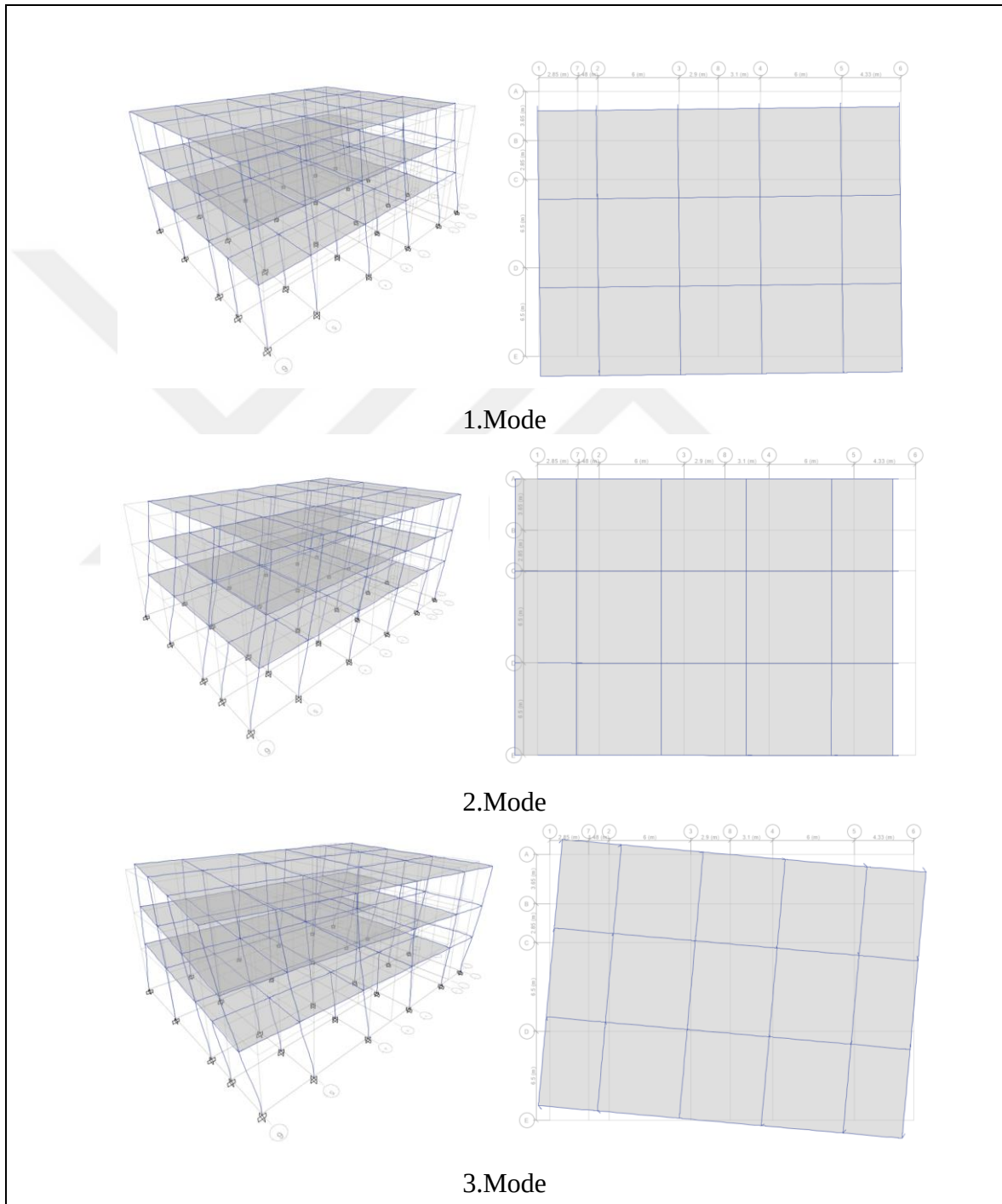


Figure 5.9. Mode shapes of the case study structure

5.3. NON-LINEAR STRUCTURAL MODELING

See Appendix-A for program definitions of nonlinear material, nonlinear hinges and earthquake loads.

5.3.1. Effective Rigidity Factor and Rotation Limits

The allowable limit for plastic rotations calculated according to the lumped plastic behavior model will be determined according to the formulas given in the following equations as a result of the curvature analysis to be made by considering the axial force acting on the section and the concrete and reinforcement rebar models given in TBSC-2018.

For the Collapse Prevention (GÖ) performance level;

$$\theta_p^{(G\ddot{O})} = \frac{2}{3} \left[(\phi_u - \phi_y) \times L_p \times \left(1 - 0.5 \frac{L_p}{L_s} \right) + 4.5 \phi_u d_b \right] \quad (5.1)$$

For the Controlled Damage (KH) performance level;

$$\theta_p^{(KH)} = 0.75 \times \theta_p^{(G\ddot{O})} \quad (5.2)$$

For the Limited Damage (SH) performance level;

$$\theta_p^{(SH)} = 0 \quad (5.3)$$

In the analysis and evaluation of the sections, the structural analysis program SAP2000 v23 (*Structural Analysis Program*) was used. [6] An example calculation for one section is given in the following procedures. Detailed calculations are given in Appendix-B.

For 45cmx45cm column, 8Φ16 reinforcement, plastic rotation limit values are calculated for different performance levels. (See Figure 5.10, Figure 5.11)

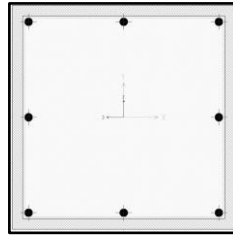


Figure 5.10. Section designer model for 45cmx45cm column

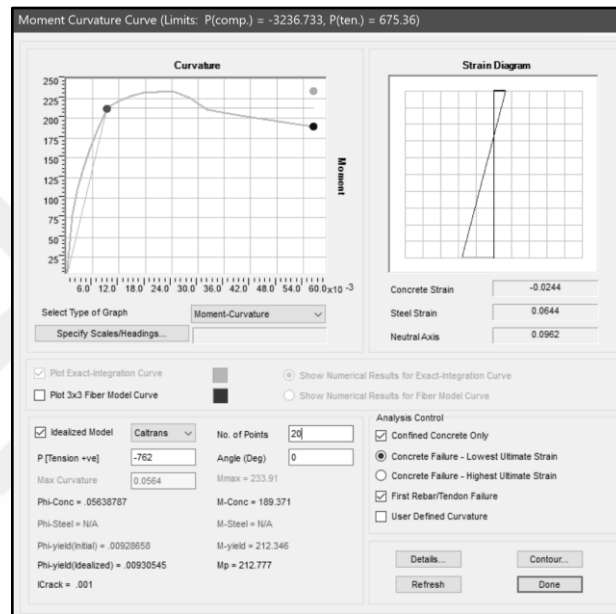


Figure 5.11. Moment-curvature diagram

Plastic Rotation Limit Values in 45cmx45cm Column Critical Cross Section:

E	: 26587000kN/m ²	f_{ce}	: 15 MPa
L_s	: 2.25 m	$(EI)_e$	: 14580
N_d	: 762kN	$(EI)_e / EI$	: 0.160
η	: 1	ϵ_{su}	: 0.08
EI	: 90853kNm ²	ϕ_u	: 0.0471 1/m
ϕ_y	: 0.00931/m	L_p	: 0.45/2 = 0.225 m
M_y	: 212.34kNm	$\epsilon_s^{(G\ddot{O})}$	: 0.032
d_b	: 0.016 m	$\epsilon_s^{(KH)}$	: 0.024
f_{ye}	: 420 MPa	$\epsilon_s^{(SH)}$	: 0.0075
Θ_y	: 0.0109 rad		

Plastic rotation limit values:

$$\Theta_p^{(G\ddot{O})} : 0.0077 \text{ rad}, \quad \Theta_p^{(KH)} : 0.0058 \text{ rad}, \quad \Theta_p^{(SH)} : 0$$

5.4. EVALUATION OF EARTHQUAKE PERFORMANCE

5.4.1. Explanation of Section Damage Zones

The charts given below and the tables given in the Appendix-B correspond to the most unfavorable damage distribution in the column and beam elements of the existing reinforced concrete building, obtained by the earthquake forces acting on the building separately in both directions.

The damage limits in each section of the structural member, which is defined in TBSC-2018 and formed a plastic section, are expressed in Limited Damage (SH) Controlled Damage (KH) and Collapse Prevention (GÖ).

Plastic rotation limit values corresponding to each limit state are defined as $\theta_p^{(SH)} \cdot \theta_p^{(KH)} \cdot \theta_p^{(GÖ)}$.

It is expressed in terms of the ratio to the limit value in the tables and graphs showing the damage distribution given below.

In this case, the damage zone in the critical section no=i was determined as a result of the comparison to be made with the following limit values $\theta_p^{(i)}$, depending on the proportional value of the plastic rotation in the relevant section to the collapse prevention limit value. $(\frac{\theta_p^{(i)}}{\theta_p^{(GÖ)}})$.

$$0 < \frac{\theta_p^{(i)}}{\theta_p^{(GÖ)}} \leq \frac{\theta_p^{(KH)}}{\theta_p^{(GÖ)}} = 0.75$$

Visible Damage Zone – (BHB)

$$0.75 < \frac{\theta_p^{(i)}}{\theta_p^{(GÖ)}} \leq \frac{\theta_p^{(GÖ)}}{\theta_p^{(GÖ)}} = 1.00$$

Limited Damage Zone – (İHB)

$$1.00 < \frac{\theta_p^{(i)}}{\theta_p^{(GÖ)}}$$

Collapse Zone – (GB)

5.4.2. Performance Assessment for Columns

Performance evaluation of column members in terms of flexural and shear effects is presented in the following graphics for all ground motion data sets. For the table showing the damage distributions of column elements, see Appendix-B. For placement of column members, See Appendix-A.

First of all, in the control of brittle failure in terms of shear effects of the bearing system members;

- a) For artificial ground motion records of Saragoni & hart envelope function (SHW):

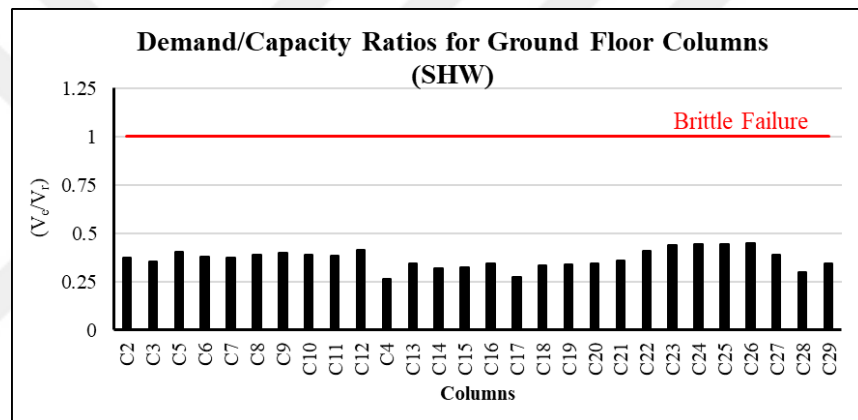


Figure 5.12. D/C ratios for ground floor columns (SHW)

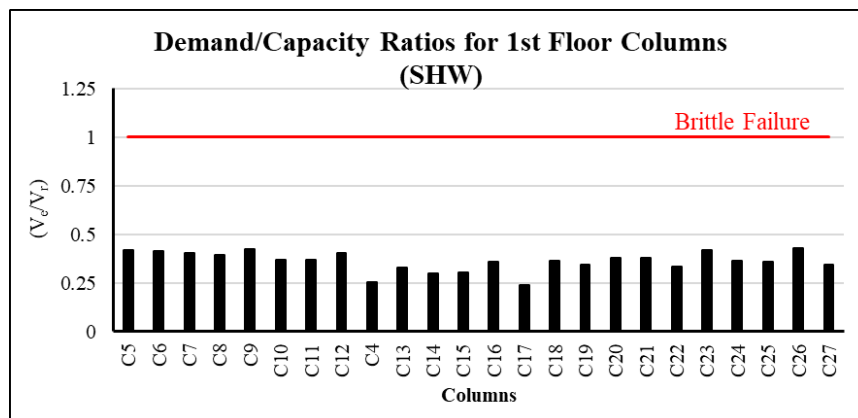


Figure 5.13. D/C ratios for ground 1st floor columns (SHW)

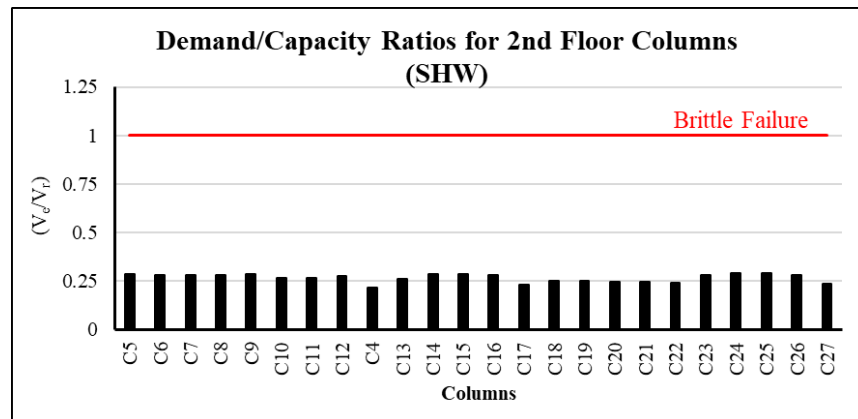


Figure 5.14. D/C ratios for ground 2nd floor columns (SHW)

b) For artificial ground motion records of exponential envelope function (EXW):

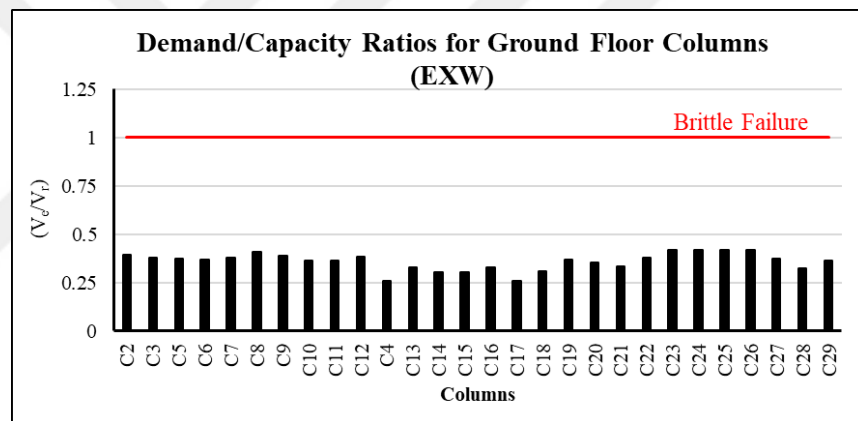


Figure 5.15. D/C ratios for ground floor columns (EXW)

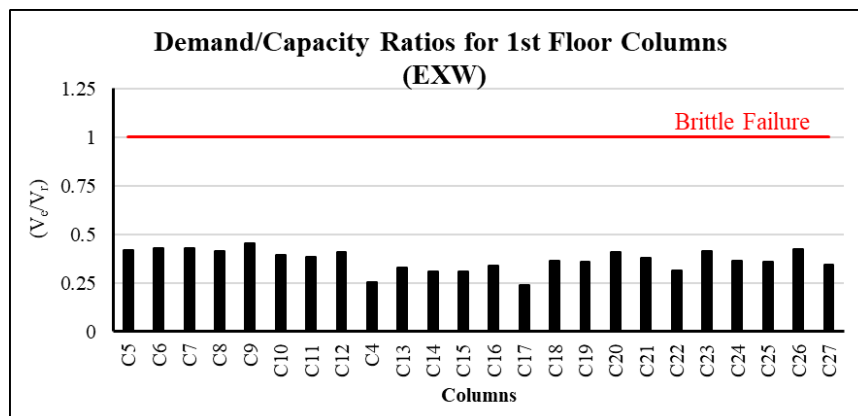


Figure 5.16. D/C ratios for 1st floor columns (EXW)

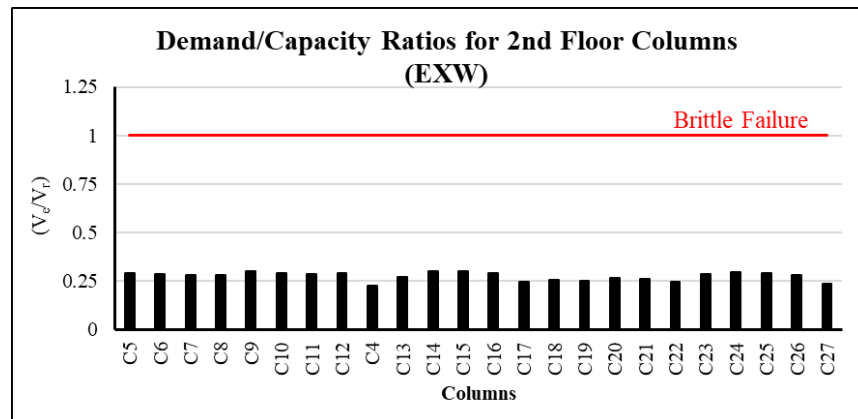


Figure 5.17. D/C ratios for 2nd floor columns (EXW)

c) For synthetic ground motion records of near-field (NF):

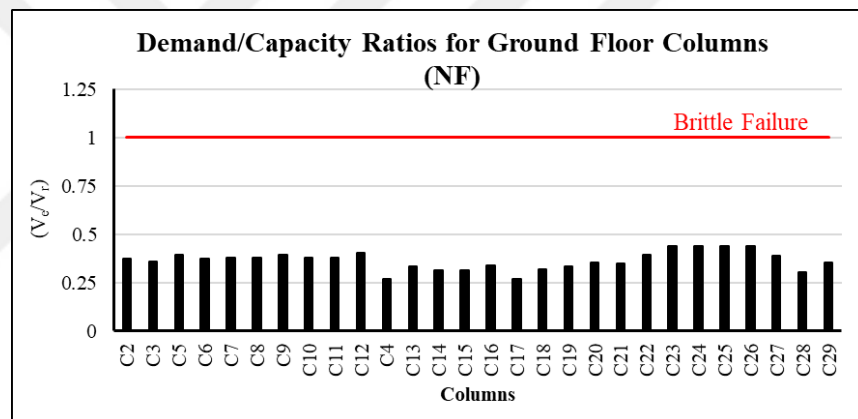


Figure 5.18. D/C ratios for ground floor columns (NF)

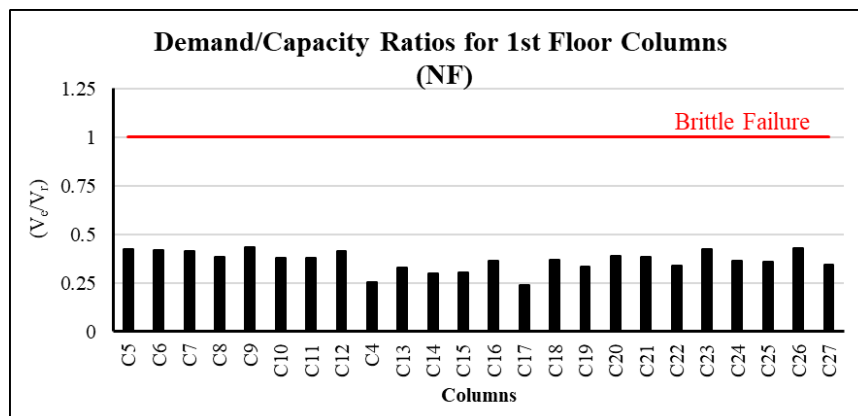


Figure 5.19. D/C ratios for 1st floor columns (NF)

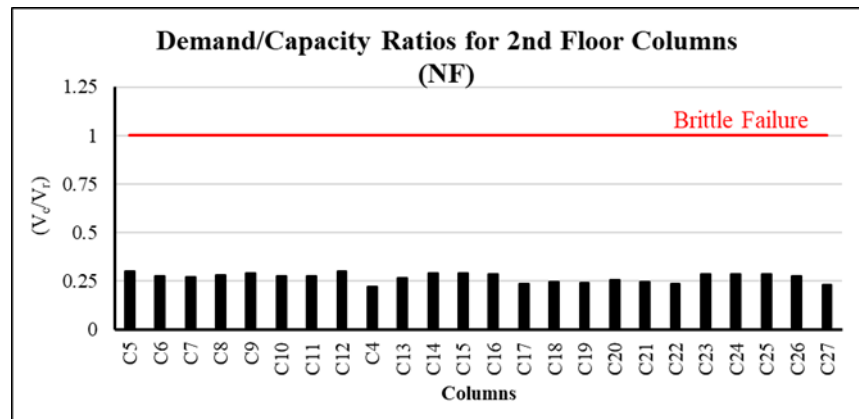


Figure 5.20. D/C ratios for 2nd floor columns (NF)

d) For synthetic ground motion records of far-field (FF):

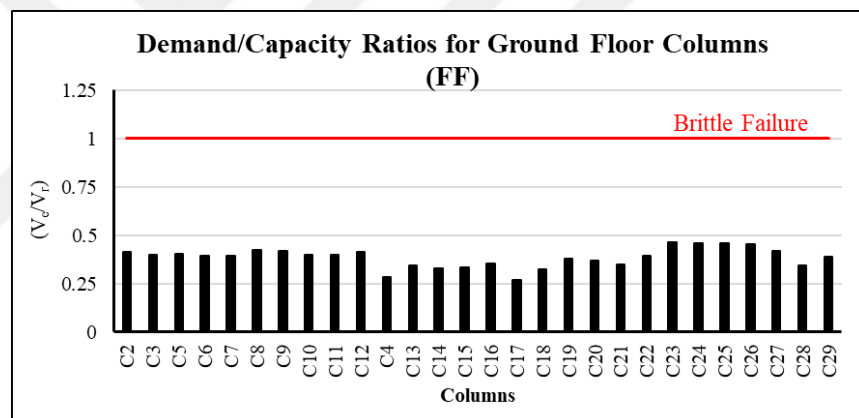


Figure 5.21. D/C ratios for ground floor columns (FF)

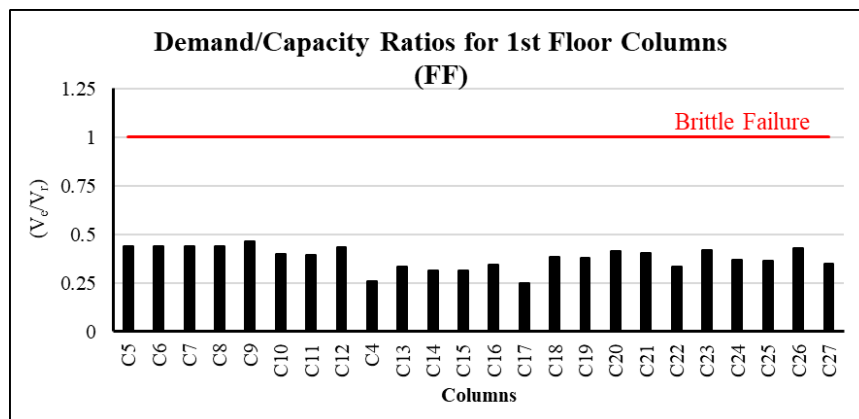


Figure 5.22. D/C ratios for 1st floor columns (FF)

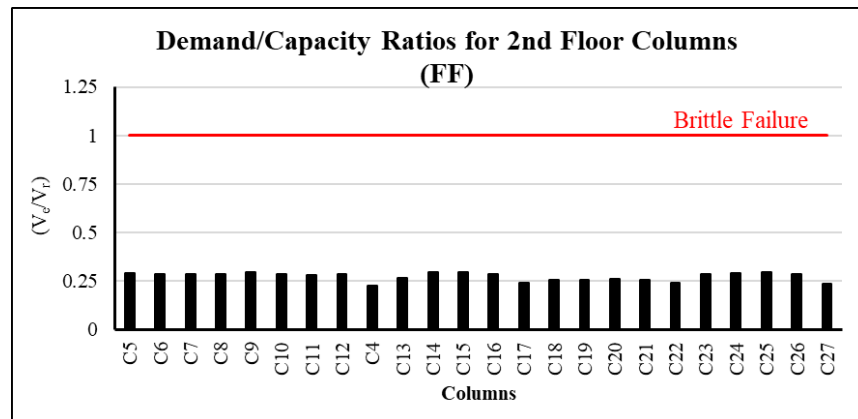


Figure 5.23. D/C ratios for 2nd floor columns (FF)

e) For scaled real ground motion records (SRGM):

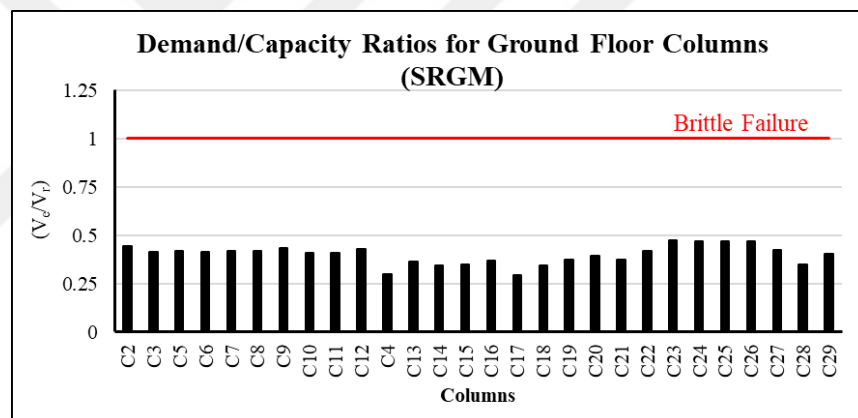


Figure 5.24. D/C ratios for ground floor columns (SRGM)

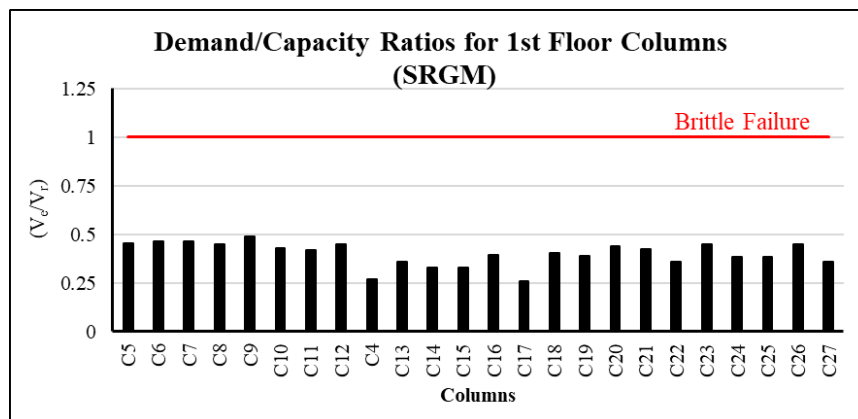


Figure 5.25. D/C ratios for 1st floor columns (SRGM)

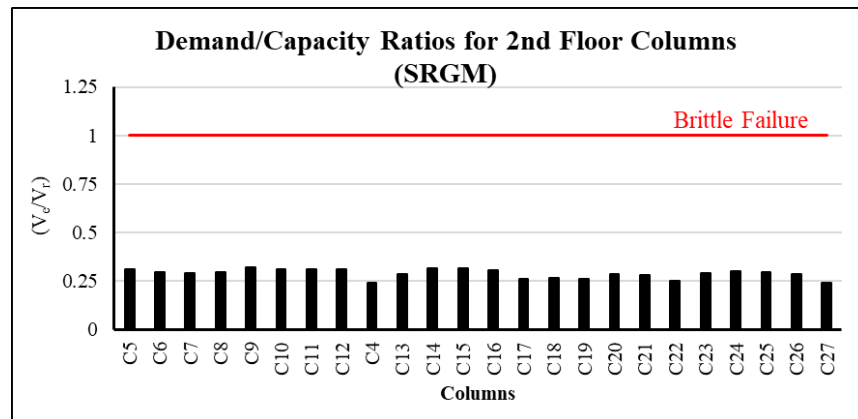


Figure 5.26. D/C ratios for 2nd floor columns (SRGM)

In the evaluation of the structural system members of the building in terms of flexural effects;

- a) For artificial ground motion records of Saragoni & hart envelope function (SHW):

Table 5.7. Column damage distributions for SHW

Story	N.D	BHB	İHB	GB	Total
Ground Floor	0 (%0.00)	28 (%100)	0 (%0)	0 (%0)	28
1 st Floor	4 (%16.67)	20 (%83.33)	0 (%0)	0 (%0)	24
2 nd Floor	15 (%62.50)	9 (%37.50)	0 (%0)	0 (%0)	24

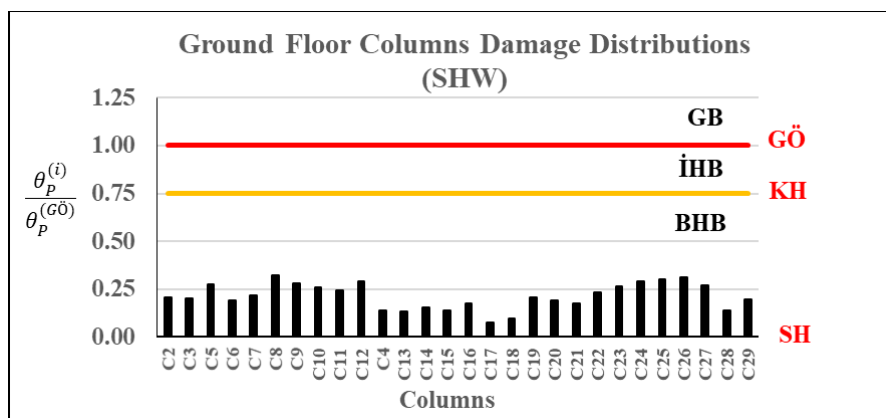
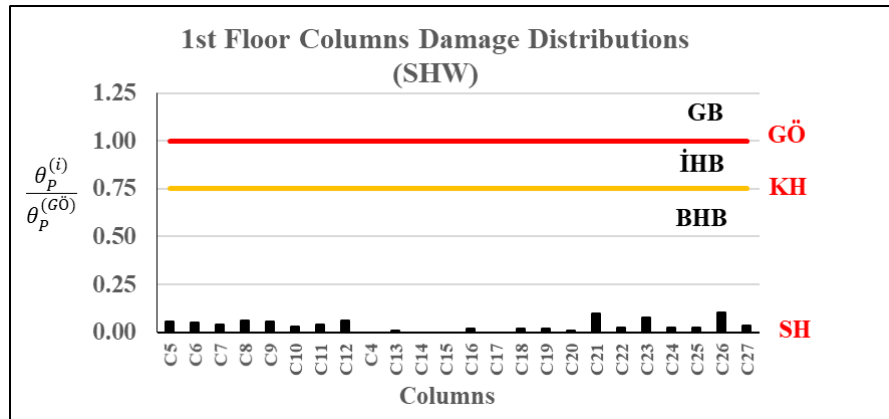
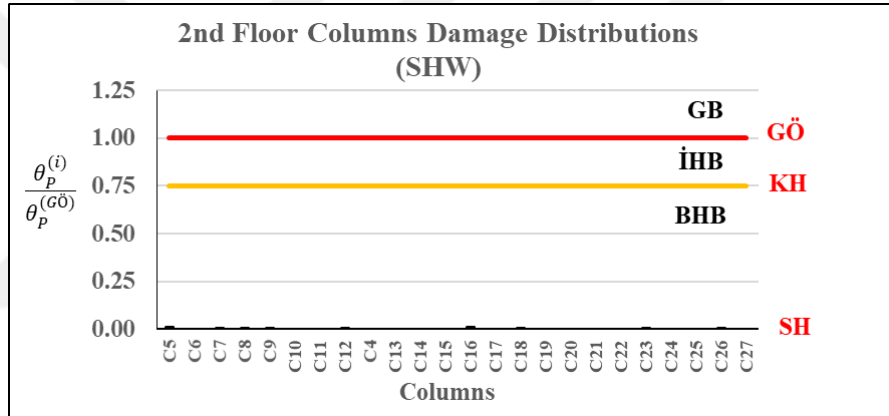


Figure 5.27. Damage distribution for ground floor columns (SHW)

Figure 5.28. Damage distribution for 1st floor columns (SHW)Figure 5.29. Damage distribution for 2nd floor columns (SHW)

b) For artificial ground motion records of exponential envelope function (EXW):

Table 5.8. Column damage distributions for EXW

Story	N.D	BHB	İHB	GB	Total
Ground Floor	0 (%0.00)	28 (%100)	0 (%0)	0 (%0)	28
1st Floor	5 (%20.83)	19 (%79.17)	0 (%0)	0 (%0)	24
2nd Floor	20 (%83.33)	4 (%16.67)	0 (%0)	0 (%0)	24

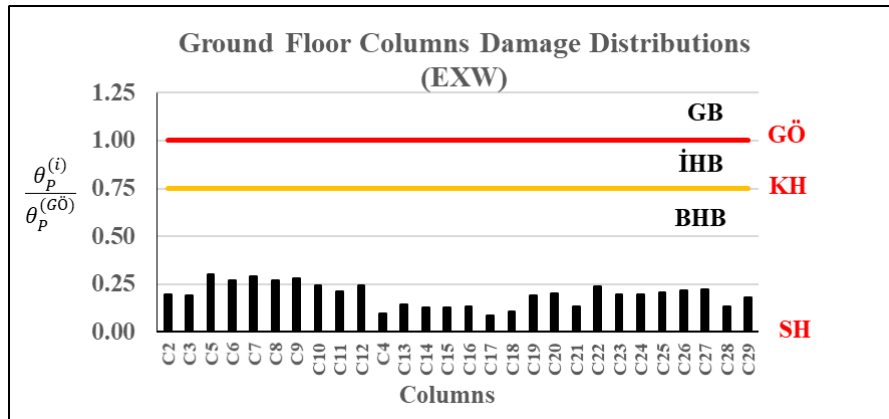
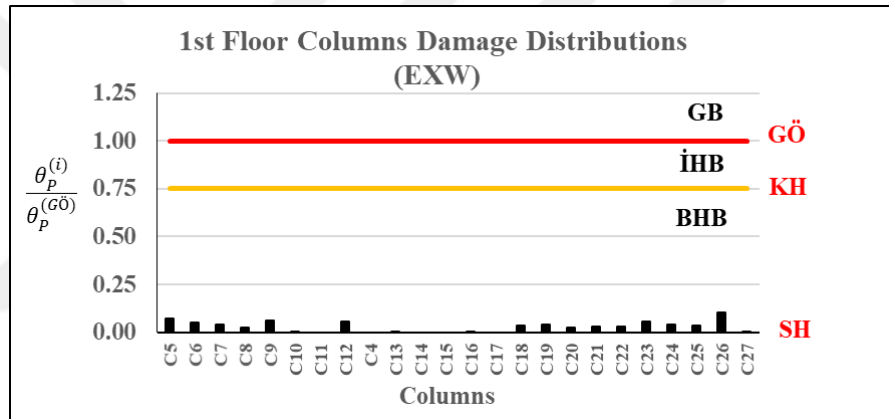
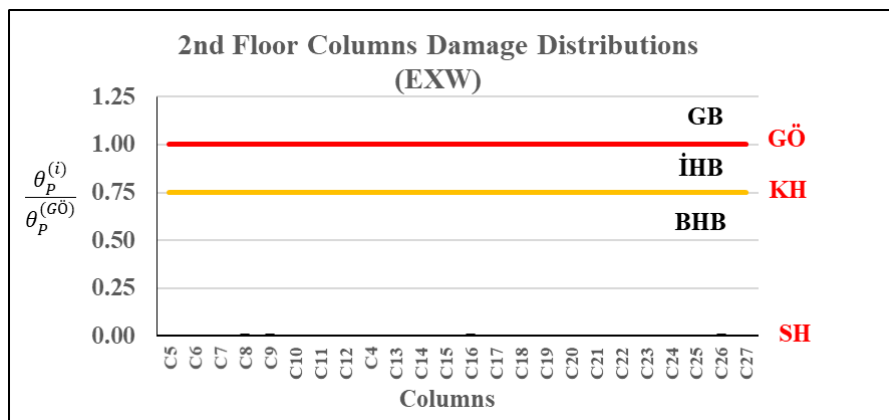


Figure 5.30. Damage distribution for ground floor columns (EXW)

Figure 5.31. Damage distribution for 1st floor columns (EXW)Figure 5.32. Damage distribution for 2nd floor columns (EXW)

c) For synthetic ground motion records of near-field (NF):

Table 5.9. Column damage distributions for NF

Story	N.D	BHB	İHB	GB	Total
Ground Floor	0 (%0.00)	28 (%100)	0 (%)	0 (%)	28
1st Floor	4 (%16.67)	20 (%83.33)	0 (%)	0 (%)	24
2nd Floor	12 (%50.00)	12 (%50.00)	0 (%)	0 (%)	24

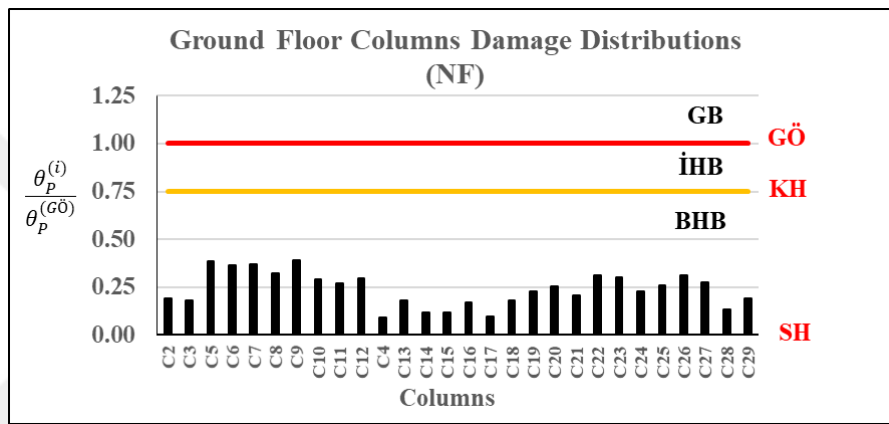


Figure 5.33. Damage distribution for ground floor columns (NF)

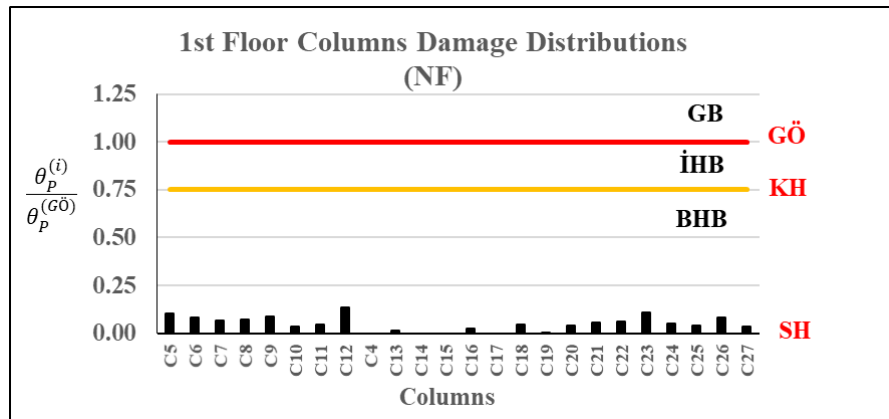


Figure 5.34. Damage distribution for 1st floor columns (NF)

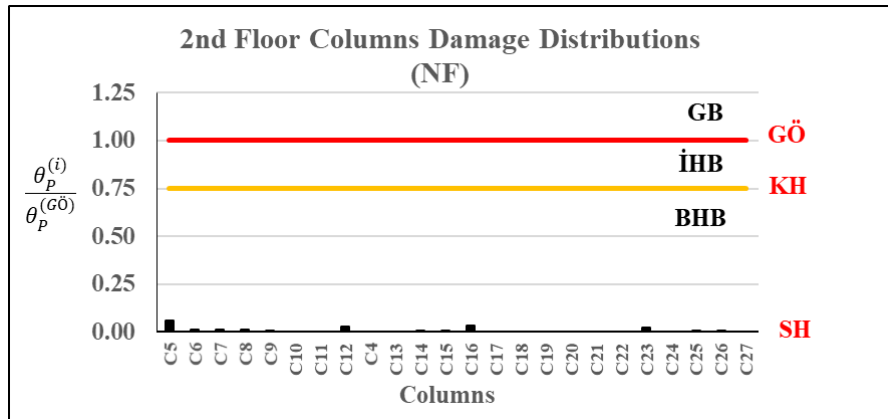


Figure 5.35. Damage distribution for 2nd floor columns (NF)

d) For synthetic ground motion records of far-field (FF):

Table 5.10. Column damage distributions for FF

Story	N.D	BHB	İHB	GB	Total
Ground Floor	0 (%0.00)	28 (%100)	0 (%)	0 (%)	28
1st Floor	4 (%16.67)	20 (%83.33)	0 (%)	0 (%)	24
2nd Floor	18 (%75.00)	6 (%25.00)	0 (%)	0 (%)	24

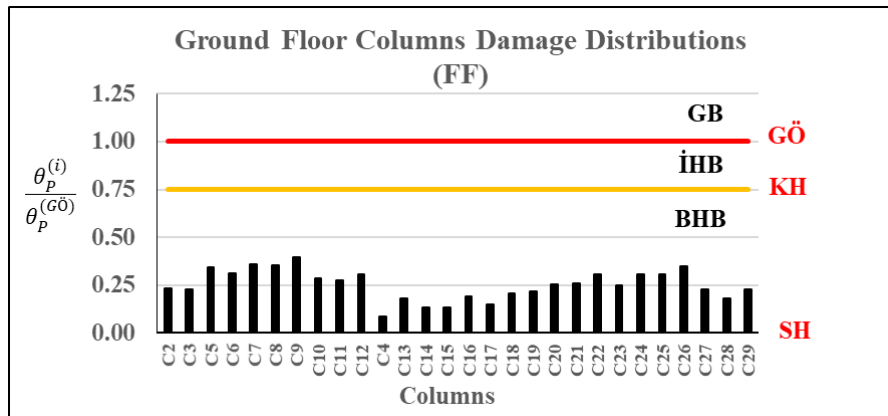
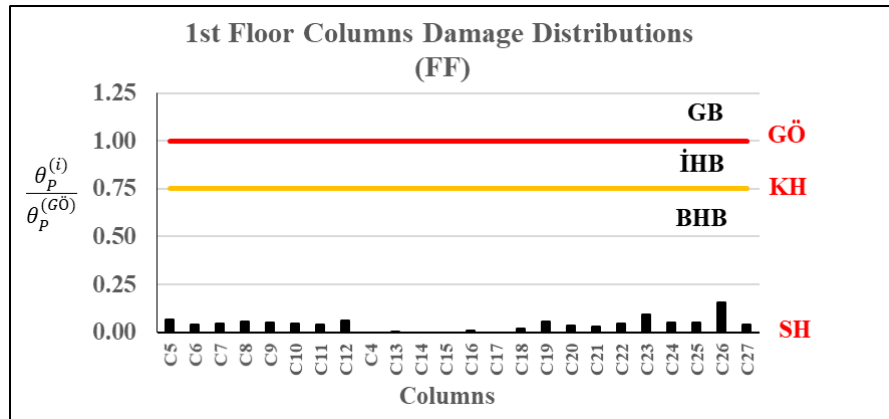
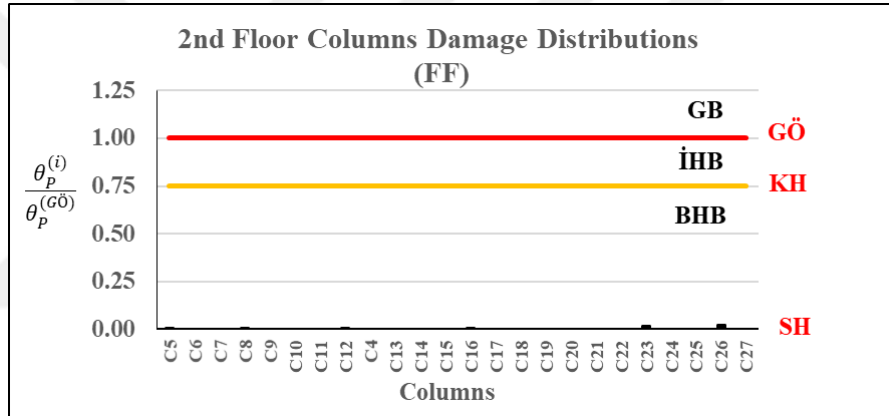


Figure 5.36. Damage distribution for ground floor columns (FF)

Figure 5.37. Damage distribution for 1st floor columns (FF)Figure 5.38. Damage distribution for 2nd floor columns (FF)

a) For scaled real ground motion records (SRGM):

Table 5.11. Column damage distributions for SRGM

Story	N.D	BHB	İHB	GB	Total
Ground Floor	0 (%0.00)	28 (%100)	0 (%)	0 (%)	28
1st Floor	4 (%16.67)	20 (%83.33)	0 (%)	0 (%)	24
2nd Floor	14 (%58.33)	10 (%41.67)	0 (%)	0 (%)	24

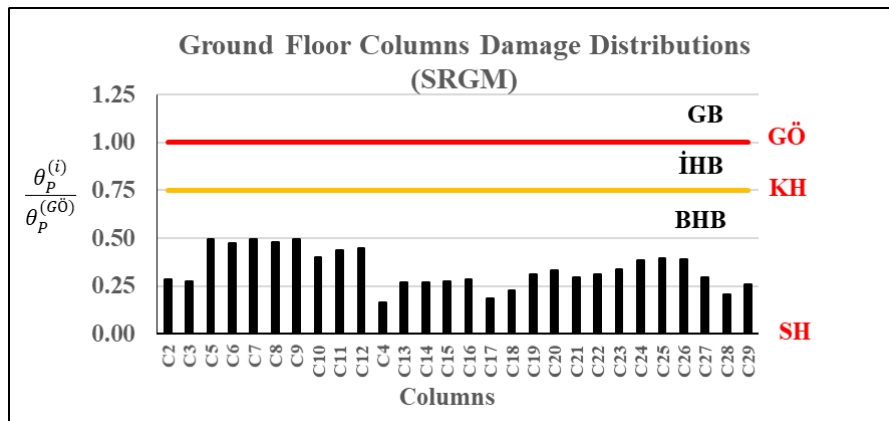
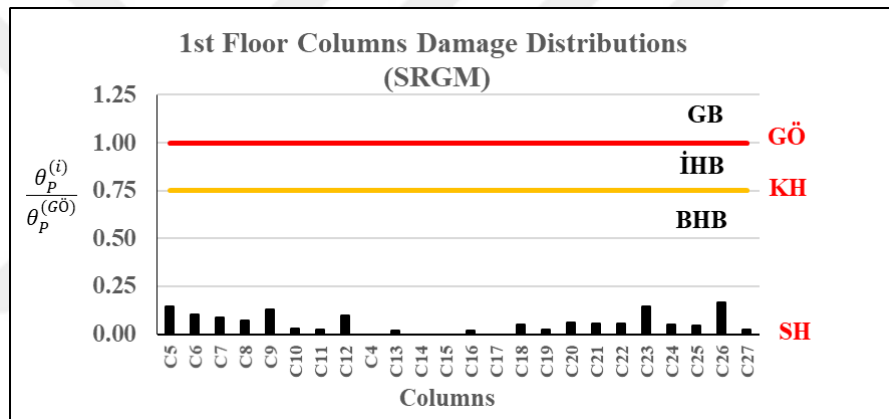
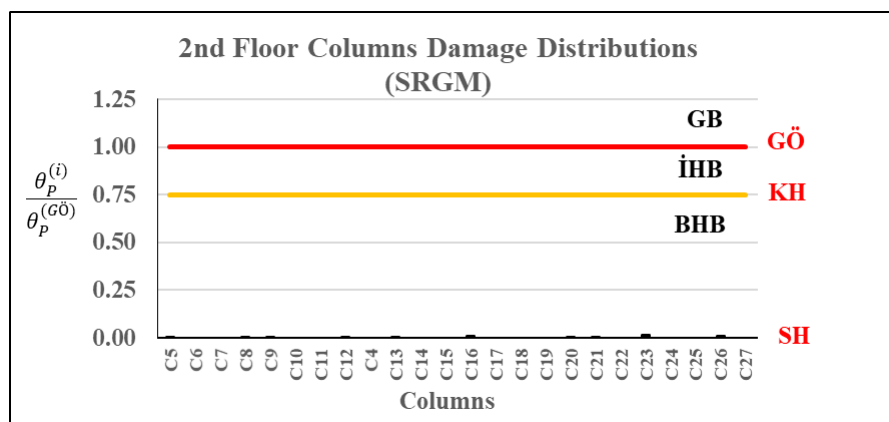


Figure 5.39. Damage distribution for ground floor columns (SRGM)

Figure 5.40. Damage distribution for 1st floor columns (SRGM)Figure 5.41. Damage distribution for 2nd floor columns (SRGM)

5.4.3. Performance Assessment for Beams

Performance evaluation of beam members in terms of flexural and shear effects is presented in the following graphics for all ground motion data sets. For the table showing the damage distributions of beam members, see Appendix-B. For placement of beam members, See Appendix-A.

First of all, in the control of brittle failure in terms of shear effects of the bearing system members;

- a) For artificial ground motion records of Saragoni & hart envelope function (SHW):

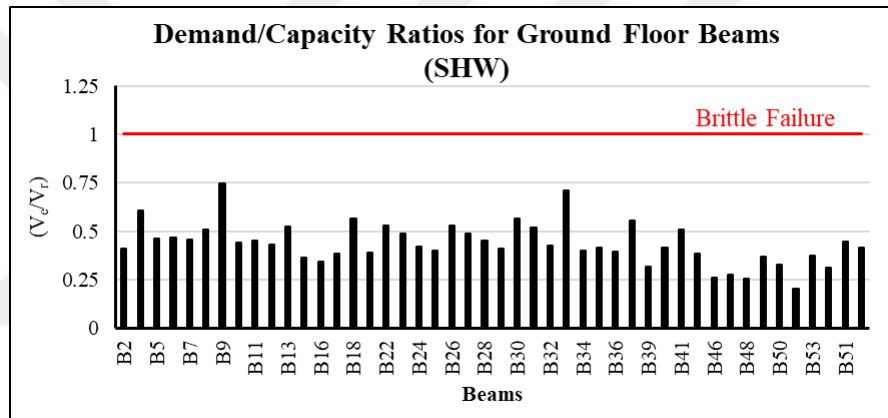


Figure 5.42. D/C ratios for ground floor beams (SHW)

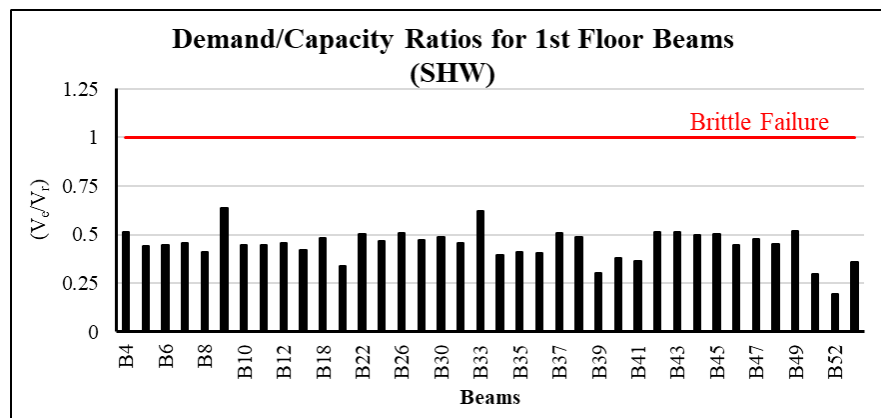


Figure 5.43. D/C ratios for 1st floor beams (SHW)

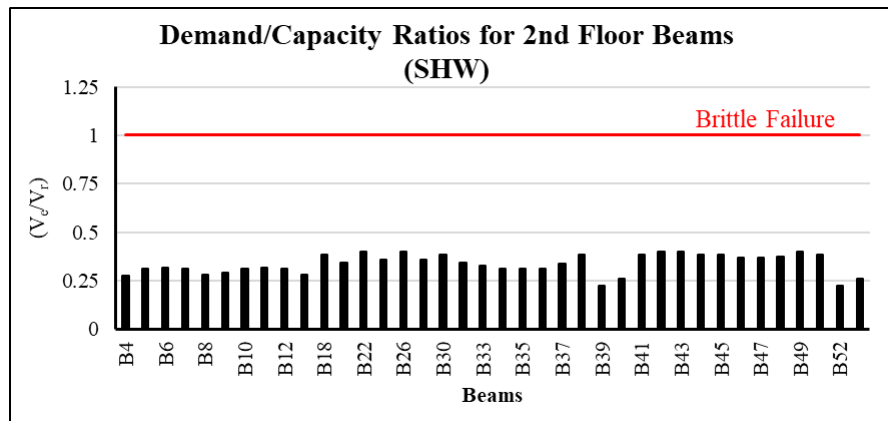


Figure 5.44. D/C ratios for 2nd floor beams (SHW)

b) For artificial ground motion records of exponential envelope function (EXW):

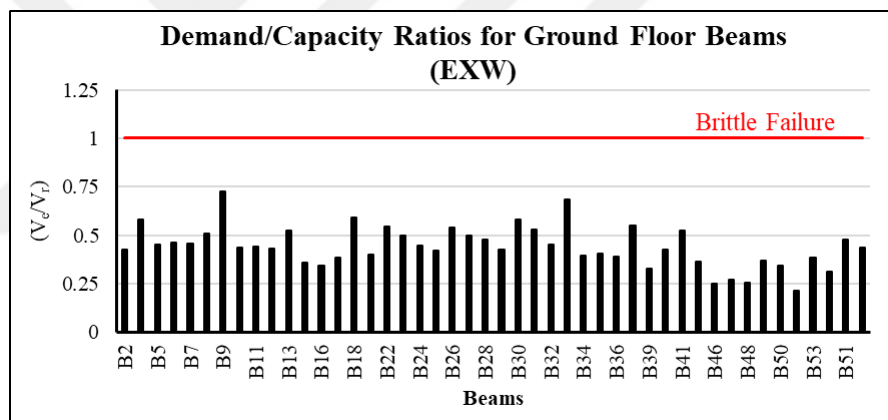


Figure 5.45. D/C ratios for ground floor beams (EXW)

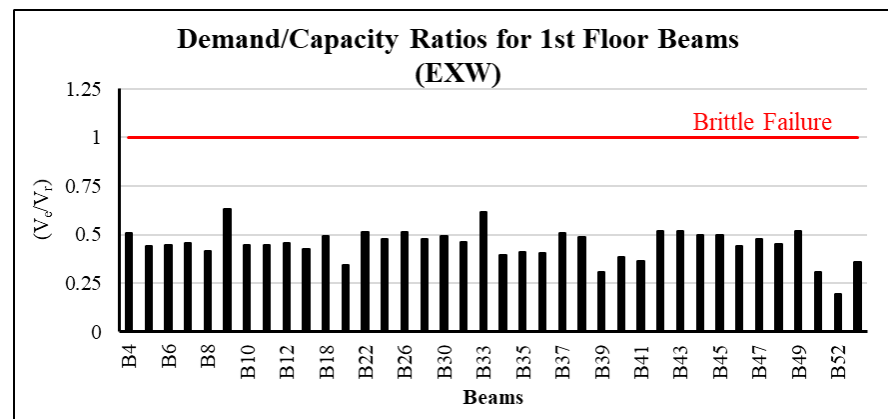
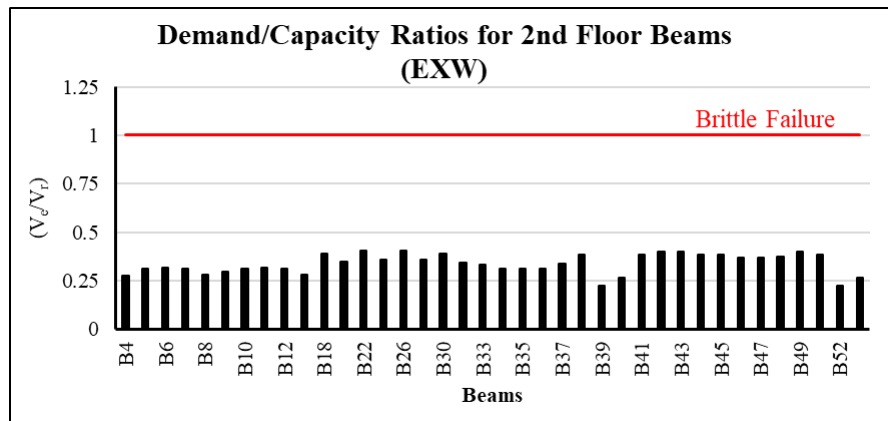


Figure 5.46. D/C ratios for 1st floor beams (EXW)

Figure 5.47. D/C ratios for 2nd floor beams (EXW)

c) For synthetic ground motion records of near-field (NF):

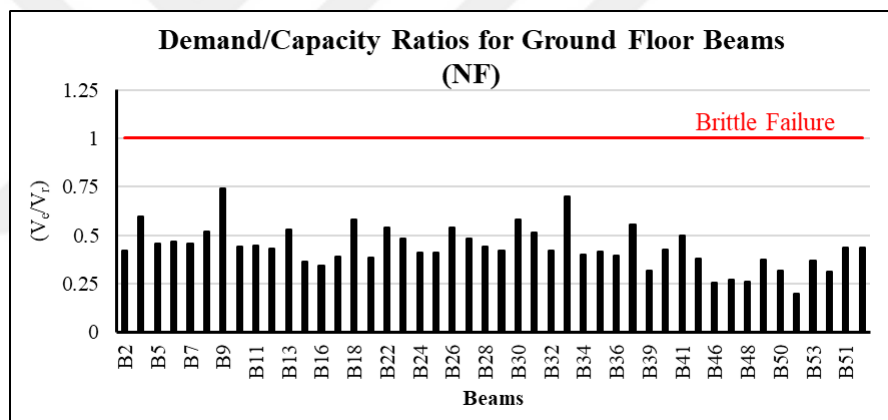
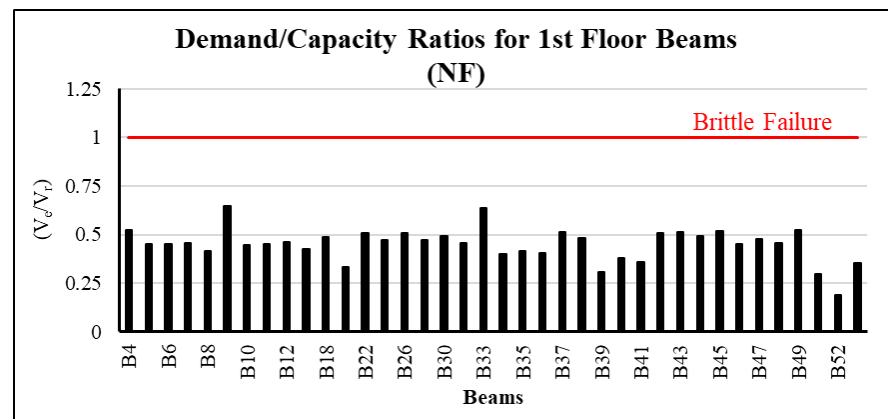
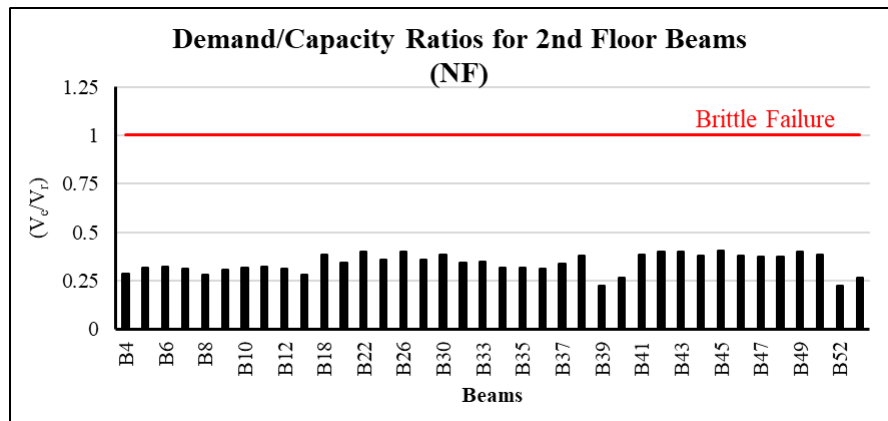


Figure 5.48. D/C ratios for ground floor beams (NF)

Figure 5.49. D/C ratios for 1st floor beams (NF)

Figure 5.50. D/C ratios for 2nd floor beams (NF)

d) For synthetic ground motion records of far-field (FF):

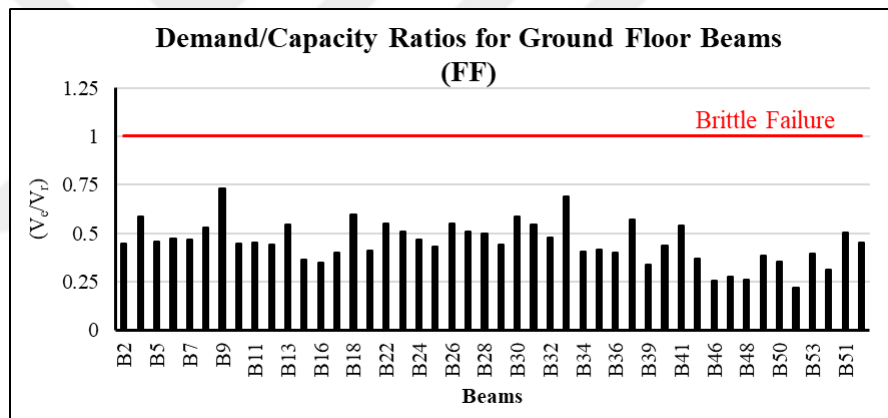
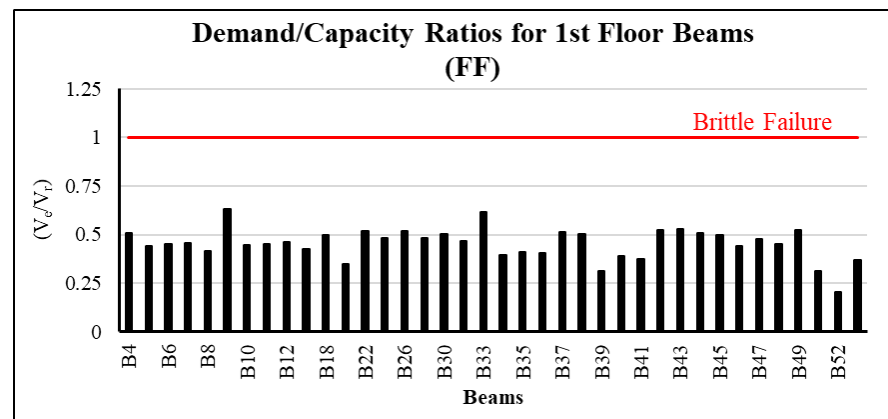


Figure 5.51. D/C ratios for ground floor beams (FF)

Figure 5.52. D/C ratios for 1st floor beams (FF)

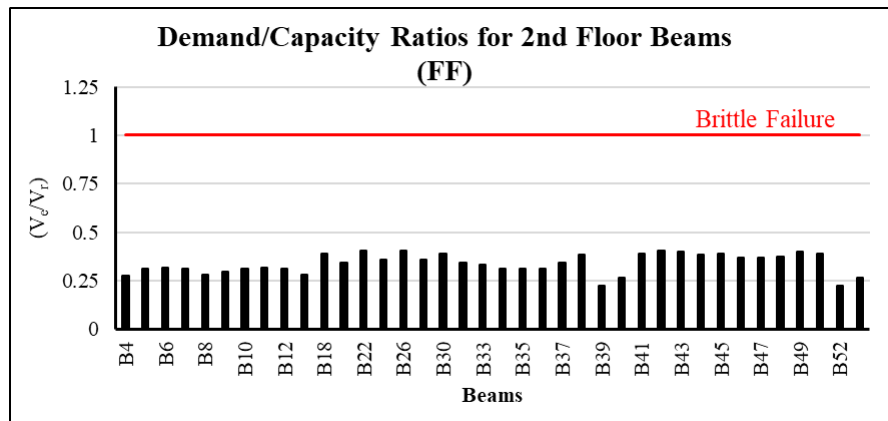


Figure 5.53. D/C ratios for 2nd floor beams (FF)

e) For scaled real ground motion records (SRGM):

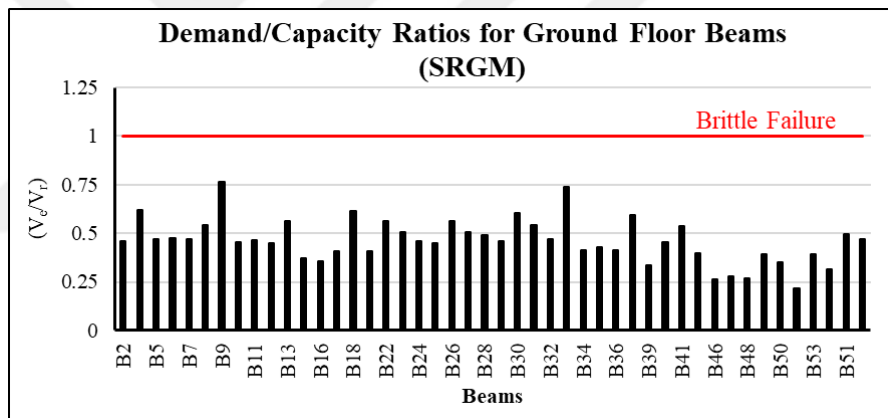


Figure 5.54. D/C ratios for ground floor beams (SRGM)

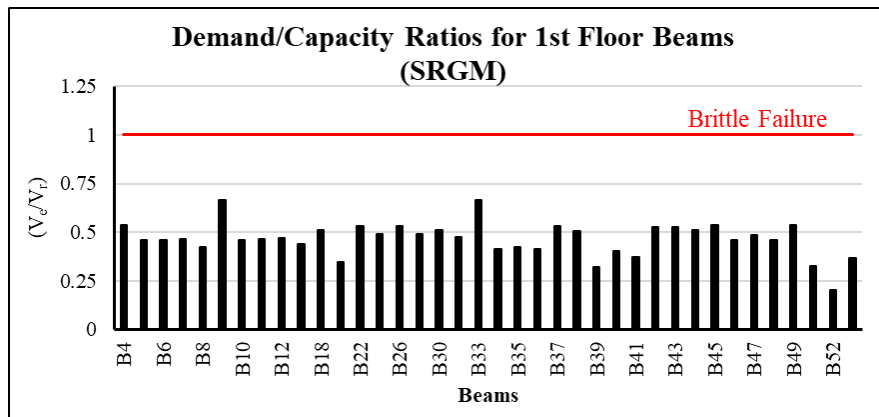


Figure 5.55. D/C ratios for 1st floor beams (SRGM)

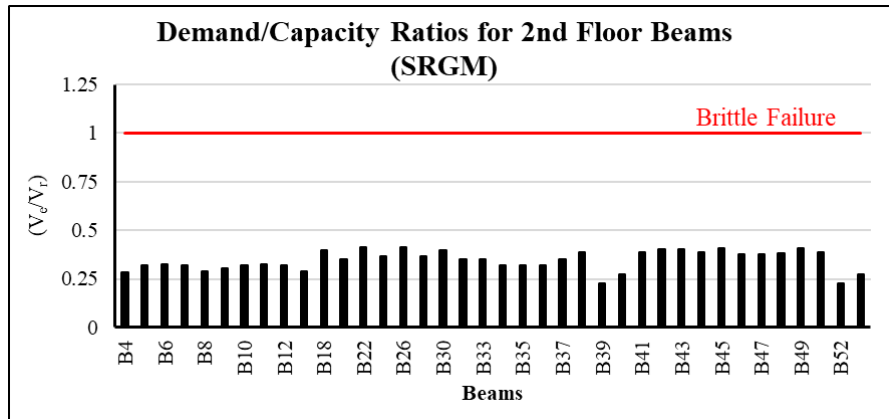


Figure 5.56. D/C ratios for 2nd floor beams (SRGM)

In the evaluation of the structural system members of the building in terms of flexural effects;

- a) For artificial ground motion records of Saragoni & hart envelope function (SHW):

Table 5.12. Beam damage distributions for SHW

Floor	N.D	BHB	İHB	GB	Total
Ground Floor	40 (%86.96)	6 (%13.04)	0 (%0)	0 (%0)	46
1 st Floor	38 (%100)	0 (%0)	0 (%0)	0 (%0)	38
2 nd Floor	26 (%68.42)	12 (%31.58)	0 (%0)	0 (%0)	38

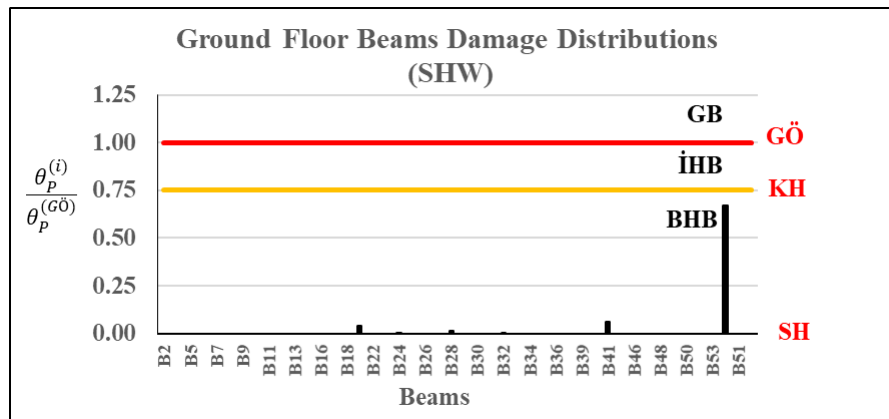


Figure 5.57. Damage distribution for ground floor beams (SHW)

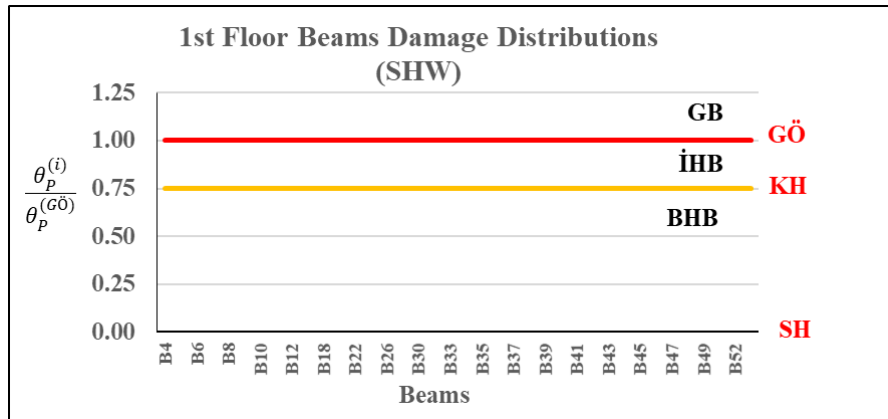


Figure 5.58. Damage distribution for 1st floor beams (SHW)

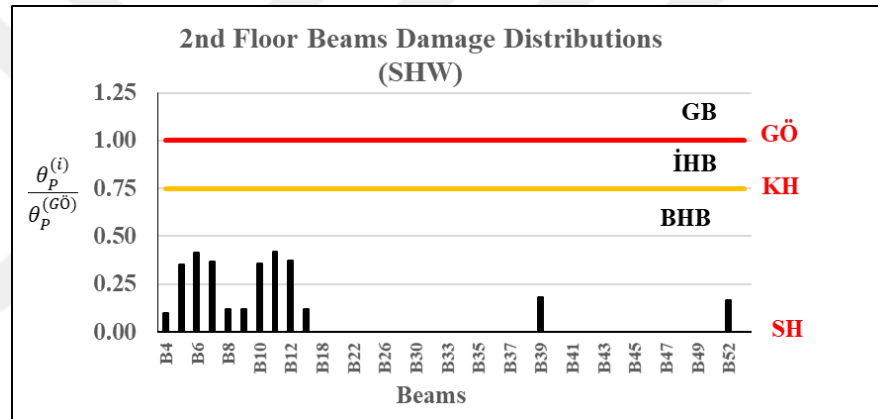


Figure 5.59. Damage distribution for 2nd floor beams (SHW)

b) For artificial ground motion records of exponential envelope function (EXW):

Table 5.13. Beam damage distributions for EXW

Story	N.D	BHB	İHB	GB	Total
Ground Floor	36 (%78.26)	10 (%21.74)	0 (%0)	0 (%0)	46
1st Floor	38 (%100)	0 (%0)	0 (%0)	0 (%0)	38
2nd Floor	26 (%68.42)	12 (%31.58)	0 (%0)	0 (%0)	38

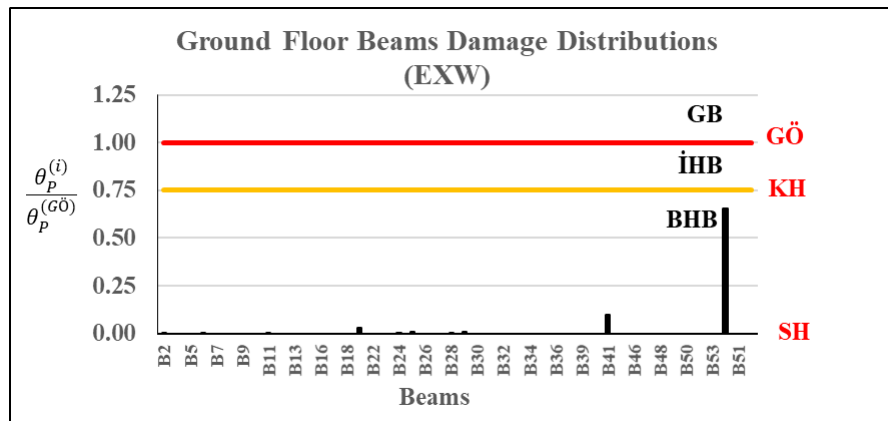
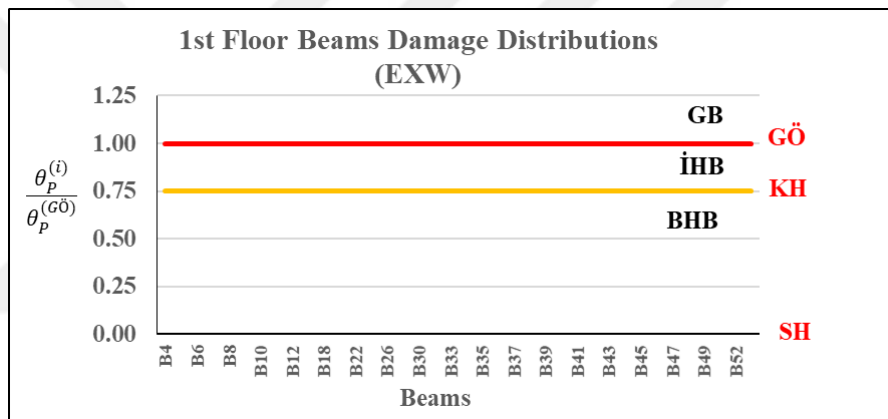
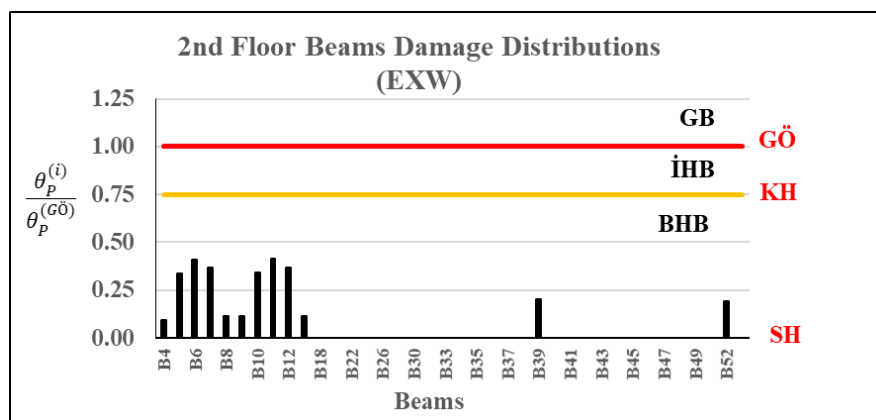


Figure 5.60. Damage distribution for ground floor beams (EXW)

Figure 5.61. Damage distribution for 1st floor beams (EXW)Figure 5.62. Damage distribution for 2nd floor beams (EXW)

c) For synthetic ground motion records of near-field (NF):

Table 5.14. Beam damage distributions for NF

Story	N.D	BHB	İHB	GB	Total
Ground Floor	42 (%91.30)	4 (%8.70)	0 (%0)	0 (%0)	46
1st Floor	38 (%100)	0 (%0)	0 (%0)	0 (%0)	38
2nd Floor	26 (%68.42)	12 (%31.58)	0 (%0)	0 (%0)	38

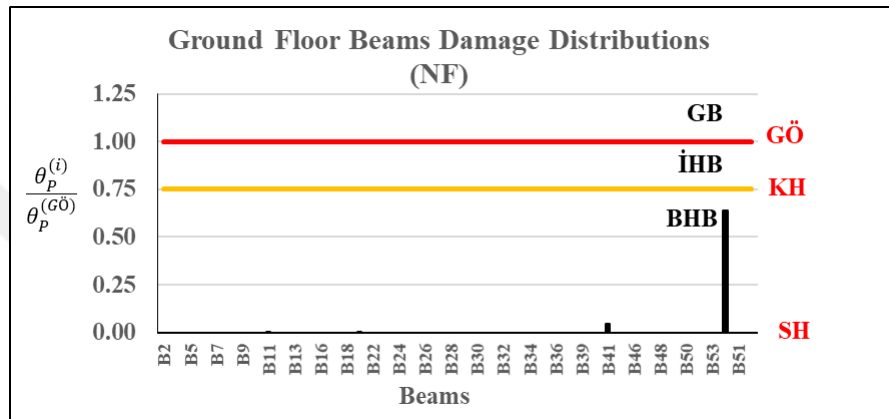


Figure 5.63. Damage distribution for ground floor beams (NF)

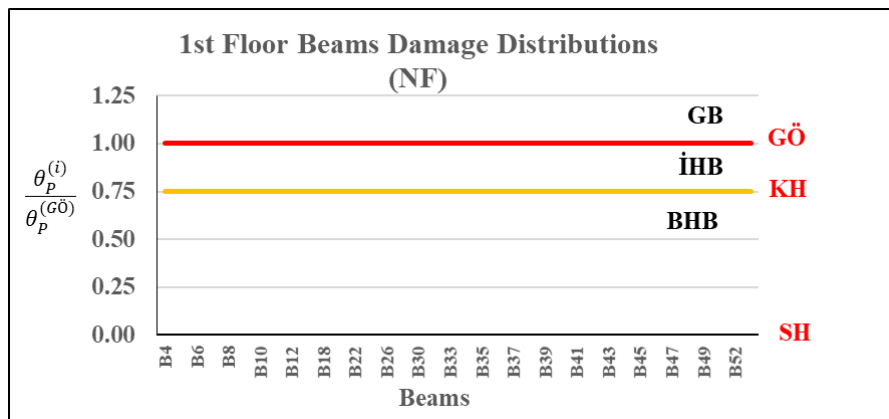


Figure 5.64. Damage distribution for 1st floor beams (NF)

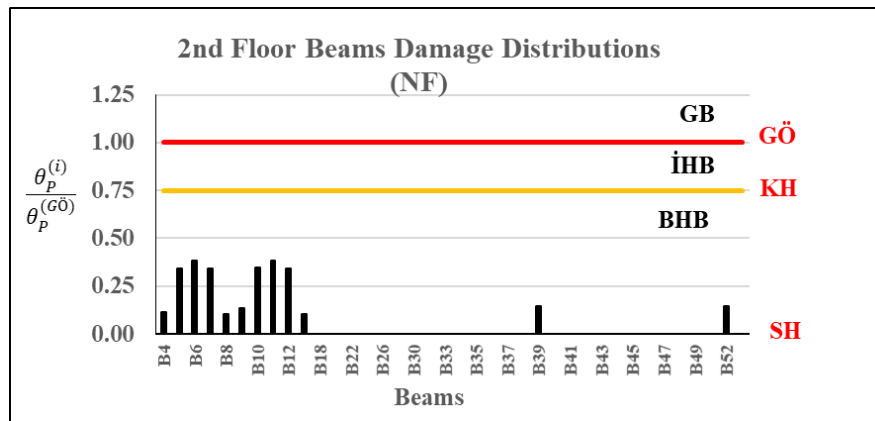


Figure 5.65. Damage distribution for 2nd floor beams (NF)

d) For synthetic ground motion records of far-field (FF):

Table 5.15. Beam damage distributions for FF

Story	N.D	BHB	İHB	GB	Total
Ground Floor	32 (%69.57)	14 (%30.43)	0 (%0)	0 (%0)	46
1st Floor	38 (%100)	0 (%0)	0 (%0)	0 (%0)	38
2nd Floor	26 (%68.42)	12 (%31.58)	0 (%0)	0 (%0)	38

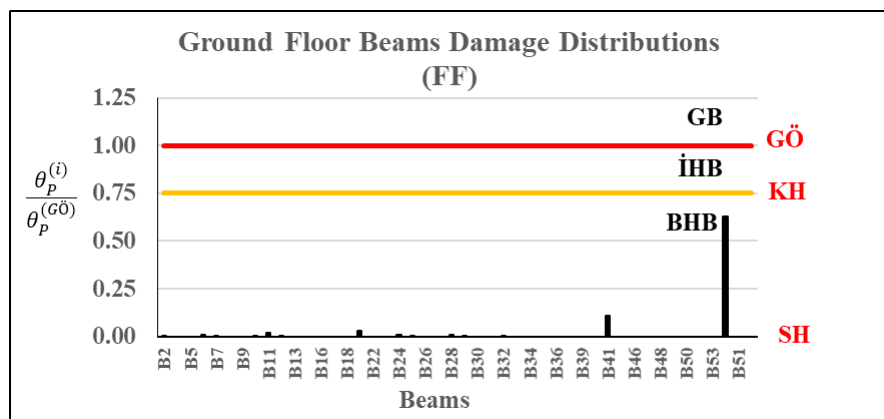
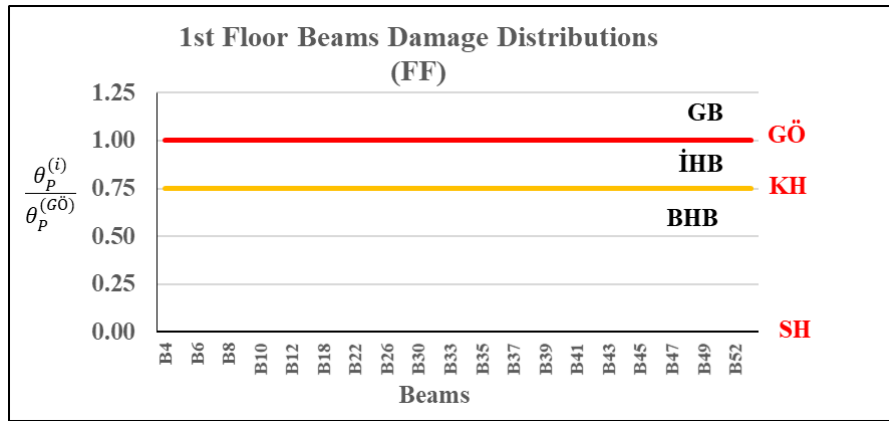
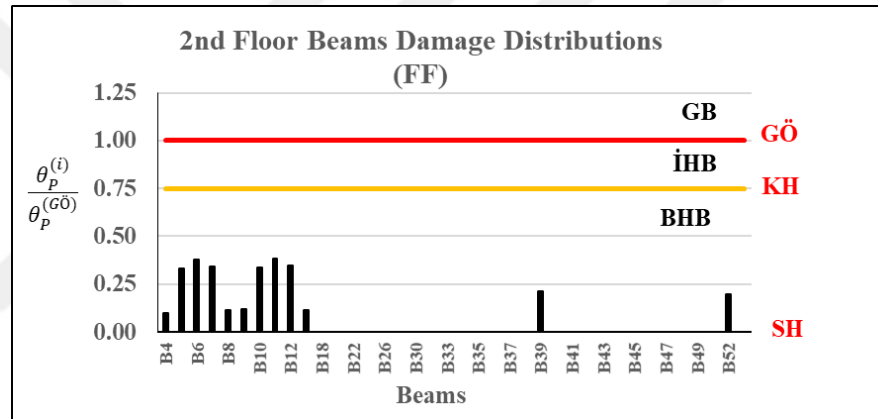


Figure 5.66. Damage distribution for ground floor beams (FF)

Figure 5.67. Damage distribution for 1st floor beams (FF)Figure 5.68. Damage distribution for 2nd floor beams (FF)

e) For scaled real ground motion records (SRGM):

Table 5.16. Beam damage distributions for SRGM

Story	N.D	BHB	İHB	GB	Total
Ground Floor	31 (%67.39)	15 (%32.61)	0 (%)	0 (%)	46
1st Floor	37 (%97.37)	1 (%2.63)	0 (%)	0 (%)	38
2nd Floor	26 (%68.42)	12 (%31.58)	0 (%)	0 (%)	38

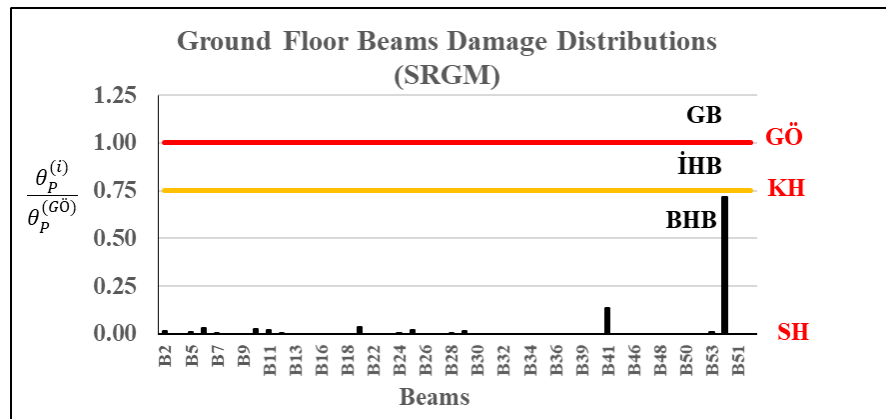
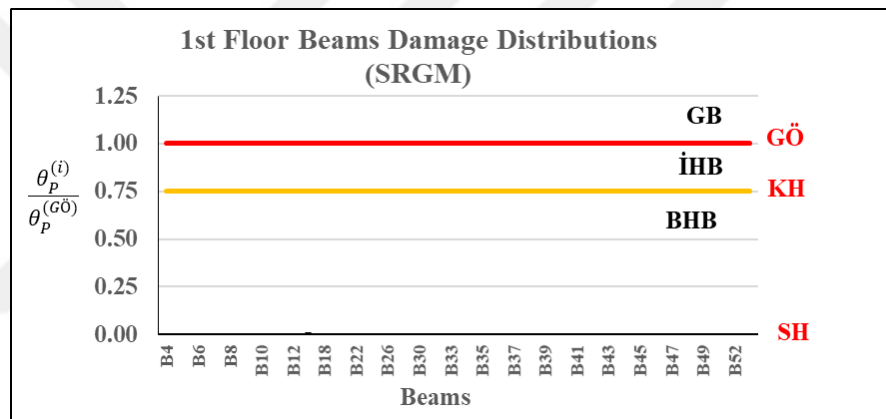
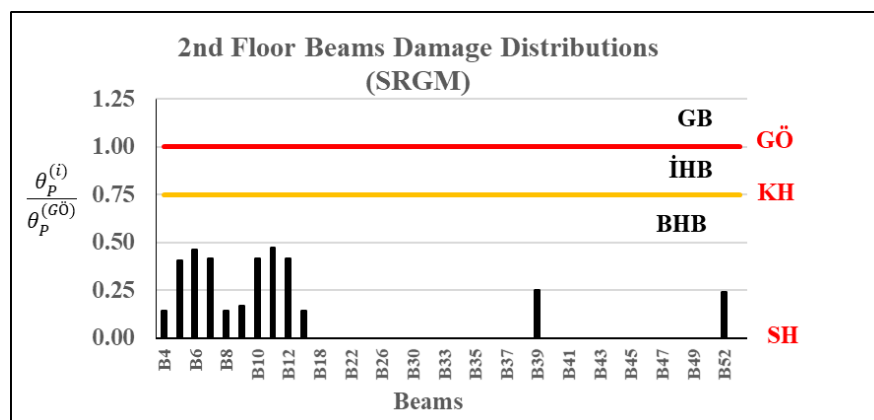


Figure 5.69. Damage distribution for ground floor beams (SRGM)

Figure 5.70. Damage distribution for 1st floor beams (SRGM)Figure 5.71. Damage distribution for 2nd floor beams (SRGM)

5.5. RELATIVE DRIFTS

When evaluated in terms of displacements in the structure for earthquake level DD-2; It is seen that the relative story drift ratios are in the order of 1.0-1.5% for all ground motion data sets. (See Figure 5.72 through Figure 5.81) For story displacements, relative story drifts, story heights, see Appendix-B.

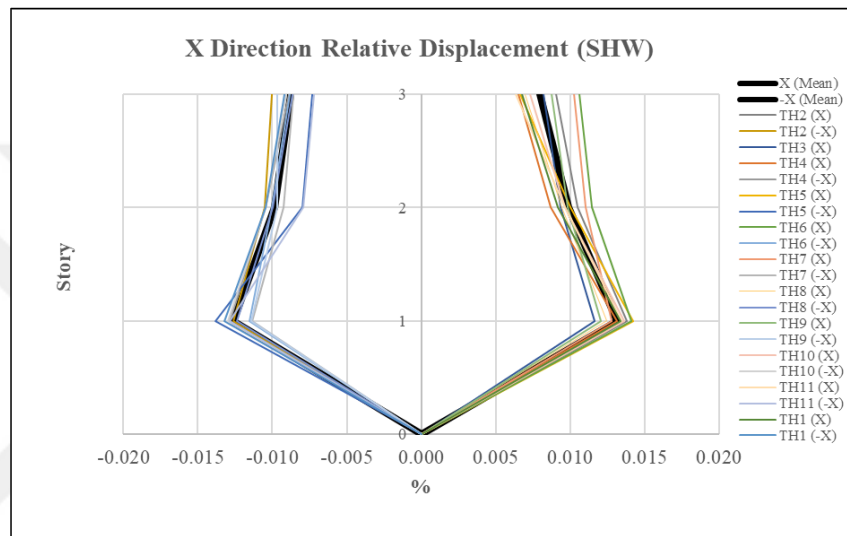


Figure 5.72. X direction relative story drifts (SHW)

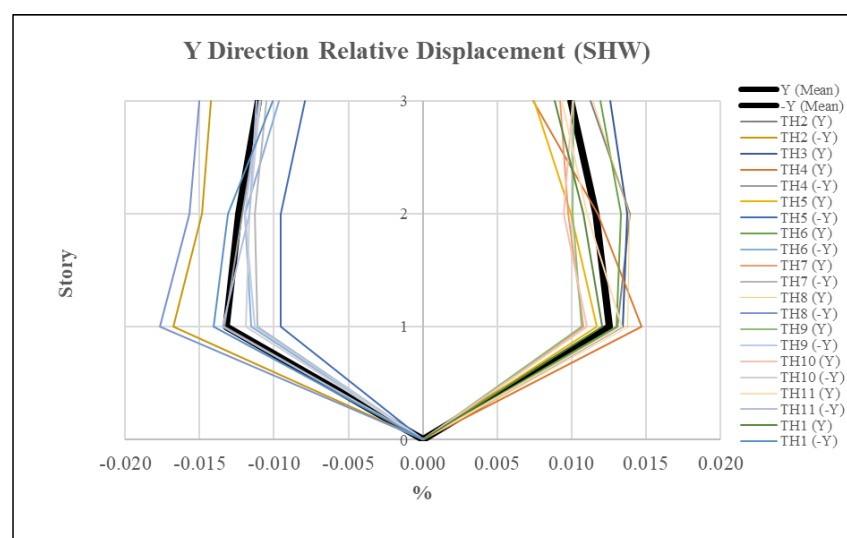


Figure 5.73. Y direction relative story drifts (SHW)

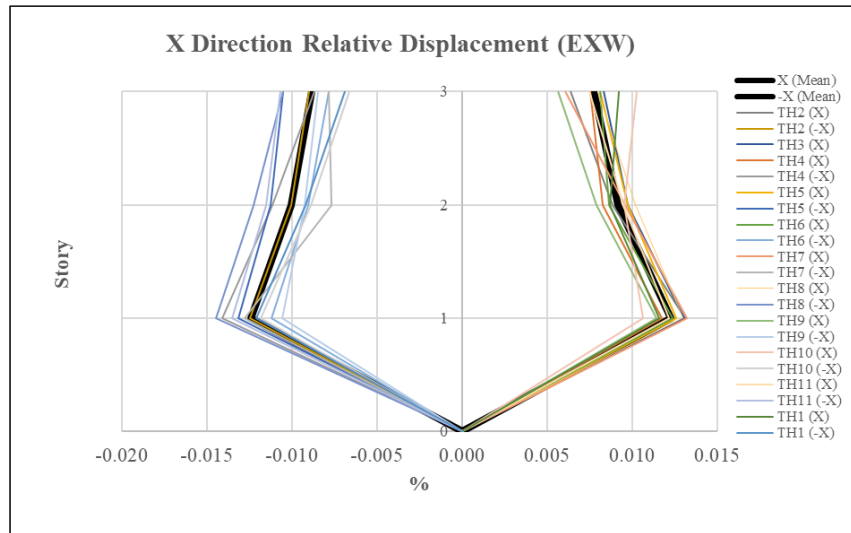


Figure 5.74. X direction relative story drifts (EXW)

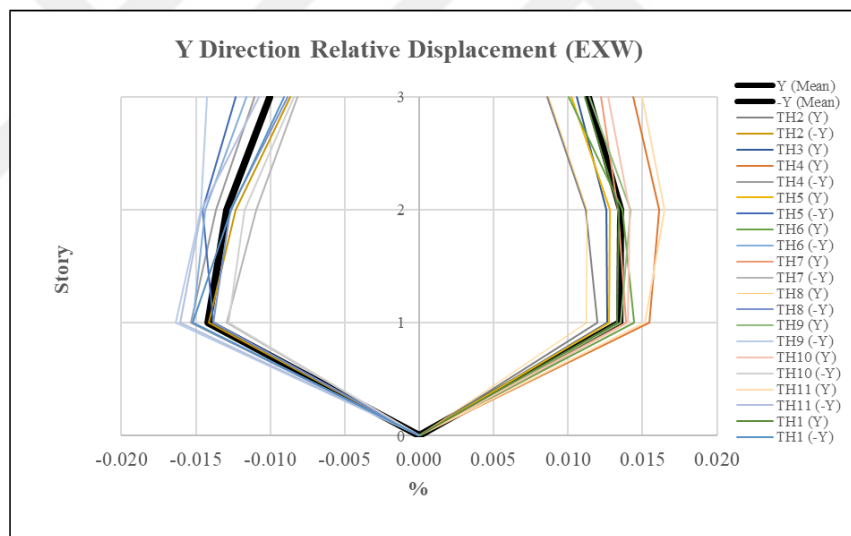


Figure 5.75. Y direction relative story drifts (EXW)

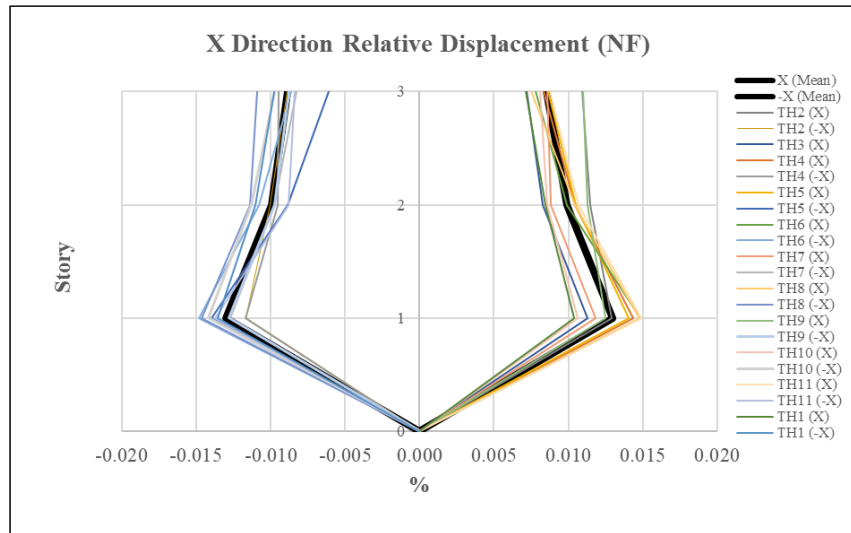


Figure 5.76. X direction relative story drifts (NF)

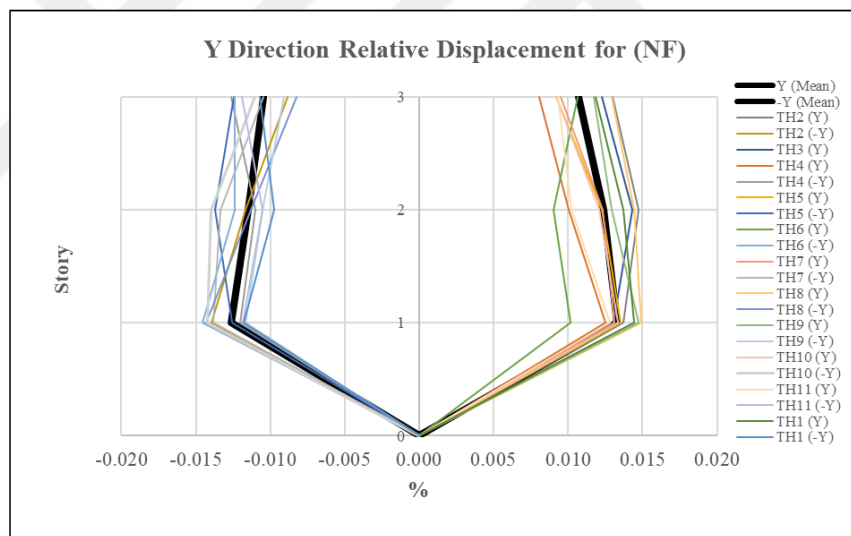


Figure 5.77. Y direction relative story drifts (NF)

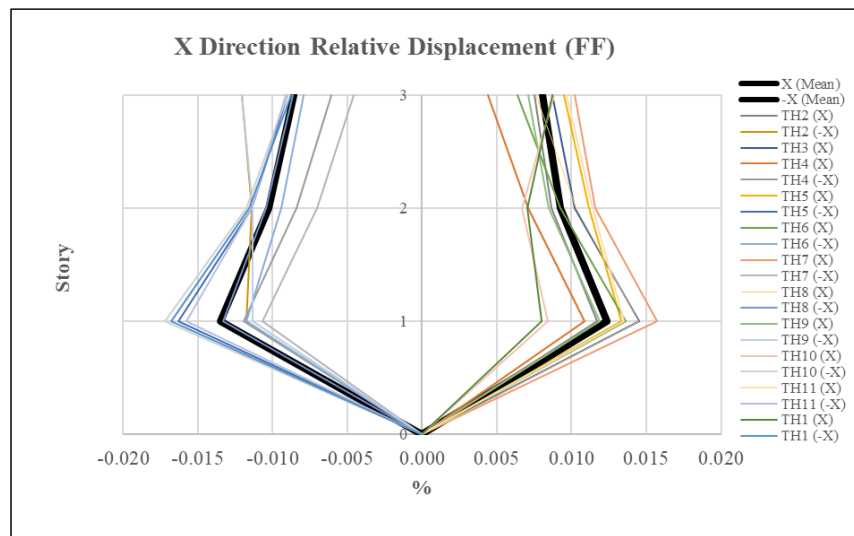


Figure 5.78. X direction relative story drifts (FF)

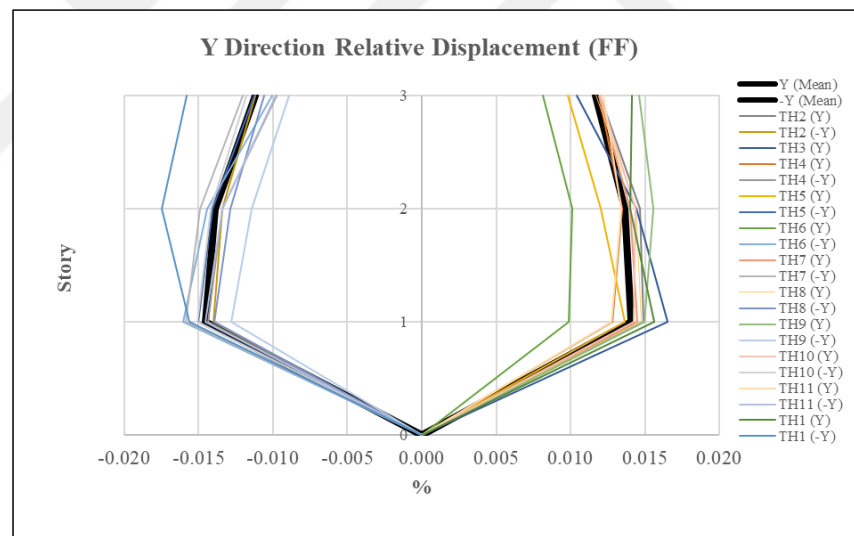


Figure 5.79. Y direction relative story drifts (FF)

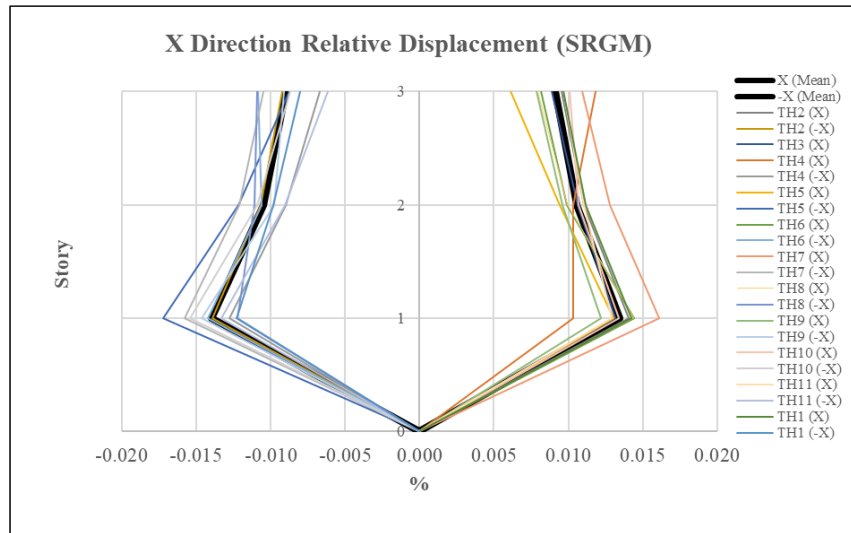


Figure 5.80. X direction relative story drifts (SRGM)

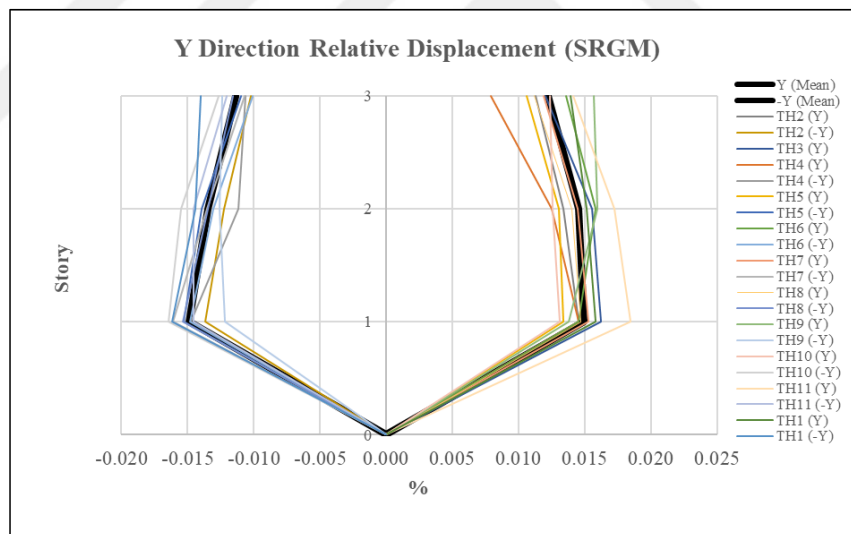


Figure 5.81. Y direction relative story drifts (SRGM)

5.6. BASE REACTIONS

Base shear forces are calculated for all cases and summary graphs are shown in Figure 5.82, 5.83, 5.84, 5.85 and 5.86. For detailed calculations see Appendix-B.

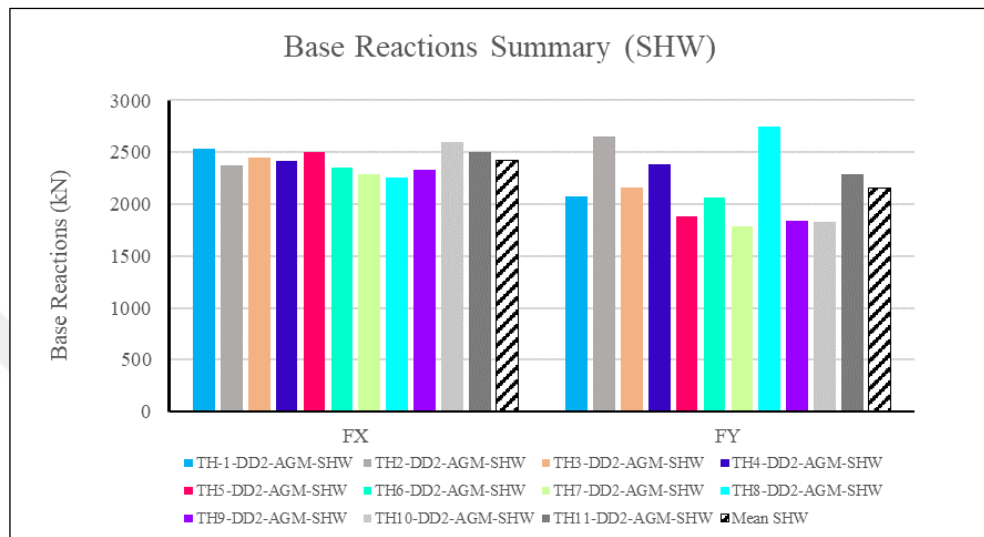


Figure 5.82. Base reactions summary for DD-2 SHW

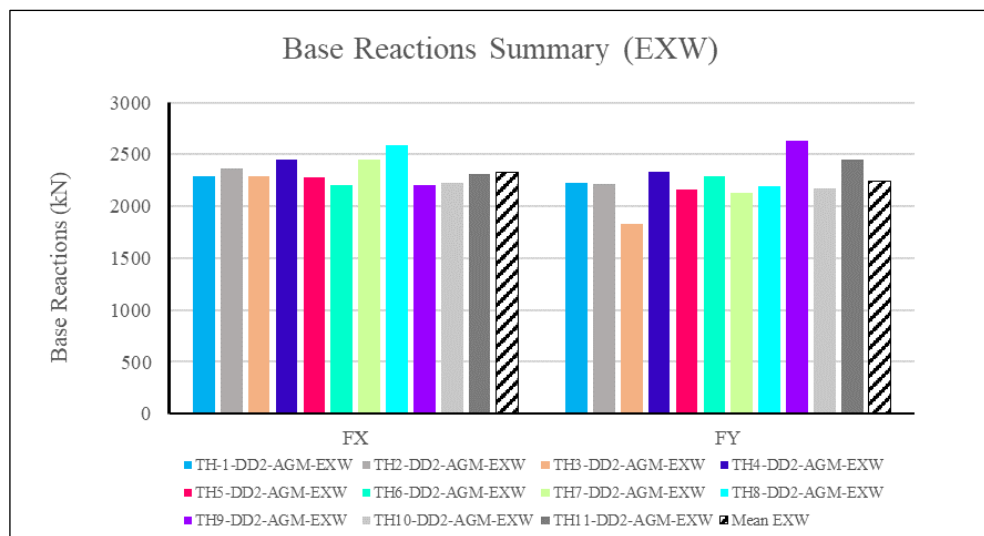


Figure 5.83. Base reactions summary for DD-2 EXW

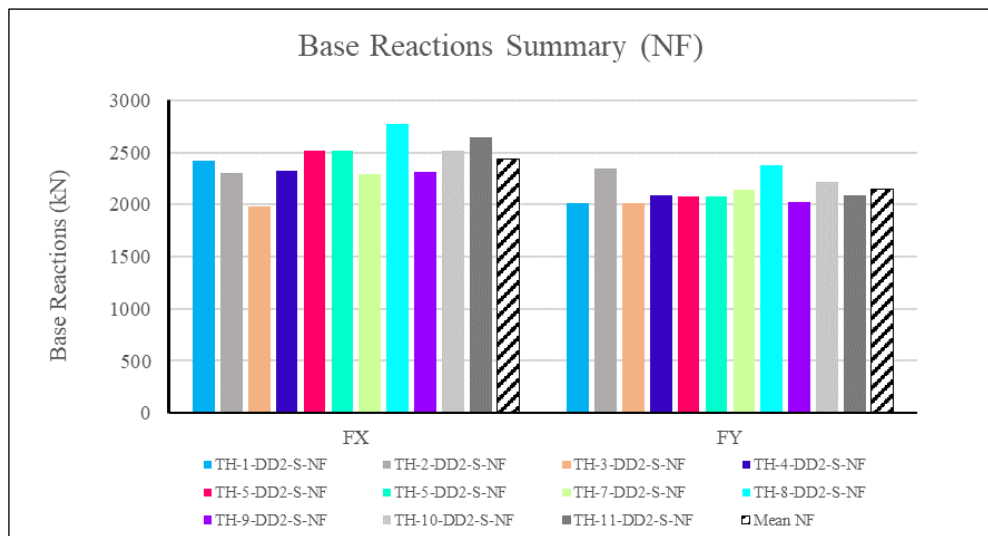


Figure 5.84. Base reactions summary for DD-2 NF

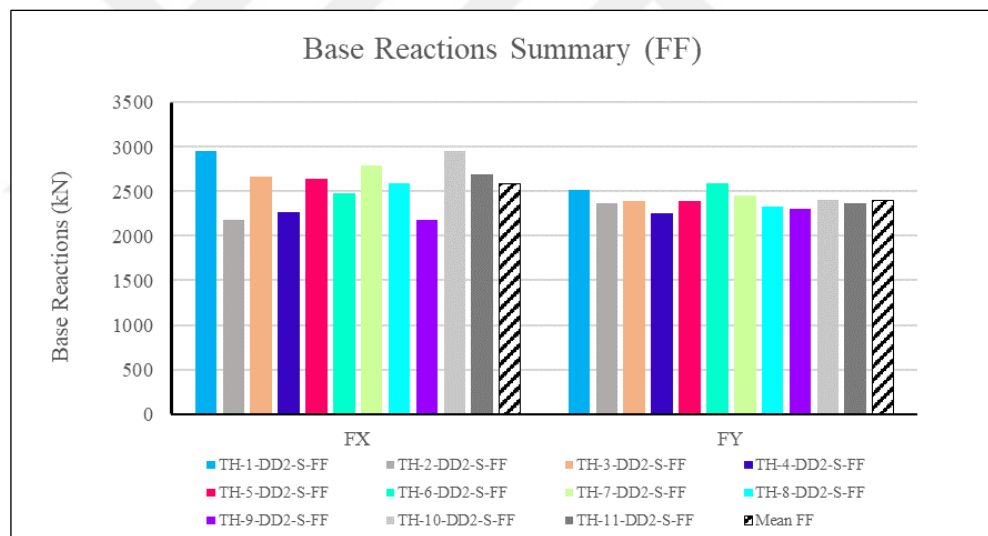


Figure 5.85. Base reactions summary for DD-2 FF

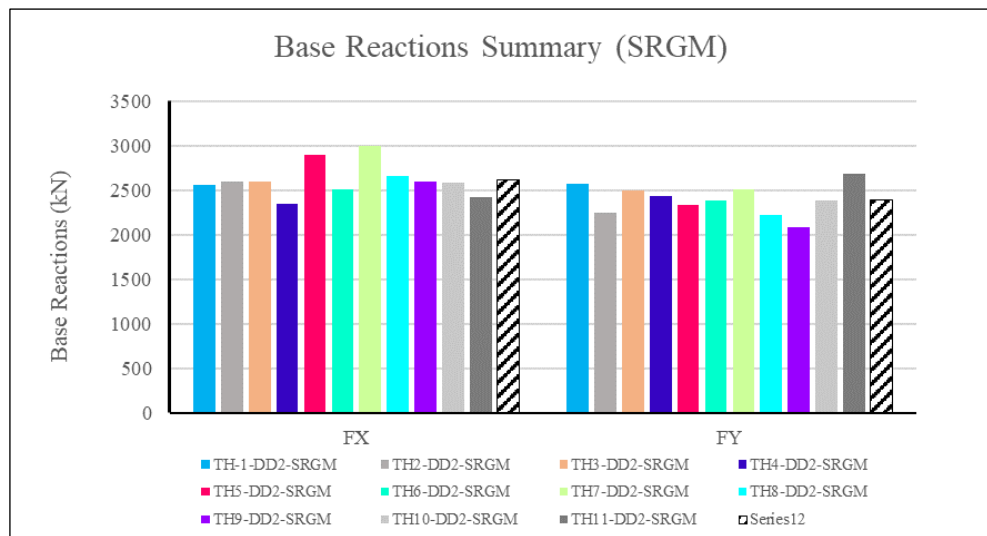


Figure 5.86. Base reactions summary for DD-2 SRGM

6. CONCLUSION

6.1. SUMMARY OF MAIN FINDINGS

In this study, the earthquake performance of an existing reinforced concrete building was evaluated using *Non-linear Time History* method considering the influence of different ground motion data sets. Within the scope of the evaluation, the cross-sectional area damages, brittle failure, base shear forces and relative drifts of the existing reinforced concrete building obtained from different seismic excitations were compared. The structural response of the building was evaluated to discuss whether the building was vulnerable to expected seismic excitations compatible with the Controlled Damage-(KH) performance level for earthquake ground motion level-2 (DD2) given in the TBSC-2018.

The main findings obtained from non-linear dynamic analyses are summarized below:

- a) The geometry of the earthquake source and the propagation properties of the energy released by fault influence the shape of the ground motion. In the synthetic data set, energy distribution in time domain was controlled through noise shaping windows. Dynamic analyses results showed that the building experienced similar deformation under synthetic and scaled ground motion data. Since generated data composed of an envelope of multiple excitations these results are meaningful.
- b) Base shear forces showed similar trend under synthetic, artificial and scaled real excitations. (See Table 6.1 and Figure 6.1)
- c) For the columns and beams, similar cross-sectional damage distributions are observed under all ground motion data sets. (See Table 6.2)
- d) Under AGM SHW, maximum relative story displacement was obtained on the ground story level (1.32 percent, Y direction). Under AGM EXW, maximum relative story displacements were in Y direction with 1.42 percent on the ground story level and 1.36 percent on the first floor. Under SYN NF and SYN FF, the building experienced the maximum relative story displacements on the ground story level in Y direction with 1.33 percent and 1.46 percent respectively. For the SRGM, the building showed 1.50 percent maximum relative story displacement on the ground story level. (See Table 6.3 and Figure 6.2)

Table 6.1. Base reactions summary

Case	FX (Mean) kN	FY (Mean) kN	FZ kN
DD2-AGM-EXW	2332.20	2239.06	17678.72
DD2-AGM-SHW	2419.12	2154.39	17678.72
DD2-SYN-FF	2582.93	2396.24	17678.72
DD2-SYN-NF	2433.22	2148.04	17678.72
DD2-SRGM	2614.23	2392.09	17678.72

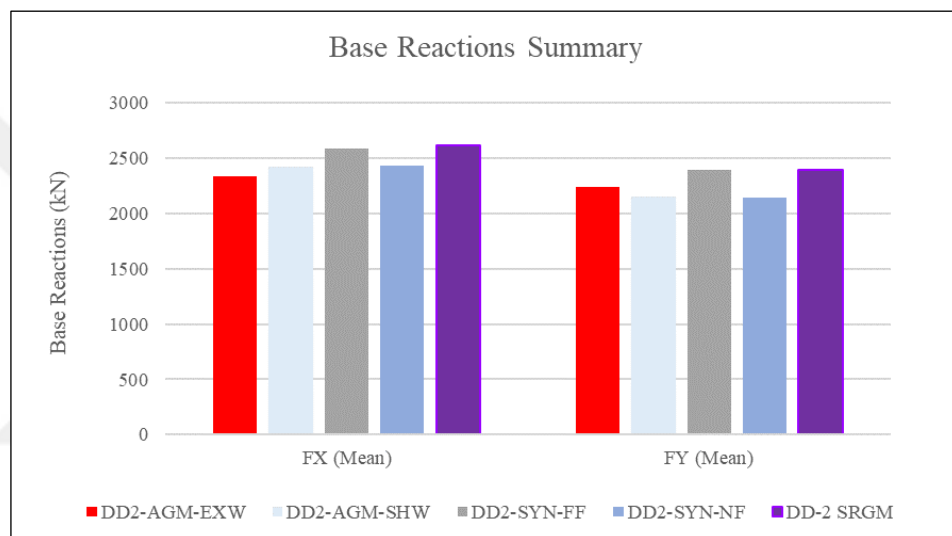


Figure 6.1. Base reactions summary

Table 6.2. Damage distributions summary for all cases

Floor	Case	Section	N.D	BHB	IHB	GB	Total	Controlled Damage (KH)
2nd	SHW	Beam	26 (%68.42)	12 (%31.58)	0 (%0)	0 (%0)	38	☑
		Column	15 (%62.50)	9 (%37.50)	0 (%0)	0 (%0)	24	☑
	EXW	Beam	26 (%68.42)	12 (%31.58)	0 (%0)	0 (%0)	38	☑
		Column	20 (%18.18)	4 (%16.67)	0 (%0)	0 (%0)	24	☑
	NFSM	Beam	26 (%68.42)	12 (%31.58)	0 (%0)	0 (%0)	38	☑
		Column	12 (%50.00)	12 (%50.00)	0 (%0)	0 (%0)	24	☑
	FFSM	Beam	26 (%68.42)	12 (%31.58)	0 (%0)	0 (%0)	38	☑
		Column	18 (%75.00)	6 (%25.00)	0 (%0)	0 (%0)	24	☑
	SRGM	Beam	26 (%68.42)	12 (%31.58)	0 (%0)	0 (%0)	38	☑
		Column	14 (%58.33)	10 (%41.67)	0 (%0)	0 (%0)	24	☑
1st	SHW	Beam	38 (%100)	0 (%0)	0 (%0)	0 (%0)	38	☑
		Column	4 (%16.67)	20 (%83.33)	0 (%0)	0 (%0)	24	☑
	EXW	Beam	38 (%100)	0 (%0)	0 (%0)	0 (%0)	38	☑
		Column	5 (%20.83)	19 (%79.17)	0 (%0)	0 (%0)	24	☑
	NFSM	Beam	38 (%100)	0 (%0)	0 (%0)	0 (%0)	38	☑
		Column	4 (%16.67)	20 (%83.33)	0 (%0)	0 (%0)	24	☑
	FFSM	Beam	38 (%100)	0 (%0)	0 (%0)	0 (%0)	38	☑
		Column	4 (%16.67)	20 (%83.33)	0 (%0)	0 (%0)	24	☑
	SRGM	Beam	37 (%97.37)	1 (%2.63)	0 (%0)	0 (%0)	38	☑
		Column	4 (%16.67)	20 (%83.33)	0 (%0)	0 (%0)	24	☑
Ground	SHW	Beam	40 (%86.96)	6 (%13.04)	0 (%0)	0 (%0)	46	☑
		Column	0 (%0)	28 (%100)	0 (%0)	0 (%0)	28	☑
	EXW	Beam	36 (%78.26)	10 (%21.74)	0 (%0)	0 (%0)	46	☑
		Column	0 (%0)	28 (%100)	0 (%0)	0 (%0)	28	☑
	NFSM	Beam	42 (%91.30)	4 (%8.70)	0 (%0)	0 (%0)	46	☑
		Column	0 (%0)	28 (%100)	0 (%0)	0 (%0)	28	☑
	FFSM	Beam	32 (%69.57)	14 (%30.43)	0 (%0)	0 (%0)	46	☑
		Column	0 (%0)	28 (%100)	0 (%0)	0 (%0)	28	☑
	SRGM	Beam	31 (%67.39)	15 (%32.61)	0 (%0)	0 (%0)	46	☑
		Column	0 (%0)	28 (%100)	0 (%0)	0 (%0)	28	☑

BHB : Visible Damage Zone IHB: Significant Damage Zone GB : Collapse Zone

Table 6.3. Relative story displacements for all cases

DD-2 AGM SHW		Direction			
Story	Story Height	+X	-X	+Y	-Y
2 nd	4.00	0.79%	-0.87%	1.00%	-1.10%
1 st	3.60	0.99%	-0.98%	1.16%	-1.24%
Ground	4.50	1.31%	-1.26%	1.25%	-1.32%
Base	-	0.00%	0.00%	0.00%	0.00%
DD-2 AGM EXW		Direction			
Story	Story Height	+X	-X	+Y	-Y
2 nd	4.00	0.77%	-0.88%	1.14%	-1.01%
1 st	3.60	0.92%	-1.00%	1.36%	-1.29%
Ground	4.50	1.23%	-1.24%	1.35%	-1.42%
Base	-	0.00%	0.00%	0.00%	0.00%
DD-2 SYN NF		Direction			
Story	Story Height	+X	-X	+Y	-Y
2 nd	4.00	0.85%	-0.89%	1.07%	-1.05%
1 st	3.60	0.99%	-0.99%	1.24%	-1.15%
Ground	4.50	1.30%	-1.30%	1.33%	-1.26%
Base	-	0.00%	0.00%	0.00%	0.00%
DD-2 SYN FF		Direction			
Story	Story Height	+X	-X	+Y	-Y
2 nd	4.00	0.81%	-0.86%	1.17%	-1.12%
1 st	3.60	0.93%	-1.02%	1.37%	-1.39%
Ground	4.50	1.24%	-1.35%	1.41%	-1.46%
Base	-	0.00%	0.00%	0.00%	0.00%
DD-2 SRGM		Direction			
Story	Story Height	+X	-X	+Y	-Y
2 nd	4.00	0.91%	-0.90%	1.23%	-1.13%
1 st	3.60	1.06%	-1.05%	1.45%	-1.35%
Ground	4.50	1.35%	-1.40%	1.50%	-1.49%
Base	-	0.00%	0.00%	0.00%	0.00%

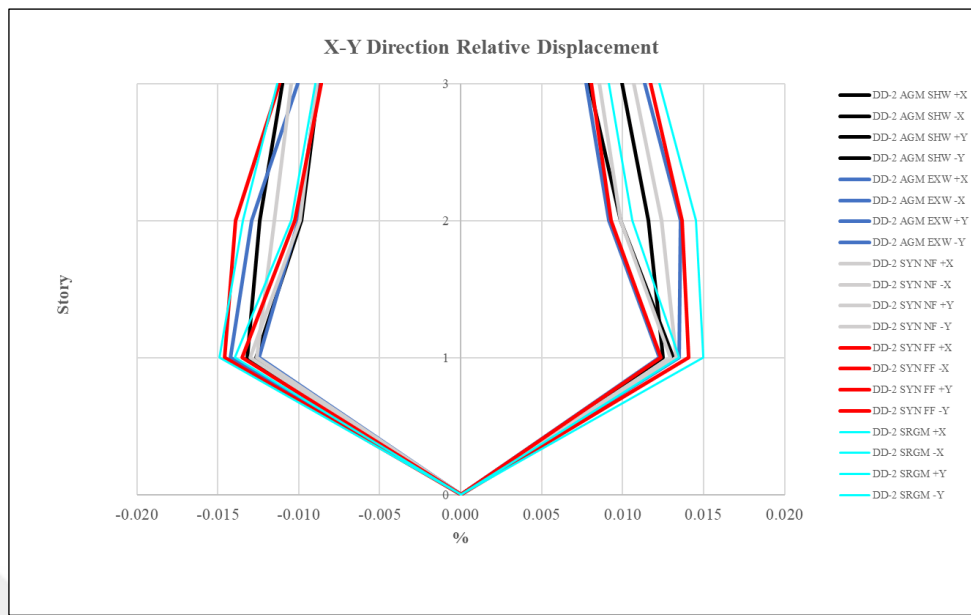


Figure 6.2. Relative displacement summary

6.2. FUTURE RESEARCH

The motivation behind the effort presented in this thesis was to try answering the question whether different ground motions have an effect on structural behavior. Seismic behavior of reinforced concrete structures is also dependent on their structural design features. More research, considering the effect of the building height and shear wall is needed on the available options to be able to ensure a reliable assessment of influence of seismic loading. No clear conclusion was found on the influence of the envelope function on the response of the building. The energy distribution is throughout the duration has an effect on the peak values. More research is definitely needed on reinforced concrete buildings to clearly state the effect of the envelope function.

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APPENDIX A: PROGRAM DEFINITIONS

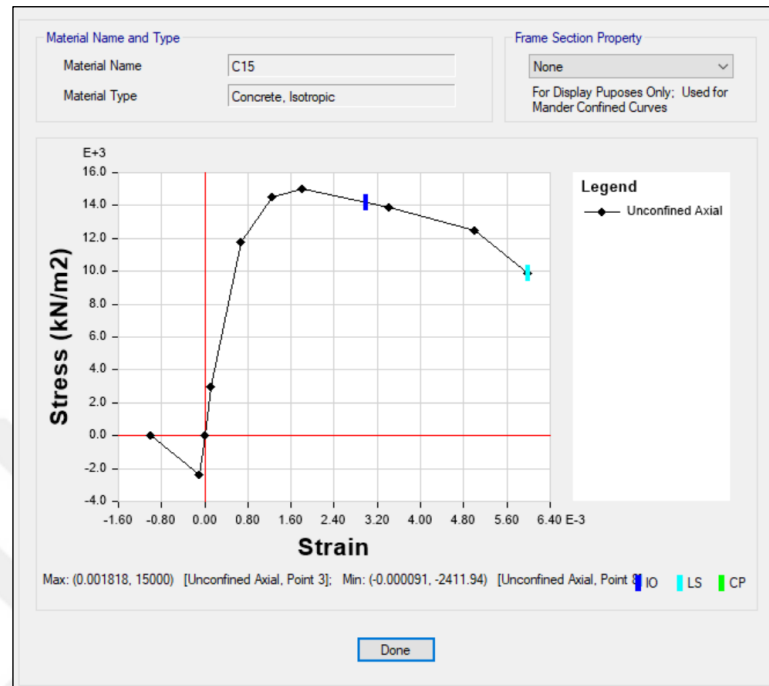


Figure A.1. Nonlinear concrete model of C15

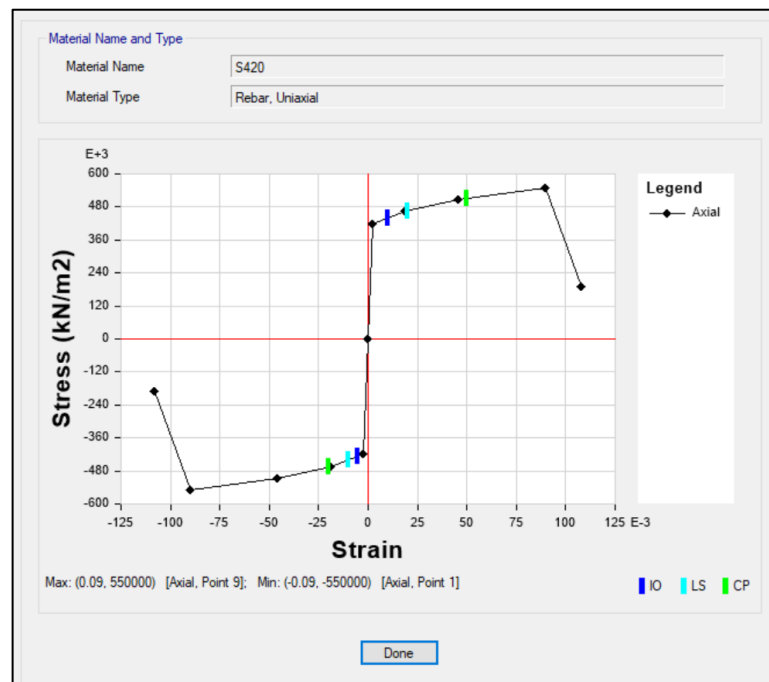


Figure A.2. Nonlinear rebar model of S420

Select Curve
Axial Force: 0 Angle: 0 Curve #1

Moment Rotation Data for Selected Curve

Point	Moment/Yield Mom	Rotation/SF
A	0	0
B	1	0
C	1.1	0.015
D	0.2	0.015
E	0.2	0.025

Note: Yield moment is defined by interaction surface

Copy Curve Data Paste Curve Data

Acceptance Criteria (Plastic Deformation / SF)

Immediate Occupancy 1E-07

Life Safety 0.015

Collapse Prevention 0.0195

Show Acceptance Points on Current Curve

3D View

Plan 315 deg Axial Force 0 kN

Elevation 35 deg

Aperture 0 deg

3D RR MR3 MR2

Hide Backbone Lines

Show Acceptance Criteria

Show Thickened Lines

Highlight Current Curve

Moment Rotation Information

Symmetry Condition Circular

Number of Axial Force Values 1

Number of Angles 1

Total Number of Curves 1

Angle Is Moment About

0 degrees = About Positive M2 Axis

90 degrees = About Positive M3 Axis

180 degrees = About Negative M2 Axis

270 degrees = About Negative M3 Axis

OK Cancel

Figure A.3. Column P-M-M nonlinear hinge definition

Displacement Control Parameters

Point	Moment/SF	Rotation/SF
E-	-0.2	-0.025
D-	-0.2	-0.015
C-	-1.1	-0.015
B-	-1	0
A	0	0
B	1	0
C	1.1	0.015
D	0.2	0.015
E	0.2	0.025

Additional Backbone Curve Points

BC - Between Points B and C

CD - Between Points C and D

Scaling for Moment and Rotation

Use Yield Moment Moment SF Positive Negative kN-m

Use Yield Rotation Rotation SF Positive Negative

Acceptance Criteria (Plastic Rotation/SF)

Immediate Occupancy 0.003

Life Safety 0.012

Collapse Prevention 0.015

Show Acceptance Criteria on Plot

Type

Moment - Rotation

Moment - Curvature

Hinge Length

Relative Length

Load Carrying Capacity Beyond Point E

Drops To Zero

Is Extrapolated

Hysteresis Type and Parameters

Hysteresis Isotropic

No Parameters Are Required For This Hysteresis Type

OK Cancel

Figure A.4. Beam M3 nonlinear hinge definition

General

Load Case Name: DL+0.6LL Design...

Load Case Type: Nonlinear Static Notes...

Mass Source: MsSrc1

Analysis Model: Default

Initial Conditions

☒ Zero Initial Conditions - Start from Unstressed State

☐ Continue from State at End of Nonlinear Case (Loads at End of Case ARE Included)

Nonlinear Case:

Loads Applied

Load Type	Load Name	Scale Factor
Load Pattern	SW	1
Load Pattern	SDL	1
Load Pattern	LL	0.6

+ Add - Delete

Other Parameters

Modal Load Case: Modal

Geometric Nonlinearity Option: None

Load Application: Full Load Modify/Show...

Results Saved: Final State Only Modify/Show...

Nonlinear Parameters: Default Modify/Show...

OK Cancel

Figure A.5. Initial vertical loads definition

General

Load Case Name: TH-1-DD2-SRGM Design...

Load Case Type/Subtype: Time History Nonlinear Direct Integration Notes...

Mass Source: MsSrc1

Analysis Model: Default

Initial Conditions

☐ Zero Initial Conditions - Start from Unstressed State

☒ Continue from State at End of Nonlinear Case (Loads at End of Case ARE Included)

Nonlinear Case: DL+0.6LL

Loads Applied

Load Type	Load Name	Function	Scale Factor
Acceleration	U1	FRK_1X_53.44an_0...	9.81
Acceleration	U2	FRK_1Y_53.44an_0...	9.81

+ Add - Delete ☐ Advanced

Other Parameters

Geometric Nonlinearity Option: None

Number of Output Time Steps: 5344

Output Time Step Size: 0.01 sec

Damping: Mass: 0.1823; Stiff: 0.0137; Modal: No Modify/Show...

Time Integration: Hilber-Hughes-Taylor Modify/Show...

Nonlinear Parameters: Default Modify/Show...

OK Cancel

Figure A.6. Earthquake loads definition

Modal Load Case			
Viscous Proportional Damping			
	Mass Proportional Coefficient	Stiffness Proportional Coefficient	
☐ Direct Specification			
☒ Specify Damping by Period	0.1823	1/sec	0.0137 sec
☐ Specify Damping by Frequency			
☐ Specify as Period Ratio, T/T_mode, for This Mode			
	Period	Frequency	Damping
First	1.805 sec		0.05
Second	1.641 sec		0.05
			Recalculate Coefficients
Additional Modal Damping			
☐ Include Additional Modal Damping			
☐	Maximum Considered Modal Frequency		
Modify/Show Modal Damping Parameters...			
OK		Cancel	

Figure A.7. Damping model

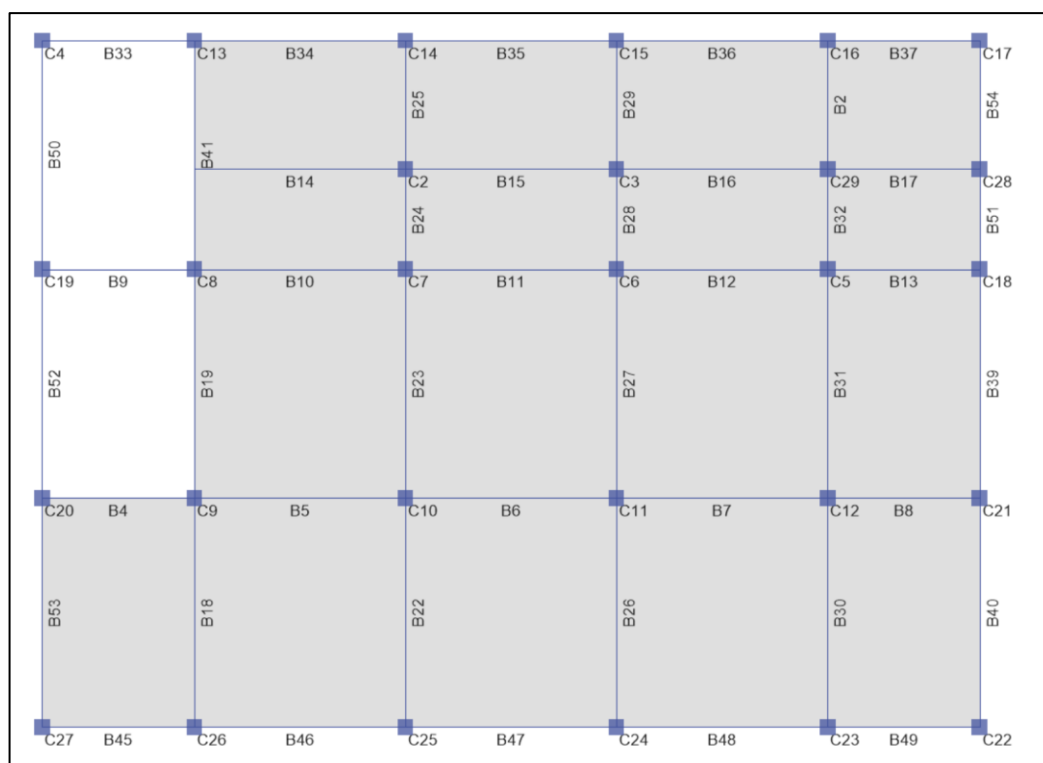


Figure A.8. Ground floor column and beam sections labels

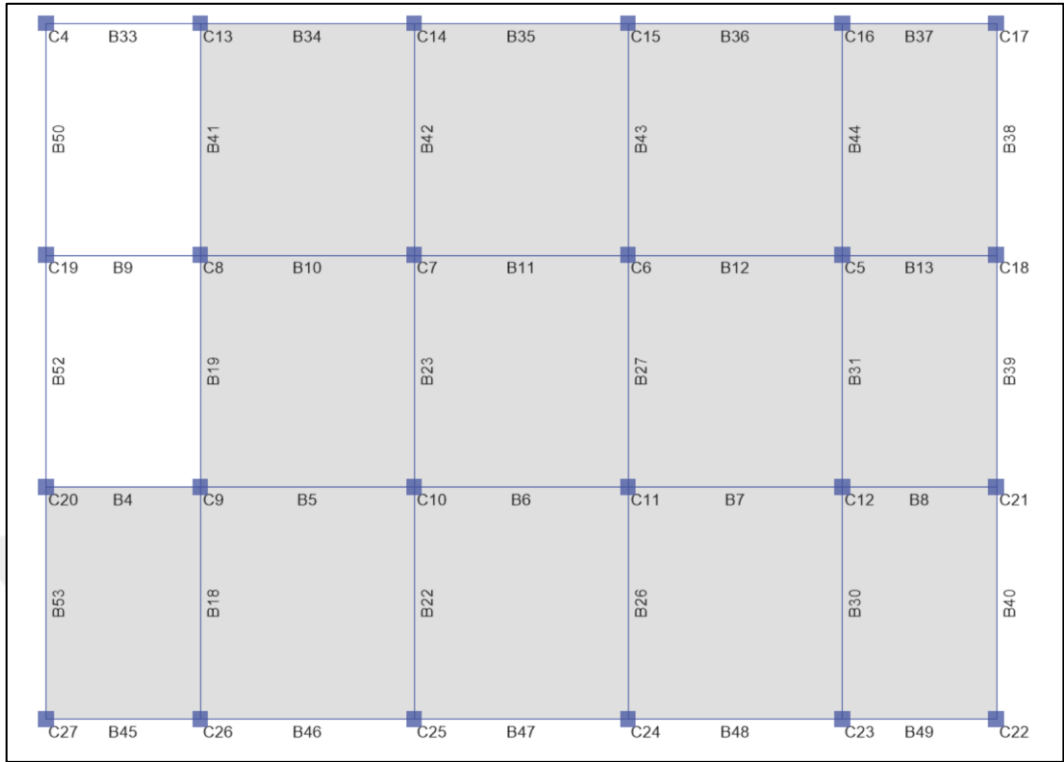


Figure A.9. 1st floor column and beam sections labels

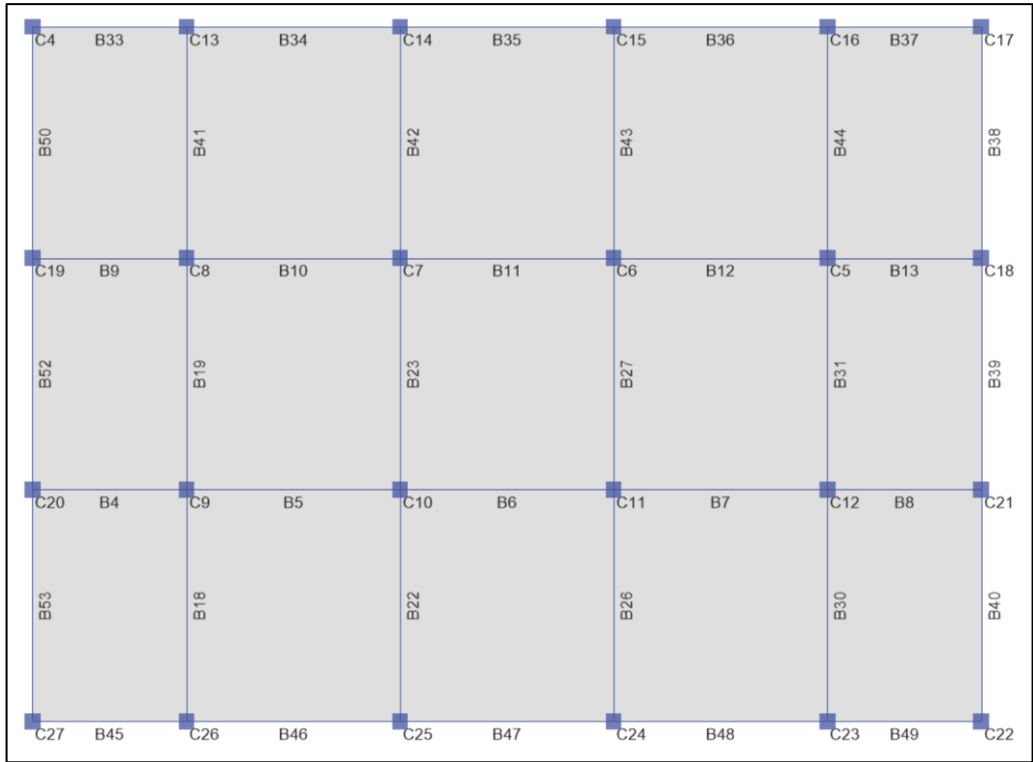


Figure A.10. 2nd floor column and beam sections labels

APPENDIX B: CALCULATION SUMMARIES

Table B.1. Effective section rigidity factor and damage limits for column sections-1

Member	Column	C45*45_T1		C45*45_T2		C45*45_T3	
Section	b [m]	0.45		0.45		0.45	
	h [m]	0.45		0.45		0.45	
L (m)		4.50		4.50		4.50	
Rebar (cm ²)	Piece	8		8		8	
	Diameter	16		16		16	
E (kN/m ²)		26587000		26587000		26587000	
N (g+nq) (kN)		1174		1074		762	
My (kNm)		248.50	248.50	240.23	240.23	212.34	212.34
Ls (m)		2.25		2.25		2.25	
ϕ_y (1/m)		0.0111	0.0111	0.0105	0.0105	0.0093	0.0093
η		1		1		1	
db (m)		0.016		0.016		0.016	
fye (MPa)		420		420		420	
fce (MPa)		15		15		15	
θ_y		0.0126	0.0126	0.0121	0.0121	0.0109	0.0109
EI		90853	90853	90853	90853	90853	90853
(EI)e		14746	14746	14875	14875	14580	14580
Effective Section Rigidity		0.162	0.162	0.164	0.164	0.160	0.160
ϵ_{su}		0.08	0.08	0.08	0.08	0.08	0.08
Lp		0.225	0.225	0.225	0.225	0.225	0.225
ϕ_u (1/m)		0.0367	0.0367	0.0386	0.0386	0.0471	0.0471
ϵ_s (GÖ)		0.032	0.032	0.032	0.032	0.032	0.032
θ_p (GÖ)		0.0054	0.0054	0.0059	0.0059	0.0077	0.0077
ϵ_s (KH)		0.024	0.024	0.024	0.024	0.024	0.024
θ_p (KH)		0.0041	0.004	0.0044	0.004	0.0057	0.006
ϵ_s (SH)		0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
θ_p (SH)		0	0	0	0	0	0

Table B.2. Effective section rigidity factor and damage limits for column sections-2

Member	Column	C45*45_T4		C45*45_T5		C45*45_T6	
Section	b [m]	0.45		0.45		0.45	
	h [m]	0.45		0.45		0.45	
L (m)		4.50		4.50		4.50	
Rebar (cm ²)	Piece	8		8		8	
	Diameter	16		16		16	
E (kN/m ²)		26587000		26587000		26587000	
N (g+nq) (kN)		695		574		471	
My (kNm)		200.41	200.41	188.60	188.60	173.17	173.17
Ls (m)		2.25		2.25		2.25	
ϕ_y (1/m)		0.0089	0.0089	0.0086	0.0086	0.0082	0.0082
η		1		1		1	
db (m)		0.016		0.016		0.016	
f _{ye} (MPa)		420		420		420	
f _{ce} (MPa)		15		15		15	
θ_y		0.0106	0.0106	0.0103	0.0103	0.0099	0.0099
EI		90853	90853	90853	90853	90853	90853
(EI)e		14240	14240	13780	13780	13148	13148
Effective Section Rigidity		0.157	0.157	0.152	0.152	0.145	0.145
ϵ_{su}		0.08	0.08	0.08	0.08	0.08	0.08
L _p		0.225	0.225	0.225	0.225	0.225	0.225
ϕ_u (1/m)		0.0488	0.0488	0.0541	0.0541	0.0602	0.0602
ϵ_s (GÖ)		0.032	0.032	0.032	0.032	0.032	0.032
θ_p (GÖ)		0.0080	0.0080	0.0091	0.0091	0.0103	0.0103
ϵ_s (KH)		0.024	0.024	0.024	0.024	0.024	0.024
θ_p (KH)		0.0060	0.006	0.0068	0.007	0.0077	0.008
ϵ_s (SH)		0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
θ_p (SH)		0	0	0	0	0	0

Table B.3. Effective section rigidity factor and damage limits for column sections-3

Member	Column	C45*45_T7		C45*45_T8		C45*45_T9	
Section	b [m]	0.45		0.45		0.45	
	h [m]	0.45		0.45		0.45	
L (m)		4.50		4.50		4.50	
Rebar (cm ²)	Piece	8		8		8	
	Diameter	16		16		16	
E (kN/m ²)		26587000		26587000		26587000	
N (g+nq) (kN)		373		278		166	
My (kNm)		163.60	163.60	143.71	143.71	126.68	126.68
Ls (m)		2.25		2.25		2.25	
ϕ_y (1/m)		0.0079	0.0079	0.0075	0.0075	0.0072	0.0072
η		1		1		1	
db (m)		0.016		0.016		0.016	
f _{ye} (MPa)		420		420		420	
f _{ce} (MPa)		15		15		15	
θ_y		0.0096	0.0096	0.0092	0.0092	0.0089	0.0089
EI		90853	90853	90853	90853	90853	90853
(EI)e		12796	12796	11713	11713	10638	10638
Effective Section Rigidity		0.141	0.141	0.129	0.129	0.117	0.117
ϵ_{su}		0.08	0.08	0.08	0.08	0.08	0.08
L _p		0.225	0.225	0.225	0.225	0.225	0.225
ϕ_u (1/m)		0.0715	0.0715	0.0839	0.0839	0.0995	0.0995
ϵ_s (GÖ)		0.032	0.032	0.032	0.032	0.032	0.032
θ_p (GÖ)		0.0125	0.0125	0.0149	0.0149	0.0179	0.0179
ϵ_s (KH)		0.024	0.024	0.024	0.024	0.024	0.024
θ_p (KH)		0.0094	0.009	0.0112	0.011	0.0134	0.013
ϵ_s (SH)		0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
θ_p (SH)		0	0	0	0	0	0

Table B.4. Effective section rigidity factor and damage limits for beam sections-1

Member	Beam	B20/60_T1		B20/60_T2		B40/60_T1		B40/60_T2	
Section	b [m]	0.20		0.20		0.40		0.40	
	h [m]	0.6		0.6		0.6		0.6	
L (m)		6.00		6.00		6.00		6.00	
E (kN / m ²)		26587000		26587000		26587000		26587000	
My (kNm)	Bottom	Top		Bottom	Top	Bottom	Top	Bottom	Top
	301.113	230.405		146.116	265.183	154.108	290.05	233.122	73.361
Ls (m)		3		3		3		3	
ϕ_y (1/m)		0.0082	0.00763	0.0063	0.0065	0.0057	0.0070	0.0068	0.0051
η		1		1		1		1	
db (m)		0.019	0.016	0.018	0.019	0.020	0.018	0.020	0.012
fye (MPa)		420		420		420		420	
fce (MPa)		15		15		15		15	
θ_y		0.0122	0.0112	0.0098	0.0102	0.0092	0.0107	0.0105	0.0079
EI		95713	95713	95713	95713	191426	191426	191426	191426
(EI)e		24532	20497	14854	25999	16759	26963	22006	9215
Effective Section Rigidity		0.256	0.214	0.155	0.272	0.088	0.141	0.115	0.048
Effective Section Rigidity (Mean)		0.235		0.213		0.114		0.082	
ϵ_{su}		0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
Lp		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
ϕ_u (1/m)		0.0744	0.0628	0.0622	0.0683	0.0609	0.0641	0.0635	0.0596
ϵ_s (GÖ)		0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
θ_p (GÖ)		0.0168	0.0135	0.0140	0.0156	0.0141	0.0143	0.0146	0.0125
ϵ_s (KH)		0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
θ_p (KH)		0.013	0.010	0.010	0.012	0.011	0.011	0.011	0.009
ϵ_s (SH)		0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
θ_p (SH)		0	0	0	0	0	0	0	0

Table B.5. Effective section rigidity factor and damage limits for beam sections-2

Member	Beam	B40/60_T3		B40/60_T4		B40/60_T5	
Section	b [m]	0.40		0.40		0.40	
	h [m]	0.6		0.6		0.6	
L (m)		6.00		6.00		6.00	
E (kN / m ²)		26587000		26587000		26587000	
My (kNm)	Bottom	Top	Bottom	Top	Bottom	Top	
	316.526	412.37	212.514	474.157	314.262	286.405	
Ls (m)		3		3		3	
ϕ_y (1/m)		0.0069	0.0075	0.0063	0.0065	0.0071	0.0069
η		1		1		1	
db (m)		0.019	0.018	0.020	0.018	0.019	0.022
fye (MPa)		420		420		420	
fce (MPa)		15		15		15	
θ_y		0.0106	0.0112	0.0099	0.0100	0.0109	0.0109
EI		191426	191426	191426	191426	191426	191426
(EI)e		29637	36558	21341	47363	28788	26195
Effective Section Rigidity		0.155	0.191	0.111	0.247	0.150	0.137
Effective Section Rigidity (Mean)		0.173		0.179		0.144	
ε_{su}		0.080	0.080	0.080	0.080	0.080	0.080
Lp		0.3	0.3	0.3	0.3	0.3	0.3
ϕ_u (1/m)		0.0628	0.0647	0.0615	0.0697	0.0628	0.0628
ε_s (GÖ)		0.032	0.032	0.032	0.032	0.032	0.032
θ_p (GÖ)		0.0142	0.0144	0.0142	0.0158	0.0142	0.0148
ε_s (KH)		0.024	0.024	0.024	0.024	0.024	0.024
θ_p (KH)		0.011	0.011	0.011	0.012	0.011	0.011
ε_s (SH)		0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
θ_p (SH)		0	0	0	0	0	0

Table B.6. Effective section rigidity factor and damage limits for beam sections-3

Member	Beam	B25/150_T1		B40/60_T6		B40/60_T7	
Section	b [m]	0.25		0.40		0.40	
	h [m]	1.5		0.6		0.6	
L (m)		6.00		6.00		6.00	
E (kN / m ²)		26587000		26587000		26587000	
My (kNm)		Bottom	Top	Bottom	Top	Bottom	Top
		1323.639	937.437	362.791	352.142	290.762	544.515
Ls (m)		3		3		3	
ϕ_y (1/m)		0.0027	0.0025	0.00731	0.0072	0.0063	0.0067
η		1		1		1	
db (m)		0.020	0.022	0.018	0.018	0.020	0.019
fye (MPa)		420		420		420	
fce (MPa)		15		15		15	
θ_y		0.0060	0.0058	0.0110	0.0109	0.0100	0.0104
EI		1869398	1869398	191426	191426	191426	191426
(EI)e		218531	159685	32851	32287	29051	52480
Effective Section Rigidity		0.117	0.085	0.172	0.169	0.152	0.274
Effective Section Rigidity (Mean)		0.101		0.170		0.213	
ϵ_{su}		0.080	0.080	0.080	0.080	0.080	0.080
Lp		0.75	0.75	0.3	0.3	0.3	0.3
ϕ_u (1/m)		0.0242	0.0239	0.0635	0.0635	0.0622	0.0702
ϵ_s (GÖ)		0.032	0.032	0.032	0.032	0.032	0.032
θ_p (GÖ)		0.0109	0.0109	0.0141	0.0141	0.0143	0.0161
ϵ_s (KH)		0.024	0.024	0.024	0.024	0.024	0.024
θ_p (KH)		0.008	0.008	0.011	0.011	0.011	0.012
ϵ_s (SH)		0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
θ_p (SH)		0	0	0	0	0	0

Table B.7. Effective section rigidity factor and damage limits for beam sections-4

Member	Beam	B40/60_T8		B40/60_T9		B20/60_T3	
Section	b [m]	0.40		0.40		0.20	
	h [m]	0.6		0.6		0.6	
L (m)		6.00		6.00		6.00	
E (kN / m ²)		26587000		26587000		26587000	
My (kNm)		Bottom	Top	Bottom	Top	Bottom	Top
		122.797	147.85	212.514	474.157	301.113	230.405
Ls (m)		3		1.55		1.5	
ϕ_y (1/m)		0.0060	0.0062	0.0063	0.00648	0.0082	0.0076
η		1		1		1	
db (m)		0.016	0.014	0.020	0.018	0.019	0.016
fye (MPa)		420		420		420	
fce (MPa)		15		15		15	
θ_y		0.0092	0.0093	0.0073	0.0073	0.0086	0.0078
EI		191426	191426	191426	191426	95713	95713
(EI)e		13239	15852	14971	33559	17467	14632
Effective Section Rigidity		0.069	0.083	0.078	0.175	0.182	0.153
Effective Section Rigidity (Mean)		0.076		0.127		0.168	
ϵ_{su}		0.080	0.080	0.080	0.080	0.080	0.080
Lp		0.3	0.3	0.3	0.3	0.3	0.3
ϕ_u (1/m)		0.0603	0.0609	0.0615	0.0697	0.0744	0.0628
ϵ_s (GÖ)		0.032	0.032	0.032	0.032	0.032	0.032
θ_p (GÖ)		0.0132	0.0130	0.0137	0.0152	0.0161	0.0129
ϵ_s (KH)		0.024	0.024	0.024	0.024	0.024	0.024
θ_p (KH)		0.010	0.010	0.010	0.011	0.012	0.010
ϵ_s (SH)		0.0075	0.0075	0.0075	0.0075	0.0075	0.0075
θ_p (SH)		0	0	0	0	0	0

Table B.8. Ground floor columns damage distributions (SHW)

Column	D/C Ratio	Hinge State
C2	0.207	BHB
C3	0.201	BHB
C5	0.273	BHB
C6	0.193	BHB
C7	0.216	BHB
C8	0.320	BHB
C9	0.281	BHB
C10	0.258	BHB
C11	0.242	BHB
C12	0.291	BHB
C4	0.138	BHB
C13	0.134	BHB
C14	0.152	BHB
C15	0.140	BHB
C16	0.173	BHB
C17	0.075	BHB
C18	0.097	BHB
C19	0.206	BHB
C20	0.193	BHB
C21	0.175	BHB
C22	0.232	BHB
C23	0.262	BHB
C24	0.288	BHB
C25	0.301	BHB
C26	0.310	BHB
C27	0.271	BHB
C28	0.141	BHB
C29	0.195	BHB

Table B.9. 1st Floor Columns Damage Distributions (SHW)

Column	D/C Ratio	Hinge State
C5	0.058	BHB
C6	0.052	BHB
C7	0.039	BHB
C8	0.062	BHB
C9	0.058	BHB
C10	0.030	BHB
C11	0.040	BHB
C12	0.062	BHB
C4	0.000	N.D

Table B.9. 1st floor columns damage distributions (SHW) (Contd.)

Column	D/C Ratio	Hinge State
C13	0.006	BHB
C14	0.000	N.D
C15	0.000	N.D
C16	0.017	BHB
C17	0.000	N.D
C18	0.022	BHB
C19	0.019	BHB
C20	0.010	BHB
C21	0.099	BHB
C22	0.024	BHB
C23	0.077	BHB
C24	0.025	BHB
C25	0.023	BHB
C26	0.105	BHB
C27	0.033	BHB

Table B.10. 2nd floor columns damage distributions (SHW)

Column	D/C Ratio	Hinge State
C5	0.014	BHB
C6	0.000	N.D
C7	0.000	BHB
C8	0.001	BHB
C9	0.004	BHB
C10	0.000	N.D
C11	0.000	N.D
C12	0.004	BHB
C4	0.000	N.D
C13	0.000	N.D
C14	0.000	N.D
C15	0.000	N.D
C16	0.010	BHB
C17	0.000	N.D
C18	0.000	BHB
C19	0.000	N.D
C20	0.000	N.D
C21	0.000	N.D
C22	0.000	N.D
C23	0.001	BHB
C24	0.000	N.D
C25	0.000	N.D

Table B.10. 2nd floor columns damage distributions (SHW) (Contd.)

Column	D/C Ratio	Hinge State
C26	0.006	BHB
C27	0.000	N.D

Table B.11. Ground floor columns damage distributions (EXW)

Column	D/C Ratio	Hinge State
C2	0.197	BHB
C3	0.191	BHB
C5	0.299	BHB
C6	0.272	BHB
C7	0.289	BHB
C8	0.267	BHB
C9	0.278	BHB
C10	0.242	BHB
C11	0.214	BHB
C12	0.243	BHB
C4	0.095	BHB
C13	0.143	BHB
C14	0.127	BHB
C15	0.127	BHB
C16	0.134	BHB
C17	0.087	BHB
C18	0.107	BHB
C19	0.192	BHB
C20	0.200	BHB
C21	0.134	BHB
C22	0.238	BHB
C23	0.194	BHB
C24	0.195	BHB
C25	0.207	BHB
C26	0.216	BHB
C27	0.221	BHB
C28	0.136	BHB
C29	0.183	BHB

Table B.12. 1st floor columns damage distributions (EXW)

Column	D/C Ratio	Hinge State
C5	0.071	BHB
C6	0.051	BHB
C7	0.042	BHB
C8	0.026	BHB

Table B.12. 1st floor columns damage distributions (EXW) (Contd.)

Column	D/C Ratio	Hinge State
C9	0.062	BHB
C10	0.005	BHB
C11	0.000	N.D
C12	0.057	BHB
C4	0.000	N.D
C13	0.002	BHB
C14	0.000	N.D
C15	0.000	N.D
C16	0.001	BHB
C17	0.000	N.D
C18	0.035	BHB
C19	0.041	BHB
C20	0.026	BHB
C21	0.029	BHB
C22	0.029	BHB
C23	0.056	BHB
C24	0.038	BHB
C25	0.034	BHB
C26	0.101	BHB
C27	0.005	BHB

Table B.13. 2nd floor columns damage distributions (EXW)

Column	D/C Ratio	Hinge State
C5	0.000	N.D
C6	0.000	N.D
C7	0.000	N.D
C8	0.002	BHB
C9	0.001	BHB
C10	0.000	N.D
C11	0.000	N.D
C12	0.000	N.D
C4	0.000	N.D
C13	0.000	N.D
C14	0.000	N.D
C15	0.000	N.D
C16	0.002	BHB
C17	0.000	N.D
C18	0.000	N.D
C19	0.000	N.D
C20	0.000	N.D

Table B.13. 2nd floor columns damage distributions (EXW) (Contd.)

Column	D/C Ratio	Hinge State
C21	0.000	N.D
C22	0.000	N.D
C23	0.000	N.D
C24	0.000	N.D
C25	0.000	N.D
C26	0.002	BHB
C27	0.000	N.D

Table B.14. Ground floor columns damage distributions (NF)

Column	D/C Ratio	Hinge State
C2	0.189	BHB
C3	0.180	BHB
C5	0.386	BHB
C6	0.364	BHB
C7	0.368	BHB
C8	0.320	BHB
C9	0.391	BHB
C10	0.293	BHB
C11	0.272	BHB
C12	0.299	BHB
C4	0.092	BHB
C13	0.182	BHB
C14	0.119	BHB
C15	0.116	BHB
C16	0.170	BHB
C17	0.097	BHB
C18	0.180	BHB
C19	0.229	BHB
C20	0.253	BHB
C21	0.205	BHB
C22	0.311	BHB
C23	0.302	BHB
C24	0.230	BHB
C25	0.258	BHB
C26	0.314	BHB
C27	0.276	BHB
C28	0.132	BHB
C29	0.188	BHB

Table B.15. 1st floor columns damage distributions (NF)

Column	D/C Ratio	Hinge State
C5	0.103	BHB
C6	0.084	BHB
C7	0.068	BHB
C8	0.070	BHB
C9	0.088	BHB
C10	0.037	BHB
C11	0.043	BHB
C12	0.133	BHB
C4	0.000	N.D
C13	0.015	BHB
C14	0.000	N.D
C15	0.000	N.D
C16	0.026	BHB
C17	0.000	N.D
C18	0.043	BHB
C19	0.005	BHB
C20	0.039	BHB
C21	0.058	BHB
C22	0.061	BHB
C23	0.107	BHB
C24	0.051	BHB
C25	0.040	BHB
C26	0.080	BHB
C27	0.035	BHB

Table B.16. 2nd floor columns damage distributions (NF)

Column	D/C Ratio	Hinge State
C5	0.060	BHB
C6	0.013	BHB
C7	0.014	BHB
C8	0.010	BHB
C9	0.003	BHB
C10	0.000	N.D
C11	0.000	N.D
C12	0.030	BHB
C4	0.000	N.D
C13	0.000	N.D
C14	0.003	BHB
C15	0.003	BHB
C16	0.034	BHB

Table B.16. 2nd floor columns damage distributions (NF) (Contd.)

Column	D/C Ratio	Hinge State
C17	0.000	N.D
C18	0.000	N.D
C19	0.000	N.D
C20	0.000	N.D
C21	0.000	N.D
C22	0.000	N.D
C23	0.025	BHB
C24	0.000	N.D
C25	0.001	BHB
C26	0.009	BHB
C27	0.000	N.D

Table B.17. Ground floor columns damage distributions (FF)

Column	D/C Ratio	Hinge State
C2	0.231	BHB
C3	0.227	BHB
C5	0.346	BHB
C6	0.312	BHB
C7	0.358	BHB
C8	0.353	BHB
C9	0.395	BHB
C10	0.284	BHB
C11	0.275	BHB
C12	0.309	BHB
C4	0.086	BHB
C13	0.180	BHB
C14	0.131	BHB
C15	0.133	BHB
C16	0.191	BHB
C17	0.149	BHB
C18	0.205	BHB
C19	0.217	BHB
C20	0.253	BHB
C21	0.259	BHB
C22	0.306	BHB
C23	0.246	BHB
C24	0.308	BHB
C25	0.304	BHB
C26	0.351	BHB
C27	0.228	BHB

Table B.17. Ground floor columns damage distributions (FF) (Contd.)

Column	D/C Ratio	Hinge State
C28	0.178	BHB
C29	0.226	BHB

Table B.18. 1st floor columns damage distributions (FF)

Column	D/C Ratio	Hinge State
C5	0.067	BHB
C6	0.041	BHB
C7	0.043	BHB
C8	0.055	BHB
C9	0.049	BHB
C10	0.043	BHB
C11	0.043	BHB
C12	0.062	BHB
C4	0.000	N.D
C13	0.002	BHB
C14	0.000	N.D
C15	0.000	N.D
C16	0.010	BHB
C17	0.000	N.D
C18	0.019	BHB
C19	0.055	BHB
C20	0.035	BHB
C21	0.030	BHB
C22	0.044	BHB
C23	0.091	BHB
C24	0.048	BHB
C25	0.051	BHB
C26	0.157	BHB
C27	0.040	BHB

Table B.19. 2nd floor columns damage distributions (FF)

Column	D/C Ratio	Hinge State
C5	0.005	BHB
C6	0.000	N.D
C7	0.000	N.D
C8	0.007	BHB
C9	0.000	N.D
C10	0.000	N.D
C11	0.000	N.D
C12	0.005	BHB

Table B.19. 2nd floor columns damage distributions (FF) (Contd.)

Column	D/C Ratio	Hinge State
C4	0.000	N.D
C13	0.000	N.D
C14	0.000	N.D
C15	0.000	N.D
C16	0.004	BHB
C17	0.000	N.D
C18	0.000	N.D
C19	0.000	N.D
C20	0.000	N.D
C21	0.000	N.D
C22	0.000	N.D
C23	0.017	BHB
C24	0.000	N.D
C25	0.000	N.D
C26	0.023	BHB
C27	0.000	N.D

Table B.20. Ground floor columns damage distributions (SRGM)

Column	D/C Ratio	Hinge State
C2	0.286	BHB
C3	0.276	BHB
C5	0.497	BHB
C6	0.473	BHB
C7	0.495	BHB
C8	0.478	BHB
C9	0.497	BHB
C10	0.400	BHB
C11	0.440	BHB
C12	0.446	BHB
C4	0.163	BHB
C13	0.269	BHB
C14	0.268	BHB
C15	0.273	BHB
C16	0.285	BHB
C17	0.184	BHB
C18	0.225	BHB
C19	0.310	BHB
C20	0.332	BHB
C21	0.293	BHB
C22	0.313	BHB
C23	0.338	BHB

Table B.20. Ground floor columns damage distributions (SRGM) (Contd.)

Column	D/C Ratio	Hinge State
C24	0.383	BHB
C25	0.396	BHB
C26	0.392	BHB
C27	0.294	BHB
C28	0.209	BHB
C29	0.261	BHB

Table B.21. 1st floor columns damage distributions (SRGM)

Column	D/C Ratio	Hinge State
C5	0.143	BHB
C6	0.103	BHB
C7	0.088	BHB
C8	0.072	BHB
C9	0.129	BHB
C10	0.030	BHB
C11	0.026	BHB
C12	0.095	BHB
C4	0.000	N.D
C13	0.016	BHB
C14	0.000	N.D
C15	0.000	N.D
C16	0.021	BHB
C17	0.000	N.D
C18	0.049	BHB
C19	0.022	BHB
C20	0.062	BHB
C21	0.056	BHB
C22	0.055	BHB
C23	0.144	BHB
C24	0.049	BHB
C25	0.046	BHB
C26	0.164	BHB
C27	0.025	BHB

Table B.22. 2nd floor columns damage distributions (SRGM)

Column	D/C Ratio	Hinge State
C5	0.005	BHB
C6	0.000	N.D
C7	0.000	N.D

Table B.22. 2nd floor columns damage distributions (SRGM) (Contd.)

Column	D/C Ratio	Hinge State
C8	0.004	BHB
C9	0.003	BHB
C10	0.000	N.D
C11	0.000	N.D
C12	0.007	BHB
C4	0.000	N.D
C13	0.007	BHB
C14	0.000	N.D
C15	0.000	N.D
C16	0.011	BHB
C17	0.000	N.D
C18	0.000	N.D
C19	0.000	N.D
C20	0.004	BHB
C21	0.006	BHB
C22	0.000	N.D
C23	0.013	BHB
C24	0.000	N.D
C25	0.000	N.D
C26	0.011	BHB
C27	0.000	N.D

Table B.23. Ground floor beams damage distributions (SHW)

Beam	D/C Ratio	Hinge State
B2	0.000	N.D
B4	0.000	N.D
B5	0.000	N.D
B6	0.000	N.D
B7	0.000	N.D
B8	0.000	N.D
B9	0.000	N.D
B10	0.000	N.D
B11	0.000	N.D
B12	0.000	N.D
B13	0.000	N.D
B15	0.000	N.D
B16	0.000	N.D
B17	0.000	N.D
B18	0.000	N.D
B19	0.040	BHB

Table B.23. Ground floor beams damage distributions (SHW) (Contd.)

Beam	D/C Ratio	Hinge State
B22	0.000	N.D
B23	0.000	N.D
B24	0.005	BHB
B25	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B28	0.015	BHB
B29	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B32	0.000	BHB
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B39	0.000	N.D
B40	0.000	N.D
B41	0.060	BHB
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.000	N.D
B53	0.000	N.D
B14	0.668	BHB
B51	0.000	N.D
B54	0.000	N.D

Table B.24. 1st floor beams damage distributions (SHW)

Beam	D/C Ratio	Hinge State
B4	0.000	N.D
B5	0.000	N.D
B6	0.000	N.D
B7	0.000	N.D
B8	0.000	N.D
B9	0.000	N.D
B10	0.000	N.D

Table B.24. 1st floor beams damage distributions (SHW) (Contd.)

Beam	D/C Ratio	Hinge State
B11	0.000	N.D
B12	0.000	N.D
B13	0.000	N.D
B18	0.000	N.D
B19	0.000	N.D
B22	0.000	N.D
B23	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B38	0.000	N.D
B39	0.000	N.D
B40	0.000	N.D
B41	0.000	N.D
B42	0.000	N.D
B43	0.000	N.D
B44	0.000	N.D
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.000	N.D
B53	0.000	N.D

Table B.25. 2nd floor beams damage distributions (SHW)

Beam	D/C Ratio	Hinge State
B4	0.098	BHB
B5	0.354	BHB
B6	0.414	BHB
B7	0.370	BHB
B8	0.118	BHB
B9	0.119	BHB

Table B.25. 2nd floor beams damage distributions (SHW) (Contd.)

Beam	D/C Ratio	Hinge State
B10	0.359	BHB
B11	0.420	BHB
B12	0.372	BHB
B13	0.119	BHB
B18	0.000	N.D
B19	0.000	N.D
B22	0.000	N.D
B23	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B38	0.000	N.D
B39	0.180	BHB
B40	0.000	N.D
B41	0.000	N.D
B42	0.000	N.D
B43	0.000	N.D
B44	0.000	N.D
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.165	BHB
B53	0.000	N.D

Table B.26. Ground floor beams damage distributions (EXW)

Beam	D/C Ratio	Hinge State
B2	0.002	BHB
B4	0.000	N.D
B5	0.000	N.D
B6	0.000	BHB

Table B.26. Ground floor beams damage distributions (EXW) (Contd.)

Beam	D/C Ratio	Hinge State
B7	0.000	N.D
B8	0.000	N.D
B9	0.000	N.D
B10	0.000	N.D
B11	0.003	BHB
B12	0.000	N.D
B13	0.000	N.D
B15	0.000	N.D
B16	0.000	N.D
B17	0.000	N.D
B18	0.000	N.D
B19	0.029	BHB
B22	0.000	N.D
B23	0.000	N.D
B24	0.000	BHB
B25	0.008	BHB
B26	0.000	N.D
B27	0.000	N.D
B28	0.003	BHB
B29	0.007	BHB
B30	0.000	N.D
B31	0.000	N.D
B32	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B39	0.000	N.D
B40	0.000	N.D
B41	0.098	BHB
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.000	N.D
B53	0.000	N.D
B14	0.654	BHB
B51	0.000	N.D
B54	0.000	N.D

Table B.27. 1st floor beams damage distributions (EXW)

Beam	D/C Ratio	Hinge State
B4	0.000	N.D
B5	0.000	N.D
B6	0.000	N.D
B7	0.000	N.D
B8	0.000	N.D
B9	0.000	N.D
B10	0.000	N.D
B11	0.000	N.D
B12	0.000	N.D
B13	0.000	N.D
B18	0.000	N.D
B19	0.000	N.D
B22	0.000	N.D
B23	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B38	0.000	N.D
B39	0.000	N.D
B40	0.000	N.D
B41	0.000	N.D
B42	0.000	N.D
B43	0.000	N.D
B44	0.000	N.D
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.000	N.D
B53	0.000	N.D

Table B.28. 2nd floor beams damage distributions (EXW)

Beam	D/C Ratio	Hinge State
B4	0.094	BHB
B5	0.337	BHB
B6	0.410	BHB
B7	0.366	BHB
B8	0.113	BHB
B9	0.113	BHB
B10	0.342	BHB
B11	0.414	BHB
B12	0.367	BHB
B13	0.112	BHB
B18	0.000	N.D
B19	0.000	N.D
B22	0.000	N.D
B23	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B38	0.000	N.D
B39	0.203	BHB
B40	0.000	N.D
B41	0.000	N.D
B42	0.000	N.D
B43	0.000	N.D
B44	0.000	N.D
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.191	BHB
B53	0.000	N.D

Table B.29. Ground floor beams damage distributions (NF)

Beam	D/C Ratio	Hinge State
B2	0.000	N.D
B4	0.000	N.D
B5	0.000	N.D
B6	0.000	N.D
B7	0.000	N.D
B8	0.000	N.D
B9	0.000	N.D
B10	0.000	N.D
B11	0.002	BHB
B12	0.000	N.D
B13	0.000	N.D
B15	0.000	N.D
B16	0.000	N.D
B17	0.000	N.D
B18	0.000	N.D
B19	0.004	BHB
B22	0.000	N.D
B23	0.000	N.D
B24	0.000	N.D
B25	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B28	0.000	N.D
B29	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B32	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B39	0.000	N.D
B40	0.000	N.D
B41	0.048	BHB
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D

Table B.29. Ground floor beams damage distributions (NF) (Contd.)

Beam	D/C Ratio	Hinge State
B52	0.000	N.D
B53	0.000	N.D
B14	0.638	BHB
B51	0.000	N.D
B54	0.000	N.D

Table B.30. 1st floor beams damage distributions (NF)

Beam	D/C Ratio	Hinge State
B4	0.000	N.D
B5	0.000	N.D
B6	0.000	N.D
B7	0.000	N.D
B8	0.000	N.D
B9	0.000	N.D
B10	0.000	N.D
B11	0.000	N.D
B12	0.000	N.D
B13	0.000	N.D
B18	0.000	N.D
B19	0.000	N.D
B22	0.000	N.D
B23	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B38	0.000	N.D
B39	0.000	N.D
B40	0.000	N.D
B41	0.000	N.D
B42	0.000	N.D
B43	0.000	N.D
B44	0.000	N.D
B45	0.000	N.D
B46	0.000	N.D

Table B.30. 1st floor beams damage distributions (nf) (Contd.)

Beam	D/C Ratio	Hinge State
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.000	N.D
B53	0.000	N.D

Table B.31. 2nd floor beams damage distributions (NF)

Beam	D/C Ratio	Hinge State
B4	0.116	BHB
B5	0.342	BHB
B6	0.381	BHB
B7	0.344	BHB
B8	0.104	BHB
B9	0.134	BHB
B10	0.346	BHB
B11	0.384	BHB
B12	0.344	BHB
B13	0.102	BHB
B18	0.000	N.D
B19	0.000	N.D
B22	0.000	N.D
B23	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B38	0.000	N.D
B39	0.146	BHB
B40	0.000	N.D
B41	0.000	N.D
B42	0.000	N.D
B43	0.000	N.D
B44	0.000	N.D
B45	0.000	N.D

Table B.31. 2nd floor beams damage distributions (NF) (Contd.)

Beam	D/C Ratio	Hinge State
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.144	BHB
B53	0.000	N.D

Table B.32. Ground floor beams damage distributions (FF)

Beam	D/C Ratio	Hinge State
B2	0.001	BHB
B4	0.000	N.D
B5	0.000	N.D
B6	0.011	BHB
B7	0.004	BHB
B8	0.000	N.D
B9	0.000	N.D
B10	0.002	BHB
B11	0.020	BHB
B12	0.002	BHB
B13	0.000	N.D
B15	0.000	N.D
B16	0.000	N.D
B17	0.000	N.D
B18	0.000	N.D
B19	0.027	BHB
B22	0.000	N.D
B23	0.000	N.D
B24	0.008	BHB
B25	0.001	BHB
B26	0.000	N.D
B27	0.000	N.D
B28	0.009	BHB
B29	0.002	BHB
B30	0.000	N.D
B31	0.000	N.D
B32	0.005	BHB
B33	0.000	N.D
B34	0.000	N.D

Table B.32. Ground floor beams damage distributions (FF) (Contd.)

Beam	D/C Ratio	Hinge State
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B39	0.000	N.D
B40	0.000	N.D
B41	0.109	BHB
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.000	N.D
B53	0.000	N.D
B14	0.630	BHB
B51	0.000	N.D
B54	0.000	N.D

Table B.33. 1st floor beams damage distributions (FF)

Beam	D/C Ratio	Hinge State
B4	0.000	N.D
B5	0.000	N.D
B6	0.000	N.D
B7	0.000	N.D
B8	0.000	N.D
B9	0.000	N.D
B10	0.000	N.D
B11	0.000	N.D
B12	0.000	N.D
B13	0.000	N.D
B18	0.000	N.D
B19	0.000	N.D
B22	0.000	N.D
B23	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B33	0.000	N.D

Table B.33. 1st floor beams damage distributions (FF) (Contd.)

Beam	D/C Ratio	Hinge State
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B38	0.000	N.D
B39	0.000	N.D
B40	0.000	N.D
B41	0.000	N.D
B42	0.000	N.D
B43	0.000	N.D
B44	0.000	N.D
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.000	N.D
B53	0.000	N.D

Table B.34. 2nd floor beams damage distributions (FF)

Beam	D/C Ratio	Hinge State
B4	0.101	BHB
B5	0.333	BHB
B6	0.381	BHB
B7	0.344	BHB
B8	0.112	BHB
B9	0.120	BHB
B10	0.338	BHB
B11	0.385	BHB
B12	0.345	BHB
B13	0.112	BHB
B18	0.000	N.D
B19	0.000	N.D
B22	0.000	N.D
B23	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B30	0.000	N.D

Table B.34. 2nd floor beams damage distributions (FF) (Contd.)

Beam	D/C Ratio	Hinge State
B31	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B38	0.000	N.D
B39	0.211	BHB
B40	0.000	N.D
B41	0.000	N.D
B42	0.000	N.D
B43	0.000	N.D
B44	0.000	N.D
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.197	BHB
B53	0.000	N.D

Table B.35. Ground floor beams damage distributions (SRGM)

Beam	D/C Ratio	Hinge State
B2	0.017	BHB
B4	0.000	N.D
B5	0.012	BHB
B6	0.029	BHB
B7	0.003	BHB
B8	0.000	N.D
B9	0.000	N.D
B10	0.028	BHB
B11	0.021	BHB
B12	0.003	BHB
B13	0.000	N.D
B15	0.000	N.D
B16	0.000	N.D
B17	0.000	N.D
B18	0.000	N.D

Table B.35. Ground floor beams damage distributions (SRGM) (Contd.)

Beam	D/C Ratio	Hinge State
B19	0.038	BHB
B22	0.000	N.D
B23	0.000	N.D
B24	0.000	BHB
B25	0.021	BHB
B26	0.000	N.D
B27	0.000	N.D
B28	0.004	BHB
B29	0.015	BHB
B30	0.000	N.D
B31	0.000	N.D
B32	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B39	0.000	N.D
B40	0.000	N.D
B41	0.133	BHB
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.000	N.D
B53	0.010	BHB
B14	0.716	BHB
B51	0.000	N.D
B54	0.000	N.D

Table B.36. 1st floor beams damage distributions (SRGM)

Beam	D/C Ratio	Hinge State
B4	0.000	N.D
B5	0.000	N.D
B6	0.000	N.D
B7	0.000	N.D
B8	0.000	N.D
B9	0.000	N.D
B10	0.000	N.D
B11	0.000	N.D
B12	0.000	N.D
B13	0.000	BHB
B18	0.000	N.D
B19	0.000	N.D
B22	0.000	N.D
B23	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B38	0.000	N.D
B39	0.000	N.D
B40	0.000	N.D
B41	0.000	N.D
B42	0.000	N.D
B43	0.000	N.D
B44	0.000	N.D
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.000	N.D
B53	0.000	N.D

Table B.37. 2nd floor beams damage distributions (SRGM)

Beam	D/C Ratio	Hinge State
B4	0.145	BHB
B5	0.406	BHB
B6	0.465	BHB
B7	0.414	BHB
B8	0.143	BHB
B9	0.170	BHB
B10	0.415	BHB
B11	0.471	BHB
B12	0.417	BHB
B13	0.143	BHB
B18	0.000	N.D
B19	0.000	N.D
B22	0.000	N.D
B23	0.000	N.D
B26	0.000	N.D
B27	0.000	N.D
B30	0.000	N.D
B31	0.000	N.D
B33	0.000	N.D
B34	0.000	N.D
B35	0.000	N.D
B36	0.000	N.D
B37	0.000	N.D
B38	0.000	N.D
B39	0.252	BHB
B40	0.000	N.D
B41	0.000	N.D
B42	0.000	N.D
B43	0.000	N.D
B44	0.000	N.D
B45	0.000	N.D
B46	0.000	N.D
B47	0.000	N.D
B48	0.000	N.D
B49	0.000	N.D
B50	0.000	N.D
B52	0.243	BHB
B53	0.000	N.D

Table B.38. Ground floor columns D/C ratios for shear effects (SHW)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C2	68	89	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.37<1
C3	71	85	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.36<1
C5	96	86	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.36<1
C6	90	87	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.37<1
C7	89	89	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.37<1
C8	93	89	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.37<1
C9	95	91	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.38<1
C10	92	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.34<1
C11	92	77	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.33<1
C12	98	82	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.34<1
C4	63	61	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.26<1
C13	82	77	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.33<1
C14	76	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.29<1
C15	77	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.28<1
C16	82	66	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.28<1
C17	65	52	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.22<1
C18	79	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.3<1
C19	78	81	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.34<1
C20	81	82	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.35<1
C21	85	75	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.31<1
C22	97	66	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.28<1
C23	105	75	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.44<1	0.31<1
C24	106	75	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.45<1	0.31<1
C25	106	77	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.45<1	0.32<1
C26	107	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.45<1	0.34<1
C27	92	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.3<1
C28	66	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.3<1
C29	76	82	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.34<1

Table B39. 1st floor columns D/C ratios for shear effects (SHW)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C5	100	99	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.42<1
C6	87	98	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.41<1
C7	85	96	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.4<1
C8	89	94	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.4<1
C9	92	100	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.42<1
C10	85	88	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.37<1

Table B39. 1st floor columns D/C ratios for shear effects (SHW) (Contd.)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C11	87	88	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.37<1
C12	97	96	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.4<1
C4	61	49	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.2<1
C13	78	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.29<1
C14	68	71	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.3<1
C15	70	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.3<1
C16	85	71	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.3<1
C17	56	57	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.24<1
C18	64	86	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.36<1
C19	72	82	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.34<1
C20	69	90	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.38<1
C21	63	90	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.38<1
C22	79	74	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.31<1
C23	99	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.34<1
C24	87	78	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.33<1
C25	86	78	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.33<1
C26	101	79	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.43<1	0.33<1
C27	82	65	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.28<1

Table B.40. 2nd floor columns D/C ratios for shear effects (SHW)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C5	66	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.29<1
C6	56	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.24<1	0.28<1
C7	55	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.28<1
C8	66	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.28<1
C9	68	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.28<1
C10	55	64	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.27<1
C11	56	63	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.24<1	0.27<1
C12	66	64	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.27<1
C4	45	51	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.19<1	0.21<1
C13	60	62	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.26<1
C14	49	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.29<1
C15	51	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.29<1
C16	59	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.28<1
C17	42	55	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.18<1	0.23<1
C18	42	60	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.18<1	0.25<1

Table B.40. 2nd floor columns D/C ratios for shear effects (SHW) (Contd.)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C19	48	60	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.25<1
C20	47	59	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.25<1
C21	43	58	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.18<1	0.25<1
C22	46	57	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.19<1	0.24<1
C23	61	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.28<1
C24	50	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.29<1
C25	48	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.29<1
C26	65	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.28<1
C27	49	56	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.24<1

Table B.41. Ground floor columns D/C ratios for shear effects (EXW)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C2	64	93	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.39<1
C3	67	90	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.38<1
C5	89	87	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.36<1
C6	85	88	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.37<1
C7	84	90	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.38<1
C8	86	97	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.41<1
C9	90	93	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.39<1
C10	86	86	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.36<1
C11	87	84	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.35<1
C12	92	88	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.37<1
C4	62	62	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.26<1
C13	77	78	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.33<1
C14	72	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.3<1
C15	73	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.31<1	0.3<1
C16	78	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.29<1
C17	61	53	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.22<1
C18	73	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.31<1	0.3<1
C19	77	88	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.37<1
C20	79	84	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.35<1
C21	79	78	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.33<1
C22	90	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.3<1
C23	100	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.34<1

Table B.41. Ground floor columns D/C ratios for shear effects (EXW) (Contd.)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C24	99	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.34<1
C25	99	82	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.34<1
C26	99	86	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.36<1
C27	89	76	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.32<1
C28	62	77	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.32<1
C29	73	87	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.31<1	0.37<1

Table B.42. 1st floor columns D/C ratios for shear effects (EXW)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C5	94	100	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.42<1
C6	88	102	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.43<1
C7	86	102	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.43<1
C8	89	98	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.41<1
C9	93	108	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.46<1
C10	85	93	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.39<1
C11	87	91	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.38<1
C12	92	97	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.41<1
C4	61	53	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.22<1
C13	78	73	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.31<1
C14	68	73	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.31<1
C15	70	73	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.31<1
C16	80	71	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.3<1
C17	53	57	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.22<1	0.24<1
C18	61	87	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.37<1
C19	72	85	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.36<1
C20	69	97	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.41<1
C21	61	91	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.38<1
C22	75	75	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.31<1	0.31<1
C23	98	82	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.34<1
C24	87	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.34<1
C25	86	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.33<1
C26	101	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.34<1
C27	82	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.28<1

Table B.43. 2nd floor columns D/C ratios for shear effects (EXW)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C5	67	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.29<1
C6	56	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.29<1
C7	54	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.28<1
C8	66	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.28<1
C9	67	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.3<1
C10	54	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.29<1
C11	55	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.29<1
C12	67	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.29<1
C4	45	54	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.19<1	0.23<1
C13	60	65	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.27<1
C14	49	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.3<1
C15	50	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.3<1
C16	60	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.29<1
C17	42	59	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.18<1	0.25<1
C18	43	61	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.18<1	0.26<1
C19	48	60	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.25<1
C20	47	64	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.27<1
C21	43	62	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.18<1	0.26<1
C22	46	58	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.19<1	0.24<1
C23	61	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.29<1
C24	49	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.29<1
C25	47	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.29<1
C26	65	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.28<1
C27	49	56	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.24<1

Table B.44. Ground floor columns D/C ratios for shear effects (NF)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C2	67	88	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.37<1
C3	70	85	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.36<1
C5	94	87	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.37<1
C6	88	89	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.37<1
C7	87	90	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.38<1
C8	90	88	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.37<1
C9	94	92	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.39<1
C10	90	81	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.34<1

Table B.44. Ground floor columns D/C ratios for shear effects (NF) (Contd.)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C11	90	79	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.33<1
C12	96	83	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.35<1
C4	64	62	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.26<1
C13	79	78	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.33<1
C14	74	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.31<1	0.3<1
C15	75	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.29<1
C16	81	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.28<1
C17	64	53	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.22<1
C18	76	73	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.31<1
C19	80	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.34<1
C20	82	84	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.35<1
C21	83	76	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.32<1
C22	94	65	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.27<1
C23	105	74	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.44<1	0.31<1
C24	104	74	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.44<1	0.31<1
C25	104	76	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.44<1	0.32<1
C26	104	79	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.44<1	0.33<1
C27	93	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.29<1
C28	64	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.3<1
C29	76	85	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.36<1

Table B.45. 1st floor columns D/C ratios for shear effects (NF)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C5	101	100	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.42<1
C6	88	100	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.42<1
C7	86	98	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.41<1
C8	90	91	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.38<1
C9	93	103	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.43<1
C10	85	90	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.38<1
C11	86	90	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.38<1
C12	98	97	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.41<1
C4	61	50	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.21<1
C13	78	71	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.3<1
C14	70	71	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.3<1
C15	70	73	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.31<1

Table B.45. 1st floor columns D/C ratios for shear effects (NF) (Contd.)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C16	86	71	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.3<1
C17	57	57	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.24<1	0.24<1
C18	66	87	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.37<1
C19	72	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.33<1
C20	69	92	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.39<1
C21	65	92	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.39<1
C22	80	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.3<1
C23	101	79	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.33<1
C24	86	77	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.32<1
C25	85	76	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.32<1
C26	102	76	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.43<1	0.32<1
C27	82	63	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.26<1

Table B.46. 2nd floor columns D/C ratios for shear effects (NF)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C5	71	66	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.28<1
C6	57	65	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.24<1	0.27<1
C7	58	65	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.27<1
C8	67	65	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.27<1
C9	69	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.29<1
C10	58	66	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.28<1
C11	57	65	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.24<1	0.27<1
C12	72	66	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.28<1
C4	45	52	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.19<1	0.22<1
C13	61	63	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.26<1
C14	53	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.22<1	0.29<1
C15	52	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.22<1	0.29<1
C16	64	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.28<1
C17	46	56	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.19<1	0.24<1
C18	46	59	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.19<1	0.25<1
C19	48	58	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.24<1
C20	47	61	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.26<1
C21	47	59	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.25<1
C22	51	56	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.24<1
C23	68	66	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.28<1

Table B.46. 2nd floor columns D/C ratios for shear effects (NF) (Contd.)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C24	50	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.29<1
C25	52	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.22<1	0.29<1
C26	66	66	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.28<1
C27	50	55	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.23<1

Table B.47. Ground floor columns D/C ratios for shear effects (FF)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C2	72	98	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.41<1
C3	74	95	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.31<1	0.4<1
C5	97	92	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.39<1
C6	94	93	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.39<1
C7	93	93	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.39<1
C8	94	100	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.42<1
C9	99	96	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.4<1
C10	95	90	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.38<1
C11	95	88	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.37<1
C12	98	93	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.39<1
C4	67	64	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.27<1
C13	82	81	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.34<1
C14	78	74	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.31<1
C15	79	73	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.31<1
C16	84	72	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.3<1
C17	64	57	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.24<1
C18	77	77	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.32<1
C19	84	91	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.38<1
C20	88	87	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.37<1
C21	83	83	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.35<1
C22	93	73	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.31<1
C23	110	84	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.46<1	0.35<1
C24	109	83	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.46<1	0.35<1
C25	109	85	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.46<1	0.36<1
C26	108	89	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.45<1	0.37<1
C27	100	78	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.33<1
C28	64	82	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.34<1
C29	76	93	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.39<1

Table B48. 1st floor columns D/C ratios for shear effects (FF)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C5	96	104	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.44<1
C6	89	105	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.44<1
C7	87	104	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.44<1
C8	90	104	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.44<1
C9	94	110	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.46<1
C10	86	95	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.4<1
C11	87	94	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.4<1
C12	94	103	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.43<1
C4	61	53	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.22<1
C13	79	74	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.31<1
C14	69	74	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.31<1
C15	71	75	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.32<1
C16	82	73	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.31<1
C17	54	59	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.25<1
C18	62	91	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.38<1
C19	72	90	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.38<1
C20	69	99	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.41<1
C21	62	96	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.4<1
C22	76	80	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.34<1
C23	100	87	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.37<1
C24	88	83	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.35<1
C25	87	83	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.35<1
C26	102	83	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.43<1	0.35<1
C27	83	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.3<1

Table B.49. 2nd floor columns D/C ratios for shear effects (FF)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C5	67	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.29<1
C6	57	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.24<1	0.29<1
C7	56	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.24<1	0.29<1
C8	67	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.29<1
C9	69	71	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.3<1
C10	56	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.29<1
C11	57	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.24<1	0.28<1

Table B.49. 2nd floor columns D/C ratios for shear effects (FF) (Contd.)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C12	67	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.29<1
C4	46	53	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.19<1	0.22<1
C13	61	64	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.27<1
C14	50	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.3<1
C15	51	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.22<1	0.3<1
C16	60	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.29<1
C17	42	58	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.18<1	0.24<1
C18	43	61	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.18<1	0.26<1
C19	48	61	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.26<1
C20	47	63	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.26<1
C21	43	61	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.18<1	0.26<1
C22	46	58	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.24<1
C23	62	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.28<1
C24	50	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.29<1
C25	48	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.29<1
C26	65	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.28<1
C27	49	57	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.24<1

Table B.50. Ground floor columns D/C ratios for shear effects (SRGM)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C2	75	105	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.44<1
C3	78	98	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.33<1	0.41<1
C5	100	97	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.41<1
C6	97	98	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.41<1
C7	96	99	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.42<1
C8	98	100	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.42<1
C9	102	103	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.43<1	0.43<1
C10	97	91	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.38<1
C11	97	89	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.37<1
C12	102	93	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.43<1	0.39<1
C4	71	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.29<1
C13	87	86	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.36<1
C14	82	79	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.33<1
C15	83	78	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.33<1
C16	88	75	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.32<1

Table B.50. Ground floor columns D/C ratios for shear effects (SRGM) (Contd.)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C17	70	61	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.26<1
C18	82	81	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.35<1	0.34<1
C19	87	89	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.38<1
C20	89	94	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.39<1
C21	89	86	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.37<1	0.36<1
C22	100	73	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.31<1
C23	113	83	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.47<1	0.35<1
C24	111	81	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.47<1	0.34<1
C25	111	83	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.47<1	0.35<1
C26	112	87	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.47<1	0.36<1
C27	101	77	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.42<1	0.33<1
C28	69	83	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.35<1
C29	81	96	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.34<1	0.4<1

Table B.51. 1st floor columns D/C ratios for shear effects (SRGM)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C5	108	108	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.45<1	0.46<1
C6	94	110	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.4<1	0.46<1
C7	93	110	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.46<1
C8	98	106	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.45<1
C9	98	116	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.41<1	0.49<1
C10	92	102	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.43<1
C11	91	100	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.42<1
C12	105	107	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.44<1	0.45<1
C4	64	57	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.24<1
C13	85	78	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.33<1
C14	75	78	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.33<1
C15	76	79	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.33<1
C16	93	76	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.39<1	0.32<1
C17	61	61	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.26<1	0.26<1
C18	70	96	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.4<1
C19	75	93	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.32<1	0.39<1
C20	72	104	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.44<1
C21	69	100	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.42<1

Table B.51. 1st floor columns D/C ratios for shear effects (SRGM) (Contd.)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C22	86	78	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.33<1
C23	107	84	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.45<1	0.35<1
C24	91	82	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.35<1
C25	91	82	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.38<1	0.34<1
C26	106	81	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.45<1	0.34<1
C27	86	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.36<1	0.29<1

Table B.52. 2nd floor columns D/C ratios for shear effects (SRGM)

No.	V ₂	V ₃	b	h	Stirrup						V _c	V _{s2}	V _{s3}	V _{2tot.}	V _{3tot.}	Control	
	kN	kN	m	m	(b)	(h)		D.S		S.S	kN	kN	kN	kN	kN	V ₂ /V _{2tot.}	V ₃ /V _{3tot.}
C5	74	71	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.31<1	0.3<1
C6	60	70	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.29<1
C7	61	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.29<1
C8	70	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.29<1
C9	72	77	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.3<1	0.32<1
C10	60	74	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.31<1
C11	60	74	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.25<1	0.31<1
C12	73	74	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.31<1	0.31<1
C4	48	57	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.24<1
C13	64	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.27<1	0.29<1
C14	55	75	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.31<1
C15	54	75	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.23<1	0.32<1
C16	66	73	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.31<1
C17	47	62	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.26<1
C18	47	64	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.27<1
C19	51	62	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.26<1
C20	49	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.28<1
C21	47	67	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.2<1	0.28<1
C22	50	60	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.21<1	0.25<1
C23	67	69	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.28<1	0.29<1
C24	52	71	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.22<1	0.3<1
C25	51	71	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.22<1	0.3<1
C26	68	68	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.29<1	0.29<1
C27	52	57	0.45	0.45	1	1	Φ	8	/	20	143	95	95	238	238	0.22<1	0.24<1

Table B.53. Ground floor beams D/C ratios for shear effects (SHW)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B2	121	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B4	179	0.4	0.6	1	Φ	8	/	20	169	127	296	0.6<1
B5	137	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B6	138	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B7	135	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B8	151	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B9	221	0.4	0.6	1	Φ	8	/	20	169	127	296	0.75<1
B10	130	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B11	134	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B12	128	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B13	155	0.4	0.6	1	Φ	8	/	20	169	127	296	0.52<1
B15	108	0.4	0.6	1	Φ	8	/	20	169	127	296	0.37<1
B16	101	0.4	0.6	1	Φ	8	/	20	169	127	296	0.34<1
B17	114	0.4	0.6	1	Φ	8	/	20	169	127	296	0.39<1
B18	168	0.4	0.6	1	Φ	8	/	20	169	127	296	0.57<1
B19	115	0.4	0.6	1	Φ	8	/	20	169	127	296	0.39<1
B22	157	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B23	145	0.4	0.6	1	Φ	8	/	20	169	127	296	0.49<1
B24	124	0.4	0.6	1	Φ	8	/	20	169	127	296	0.42<1
B25	118	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B26	156	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B27	144	0.4	0.6	1	Φ	8	/	20	169	127	296	0.49<1
B28	133	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B29	121	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B30	167	0.4	0.6	1	Φ	8	/	20	169	127	296	0.57<1
B31	153	0.4	0.6	1	Φ	8	/	20	169	127	296	0.52<1
B32	126	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B33	150	0.2	0.6	1	Φ	8	/	20	85	127	211	0.71<1
B34	85	0.2	0.6	1	Φ	8	/	20	85	127	211	0.4<1
B35	88	0.2	0.6	1	Φ	8	/	20	85	127	211	0.42<1
B36	83	0.2	0.6	1	Φ	8	/	20	85	127	211	0.39<1
B37	117	0.2	0.6	1	Φ	8	/	20	85	127	211	0.56<1
B39	95	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B40	123	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B41	150	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B45	222	0.25	1.5	1	Φ	8	/	20	264	317	581	0.38<1
B46	151	0.25	1.5	1	Φ	8	/	20	264	317	581	0.26<1
B47	159	0.25	1.5	1	Φ	8	/	20	264	317	581	0.27<1

Table B.53. Ground floor beams D/C ratios for shear effects (SHW) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B48	149	0.25	1.5	1	Φ	8	/	20	264	317	581	0.26<1
B49	214	0.25	1.5	1	Φ	8	/	20	264	317	581	0.37<1
B50	69	0.2	0.6	1	Φ	8	/	20	85	127	211	0.33<1
B52	60	0.4	0.6	1	Φ	8	/	20	169	127	296	0.2<1
B53	110	0.4	0.6	1	Φ	8	/	20	169	127	296	0.37<1
B14	92	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B51	95	0.2	0.6	1	Φ	8	/	20	85	127	211	0.45<1
B54	88	0.2	0.6	1	Φ	8	/	20	85	127	211	0.42<1

Table B.54. 1st floor beams D/C ratios for shear effects (SHW)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B4	152	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B5	131	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B6	132	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B7	134	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B8	122	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B9	188	0.4	0.6	1	Φ	8	/	20	169	127	296	0.63<1
B10	132	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B11	132	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B12	135	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B13	125	0.4	0.6	1	Φ	8	/	20	169	127	296	0.42<1
B18	143	0.4	0.6	1	Φ	8	/	20	169	127	296	0.48<1
B19	100	0.4	0.6	1	Φ	8	/	20	169	127	296	0.34<1
B22	149	0.4	0.6	1	Φ	8	/	20	169	127	296	0.5<1
B23	139	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B26	150	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B27	139	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B30	145	0.4	0.6	1	Φ	8	/	20	169	127	296	0.49<1
B31	134	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B33	132	0.2	0.6	1	Φ	8	/	20	85	127	211	0.62<1
B34	84	0.2	0.6	1	Φ	8	/	20	85	127	211	0.4<1
B35	86	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B36	85	0.2	0.6	1	Φ	8	/	20	85	127	211	0.4<1
B37	107	0.2	0.6	1	Φ	8	/	20	85	127	211	0.51<1

Table B.54. 1st floor beams D/C ratios for shear effects (SHW) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B38	103	0.2	0.6	1	Φ	8	/	20	85	127	211	0.49<1
B39	90	0.4	0.6	1	Φ	8	/	20	169	127	296	0.3<1
B40	112	0.4	0.6	1	Φ	8	/	20	169	127	296	0.38<1
B41	107	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1
B42	152	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B43	152	0.4	0.6	1	Φ	8	/	20	169	127	296	0.52<1
B44	147	0.4	0.6	1	Φ	8	/	20	169	127	296	0.5<1
B45	148	0.4	0.6	1	Φ	8	/	20	169	127	296	0.5<1
B46	94	0.2	0.6	1	Φ	8	/	20	85	127	211	0.44<1
B47	101	0.2	0.6	1	Φ	8	/	20	85	127	211	0.48<1
B48	95	0.2	0.6	1	Φ	8	/	20	85	127	211	0.45<1
B49	153	0.4	0.6	1	Φ	8	/	20	169	127	296	0.52<1
B50	63	0.2	0.6	1	Φ	8	/	20	85	127	211	0.3<1
B52	57	0.4	0.6	1	Φ	8	/	20	169	127	296	0.19<1
B53	106	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1

Table B.55. 2nd floor beams D/C ratios for shear effects (SHW)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B4	81	0.4	0.6	1	Φ	8	/	20	169	127	296	0.27<1
B5	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B6	94	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B7	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B8	83	0.4	0.6	1	Φ	8	/	20	169	127	296	0.28<1
B9	87	0.4	0.6	1	Φ	8	/	20	169	127	296	0.29<1
B10	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B11	94	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B12	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B13	83	0.4	0.6	1	Φ	8	/	20	169	127	296	0.28<1
B18	114	0.4	0.6	1	Φ	8	/	20	169	127	296	0.38<1
B19	101	0.4	0.6	1	Φ	8	/	20	169	127	296	0.34<1
B22	118	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B23	106	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1
B26	118	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B27	106	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1
B30	114	0.4	0.6	1	Φ	8	/	20	169	127	296	0.38<1

Table B.55. 2nd floor beams D/C ratios for shear effects (SHW) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B31	102	0.4	0.6	1	Φ	8	/	20	169	127	296	0.34<1
B33	70	0.2	0.6	1	Φ	8	/	20	85	127	211	0.33<1
B34	66	0.2	0.6	1	Φ	8	/	20	85	127	211	0.31<1
B35	66	0.2	0.6	1	Φ	8	/	20	85	127	211	0.31<1
B36	66	0.2	0.6	1	Φ	8	/	20	85	127	211	0.31<1
B37	72	0.2	0.6	1	Φ	8	/	20	85	127	211	0.34<1
B38	81	0.2	0.6	1	Φ	8	/	20	85	127	211	0.38<1
B39	66	0.4	0.6	1	Φ	8	/	20	169	127	296	0.22<1
B40	77	0.4	0.6	1	Φ	8	/	20	169	127	296	0.26<1
B41	114	0.4	0.6	1	Φ	8	/	20	169	127	296	0.39<1
B42	119	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B43	119	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B44	113	0.4	0.6	1	Φ	8	/	20	169	127	296	0.38<1
B45	81	0.2	0.6	1	Φ	8	/	20	85	127	211	0.39<1
B46	78	0.2	0.6	1	Φ	8	/	20	85	127	211	0.37<1
B47	78	0.2	0.6	1	Φ	8	/	20	85	127	211	0.37<1
B48	79	0.2	0.6	1	Φ	8	/	20	85	127	211	0.37<1
B49	84	0.2	0.6	1	Φ	8	/	20	85	127	211	0.4<1
B50	81	0.2	0.6	1	Φ	8	/	20	85	127	211	0.39<1
B52	66	0.4	0.6	1	Φ	8	/	20	169	127	296	0.22<1
B53	77	0.4	0.6	1	Φ	8	/	20	169	127	296	0.26<1

Table B.56. Ground floor beams D/C ratios for shear effects (EXW)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B2	126	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B4	173	0.4	0.6	1	Φ	8	/	20	169	127	296	0.58<1
B5	133	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B6	136	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B7	135	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B8	151	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B9	214	0.4	0.6	1	Φ	8	/	20	169	127	296	0.72<1
B10	129	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B11	130	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B12	127	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B13	155	0.4	0.6	1	Φ	8	/	20	169	127	296	0.52<1
B15	106	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1

Table B.56. Ground floor beams D/C ratios for shear effects (EXW) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B16	101	0.4	0.6	1	Φ	8	/	20	169	127	296	0.34<1
B17	113	0.4	0.6	1	Φ	8	/	20	169	127	296	0.38<1
B18	174	0.4	0.6	1	Φ	8	/	20	169	127	296	0.59<1
B19	119	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B22	161	0.4	0.6	1	Φ	8	/	20	169	127	296	0.55<1
B23	148	0.4	0.6	1	Φ	8	/	20	169	127	296	0.5<1
B24	132	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B25	125	0.4	0.6	1	Φ	8	/	20	169	127	296	0.42<1
B26	160	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B27	147	0.4	0.6	1	Φ	8	/	20	169	127	296	0.5<1
B28	141	0.4	0.6	1	Φ	8	/	20	169	127	296	0.48<1
B29	127	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B30	172	0.4	0.6	1	Φ	8	/	20	169	127	296	0.58<1
B31	157	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B32	134	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B33	144	0.2	0.6	1	Φ	8	/	20	85	127	211	0.68<1
B34	83	0.2	0.6	1	Φ	8	/	20	85	127	211	0.39<1
B35	86	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B36	83	0.2	0.6	1	Φ	8	/	20	85	127	211	0.39<1
B37	116	0.2	0.6	1	Φ	8	/	20	85	127	211	0.55<1
B39	97	0.4	0.6	1	Φ	8	/	20	169	127	296	0.33<1
B40	127	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B41	156	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B45	212	0.3	1.5	1	Φ	8	/	20	264	317	581	0.36<1
B46	146	0.3	1.5	1	Φ	8	/	20	264	317	581	0.25<1
B47	156	0.3	1.5	1	Φ	8	/	20	264	317	581	0.27<1
B48	149	0.3	1.5	1	Φ	8	/	20	264	317	581	0.26<1
B49	214	0.3	1.5	1	Φ	8	/	20	264	317	581	0.37<1
B50	72	0.2	0.6	1	Φ	8	/	20	85	127	211	0.34<1
B52	63	0.4	0.6	1	Φ	8	/	20	169	127	296	0.21<1
B53	114	0.4	0.6	1	Φ	8	/	20	169	127	296	0.38<1
B14	92	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B51	101	0.2	0.6	1	Φ	8	/	20	85	127	211	0.48<1
B54	92	0.2	0.6	1	Φ	8	/	20	85	127	211	0.43<1

Table B.57. 1st floor beams D/C ratios for shear effects (EXW)

No.	V ₂	b	h	Stirrup						V _c	V _s	V _{tot.}	Control
	kN	m	m							kN	kN	kN	V ₂ /V _{tot.}
B4	150	0.40	0.60	1	Φ	8	/	20		169	127	296	0.51<1
B5	130	0.40	0.60	1	Φ	8	/	20		169	127	296	0.44<1
B6	133	0.40	0.60	1	Φ	8	/	20		169	127	296	0.45<1
B7	135	0.40	0.60	1	Φ	8	/	20		169	127	296	0.46<1
B8	122	0.40	0.60	1	Φ	8	/	20		169	127	296	0.41<1
B9	186	0.40	0.60	1	Φ	8	/	20		169	127	296	0.63<1
B10	132	0.40	0.60	1	Φ	8	/	20		169	127	296	0.45<1
B11	132	0.40	0.60	1	Φ	8	/	20		169	127	296	0.45<1
B12	135	0.40	0.60	1	Φ	8	/	20		169	127	296	0.46<1
B13	125	0.40	0.60	1	Φ	8	/	20		169	127	296	0.42<1
B18	146	0.40	0.60	1	Φ	8	/	20		169	127	296	0.49<1
B19	101	0.40	0.60	1	Φ	8	/	20		169	127	296	0.34<1
B22	152	0.40	0.60	1	Φ	8	/	20		169	127	296	0.51<1
B23	141	0.40	0.60	1	Φ	8	/	20		169	127	296	0.48<1
B26	152	0.40	0.60	1	Φ	8	/	20		169	127	296	0.51<1
B27	141	0.40	0.60	1	Φ	8	/	20		169	127	296	0.48<1
B30	146	0.40	0.60	1	Φ	8	/	20		169	127	296	0.49<1
B31	136	0.40	0.60	1	Φ	8	/	20		169	127	296	0.46<1
B33	130	0.20	0.60	1	Φ	8	/	20		85	127	211	0.62<1
B34	83	0.20	0.60	1	Φ	8	/	20		85	127	211	0.4<1
B35	86	0.20	0.60	1	Φ	8	/	20		85	127	211	0.41<1
B36	85	0.20	0.60	1	Φ	8	/	20		85	127	211	0.4<1
B37	107	0.20	0.60	1	Φ	8	/	20		85	127	211	0.51<1
B38	103	0.20	0.60	1	Φ	8	/	20		85	127	211	0.49<1
B39	91	0.40	0.60	1	Φ	8	/	20		169	127	296	0.31<1
B40	113	0.40	0.60	1	Φ	8	/	20		169	127	296	0.38<1
B41	108	0.40	0.60	1	Φ	8	/	20		169	127	296	0.36<1
B42	153	0.40	0.60	1	Φ	8	/	20		169	127	296	0.52<1
B43	153	0.40	0.60	1	Φ	8	/	20		169	127	296	0.52<1
B44	148	0.40	0.60	1	Φ	8	/	20		169	127	296	0.5<1
B45	147	0.40	0.60	1	Φ	8	/	20		169	127	296	0.5<1
B46	93	0.20	0.60	1	Φ	8	/	20		85	127	211	0.44<1
B47	101	0.20	0.60	1	Φ	8	/	20		85	127	211	0.48<1
B48	96	0.20	0.60	1	Φ	8	/	20		85	127	211	0.45<1
B49	153	0.40	0.60	1	Φ	8	/	20		169	127	296	0.52<1
B50	65	0.20	0.60	1	Φ	8	/	20		85	127	211	0.31<1
B52	58	0.40	0.60	1	Φ	8	/	20		169	127	296	0.2<1
B53	107	0.40	0.60	1	Φ	8	/	20		169	127	296	0.36<1

Table B.58. 2nd floor beams D/C ratios for shear effects (EXW)

No.	V ₂	b	h	Stirrup						V _c	V _s	V _{tot.}	Control
	kN	m	m							kN	kN	kN	V ₂ /V _{tot.}
B4	82	0.40	0.60	1	Φ	8	/	20		169	127	296	0.28<1
B5	93	0.40	0.60	1	Φ	8	/	20		169	127	296	0.31<1
B6	94	0.40	0.60	1	Φ	8	/	20		169	127	296	0.32<1
B7	92	0.40	0.60	1	Φ	8	/	20		169	127	296	0.31<1
B8	83	0.40	0.60	1	Φ	8	/	20		169	127	296	0.28<1
B9	88	0.40	0.60	1	Φ	8	/	20		169	127	296	0.3<1
B10	93	0.40	0.60	1	Φ	8	/	20		169	127	296	0.31<1
B11	94	0.40	0.60	1	Φ	8	/	20		169	127	296	0.32<1
B12	92	0.40	0.60	1	Φ	8	/	20		169	127	296	0.31<1
B13	83	0.40	0.60	1	Φ	8	/	20		169	127	296	0.28<1
B18	115	0.40	0.60	1	Φ	8	/	20		169	127	296	0.39<1
B19	102	0.40	0.60	1	Φ	8	/	20		169	127	296	0.35<1
B22	120	0.40	0.60	1	Φ	8	/	20		169	127	296	0.41<1
B23	106	0.40	0.60	1	Φ	8	/	20		169	127	296	0.36<1
B26	120	0.40	0.60	1	Φ	8	/	20		169	127	296	0.41<1
B27	106	0.40	0.60	1	Φ	8	/	20		169	127	296	0.36<1
B30	115	0.40	0.60	1	Φ	8	/	20		169	127	296	0.39<1
B31	102	0.40	0.60	1	Φ	8	/	20		169	127	296	0.34<1
B33	70	0.20	0.60	1	Φ	8	/	20		85	127	211	0.33<1
B34	66	0.20	0.60	1	Φ	8	/	20		85	127	211	0.31<1
B35	66	0.20	0.60	1	Φ	8	/	20		85	127	211	0.31<1
B36	66	0.20	0.60	1	Φ	8	/	20		85	127	211	0.31<1
B37	72	0.20	0.60	1	Φ	8	/	20		85	127	211	0.34<1
B38	81	0.20	0.60	1	Φ	8	/	20		85	127	211	0.38<1
B39	67	0.40	0.60	1	Φ	8	/	20		169	127	296	0.23<1
B40	79	0.40	0.60	1	Φ	8	/	20		169	127	296	0.27<1
B41	114	0.40	0.60	1	Φ	8	/	20		169	127	296	0.39<1
B42	119	0.40	0.60	1	Φ	8	/	20		169	127	296	0.4<1
B43	119	0.40	0.60	1	Φ	8	/	20		169	127	296	0.4<1
B44	114	0.40	0.60	1	Φ	8	/	20		169	127	296	0.38<1
B45	82	0.20	0.60	1	Φ	8	/	20		85	127	211	0.39<1
B46	78	0.20	0.60	1	Φ	8	/	20		85	127	211	0.37<1
B47	78	0.20	0.60	1	Φ	8	/	20		85	127	211	0.37<1
B48	79	0.20	0.60	1	Φ	8	/	20		85	127	211	0.37<1
B49	84	0.20	0.60	1	Φ	8	/	20		85	127	211	0.4<1
B50	82	0.20	0.60	1	Φ	8	/	20		85	127	211	0.39<1
B52	67	0.40	0.60	1	Φ	8	/	20		169	127	296	0.23<1
B53	79	0.40	0.60	1	Φ	8	/	20		169	127	296	0.27<1

Table B.59. Ground floor beams D/C ratios for shear effects (NF)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B2	125	0.4	0.6	1	Φ	8	/	20	169	127	296	0.42<1
B4	177	0.4	0.6	1	Φ	8	/	20	169	127	296	0.6<1
B5	136	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B6	138	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B7	136	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B8	153	0.4	0.6	1	Φ	8	/	20	169	127	296	0.52<1
B9	219	0.4	0.6	1	Φ	8	/	20	169	127	296	0.74<1
B10	130	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B11	132	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B12	128	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B13	157	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B15	107	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1
B16	102	0.4	0.6	1	Φ	8	/	20	169	127	296	0.34<1
B17	115	0.4	0.6	1	Φ	8	/	20	169	127	296	0.39<1
B18	171	0.4	0.6	1	Φ	8	/	20	169	127	296	0.58<1
B19	113	0.4	0.6	1	Φ	8	/	20	169	127	296	0.38<1
B22	160	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B23	143	0.4	0.6	1	Φ	8	/	20	169	127	296	0.48<1
B24	122	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B25	122	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B26	159	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B27	143	0.4	0.6	1	Φ	8	/	20	169	127	296	0.48<1
B28	130	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B29	125	0.4	0.6	1	Φ	8	/	20	169	127	296	0.42<1
B30	171	0.4	0.6	1	Φ	8	/	20	169	127	296	0.58<1
B31	152	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B32	124	0.4	0.6	1	Φ	8	/	20	169	127	296	0.42<1
B33	148	0.2	0.6	1	Φ	8	/	20	85	127	211	0.7<1
B34	84	0.2	0.6	1	Φ	8	/	20	85	127	211	0.4<1
B35	87	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B36	83	0.2	0.6	1	Φ	8	/	20	85	127	211	0.39<1
B37	118	0.2	0.6	1	Φ	8	/	20	85	127	211	0.56<1
B39	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B40	127	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B41	147	0.4	0.6	1	Φ	8	/	20	169	127	296	0.5<1
B45	220	0.3	1.5	1	Φ	8	/	20	264	317	581	0.38<1
B46	149	0.3	1.5	1	Φ	8	/	20	264	317	581	0.26<1

Table B.59. Ground floor beams D/C ratios for shear effects (NF) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B47	158	0.3	1.5	1	Φ	8	/	20	264	317	581	0.27<1
B48	151	0.3	1.5	1	Φ	8	/	20	264	317	581	0.26<1
B49	218	0.3	1.5	1	Φ	8	/	20	264	317	581	0.37<1
B50	67	0.2	0.6	1	Φ	8	/	20	85	127	211	0.32<1
B52	59	0.4	0.6	1	Φ	8	/	20	169	127	296	0.2<1
B53	109	0.4	0.6	1	Φ	8	/	20	169	127	296	0.37<1
B14	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B51	92	0.2	0.6	1	Φ	8	/	20	85	127	211	0.44<1
B54	92	0.2	0.6	1	Φ	8	/	20	85	127	211	0.43<1

Table B.60. 1st floor beams D/C ratios for shear effects (NF)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B4	155	0.4	0.6	1	Φ	8	/	20	169	127	296	0.52<1
B5	133	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B6	133	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B7	135	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B8	123	0.4	0.6	1	Φ	8	/	20	169	127	296	0.42<1
B9	191	0.4	0.6	1	Φ	8	/	20	169	127	296	0.65<1
B10	133	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B11	134	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B12	136	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B13	126	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B18	145	0.4	0.6	1	Φ	8	/	20	169	127	296	0.49<1
B19	99	0.4	0.6	1	Φ	8	/	20	169	127	296	0.33<1
B22	151	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B23	140	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B26	151	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B27	140	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B30	146	0.4	0.6	1	Φ	8	/	20	169	127	296	0.49<1
B31	135	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B33	135	0.2	0.6	1	Φ	8	/	20	85	127	211	0.64<1
B34	85	0.2	0.6	1	Φ	8	/	20	85	127	211	0.4<1
B35	87	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B36	86	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B37	108	0.2	0.6	1	Φ	8	/	20	85	127	211	0.51<1

Table B.60. 1st floor beams D/C ratios for shear effects (NF) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B38	102	0.2	0.6	1	Φ	8	/	20	85	127	211	0.48<1
B39	91	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B40	113	0.4	0.6	1	Φ	8	/	20	169	127	296	0.38<1
B41	106	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1
B42	151	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B43	151	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B44	146	0.4	0.6	1	Φ	8	/	20	169	127	296	0.49<1
B45	154	0.4	0.6	1	Φ	8	/	20	169	127	296	0.52<1
B46	95	0.2	0.6	1	Φ	8	/	20	85	127	211	0.45<1
B47	101	0.2	0.6	1	Φ	8	/	20	85	127	211	0.48<1
B48	96	0.2	0.6	1	Φ	8	/	20	85	127	211	0.45<1
B49	155	0.4	0.6	1	Φ	8	/	20	169	127	296	0.52<1
B50	63	0.2	0.6	1	Φ	8	/	20	85	127	211	0.3<1
B52	56	0.4	0.6	1	Φ	8	/	20	169	127	296	0.19<1
B53	104	0.4	0.6	1	Φ	8	/	20	169	127	296	0.35<1

Table B.61. 2nd floor beams D/C ratios for shear effects (NF)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B4	85	0.4	0.6	1	Φ	8	/	20	169	127	296	0.29<1
B5	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B6	95	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B7	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B8	84	0.4	0.6	1	Φ	8	/	20	169	127	296	0.28<1
B9	91	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B10	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B11	95	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B12	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B13	84	0.4	0.6	1	Φ	8	/	20	169	127	296	0.28<1
B18	115	0.4	0.6	1	Φ	8	/	20	169	127	296	0.39<1
B19	102	0.4	0.6	1	Φ	8	/	20	169	127	296	0.34<1
B22	119	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B23	106	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1
B26	119	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B27	105	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1
B30	114	0.4	0.6	1	Φ	8	/	20	169	127	296	0.39<1
B31	101	0.4	0.6	1	Φ	8	/	20	169	127	296	0.34<1

Table B.61. 2nd floor beams D/C ratios for shear effects (NF) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B33	73	0.2	0.6	1	Φ	8	/	20	85	127	211	0.35<1
B34	67	0.2	0.6	1	Φ	8	/	20	85	127	211	0.32<1
B35	67	0.2	0.6	1	Φ	8	/	20	85	127	211	0.32<1
B36	66	0.2	0.6	1	Φ	8	/	20	85	127	211	0.31<1
B37	72	0.2	0.6	1	Φ	8	/	20	85	127	211	0.34<1
B38	80	0.2	0.6	1	Φ	8	/	20	85	127	211	0.38<1
B39	66	0.4	0.6	1	Φ	8	/	20	169	127	296	0.22<1
B40	78	0.4	0.6	1	Φ	8	/	20	169	127	296	0.26<1
B41	113	0.4	0.6	1	Φ	8	/	20	169	127	296	0.38<1
B42	118	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B43	118	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B44	113	0.4	0.6	1	Φ	8	/	20	169	127	296	0.38<1
B45	86	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B46	80	0.2	0.6	1	Φ	8	/	20	85	127	211	0.38<1
B47	79	0.2	0.6	1	Φ	8	/	20	85	127	211	0.37<1
B48	79	0.2	0.6	1	Φ	8	/	20	85	127	211	0.38<1
B49	85	0.2	0.6	1	Φ	8	/	20	85	127	211	0.4<1
B50	81	0.2	0.6	1	Φ	8	/	20	85	127	211	0.38<1
B52	66	0.4	0.6	1	Φ	8	/	20	169	127	296	0.22<1
B53	78	0.4	0.6	1	Φ	8	/	20	169	127	296	0.26<1

Table B.62. Ground floor beams D/C ratios for shear effects (FF)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B2	131	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B4	174	0.4	0.6	1	Φ	8	/	20	169	127	296	0.59<1
B5	135	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B6	139	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B7	138	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B8	157	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B9	216	0.4	0.6	1	Φ	8	/	20	169	127	296	0.73<1
B10	132	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B11	134	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B12	131	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B13	161	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B15	108	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1

Table B.62. Ground floor beams D/C ratios for shear effects (FF) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B16	103	0.4	0.6	1	Φ	8	/	20	169	127	296	0.35<1
B17	118	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B18	176	0.4	0.6	1	Φ	8	/	20	169	127	296	0.6<1
B19	122	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B22	163	0.4	0.6	1	Φ	8	/	20	169	127	296	0.55<1
B23	150	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B24	138	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B25	128	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B26	162	0.4	0.6	1	Φ	8	/	20	169	127	296	0.55<1
B27	150	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B28	147	0.4	0.6	1	Φ	8	/	20	169	127	296	0.5<1
B29	130	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B30	174	0.4	0.6	1	Φ	8	/	20	169	127	296	0.59<1
B31	161	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B32	141	0.4	0.6	1	Φ	8	/	20	169	127	296	0.48<1
B33	146	0.2	0.6	1	Φ	8	/	20	85	127	211	0.69<1
B34	85	0.2	0.6	1	Φ	8	/	20	85	127	211	0.4<1
B35	88	0.2	0.6	1	Φ	8	/	20	85	127	211	0.42<1
B36	85	0.2	0.6	1	Φ	8	/	20	85	127	211	0.4<1
B37	121	0.2	0.6	1	Φ	8	/	20	85	127	211	0.57<1
B39	100	0.4	0.6	1	Φ	8	/	20	169	127	296	0.34<1
B40	129	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B41	159	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B45	214	0.3	1.5	1	Φ	8	/	20	264	317	581	0.37<1
B46	147	0.3	1.5	1	Φ	8	/	20	264	317	581	0.25<1
B47	161	0.3	1.5	1	Φ	8	/	20	264	317	581	0.28<1
B48	153	0.3	1.5	1	Φ	8	/	20	264	317	581	0.26<1
B49	223	0.3	1.5	1	Φ	8	/	20	264	317	581	0.38<1
B50	75	0.2	0.6	1	Φ	8	/	20	85	127	211	0.36<1
B52	65	0.4	0.6	1	Φ	8	/	20	169	127	296	0.22<1
B53	116	0.4	0.6	1	Φ	8	/	20	169	127	296	0.39<1
B14	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B51	106	0.2	0.6	1	Φ	8	/	20	85	127	211	0.5<1
B54	96	0.2	0.6	1	Φ	8	/	20	85	127	211	0.45<1

Table B.63. 1st floor beams D/C ratios for shear effects (FF)

No.	V ₂	b	h	Stirrup						V _c	V _s	V _{tot.}	Control
	kN	m	m							kN	kN	kN	V ₂ /V _{tot.}
B4	151	0.40	0.60	1	Φ	8	/	20		169	127	296	0.51<1
B5	131	0.40	0.60	1	Φ	8	/	20		169	127	296	0.44<1
B6	133	0.40	0.60	1	Φ	8	/	20		169	127	296	0.45<1
B7	135	0.40	0.60	1	Φ	8	/	20		169	127	296	0.46<1
B8	123	0.40	0.60	1	Φ	8	/	20		169	127	296	0.42<1
B9	187	0.40	0.60	1	Φ	8	/	20		169	127	296	0.63<1
B10	133	0.40	0.60	1	Φ	8	/	20		169	127	296	0.45<1
B11	133	0.40	0.60	1	Φ	8	/	20		169	127	296	0.45<1
B12	136	0.40	0.60	1	Φ	8	/	20		169	127	296	0.46<1
B13	126	0.40	0.60	1	Φ	8	/	20		169	127	296	0.43<1
B18	147	0.40	0.60	1	Φ	8	/	20		169	127	296	0.5<1
B19	103	0.40	0.60	1	Φ	8	/	20		169	127	296	0.35<1
B22	153	0.40	0.60	1	Φ	8	/	20		169	127	296	0.52<1
B23	142	0.40	0.60	1	Φ	8	/	20		169	127	296	0.48<1
B26	154	0.40	0.60	1	Φ	8	/	20		169	127	296	0.52<1
B27	143	0.40	0.60	1	Φ	8	/	20		169	127	296	0.48<1
B30	148	0.40	0.60	1	Φ	8	/	20		169	127	296	0.5<1
B31	138	0.40	0.60	1	Φ	8	/	20		169	127	296	0.46<1
B33	130	0.20	0.60	1	Φ	8	/	20		85	127	211	0.62<1
B34	84	0.20	0.60	1	Φ	8	/	20		85	127	211	0.4<1
B35	87	0.20	0.60	1	Φ	8	/	20		85	127	211	0.41<1
B36	86	0.20	0.60	1	Φ	8	/	20		85	127	211	0.41<1
B37	108	0.20	0.60	1	Φ	8	/	20		85	127	211	0.51<1
B38	106	0.20	0.60	1	Φ	8	/	20		85	127	211	0.5<1
B39	93	0.40	0.60	1	Φ	8	/	20		169	127	296	0.31<1
B40	116	0.40	0.60	1	Φ	8	/	20		169	127	296	0.39<1
B41	110	0.40	0.60	1	Φ	8	/	20		169	127	296	0.37<1
B42	155	0.40	0.60	1	Φ	8	/	20		169	127	296	0.53<1
B43	156	0.40	0.60	1	Φ	8	/	20		169	127	296	0.53<1
B44	151	0.40	0.60	1	Φ	8	/	20		169	127	296	0.51<1
B45	147	0.40	0.60	1	Φ	8	/	20		169	127	296	0.5<1
B46	93	0.20	0.60	1	Φ	8	/	20		85	127	211	0.44<1
B47	101	0.20	0.60	1	Φ	8	/	20		85	127	211	0.48<1
B48	96	0.20	0.60	1	Φ	8	/	20		85	127	211	0.45<1
B49	154	0.40	0.60	1	Φ	8	/	20		169	127	296	0.52<1
B50	66	0.20	0.60	1	Φ	8	/	20		85	127	211	0.31<1
B52	60	0.40	0.60	1	Φ	8	/	20		169	127	296	0.2<1
B53	109	0.40	0.60	1	Φ	8	/	20		169	127	296	0.37<1

Table B.64. 2nd floor beams D/C ratios for shear effects (FF)

No.	V ₂	b	h	Stirrup						V _c	V _s	V _{tot.}	Control
	kN	m	m							kN	kN	kN	V ₂ /V _{tot.}
B4	82	0.40	0.60	1	Φ	8	/	20		169	127	296	0.28<1
B5	93	0.40	0.60	1	Φ	8	/	20		169	127	296	0.31<1
B6	94	0.40	0.60	1	Φ	8	/	20		169	127	296	0.32<1
B7	92	0.40	0.60	1	Φ	8	/	20		169	127	296	0.31<1
B8	83	0.40	0.60	1	Φ	8	/	20		169	127	296	0.28<1
B9	87	0.40	0.60	1	Φ	8	/	20		169	127	296	0.29<1
B10	93	0.40	0.60	1	Φ	8	/	20		169	127	296	0.31<1
B11	94	0.40	0.60	1	Φ	8	/	20		169	127	296	0.32<1
B12	92	0.40	0.60	1	Φ	8	/	20		169	127	296	0.31<1
B13	84	0.40	0.60	1	Φ	8	/	20		169	127	296	0.28<1
B18	115	0.40	0.60	1	Φ	8	/	20		169	127	296	0.39<1
B19	102	0.40	0.60	1	Φ	8	/	20		169	127	296	0.35<1
B22	120	0.40	0.60	1	Φ	8	/	20		169	127	296	0.4<1
B23	106	0.40	0.60	1	Φ	8	/	20		169	127	296	0.36<1
B26	120	0.40	0.60	1	Φ	8	/	20		169	127	296	0.4<1
B27	106	0.40	0.60	1	Φ	8	/	20		169	127	296	0.36<1
B30	115	0.40	0.60	1	Φ	8	/	20		169	127	296	0.39<1
B31	102	0.40	0.60	1	Φ	8	/	20		169	127	296	0.34<1
B33	70	0.20	0.60	1	Φ	8	/	20		85	127	211	0.33<1
B34	66	0.20	0.60	1	Φ	8	/	20		85	127	211	0.31<1
B35	66	0.20	0.60	1	Φ	8	/	20		85	127	211	0.31<1
B36	66	0.20	0.60	1	Φ	8	/	20		85	127	211	0.31<1
B37	72	0.20	0.60	1	Φ	8	/	20		85	127	211	0.34<1
B38	81	0.20	0.60	1	Φ	8	/	20		85	127	211	0.38<1
B39	66	0.40	0.60	1	Φ	8	/	20		169	127	296	0.22<1
B40	79	0.40	0.60	1	Φ	8	/	20		169	127	296	0.27<1
B41	115	0.40	0.60	1	Φ	8	/	20		169	127	296	0.39<1
B42	119	0.40	0.60	1	Φ	8	/	20		169	127	296	0.4<1
B43	119	0.40	0.60	1	Φ	8	/	20		169	127	296	0.4<1
B44	114	0.40	0.60	1	Φ	8	/	20		169	127	296	0.38<1
B45	82	0.20	0.60	1	Φ	8	/	20		85	127	211	0.39<1
B46	78	0.20	0.60	1	Φ	8	/	20		85	127	211	0.37<1
B47	78	0.20	0.60	1	Φ	8	/	20		85	127	211	0.37<1
B48	79	0.20	0.60	1	Φ	8	/	20		85	127	211	0.38<1
B49	85	0.20	0.60	1	Φ	8	/	20		85	127	211	0.4<1
B50	82	0.20	0.60	1	Φ	8	/	20		85	127	211	0.39<1
B52	66	0.40	0.60	1	Φ	8	/	20		169	127	296	0.22<1
B53	79	0.40	0.60	1	Φ	8	/	20		169	127	296	0.27<1

Table B.65. Ground floor beams D/C ratios for shear effects (SRGM)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B2	135	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B4	183	0.4	0.6	1	Φ	8	/	20	169	127	296	0.62<1
B5	139	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B6	141	0.4	0.6	1	Φ	8	/	20	169	127	296	0.48<1
B7	140	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B8	161	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B9	227	0.4	0.6	1	Φ	8	/	20	169	127	296	0.77<1
B10	135	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B11	137	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B12	133	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B13	166	0.4	0.6	1	Φ	8	/	20	169	127	296	0.56<1
B15	110	0.4	0.6	1	Φ	8	/	20	169	127	296	0.37<1
B16	105	0.4	0.6	1	Φ	8	/	20	169	127	296	0.35<1
B17	121	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B18	181	0.4	0.6	1	Φ	8	/	20	169	127	296	0.61<1
B19	121	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B22	167	0.4	0.6	1	Φ	8	/	20	169	127	296	0.56<1
B23	150	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B24	136	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B25	133	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B26	166	0.4	0.6	1	Φ	8	/	20	169	127	296	0.56<1
B27	150	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B28	146	0.4	0.6	1	Φ	8	/	20	169	127	296	0.49<1
B29	136	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B30	179	0.4	0.6	1	Φ	8	/	20	169	127	296	0.61<1
B31	160	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B32	139	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B33	156	0.2	0.6	1	Φ	8	/	20	85	127	211	0.74<1
B34	88	0.2	0.6	1	Φ	8	/	20	85	127	211	0.42<1
B35	91	0.2	0.6	1	Φ	8	/	20	85	127	211	0.43<1
B36	87	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B37	126	0.2	0.6	1	Φ	8	/	20	85	127	211	0.6<1
B39	99	0.4	0.6	1	Φ	8	/	20	169	127	296	0.34<1
B40	134	0.4	0.6	1	Φ	8	/	20	169	127	296	0.45<1
B41	158	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B45	230	0.3	1.5	1	Φ	8	/	20	264	317	581	0.4<1
B46	154	0.3	1.5	1	Φ	8	/	20	264	317	581	0.27<1

Table B.65. Ground floor beams D/C ratios for shear effects (SRGM) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B47	163	0.3	1.5	1	Φ	8	/	20	264	317	581	0.28<1
B48	155	0.3	1.5	1	Φ	8	/	20	264	317	581	0.27<1
B49	227	0.3	1.5	1	Φ	8	/	20	264	317	581	0.39<1
B50	74	0.2	0.6	1	Φ	8	/	20	85	127	211	0.35<1
B52	65	0.4	0.6	1	Φ	8	/	20	169	127	296	0.22<1
B53	117	0.4	0.6	1	Φ	8	/	20	169	127	296	0.39<1
B14	93	0.4	0.6	1	Φ	8	/	20	169	127	296	0.31<1
B51	105	0.2	0.6	1	Φ	8	/	20	85	127	211	0.5<1
B54	99	0.2	0.6	1	Φ	8	/	20	85	127	211	0.47<1

Table B.66. 1st floor beams D/C ratios for shear effects (SRGM)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B4	159	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B5	136	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B6	136	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B7	137	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B8	126	0.4	0.6	1	Φ	8	/	20	169	127	296	0.43<1
B9	196	0.4	0.6	1	Φ	8	/	20	169	127	296	0.66<1
B10	136	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B11	137	0.4	0.6	1	Φ	8	/	20	169	127	296	0.46<1
B12	138	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B13	130	0.4	0.6	1	Φ	8	/	20	169	127	296	0.44<1
B18	151	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B19	103	0.4	0.6	1	Φ	8	/	20	169	127	296	0.35<1
B22	156	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B23	145	0.4	0.6	1	Φ	8	/	20	169	127	296	0.49<1
B26	156	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B27	145	0.4	0.6	1	Φ	8	/	20	169	127	296	0.49<1
B30	151	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B31	140	0.4	0.6	1	Φ	8	/	20	169	127	296	0.47<1
B33	141	0.2	0.6	1	Φ	8	/	20	85	127	211	0.67<1
B34	87	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B35	90	0.2	0.6	1	Φ	8	/	20	85	127	211	0.43<1
B36	88	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B37	112	0.2	0.6	1	Φ	8	/	20	85	127	211	0.53<1

Table B.66. 1st floor beams D/C ratios for shear effects (SRGM) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B38	106	0.2	0.6	1	Φ	8	/	20	85	127	211	0.5<1
B39	95	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B40	119	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B41	110	0.4	0.6	1	Φ	8	/	20	169	127	296	0.37<1
B42	155	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B43	156	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B44	151	0.4	0.6	1	Φ	8	/	20	169	127	296	0.51<1
B45	159	0.4	0.6	1	Φ	8	/	20	169	127	296	0.54<1
B46	97	0.2	0.6	1	Φ	8	/	20	85	127	211	0.46<1
B47	103	0.2	0.6	1	Φ	8	/	20	85	127	211	0.49<1
B48	97	0.2	0.6	1	Φ	8	/	20	85	127	211	0.46<1
B49	158	0.4	0.6	1	Φ	8	/	20	169	127	296	0.53<1
B50	69	0.2	0.6	1	Φ	8	/	20	85	127	211	0.33<1
B52	60	0.4	0.6	1	Φ	8	/	20	169	127	296	0.2<1
B53	109	0.4	0.6	1	Φ	8	/	20	169	127	296	0.37<1

Table B.67. 2nd floor beams D/C ratios for shear effects (SRGM)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B4	84	0.4	0.6	1	Φ	8	/	20	169	127	296	0.29<1
B5	94	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B6	95	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B7	94	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B8	85	0.4	0.6	1	Φ	8	/	20	169	127	296	0.29<1
B9	90	0.4	0.6	1	Φ	8	/	20	169	127	296	0.3<1
B10	94	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B11	96	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B12	94	0.4	0.6	1	Φ	8	/	20	169	127	296	0.32<1
B13	85	0.4	0.6	1	Φ	8	/	20	169	127	296	0.29<1
B18	117	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B19	104	0.4	0.6	1	Φ	8	/	20	169	127	296	0.35<1
B22	122	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B23	108	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1
B26	122	0.4	0.6	1	Φ	8	/	20	169	127	296	0.41<1
B27	108	0.4	0.6	1	Φ	8	/	20	169	127	296	0.36<1
B30	117	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1

Table B.67. 2nd floor beams D/C ratios for shear effects (SRGM) (Contd.)

No.	V ₂	b	h	Stirrup					V _c	V _s	V _{tot.}	Control
	kN	m	m						kN	kN	kN	V ₂ /V _{tot.}
B31	103	0.4	0.6	1	Φ	8	/	20	169	127	296	0.35<1
B33	75	0.2	0.6	1	Φ	8	/	20	85	127	211	0.35<1
B34	68	0.2	0.6	1	Φ	8	/	20	85	127	211	0.32<1
B35	68	0.2	0.6	1	Φ	8	/	20	85	127	211	0.32<1
B36	67	0.2	0.6	1	Φ	8	/	20	85	127	211	0.32<1
B37	74	0.2	0.6	1	Φ	8	/	20	85	127	211	0.35<1
B38	82	0.2	0.6	1	Φ	8	/	20	85	127	211	0.39<1
B39	68	0.4	0.6	1	Φ	8	/	20	169	127	296	0.23<1
B40	81	0.4	0.6	1	Φ	8	/	20	169	127	296	0.27<1
B41	115	0.4	0.6	1	Φ	8	/	20	169	127	296	0.39<1
B42	119	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B43	120	0.4	0.6	1	Φ	8	/	20	169	127	296	0.4<1
B44	115	0.4	0.6	1	Φ	8	/	20	169	127	296	0.39<1
B45	86	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B46	80	0.2	0.6	1	Φ	8	/	20	85	127	211	0.38<1
B47	79	0.2	0.6	1	Φ	8	/	20	85	127	211	0.38<1
B48	80	0.2	0.6	1	Φ	8	/	20	85	127	211	0.38<1
B49	87	0.2	0.6	1	Φ	8	/	20	85	127	211	0.41<1
B50	82	0.2	0.6	1	Φ	8	/	20	85	127	211	0.39<1
B52	68	0.4	0.6	1	Φ	8	/	20	169	127	296	0.23<1
B53	81	0.4	0.6	1	Φ	8	/	20	169	127	296	0.27<1

Table B.68. Base reactions (SHW)

DD-2 AGM SHW Base Reactions									
Output Case	Step Type	FX	FY	FZ	FX	FY	FX(Mean)	FY(Mean)	FZ
		kN	kN	kN	kN	kN	kN	kN	kN
DL+0.6LL	Max	0	0	17679			2419	2154	17679
DL+0.6LL	Min	0	0	17679					
TH1-DD2-AGM-SHW	Max	2302	2075	17679	2534	2075			
TH1-DD2-AGM-SHW	Min	-2534	-1774	17679					
TH2-DD2-AGM-SHW	Max	2240	2654	17679	2377	2654			
TH2-DD2-AGM-SHW	Min	-2377	-2316	17679					
TH3-DD2-AGM-SHW	Max	2449	2165	17679	2449	2165			
TH3-DD2-AGM-SHW	Min	-2145	-2011	17679					
TH4-DD2-AGM-SHW	Max	2415	2190	17679	2415	2382			
TH4-DD2-AGM-SHW	Min	-2225	-2382	17679					

Table B.68. Base reactions (SHW) (Contd.)

DD-2 AGM SHW Base Reactions									
Output Case	Step Type	FX	FY	FZ	FX	FY	FX(Mean)	FY(Mean)	FZ
		kN	kN	kN	kN	kN	kN	kN	kN
TH5-DD2-AGM-SHW	Max	2439	1481	17679	2501	1878			
TH5-DD2-AGM-SHW	Min	-2501	-1878	17679					
TH6-DD2-AGM-SHW	Max	2056	1823	17679	2354	2060			
TH6-DD2-AGM-SHW	Min	-2354	-2060	17679					
TH7-DD2-AGM-SHW	Max	2014	1734	17679	2290	1788			
TH7-DD2-AGM-SHW	Min	-2290	-1788	17679					
TH8-DD2-AGM-SHW	Max	2188	2747	17679	2259	2747			
TH8-DD2-AGM-SHW	Min	-2259	-2313	17679					
TH9-DD2-AGM-SHW	Max	2154	1835	17679	2328	1835			
TH9-DD2-AGM-SHW	Min	-2328	-1733	17679					
TH10-DD2-AGM-SHW	Max	2340	1829	17679	2598	1829			
TH10-DD2-AGM-SHW	Min	-2598	-1788	17679					
TH11-DD2-AGM-SHW	Max	2425	2049	17679	2505	2285			
TH11-DD2-AGM-SHW	Min	-2505	-2285	17679					

Table B.69. Base reactions (EXW)

DD-2 AGM EXW Base Reactions									
Output Case	Step Type	FX	FY	FZ	FX	FY	FX(Mean)	FY(Mean)	FZ
		kN	kN	kN	kN	kN	kN	kN	kN
DL+0.6LL	Max	0	0	17679			2332	2239	17679
DL+0.6LL	Min	0	0	17679					
TH-1-DD2-AGM-EXW	Max	2293	2230	17679	2293	2230			
TH-1-DD2-AGM-EXW	Min	-2007	-2102	17679					
TH2-DD2-AGM-EXW	Max	2059	2212	17679	2362	2212			
TH2-DD2-AGM-EXW	Min	-2362	-1903	17679					
TH3-DD2-AGM-EXW	Max	1953	1832	17679	2294	1832			
TH3-DD2-AGM-EXW	Min	-2294	-1775	17679					
TH4-DD2-AGM-EXW	Max	2453	2333	17679	2453	2333			
TH4-DD2-AGM-EXW	Min	-2012	-2232	17679					
TH5-DD2-AGM-EXW	Max	2274	2156	17679	2274	2156			
TH5-DD2-AGM-EXW	Min	-2221	-1964	17679					
TH6-DD2-AGM-EXW	Max	1929	2293	17679	2200	2293			
TH6-DD2-AGM-EXW	Min	-2200	-2272	17679					
TH7-DD2-AGM-EXW	Max	2337	2131	17679	2450	2131			
TH7-DD2-AGM-EXW	Min	-2450	-2016	17679					
TH8-DD2-AGM-EXW	Max	2590	2196	17679	2590	2196			
TH8-DD2-AGM-EXW	Min	-2490	-1865	17679					

Table B.69. Base reactions (EXW) (Contd.)

DD-2 AGM EXW Base Reactions									
Output Case	Step Type	FX	FY	FZ	FX	FY	FX(Mean)	FY(Mean)	FZ
		kN	kN	kN	kN	kN	kN	kN	kN
TH9-DD2-AGM-EXW	Max	1941	2631	17679	2206	2631			
TH9-DD2-AGM-EXW	Min	-2206	-2338	17679					
TH10-DD2-AGM-EXW	Max	2222	2167	17679	2222	2167			
TH10-DD2-AGM-EXW	Min	-1960	-2040	17679					
TH11-DD2-AGM-EXW	Max	2311	2449	17679	2311	2449			
TH11-DD2-AGM-EXW	Min	-2244	-2259	17679					

Table B.70. Base reactions (NF)

DD-2 SYN NF Base Reactions									
Output Case	Step Type	FX	FY	FZ	FX	FY	FX(Mean)	FY(Mean)	FZ
		kN	kN	kN	kN	kN	kN	kN	kN
DL+0.6LL	Max	0	0	17679			2433	2148	17679
DL+0.6LL	Min	0	0	17679					
TH-1-DD2-S-NF	Max	2422	1813	17679	2422	2014			
TH-1-DD2-S-NF	Min	-1832	-2014	17679					
TH-2-DD2-S-NF	Max	2217	2351	17679	2303	2351			
TH-2-DD2-S-NF	Min	-2303	-2147	17679					
TH-3-DD2-S-NF	Max	1649	1348	17679	1984	2010			
TH-3-DD2-S-NF	Min	-1984	-2010	17679					
TH-4-DD2-S-NF	Max	2027	1974	17679	2329	2090			
TH-4-DD2-S-NF	Min	-2329	-2090	17679					
TH-5-DD2-S-NF	Max	2475	1922	17679	2520	2080			
TH-5-DD2-S-NF	Min	-2520	-2080	17679					
TH-6-DD2-S-NF	Max	2660	2235	17679	2660	2235			
TH-6-DD2-S-NF	Min	-2445	-1508	17679					
TH-7-DD2-S-NF	Max	2282	2053	17679	2288	2138			
TH-7-DD2-S-NF	Min	-2288	-2138	17679					
TH-8-DD2-S-NF	Max	2647	2382	17679	2778	2382			
TH-8-DD2-S-NF	Min	-2778	-2234	17679					
TH-9-DD2-S-NF	Max	2074	1994	17679	2313	2023			
TH-9-DD2-S-NF	Min	-2313	-2023	17679					
TH-10-DD2-S-NF	Max	2520	2214	17679	2520	2214			
TH-10-DD2-S-NF	Min	-1984	-2157	17679					
TH-11-DD2-S-NF	Max	2525	1962	17679	2648	2092			
TH-11-DD2-S-NF	Min	-2648	-2092	17679					

Table B.71. Base reactions (FF)

DD-2 SYN FF Base Reactions									
Output Case	Step Type	FX	FY	FZ	FX	FY	FX(Mean)	FY(Mean)	FZ
		kN	kN	kN	kN	kN	kN	kN	kN
DL+0.6LL	Max	0	0	17679			2583	2396	17679
DL+0.6LL	Min	0	0	17679					
TH-1-DD2-S-FF	Max	2956	2513	17679	2956	2513			
TH-1-DD2-S-FF	Min	-1801	-2355	17679					
TH-2-DD2-S-FF	Max	2122	2245	17679	2184	2368			
TH-2-DD2-S-FF	Min	-2184	-2368	17679					
TH-3-DD2-S-FF	Max	2243	2071	17679	2666	2387			
TH-3-DD2-S-FF	Min	-2666	-2387	17679					
TH-4-DD2-S-FF	Max	2268	2249	17679	2268	2249			
TH-4-DD2-S-FF	Min	-2035	-1917	17679					
TH-5-DD2-S-FF	Max	2639	2395	17679	2639	2395			
TH-5-DD2-S-FF	Min	-2406	-2139	17679					
TH-6-DD2-S-FF	Max	2165	2591	17679	2475	2591			
TH-6-DD2-S-FF	Min	-2475	-1623	17679					
TH-7-DD2-S-FF	Max	2230	2449	17679	2793	2449			
TH-7-DD2-S-FF	Min	-2793	-2214	17679					
TH-8-DD2-S-FF	Max	2464	2190	17679	2597	2331			
TH-8-DD2-S-FF	Min	-2597	-2331	17679					
TH-9-DD2-S-FF	Max	2120	2213	17679	2186	2301			
TH-9-DD2-S-FF	Min	-2186	-2301	17679					
TH-10-DD2-S-FF	Max	2960	2407	17679	2960	2407			
TH-10-DD2-S-FF	Min	-1811	-2213	17679					
TH-11-DD2-S-FF	Max	2688	2367	17679	2688	2367			
TH-11-DD2-S-FF	Min	-2431	-1916	17679					

Table B.72. Base reactions (SRGM)

DD-2 SRGM Base Reactions									
Output Case	Step Type	FX	FY	FZ	FX	FY	FX(Mean)	FY(Mean)	FZ
		kN	kN	kN	kN	kN	kN	kN	kN
DL+0.6LL	Max	0	0	17679			2614	2392	17679
DL+0.6LL	Min	0	0	17679					
TH-1-DD2-SRGM	Max	2437	2564	17679	2557	2564			
TH-1-DD2-SRGM	Min	-2557	-2364	17679					
TH-2-DD2-SRGM	Max	2402	2086	17679	2600	2245			
TH-2-DD2-SRGM	Min	-2600	-2245	17679					

Table B.72. Base reactions (SRGM) (Contd.)

DD-2 SRGM Base Reactions									
Output Case	Step Type	FX	FY	FZ	FX	FY	FX(Mean)	FY(Mean)	FZ
		kN	kN	kN	kN	kN	kN	kN	kN
TH3-DD2-SRGM	Max	2174	2240	17679	2594	2496			
TH3-DD2-SRGM	Min	-2594	-2496	17679					
TH4-DD2-SRGM	Max	2351	2370	17679	2351	2429			
TH4-DD2-SRGM	Min	-1868	-2429	17679					
TH5-DD2-SRGM	Max	2889	2327	17679	2889	2327			
TH5-DD2-SRGM	Min	-2441	-2077	17679					
TH6-DD2-SRGM	Max	2513	2175	17679	2513	2382			
TH6-DD2-SRGM	Min	-2450	-2382	17679					
TH7-DD2-SRGM	Max	2994	2505	17679	2994	2505			
TH7-DD2-SRGM	Min	-2889	-2248	17679					
TH8-DD2-SRGM	Max	2204	2211	17679	2651	2226			
TH8-DD2-SRGM	Min	-2651	-2226	17679					
TH9-DD2-SRGM	Max	2600	2025	17679	2600	2079			
TH9-DD2-SRGM	Min	-2394	-2079	17679					
TH10-DD2-SRGM	Max	2586	2385	17679	2586	2385			
TH10-DD2-SRGM	Min	-2521	-2251	17679					
TH11-DD2-SRGM	Max	2423	2216	17679	2423	2676			
TH11-DD2-SRGM	Min	-2303	-2676	17679					

Table B.73. Relative story drifts (SHW)

TH1		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.68%	-0.92%	0.88%	-1.01%
1st	3.6	0.92%	-1.05%	1.08%	-1.31%
Ground	4.5	1.34%	-1.32%	1.20%	-1.41%
Base	-	0.00%	0.00%	0.00%	0.00%
TH2		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.91%	-1.00%	1.13%	-1.42%
1st	3.6	1.05%	-1.05%	1.39%	-1.48%
Ground	4.5	1.38%	-1.26%	1.31%	-1.67%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B.73. Relative story drifts (SHW) (Contd.)

TH3		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.82%	-0.87%	1.26%	-0.98%
1st	3.6	0.93%	-1.13%	1.37%	-1.26%
Ground	4.5	1.16%	-1.40%	1.34%	-1.45%
Base	-	0.00%	0.00%	0.00%	0.00%
TH4		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.65%	-0.89%	0.74%	-1.09%
1st	3.6	0.87%	-1.05%	1.17%	-1.21%
Ground	4.5	1.31%	-1.28%	1.47%	-1.33%
Base	-	0.00%	0.00%	0.00%	0.00%
TH5		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.66%	-0.73%	0.75%	-0.79%
1st	3.6	1.00%	-0.80%	1.00%	-0.96%
Ground	4.5	1.42%	-1.38%	1.17%	-0.95%
Base	-	0.00%	0.00%	0.00%	0.00%
TH6		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	1.06%	-0.88%	1.19%	-0.96%
1st	3.6	1.15%	-1.00%	1.33%	-1.19%
Ground	4.5	1.41%	-1.15%	1.30%	-1.15%
Base	-	0.00%	0.00%	0.00%	0.00%
TH7		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	1.03%	-0.86%	0.92%	-1.05%
1st	3.6	1.10%	-0.92%	0.98%	-1.13%
Ground	4.5	1.28%	-1.14%	1.08%	-1.11%
Base	-	0.00%	0.00%	0.00%	0.00%
TH8		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.70%	-0.87%	1.14%	-1.50%
1st	3.6	0.94%	-1.00%	1.39%	-1.57%
Ground	4.5	1.24%	-1.24%	1.38%	-1.77%
Base	-	0.00%	0.00%	0.00%	0.00%
TH9		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.87%	-0.97%	1.01%	-1.10%
1st	3.6	0.98%	-0.96%	1.00%	-1.20%
Ground	4.5	1.20%	-1.14%	1.07%	-1.13%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B.73. Relative story drifts (SHW) (Contd.)

TH10		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.73%	-0.90%	1.00%	-1.09%
1st	3.6	0.96%	-1.05%	0.94%	-1.17%
Ground	4.5	1.36%	-1.30%	1.10%	-1.19%
Base	-	0.00%	0.00%	0.00%	0.00%
TH11		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.64%	-0.72%	0.93%	-1.12%
1st	3.6	0.96%	-0.79%	1.10%	-1.17%
Ground	4.5	1.34%	-1.29%	1.33%	-1.34%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B74. Relative story drifts (EXW)

TH1		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.92%	-0.69%	1.12%	-0.91%
1st	3.6	0.87%	-0.92%	1.34%	-1.26%
Ground	4.5	1.16%	-1.21%	1.33%	-1.52%
Base	-	0.00%	0.00%	0.00%	0.00%
TH2		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.64%	-0.90%	0.86%	-0.87%
1st	3.6	0.89%	-1.01%	1.12%	-1.23%
Ground	4.5	1.31%	-1.25%	1.20%	-1.41%
Base	-	0.00%	0.00%	0.00%	0.00%
TH3		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.83%	-1.01%	1.06%	-0.75%
1st	3.6	0.98%	-1.01%	1.26%	-1.00%
Ground	4.5	1.31%	-1.06%	1.26%	-1.07%
Base	-	0.00%	0.00%	0.00%	0.00%
TH4		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.76%	-0.87%	1.44%	-1.11%
1st	3.6	0.83%	-1.12%	1.61%	-1.37%
Ground	4.5	1.18%	-1.41%	1.55%	-1.53%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B74. Relative story drifts (EXW) (Contd.)

TH5		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.81%	-1.05%	1.02%	-1.23%
1st	3.6	0.98%	-1.12%	1.28%	-1.45%
Ground	4.5	1.26%	-1.32%	1.28%	-1.39%
Base	-	0.00%	0.00%	0.00%	0.00%
TH6		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.81%	-0.78%	1.01%	-1.16%
1st	3.6	0.86%	-0.90%	1.37%	-1.44%
Ground	4.5	1.24%	-1.12%	1.44%	-1.52%
Base	-	0.00%	0.00%	0.00%	0.00%
TH7		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.61%	-0.78%	1.22%	-0.82%
1st	3.6	0.96%	-0.77%	1.33%	-1.09%
Ground	4.5	1.32%	-1.28%	1.39%	-1.30%
Base	-	0.00%	0.00%	0.00%	0.00%
TH8		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.80%	-1.05%	0.87%	-0.89%
1st	3.6	1.02%	-1.22%	1.13%	-1.27%
Ground	4.5	1.30%	-1.45%	1.12%	-1.39%
Base	-	0.00%	0.00%	0.00%	0.00%
TH9		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.56%	-0.85%	1.15%	-1.42%
1st	3.6	0.79%	-0.93%	1.42%	-1.47%
Ground	4.5	1.14%	-1.06%	1.35%	-1.63%
Base	-	0.00%	0.00%	0.00%	0.00%
TH10		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	1.03%	-0.66%	1.27%	-0.84%
1st	3.6	0.95%	-0.89%	1.41%	-1.17%
Ground	4.5	1.06%	-1.18%	1.40%	-1.28%
Base	-	0.00%	0.00%	0.00%	0.00%
TH11		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.75%	-1.07%	1.50%	-1.08%
1st	3.6	0.95%	-1.15%	1.65%	-1.46%
Ground	4.5	1.21%	-1.35%	1.51%	-1.60%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B.75. Relative story drifts (NF)

TH1		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.71%	-0.98%	1.19%	-1.07%
1st	3.6	0.84%	-1.10%	1.37%	-0.98%
Ground	4.5	1.04%	-1.36%	1.44%	-1.18%
Base	-	0.00%	0.00%	0.00%	0.00%
TH2		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	1.09%	-0.89%	1.30%	-0.88%
1st	3.6	1.15%	-1.00%	1.47%	-1.17%
Ground	4.5	1.29%	-1.17%	1.37%	-1.40%
Base	-	0.00%	0.00%	0.00%	0.00%
TH3		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.72%	-0.88%	1.22%	-0.75%
1st	3.6	0.83%	-0.79%	1.43%	-0.83%
Ground	4.5	1.13%	-0.90%	1.30%	-0.79%
Base	-	0.00%	0.00%	0.00%	0.00%
TH4		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.84%	-0.95%	0.81%	-1.26%
1st	3.6	1.04%	-0.95%	1.01%	-1.10%
Ground	4.5	1.44%	-1.17%	1.25%	-1.20%
Base	-	0.00%	0.00%	0.00%	0.00%
TH5		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.87%	-0.61%	0.92%	-1.24%
1st	3.6	1.05%	-0.88%	1.22%	-1.37%
Ground	4.5	1.41%	-1.40%	1.35%	-1.26%
Base	-	0.00%	0.00%	0.00%	0.00%
TH6		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.78%	-0.86%	1.06%	-1.24%
1st	3.6	0.99%	-1.08%	0.90%	-1.24%
Ground	4.5	1.49%	-1.48%	1.01%	-1.46%
Base	-	0.00%	0.00%	0.00%	0.00%
TH7		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.86%	-0.83%	0.95%	-1.05%
1st	3.6	0.88%	-0.98%	1.23%	-1.33%
Ground	4.5	1.18%	-1.27%	1.31%	-1.38%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B.75. Relative story drifts (NF) (Contd.)

TH8		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.75%	-1.09%	1.30%	-0.83%
1st	3.6	1.05%	-1.14%	1.44%	-1.13%
Ground	4.5	1.48%	-1.47%	1.49%	-1.43%
Base	-	0.00%	0.00%	0.00%	0.00%
TH9		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	1.10%	-0.88%	1.17%	-0.91%
1st	3.6	1.13%	-0.97%	1.29%	-1.05%
Ground	4.5	1.25%	-1.28%	1.47%	-1.17%
Base	-	0.00%	0.00%	0.00%	0.00%
TH10		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.81%	-0.97%	0.92%	-1.10%
1st	3.6	0.86%	-1.13%	1.21%	-1.40%
Ground	4.5	1.06%	-1.42%	1.33%	-1.42%
Base	-	0.00%	0.00%	0.00%	0.00%
TH11		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.88%	-0.84%	0.93%	-1.19%
1st	3.6	1.07%	-0.88%	1.02%	-1.05%
Ground	4.5	1.49%	-1.38%	1.28%	-1.18%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B.76. Relative story drifts (FF)

TH1		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.87%	-0.88%	1.41%	-1.58%
1st	3.6	0.70%	-1.15%	1.40%	-1.75%
Ground	4.5	0.80%	-1.68%	1.56%	-1.56%
Base	-	0.00%	0.00%	0.00%	0.00%
TH2		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.75%	-1.21%	1.20%	-1.12%
1st	3.6	0.87%	-1.14%	1.47%	-1.34%
Ground	4.5	1.17%	-1.17%	1.49%	-1.40%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B.76. Relative story drifts (FF) (Contd.)

TH3		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.87%	-0.75%	1.04%	-1.17%
1st	3.6	1.02%	-0.86%	1.44%	-1.34%
Ground	4.5	1.45%	-1.15%	1.65%	-1.29%
Base	-	0.00%	0.00%	0.00%	0.00%
TH4		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.44%	-0.61%	1.19%	-0.97%
1st	3.6	0.71%	-0.84%	1.35%	-1.34%
Ground	4.5	1.09%	-1.19%	1.28%	-1.44%
Base	-	0.00%	0.00%	0.00%	0.00%
TH5		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.95%	-0.90%	0.98%	-1.12%
1st	3.6	1.11%	-1.14%	1.20%	-1.40%
Ground	4.5	1.34%	-1.63%	1.36%	-1.50%
Base	-	0.00%	0.00%	0.00%	0.00%
TH6		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.64%	-0.79%	0.82%	-1.01%
1st	3.6	0.93%	-0.94%	1.01%	-1.44%
Ground	4.5	1.36%	-1.18%	0.99%	-1.61%
Base	-	0.00%	0.00%	0.00%	0.00%
TH7		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	1.02%	-0.46%	1.19%	-1.20%
1st	3.6	1.16%	-0.70%	1.40%	-1.49%
Ground	4.5	1.57%	-1.07%	1.45%	-1.58%
Base	-	0.00%	0.00%	0.00%	0.00%
TH8		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.76%	-0.87%	1.17%	-1.06%
1st	3.6	1.03%	-1.05%	1.44%	-1.29%
Ground	4.5	1.45%	-1.33%	1.47%	-1.39%
Base	-	0.00%	0.00%	0.00%	0.00%
TH9		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.71%	-1.21%	1.46%	-0.89%
1st	3.6	0.85%	-1.13%	1.56%	-1.14%
Ground	4.5	1.19%	-1.13%	1.50%	-1.28%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B.76. Relative story drifts (FF) (Contd.)

TH10		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.88%	-0.90%	1.20%	-1.18%
1st	3.6	0.67%	-1.18%	1.44%	-1.42%
Ground	4.5	0.84%	-1.72%	1.43%	-1.51%
Base	-	0.00%	0.00%	0.00%	0.00%
TH11		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.97%	-0.91%	1.22%	-0.98%
1st	3.6	1.14%	-1.14%	1.34%	-1.34%
Ground	4.5	1.35%	-1.58%	1.28%	-1.46%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B.77. Relative story drifts (SRGM)

TH1		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.96%	-0.80%	1.40%	-1.40%
1st	3.6	1.12%	-0.98%	1.51%	-1.44%
Ground	4.5	1.42%	-1.23%	1.58%	-1.62%
Base	-	0.00%	0.00%	0.00%	0.00%
TH2		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.95%	-0.92%	1.13%	-1.02%
1st	3.6	1.11%	-1.06%	1.34%	-1.22%
Ground	4.5	1.41%	-1.39%	1.46%	-1.36%
Base	-	0.00%	0.00%	0.00%	0.00%
TH3		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.89%	-0.99%	1.20%	-0.96%
1st	3.6	1.06%	-1.00%	1.55%	-1.37%
Ground	4.5	1.31%	-1.18%	1.63%	-1.48%
Base	-	0.00%	0.00%	0.00%	0.00%
TH4		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	1.18%	-0.67%	0.79%	-1.06%
1st	3.6	1.03%	-0.90%	1.25%	-1.12%
Ground	4.5	1.03%	-1.28%	1.46%	-1.48%
Base	-	0.00%	0.00%	0.00%	0.00%

Table B.77. Relative story drifts (SRGM) (Contd.)

TH5		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.61%	-0.87%	1.06%	-1.09%
1st	3.6	0.94%	-1.22%	1.31%	-1.40%
Ground	4.5	1.30%	-1.72%	1.34%	-1.53%
Base	-	0.00%	0.00%	0.00%	0.00%
TH6		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.81%	-1.09%	1.36%	-1.01%
1st	3.6	0.99%	-1.06%	1.59%	-1.31%
Ground	4.5	1.44%	-1.42%	1.45%	-1.49%
Base	-	0.00%	0.00%	0.00%	0.00%
TH7		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	1.09%	-1.05%	1.19%	-1.07%
1st	3.6	1.28%	-1.21%	1.44%	-1.36%
Ground	4.5	1.61%	-1.58%	1.53%	-1.61%
Base	-	0.00%	0.00%	0.00%	0.00%
TH8		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.79%	-1.09%	1.12%	-1.16%
1st	3.6	0.99%	-1.11%	1.40%	-1.34%
Ground	4.5	1.44%	-1.22%	1.47%	-1.53%
Base	-	0.00%	0.00%	0.00%	0.00%
TH9		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.79%	-0.91%	1.57%	-1.24%
1st	3.6	0.96%	-0.98%	1.60%	-1.26%
Ground	4.5	1.22%	-1.47%	1.38%	-1.22%
Base	-	0.00%	0.00%	0.00%	0.00%
TH10		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	1.01%	-0.87%	1.24%	-1.26%
1st	3.6	1.07%	-1.09%	1.26%	-1.55%
Ground	4.5	1.34%	-1.54%	1.32%	-1.64%
Base	-	0.00%	0.00%	0.00%	0.00%
TH11		Direction			
Story	Story Height	+X	-X	+Y	-Y
2nd	4	0.96%	-0.62%	1.42%	-1.21%
1st	3.6	1.10%	-0.90%	1.73%	-1.46%
Ground	4.5	1.29%	-1.33%	1.85%	-1.45%
Base	-	0.00%	0.00%	0.00%	0.00%