ISTANBUL TECHNICAL UNIVERSITY « EARTHQUAKE ENGINEERING AND DISASTER MANAGEMENT INSTITUTE

SIMULATION OF A COLLAPSED REINFORCED CONCRETE SCHOOL BUILDING AFTER 2011 VAN EARTHQUAKES

M.Sc. THESIS

Menekşe CANATAN

Department of Earthquake Engineering and Disaster Management

Earthquake Engineering Programme

NOVEMBER 2018

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Menekşe CANATAN
(802121026)

Department of Earthquake Engineering and Disaster Management

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Thesis Advisor: Prof. Dr. Ayfer ERKEN

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İSTANBUL TEKNİK ÜNİVERSİTESİ « DEPREM MÜHENDİSLİĞİ VE AFET YÖNETİMİ ENSTİTÜSÜ

2011 VAN DEPREMLERİNDE HASAR GÖREN BİR BETONARME OKUL BİNASININ SİMÜLASYONU

YÜKSEK LİSANS TEZİ

Menekşe CANATAN
(802121026)

Deprem Mühendisliği ve Afet Yönetimi Enstitüsü

Deprem Mühendisliği Programı

Tez Danışmanı: Prof. Dr. Ayfer ERKEN

KASIM 2018

Menekşe Canatan, a M.Sc. student of ITU Institute of Earthquake Engineering And Disaster Management student ID 802121026, successfully defended the thesis entitled "SIMULATION OF A COLLAPSED REINFORCED CONCRETE SCHOOL BUILDING AFTER 2011 VAN EARTHQUAKES", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

Thesis Advisor :	**Prof. Dr. Ayfer ERKEN** İstanbul Technical University	....
Jury Members :	**Prof. Dr. Ayfer ERKEN** Istanbul Technical University	....
	Assoc. Prof. Dr. Reşat Atalay OYGUÇ Istanbul Technical University	....
	Assoc. Prof. Dr. Murat Serdar KIRÇIL Yildiz Technical University	....

Date of Submission : 19 November 2018
Date of Defense : 05 December 2018

To my family,

FOREWORD

I would like to express my great appreciation and gratitude to my thesis supervisor Prof. Dr. Ayfer ERKEN and Assoc. Prof. Dr. Reşat Atalay OYGUÇ for sharing their knowledge and experience in earthquake engineering during my MSc. education.
I owe it all CANATAN family for their moral contributions and supports in my whole education life.

November 2018 Menekşe CANATAN
(Structural Engineer)

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SUMMARY

Many structures are exposed to mainshocks and aftershocks in terms of tectonic conditions in our contry. Multiple earthquakes occur as a result of the fact that all plate stresses cannot be released at the time of the first rupture. Reinforced concrete systems can have severe damage due to repeated loads. In particular, building type structures can be used according to their damage level after an earthquake.

Nonlinear analysis methods are broadly accepted to determine secondary earthquake behavior of reinforced concrete structures. One of the main reason for the damage on the reinforced concrete buildings exposed to repeated excitations is the loss of strength and stiffness in the material. A number of reinforced concrete buildings which were not heavily damaged after the main earthquake can access the mechanism of collapse after aftershocks. In previous studies, it has been proven that the consideration of the strength and stiffness degradation under repetitive loads provides the most realistic approach.

Structural designs are being done based on a single earthquake scenario according to the current specifications. However, past experiences show that structures cannot resist the secondary earthquakes with their designed strength and rigidity. In this study, effects of multiple excitations are taken into account to define reinforced concrete structural behavior. This behavior is simulated using with the finite element program named ZeusNL which considers the degradation effects of materials.

In this context, a school building which was heavily damaged after the October 23 and November 11, 2011 Van earthquakes was examined. The building was modeled according to the in-site researches and nonlinear time-history anayses are conducted.

2011 VAN DEPREMLERİNDE HASAR GÖREN BİR BETONARME OKUL BİNASININ SİMÜLASYONU

ÖZET

Ülkemizde bulunan yapıların birçoğu, tektonik koşullar sebebiyle ana depremlere ve artçışoklara maruz kalmaktadırlar. Çoklu depremler, plaka gerilmelerinin tümünün ilk yer hareketi sırasında serbest kalamamasının sonucu olarak ortaya çıkar. Betonarme sistemler, tekrarlı yükler sebebiyle ağır hasarlar alabilmektedirler. Özellikle bina türü sistemler, depremlerden sonra aldıkları hasar derecesine göre yeniden kullanılabilirler.

Betonarme yapılarda ardıl depremlerin etkilerini belirlemek için genellikle linner olmayan analiz yöntemleri kullanılmaktadır. Tekrarlı yüklere maruz kalan betonarme binalarda oluşan hasarın ana sebeplerinden biri malzemedeki rijitlik ve dayanım kaybıdır. Ana depremden sonra ağır hasar almayan bir çok betonarme bina, daha küçük etkiye sahip olan artçı şoklardan sonra göçme mekanizmasına erişebilmektedir. Yapısal elemanların analiz aşamalarında, uygun deprem senaryosu ile birlikte, rijitlik ve dayanım azalımlarının dikkare alınmasının en gerçekçi yaklaşımı sağladığı birçok nümerik çalışmanın, deneysel sonuçlar ile karşılaştırılmasıyla kanıtlanmıştır.

Geçmişte yaşanan tecrübeler, tekrarlı yükler altında yapılarn tasarlandıkları dayanım ve rijitlik ile mukavemet sağlayamayabildiklerini göstermiştir. Buna rağmen yapısal elemanlara ait tasarımlar esnasında yapılan malzeme kabulleri, geleneksel olarak kabul edilen modeller kullanılarak yapılmakta, dinamik etki sırasında oluşan rijitlik ve dayanım kayıpları göz önüne alınmamaktadır. Bu çalışma, betonarme bir sistemin davranışının incelenmesinde malzeme davranışındaki bozulma etkilerini dikkate almaktadır. Bu davranış, ZeusNL isimli sonlu eleman programı yardımıyla simüle edilmiştir.

Bu kapsamda, 23 Ekim ve 11 Kasım, 2011'de Van'da meydana gelen depremler sonrasında ağır hasar gören bir okul binası incelenmiştir. Söz konusu bina, deprem sonrasında yerinde yapılan araştırma verilerine göre modellenerek zaman-tanım

alanında lineer olmayan analizler ile malzeme davranışının çoklu deprem altındaki etkisi incelenmiştir. Bu doğrultuda 23 Ekim ve 11 Kasım, 2011 Van Depremleri'nde yer hareketi kaydı alan istasyonların, depremin merkezüssü ve incelenen yapının konumuna olan mesafesine göre değerlendirilmiştir. Bu değerlendirmede, depremler esnasında işlevde olan en yakın istasyonun depremin merkezüssüne olan uzaklığından dolayı simüle edilen yer hareketleri kullanılmıştır.

1. INTRODUCTION

Many of the buildings in our country are exposed to large ground motions due to tectonic conditions. Reinforced concrete systems can have great damages due to those ground motions. Structural designs are being done based on a single earthquake scenario according to the current specifications. However, past experiences show that structures cannot resist the aftershocks with their designed strength and rigidity.

Reinforced concrete systems are fragile under repeated loadings. In the reinforced concrete structures exposed to those repetitive loads, stress and stiffness degradations occur due to the first shaking. Prior shaking effects include stiffness and strength degradation due to damage accumulation in construction materials under large cyclic excursions as well as P-Δ effects that are introduced due to residual displacements induced from previous shaking (Abdelnaby, 2012).

According to Disaster and Emergency Management Presidency data (AFAD, 2011); when the last 58 years of earthquakes were examined, it was determined that more than 400 thousands buildings were destroyed or seriously damaged due to earthquakes in our country. Even if many of these structures remain at repairable damage level after the main earthquakes, reconnaissance studies show that they can collapse after aftershocks with less impact.

One of the main reason for the damage to the reinforced concrete buildings exposed to repeated excitations is the loss of strength and stiffness in the material. Consideration of stiffness and strength degradation of structural members with the proper earthquake scenario in the analysis stage provides the most realistic approach.

1.1 Purpose of Thesis and Problem Statement

In 2011, two earthquakes hit the province of Van causing collapse of structures and loss of life. According to AFAD data, these earthquakes are October 23 Van Earthquake (moment magnitude is 7.2) and November 9 Van-Edremit Earthquake (moment magnitude is 5.7). Many buildings damaged by this earthquake were examined on site by AFAD. Buildings that are damaged after Van earthquakes are shown in the Figure 1.1.

Figure 1.1 Heavily damaged building is collapsed after secondary excitations (AFAD, Van Earthquakes 2011).

In this study a school building which was damaged by these earthquakes was investigated by considering the degrading effect of the material model.

Within the scope of the thesis, the three-dimensional model of the structure created with the definition of material degrading effects in order to observe degraded material model effects. The finite element model of this building is obtained with a nonlinear definition of section and material level. Analyzes are done with the ZeusNL program.

2. LITERATURE REVIEW

A general review of the previous studies is represented in this chapter. Material deterioration effects were investigated by researchers who examined the effects of multiple earthquakes. Those studies are focused on system level based models for a single degree of freedom systems and component level based models for multi-degree of freedom systems. For the component level based models, multi degree of freedom systems have been studied by utilized moment-rotation relationships characterizing the behavior of plastic hinges, developed at beam-to-column connections (Abdelnaby, 2012). Implementing the systems in material level based models is computationally expensive and usually leads to convergence problems.

Degrading systems were first intorduced by Aschheim (1999) with single degree of freedom systems. The behavior of the systems are modeled using with the Takeda hysteretic models that integrated the pinched hysteresis as well as stiffness and strength degradations. In Figure 2.2 load-deformation relation of the modified Takeda hysteresis model is represented.

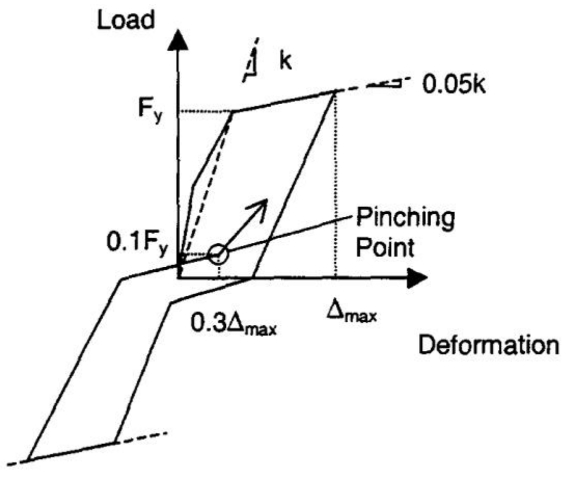

Figure 2.1 : Modified Takeda hyteresis model for single degree of freedom systems incorporating pinching and strength degradation (Aschheim, 199).

The study concluded that the displacement response of initially damaded systems match their undamaged situation after the system has the peak displacement during the dynamic loading.

Amadio et al. (2003) were studied for single degree of freedom systems under repeated earthquake ground motions with nonlinear behavior. They mentioned the principal factors which are influence the structural behavior: structural period, earthquake ground motion and level of available ductility. That study was taken into account the nonlinear behavior with hysteretic models including non-degrading, degrading stiffness, and degrading stiffnes and strength models. Those three different hysteretic behaviors were represented with the Figure 2.3 given below.

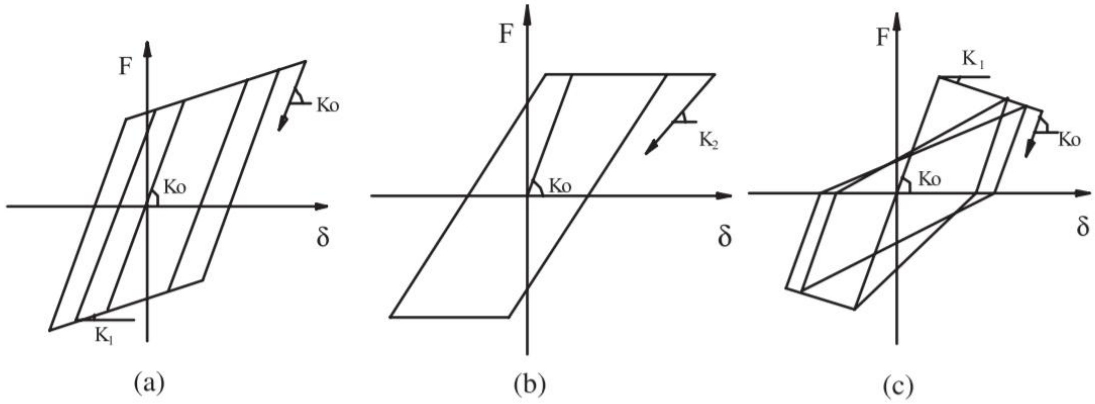

Figure 2.2 : Hysteretic models of the analysed single degree of freedom systems (Amadio et al., 2003)

Amadio et al. İndicated that multiple loadings are lead to damage accumulation and reduction in the q factor which is defined as the ratio between the maximum accelerogram that a structure can withstand without failure and first yielding appears in the structure. They have concluded that the nondegraded model is the weakest system in terms of q factor than degraded stiffness, and degraded stiffness and degraded strength systems.

Hatzigeorgiou (2010) studied reinforced concrete structures assuming bilinear moment-rotation relationship at beam column connections including with the geometric nonlinearty (P-Δ effects). As shown in the Figure 2.4, it was concluded that the residual displacements have a major effect on the stiffness degradation due to the P-Δ effects however material deterioration was not accounted for.

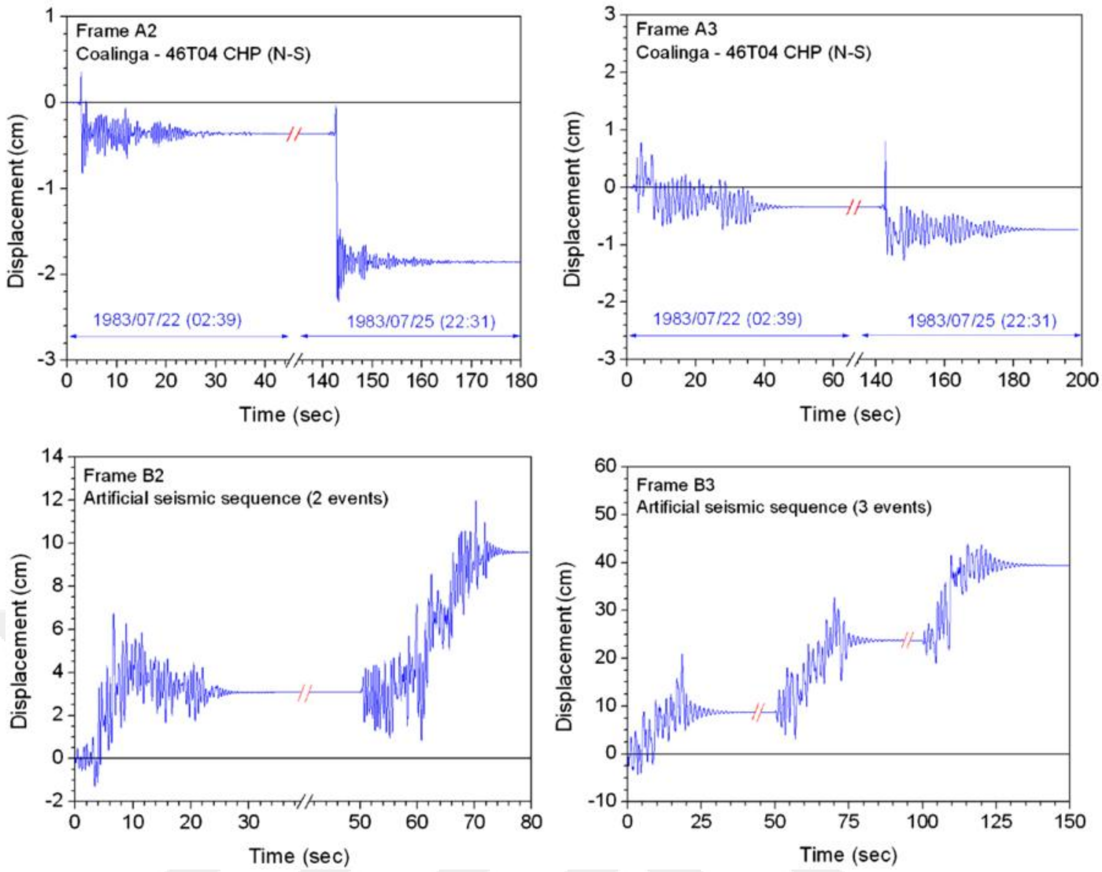

Figure 2.3 : Residual displacement of a reinforced concrete frame system (Hatzigeorgiou, 2010).

Abdelnaby (2012) investigated the comprehensive study in 2D structures in material level based. That study also mentioned current anaylsis programmes are capable of performing inelastic nonlinear dynamic solutions (such as SAP2000, ETABS, OpenSees) can not take into account the degrading effects. Reinforced cocnrete structure is analyzed with the nondegrading material models (conventional material models) and degrading material models. Bilinear stress-strain relationship for steel and Mander model for concrete behavior were used for the conventional material models. Modified Menegotto-Pinto model for steel anf plastic damage model for concrete were used for the degraded material models. The software named Zeus-NL was used to taking into account the material degradation effect.

It was concluded that the degrading response was not accurately specified by system level based model and component level models (Abdelnaby, 2012). Buckling of longitidunal reinforcing bars, fracture of reinforcing bars, and concrete crushing effect are significantly influence the reinforced concrete structures beahvior under dynamic loads. This effect can be seen in Figure 2.5 and Figure 2.6, stiffness degradation and strength deterioration of the reinforced concrete system.

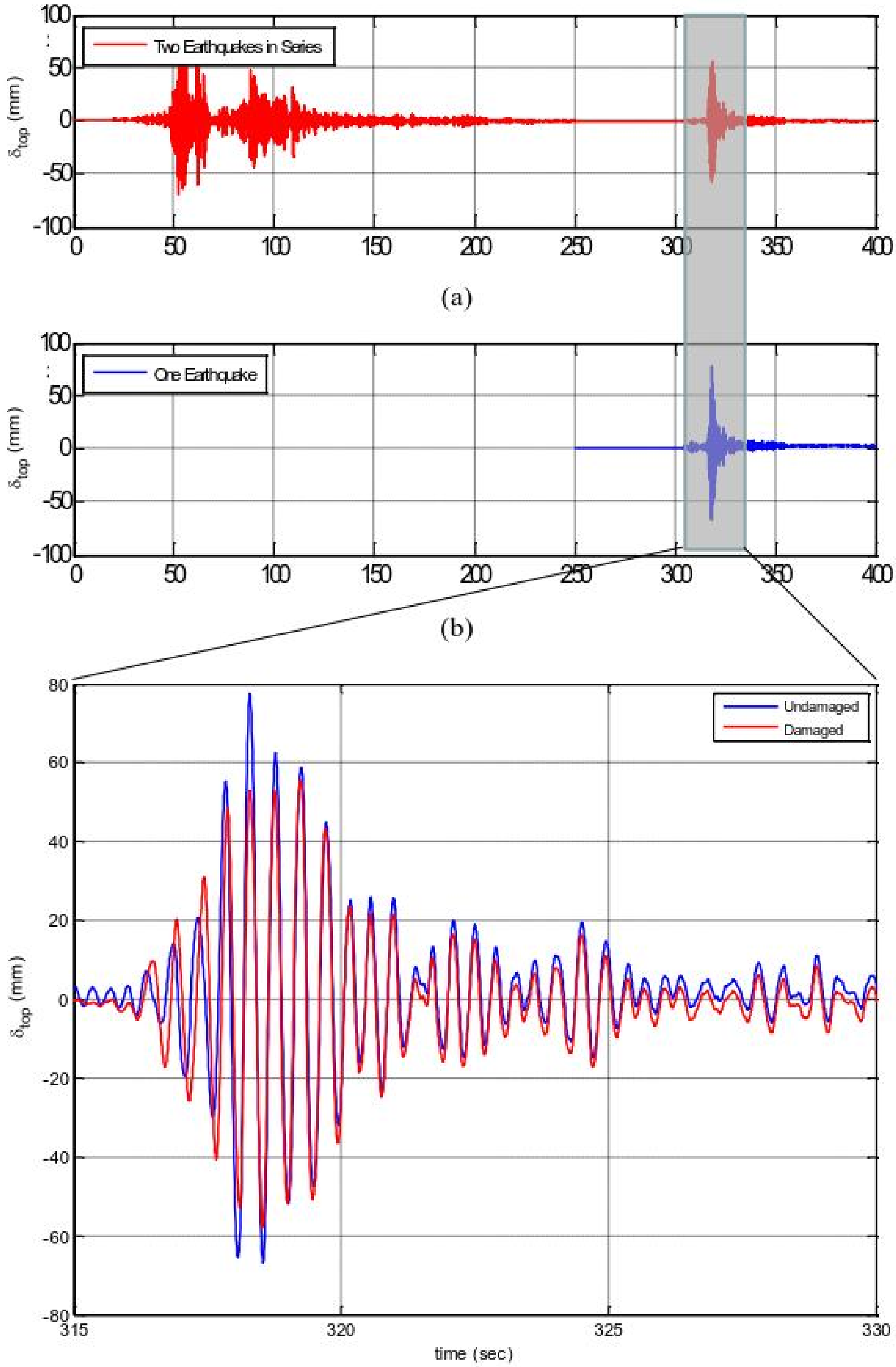

Figure 2.4 : Top displacements response comparison of damaged and undamaged nondegrading frame model (Abdelnaby, 2012).

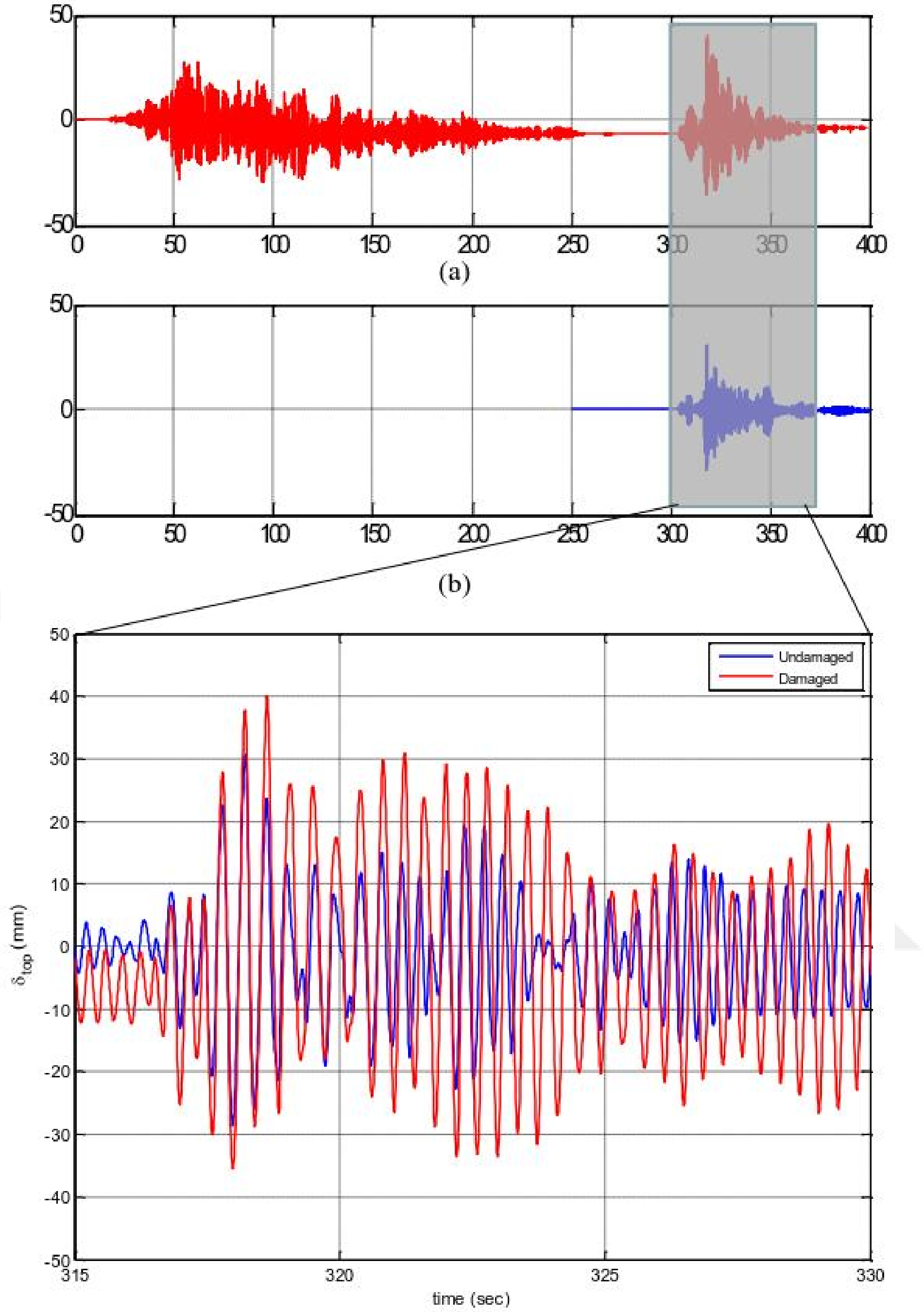

Figure 2.5 : Top displacements response comparison of damaged and undamaged degrading frame model (Abdelnaby, 2012).

3. GENERAL INFORMATION ABOUT THE 2011 VAN EARTHQUAKES

Van region is in the north-south direction contraction-compaction zone formed as a result of the Arab Plate's convergence to the Eurasian Plate.

This compression causes the occurrence of northeast-southeast right-sided and northeast-southwest extending left-hand strike-slip faults with east-west extension thrust faults, northwest-southeast right-sided and northeast-southwest oriented left-sided strike-slip faults. The earthquake on 23 October 2011 was formed in this zone of compression (METU/EERC, 2011-04). In Figure 3.1 tectonic map of the Turkey and the Van Earthquakes epicenters are represented.

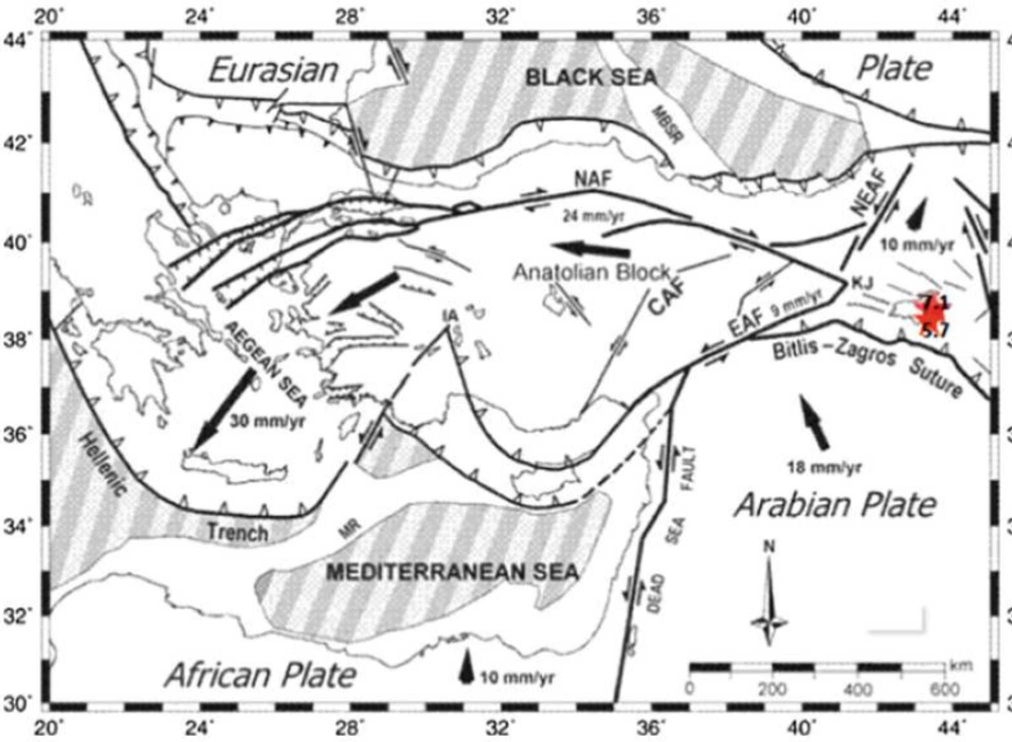

Figure 3.1 : Tectonic map and epicenters of the 2011 Van Earthquakes (Sarno and Erdik, 2012).

The moment magnitude value of Van Earthquake on 23 October 2011 varies between 7.1 and 7.3 according to different organizations. The approximate epicenter of the earthquake is Van provincial center and its exact position differs from the various institutions (METU, 2011). According to the data of the National Seismological Observation Network, the amount of energy released after the earthquake is considerably large. On 23rd of October, the energy that the main shock creates is 33.2 times of the atomic bomb in Hiroshima (AFAD, Van Earthquake 2011).

About three weeks later on 9 November 2011, an earthquake magnitude Mw 5.7 occurred in Edremit-Van. Those earthquakes are independent earthquakes on different faults close rupture locations.

The school building investigated in the scope of the thesis study is located at Alaköy-Van. In the Figure 3.2 and Figure 3.3 given below, the distances between Alaköy and the center of the earthquakes are represented. According to this, the 23 October Van Earhquake was used as the main earthquake (Oyguc et al., 2017).

Figure 3.2 : Distances between Alaköy and earthquakes epicenters.

Figure 3.3 : Intensity map of the October 23, 2011 Van earthquake (Oyguç et al., 2017).

October 23, 2011 Van Earthquake (Mw 7.2) is one of the first 3 major earthquakes (1999 Kocaeli Mw 7.1 and Düzce Mw 7.6) with ground motion acceleration recorded in terms of moment magnitude size. Furthermore, this earthquake is among the top 10 largest earthquakes in the last 110 years in Turkey. After the mainshock on October 23, 2011, 340 aftershocks of the first day occurred. During the eighth and fifteenth days, averaged 200 aftershocks occur (AFAD, 2011). It then continued to decline gradually. As of the twenty-eighth day, there were 90 aftershocks. Distribution of the aftershocks according to days is represented in the Figure 3.4.

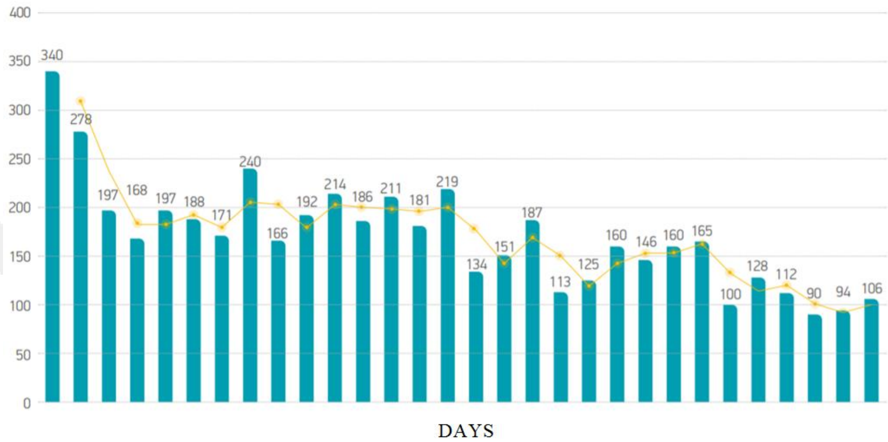

Figure 3.4 : Aftershocks occurred within the first 30 days after 23 October Van Earthquake (AFAD, Van Earthquake 2011).

Middle East Technical University studied the seismic and structural damage in the Van earthquakes (METU/EERC, İMO 2012-01 and METU/EERC 2011-04). In that report major aftershocks locations and magnitudes are provided. In Figure 3.5 fault sources and aftershocks distribution is represented.

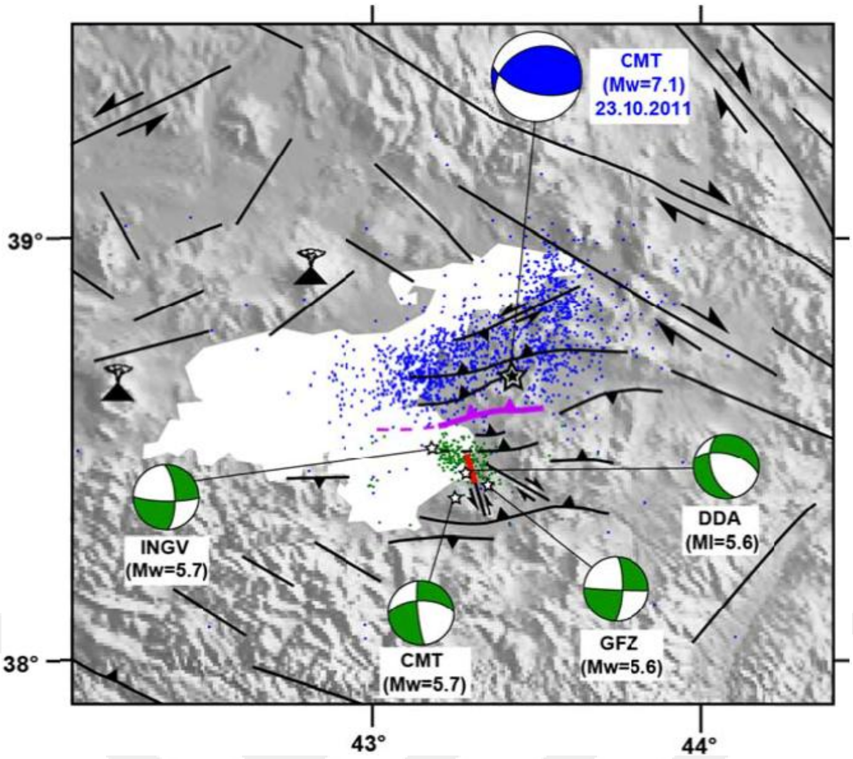

Figure 3.5 : Aftershocks which recorded after 23 October 2011 (Mw 7.2) and 9 November 2011 (Mw 5.7) earthquakes within a week of earthquakes (blue / green) and fault sources (pink / red) (METU/EERC, İMO 2012-01).

Another important information of the Van Earthquakes is that the structures can collapse after multiple excitations even if the main shcok is moderate in terms of spectral acceleration. This evidence reveals that the moderate earthquakes and its aftershocks, which are expected to occur in our country, have the potential for the danger (METU/EERC, İMO 2012-01).

3.1 Ground Motions

Although the October 23, 2011 Van earthquake was recorded by 22 stations within the region, the closest strong motion recording instrument which is located in Van city center lost its power during the event (Erken et al., 2012). Epicentral distances from different sources for both October 23 and November 11, 2011 Van Earthquakes are represented in Table 3.1.

Table 3.1: Epicentral distances from different sources for both October 23 and November 11, 2011 Van Earthquakes (Erken et al., 2012).

Source	Location	R (km)	
		October 23, 2011 Van	November 11,2011 Van
AFAD	Van city centre	21.39	13.56
	Erciş city centre	38.81	64.96
	Muradiye city centre	42.29	74.38
KOREI	Van city centre	28.57	16.81
	Erciş city centre	29.89	67.32
	Muradiye city centre	43.45	77.55
USGS	Van city centre	22.46	17.2
	Erciş city centre	39.37	75.54
	Muradiye city centre	40.51	77.93
EMSC	Van city centre	37.78	13.46
	Erciş city centre	27.74	67.74
	Muradiye city centre	39.2	75.61

The closest station to the epicenter of the October 23 Van Earthquake is the Muradiye Station. Figure 3.6 shows the acceleration, velocity and displacement traces for the Muradiye Station.

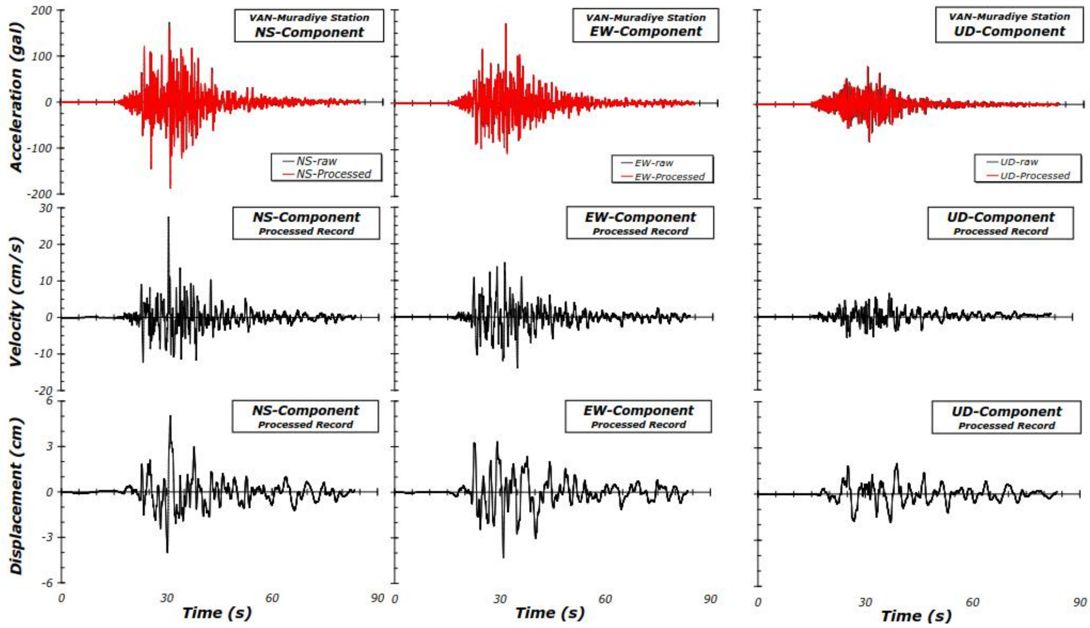

Figure 3.6 : Acceleration, velocity and displacement histories of Muradiye NS (left columns), EW (middle column) and UD (right column) components (Erken et al., 2012)

Comparison of the normalized spectra with the design spectra is obtained by Erken et al., 2012. This spectra is given in Figure 3.7 for the soil classes Z1, Z2, Z3 and Z4, where Z1 represents the firmest and Z4 represents the softest soil.

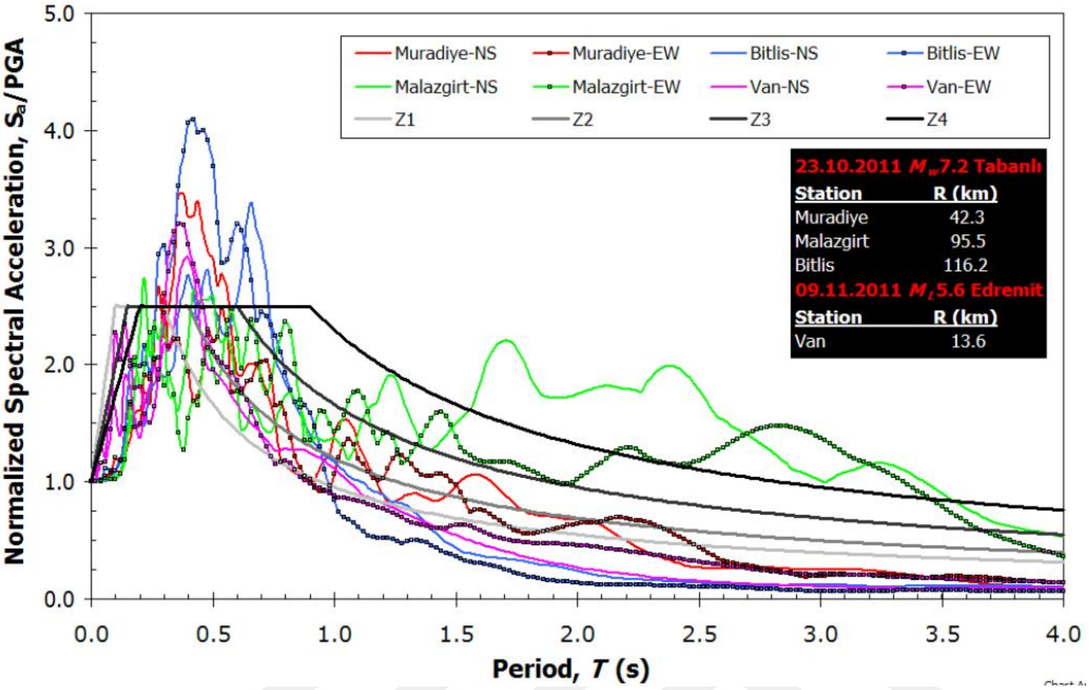

Figure 3.7 : Comparison of the normalized spectra with the design spectra for Z1, Z2, Z3 and Z4 (Erken et al., 2012)

The location of the studied structure is approximately 40 km away from the Muradiye Station. Therefore the acceleration records are simulated and scaled compatible with the tectonic conditions of the area, fault mechanism and soil characteristics. In this context, the methodology mentioned in the studies of Ansal and Tönük (2015) was followed in order to obtain 7 site-specific design earthquakes used in the analyzes. Selected earthquakes list is given in Table 3.1.

Bommer and Acevedo (2004) and Bommer et al. (2000) suggested that reliable analyzes can be made by using the previously recorded earthquake records. Ansal and Tönük (2015) compared different scaling options in order to use the previously recorded earthquakes. The estimation of design earthquake characteristics on the ground surface is based on regional seismic hazard assessment, detailed site characterization, and site response analysis utilizing avaliable data concerning geotechnical and gelogical site conditions (Ansal and Tönük, 2015). Ansal and Tönük (2015) compared peak ground acceleration scaled method and spectra scaled method which are two different scaling methods using with the 25 soil profiles and 22 acceleration records. They have concluded that spectral scaling method provides more realistic and economical design parameters.

Selected records are summarized in Table 3.2 and the simulation of acceleration time history graphics with the peak groud acceleration (PGA) values are represented in Figure 3.8 to Figure 3.21.

Table 3.2: Summary of selected records

Earthquake Name	Station Name	Magnitude	Vs30 (m/sec)	Mechanism	Rjb (km)	Rrup (km)	PGA
“Tabas_ Iran”	“Boshrooyeh”	7.35	324.57	Reverse	24.07	28.8	0.4418
“Landers”	“Yermo Fire Station”	7.28	353.63	strike slip	23.62	23.6	0.4534
“Cape Mendocino”	“Ferndale Fire Station”	7.01	387.95	Reverse	16.64	19.3	0.4405
“El Mayor-Cucapah_ Mexico”	“EJIDO SALTILLO”	7.2	242.05	strike slip	14.8	17.3	0.366
“Darfield_ New Zealand”	“Christchurch Cathedral College”	7	198	strike slip	19.89	19.9	0.3685
“Darfield_ New Zealand”	“Christchurch Hospital”	7	194	strike slip	18.4	18.4	0.366
“Darfield_ New Zealand”	“Papanui High School “	7	263.2	strike slip	18.73	18.7	0.386

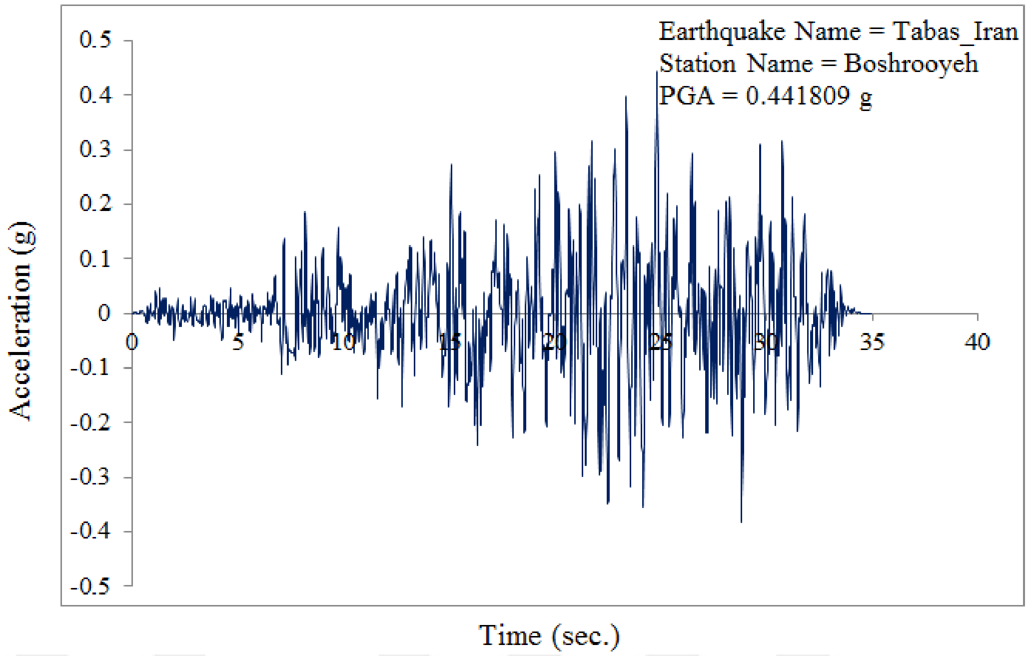

Figure 3.8 : Simulated accelerations from Tabas-Iran Earthquake record in H1 direction.

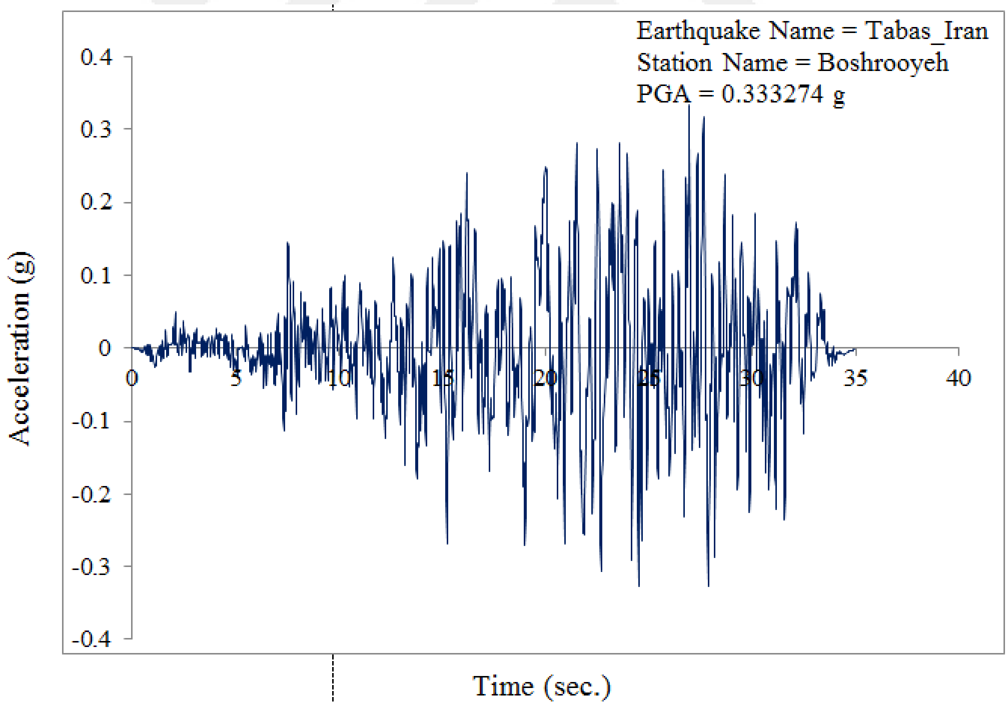

Figure 3.9 : Simulated accelerations from Tabas-Iran Earthquake record in H2 direction.

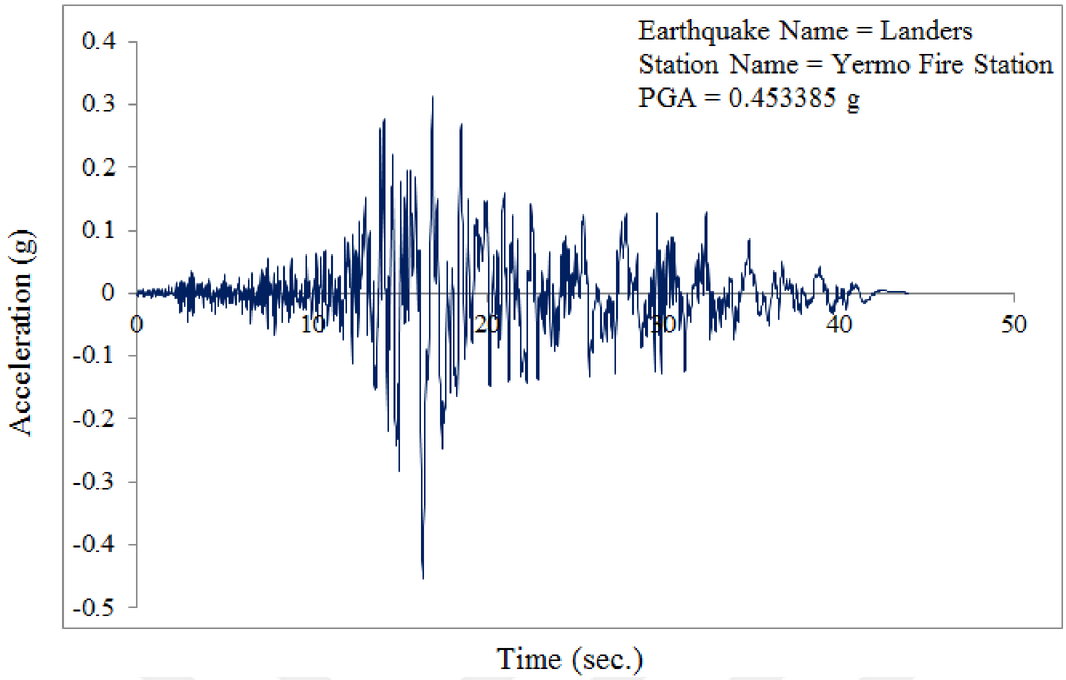

Figure 3.10 : Simulated accelerations from Landers Earthquake record in H1 direction.

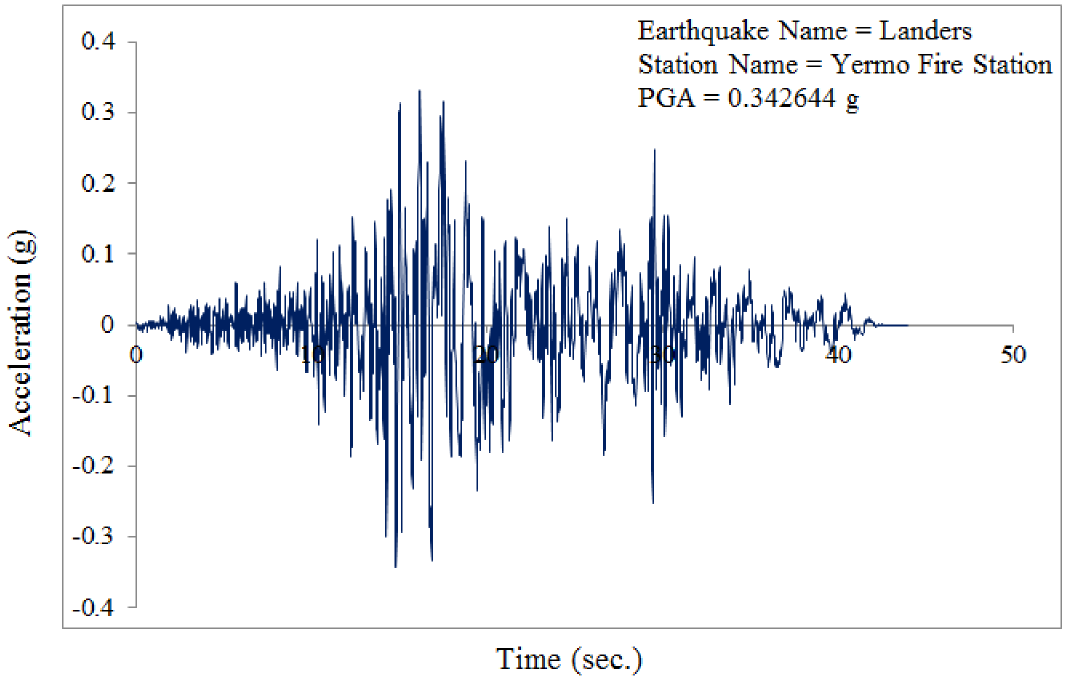

Figure 3.11 : Simulated accelerations from Landers Earthquake record in H2 direction.

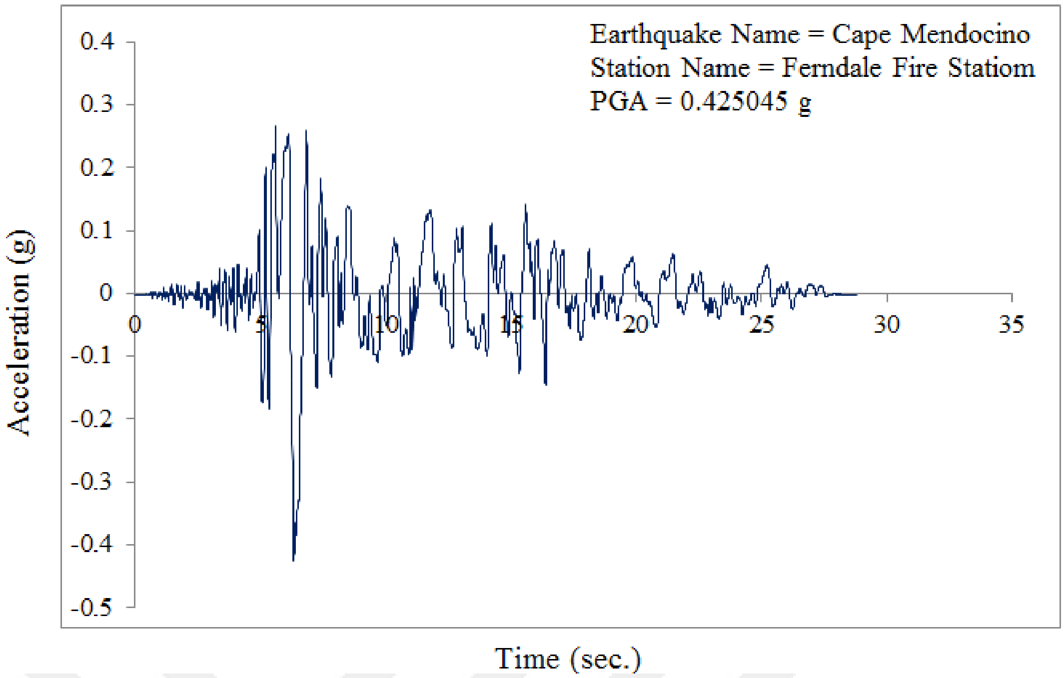

Figure 3.12 : Simulated accelerations from Cape Mendocino Earthquake record in H1 direction.

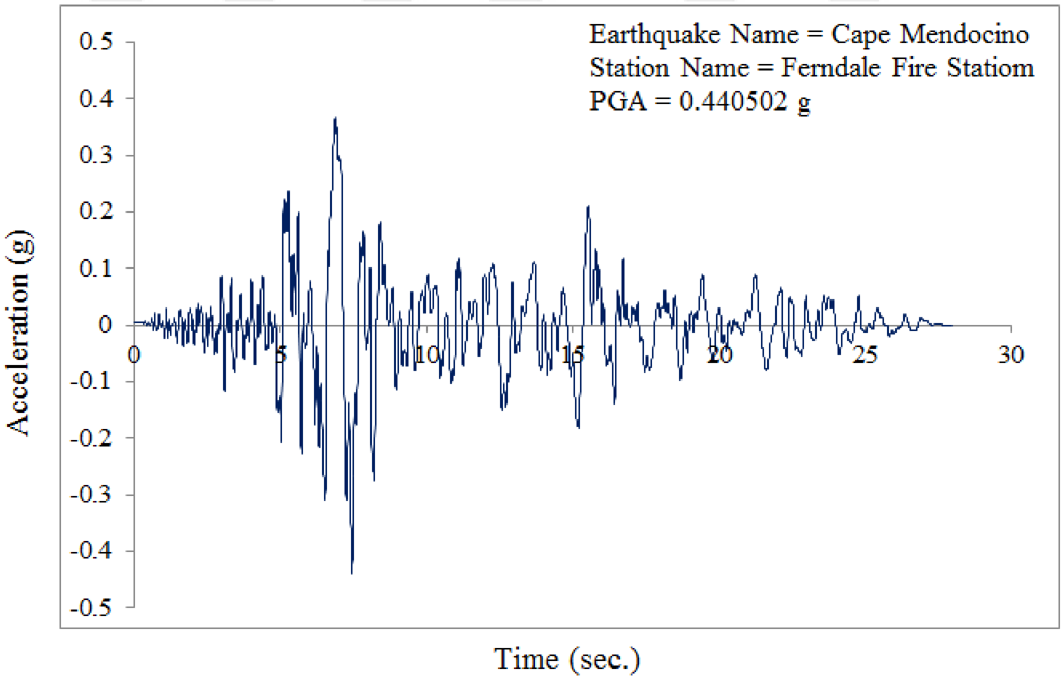

Figure 3.13 : Simulated accelerations from Cape Mendocino Earthquake record in H2 direction.

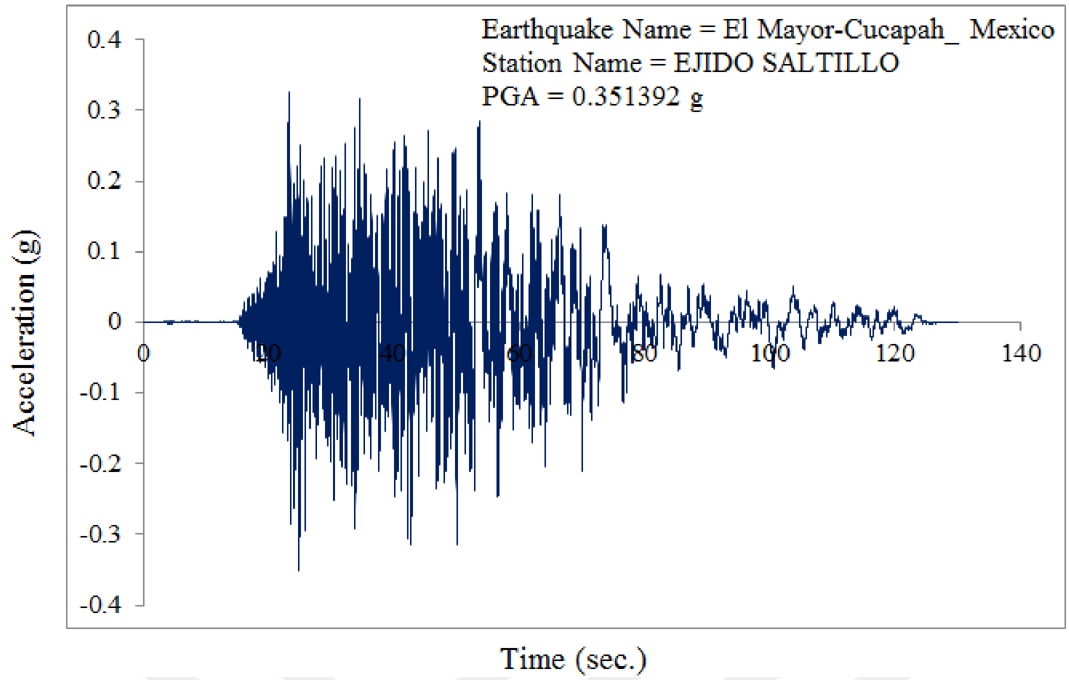

Figure 3.14 : Simulated accelerations from El Mayor-Cucapah_ Mexico Earthquake record in H1 direction.

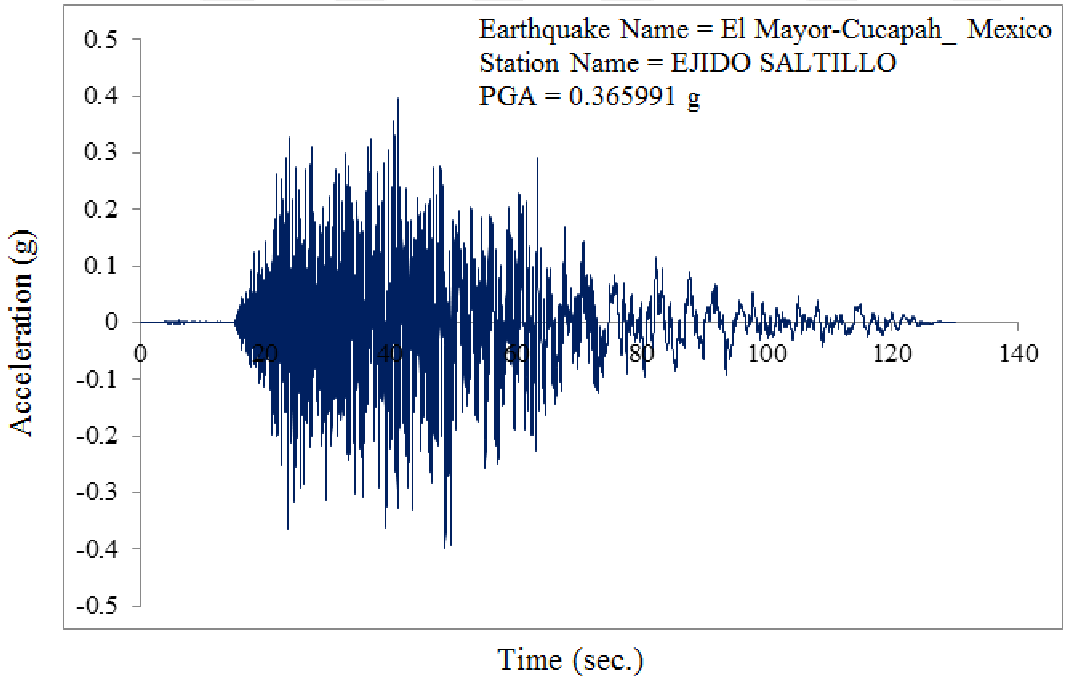

Figure 3.15 : Simulated accelerations from El Mayor-Cucapah_ Mexico Earthquake record in H2 direction.

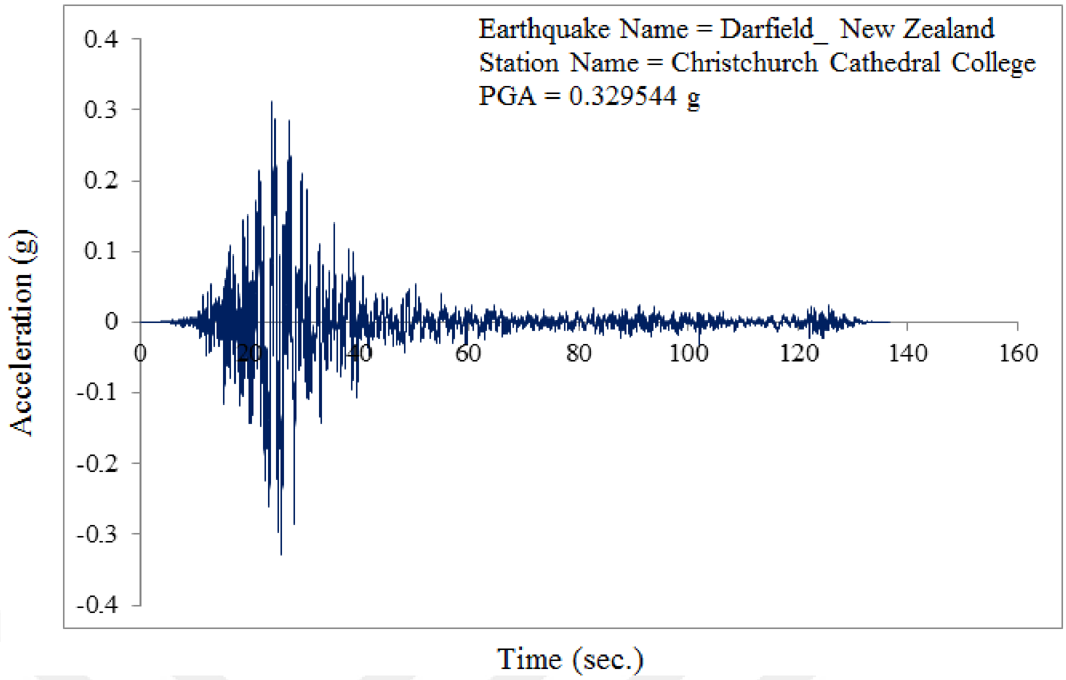

Figure 3.16 : Simulated accelerations from Darfield_ New Zealand Earthquake (from Christchurch Cathedral College Station) record in H1 direction.

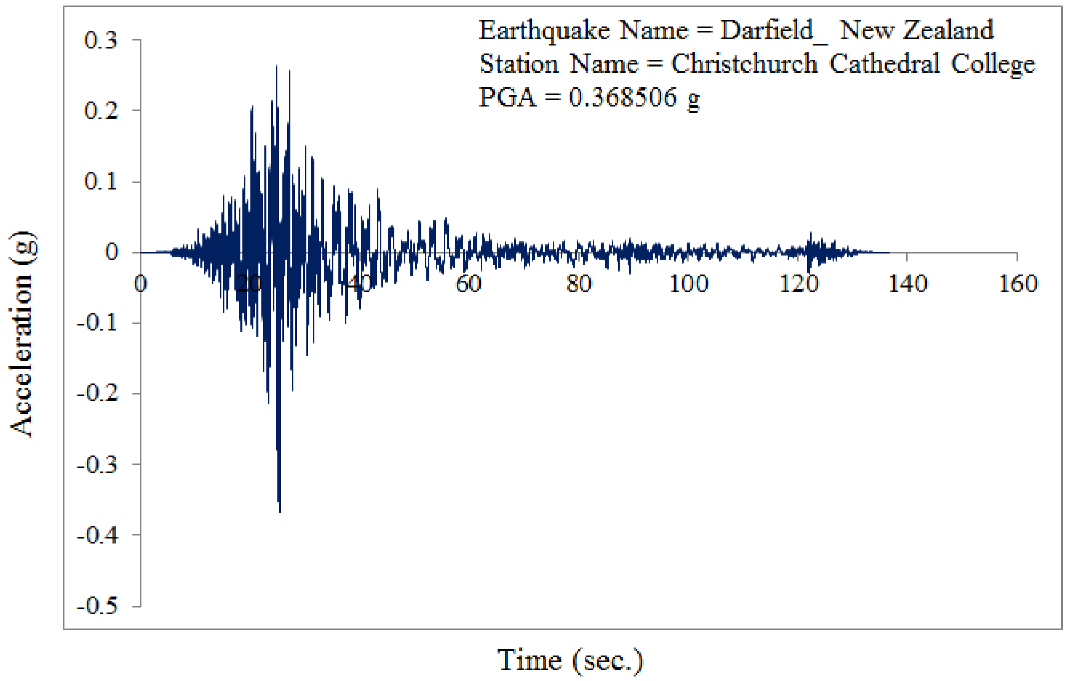

Figure 3.17 : Simulated accelerations from Darfield_ New Zealand Earthquake (from Christchurch Cathedral College Station) record in H2 direction.

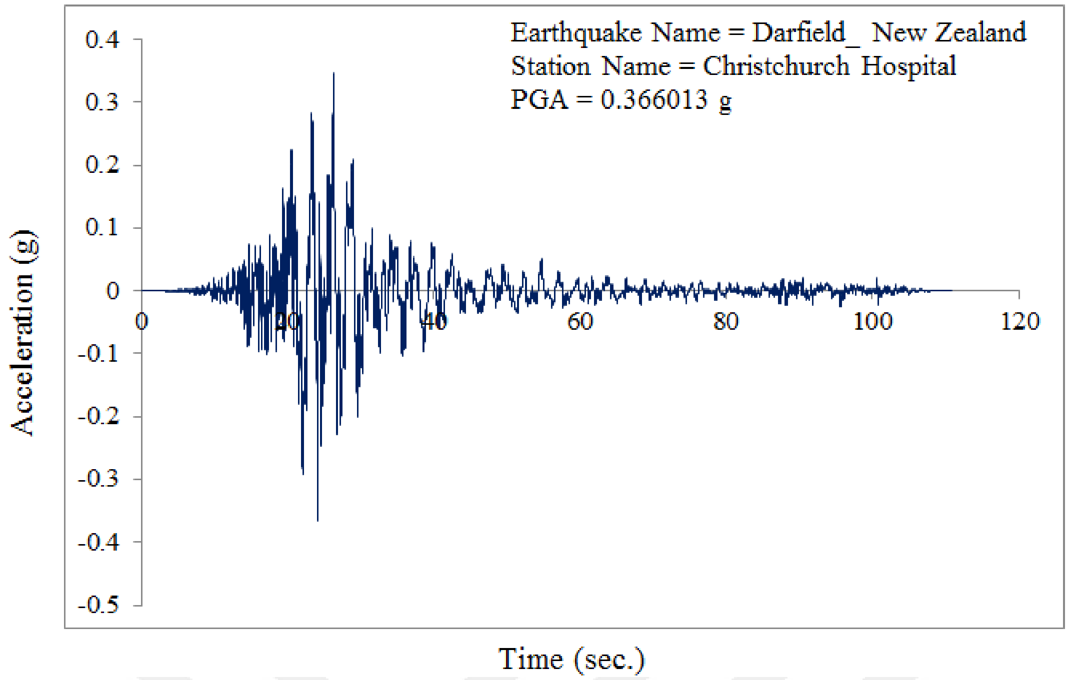

Figure 3.18 : Simulated accelerations from Darfield_ New Zealand Earthquake (from Christchurch Hospital Station) record in H1 direction.

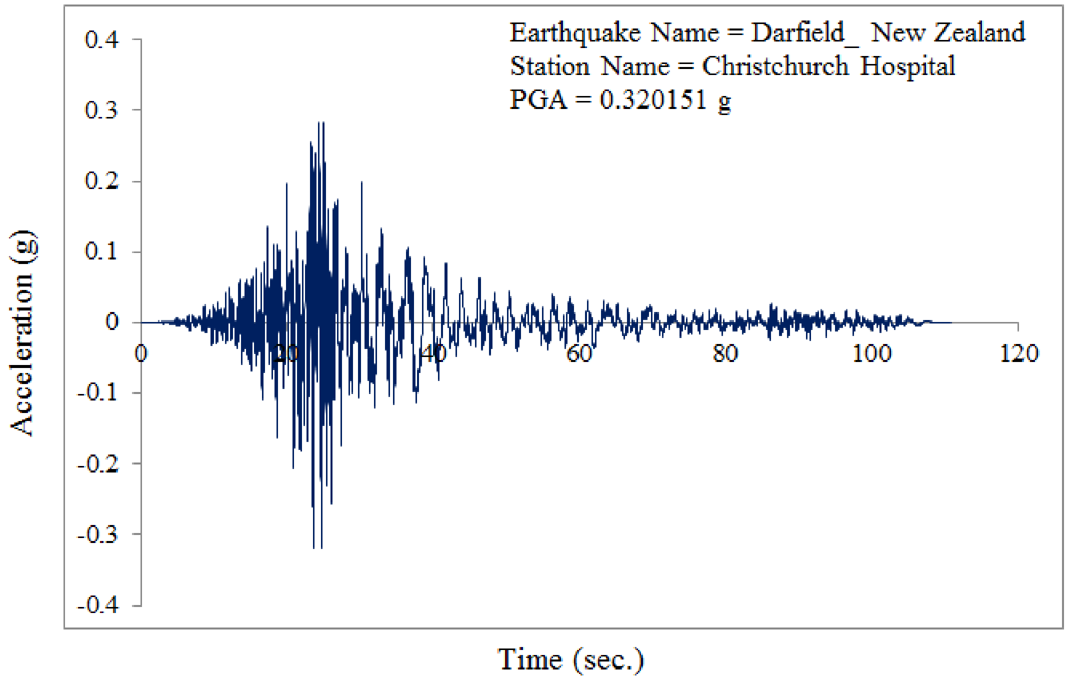

Figure 3.19 : Simulated accelerations from Darfield_ New Zealand Earthquake (from Christchurch Hospital Station) record in H2 direction.

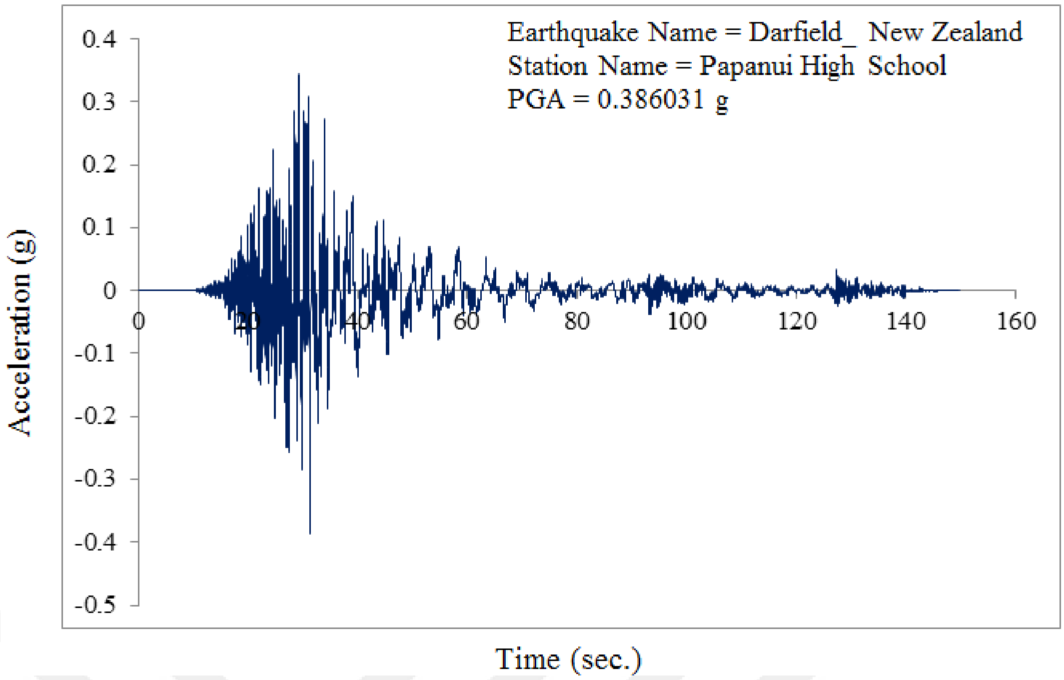

Figure 3.20 : Simulated accelerations from Darfield_ New Zealand Earthquake (from Papanui High School Station) record in H1 direction.

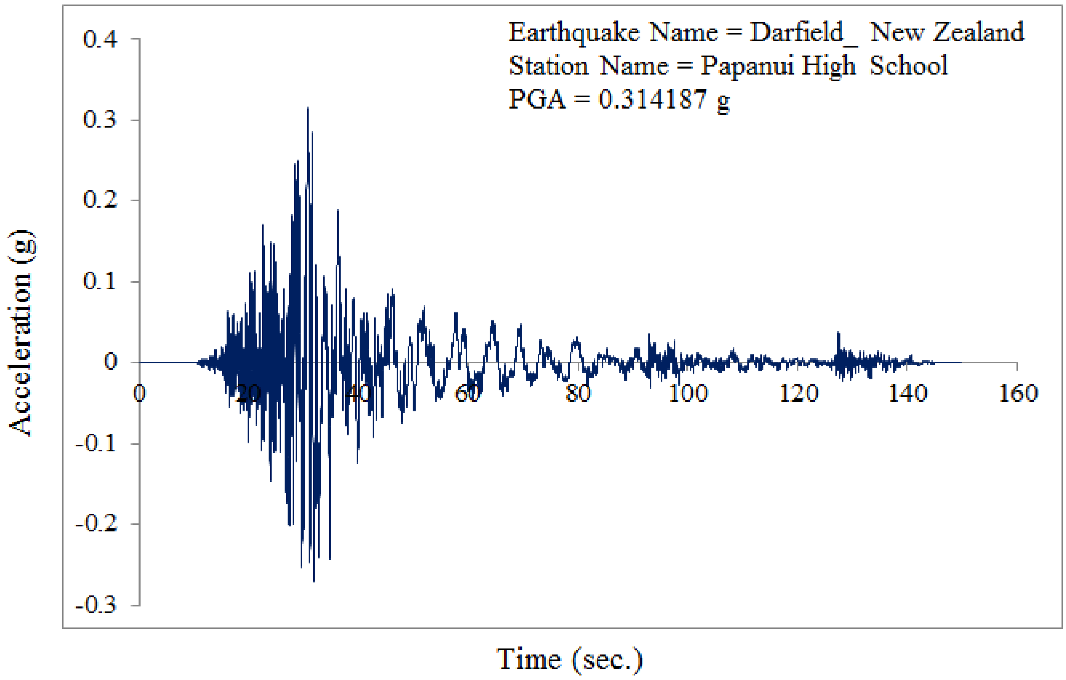

Figure 3.21 : Simulated accelerations from Darfield_ New Zealand Earthquake (from Papanui High School Station) record in H2 direction.

Where H1 is the one horizontal direction and the H2 is the another horizontal direction.

In Figure 3.20 unscaled and scaled acceleration response spectra of simultaed records are represented.

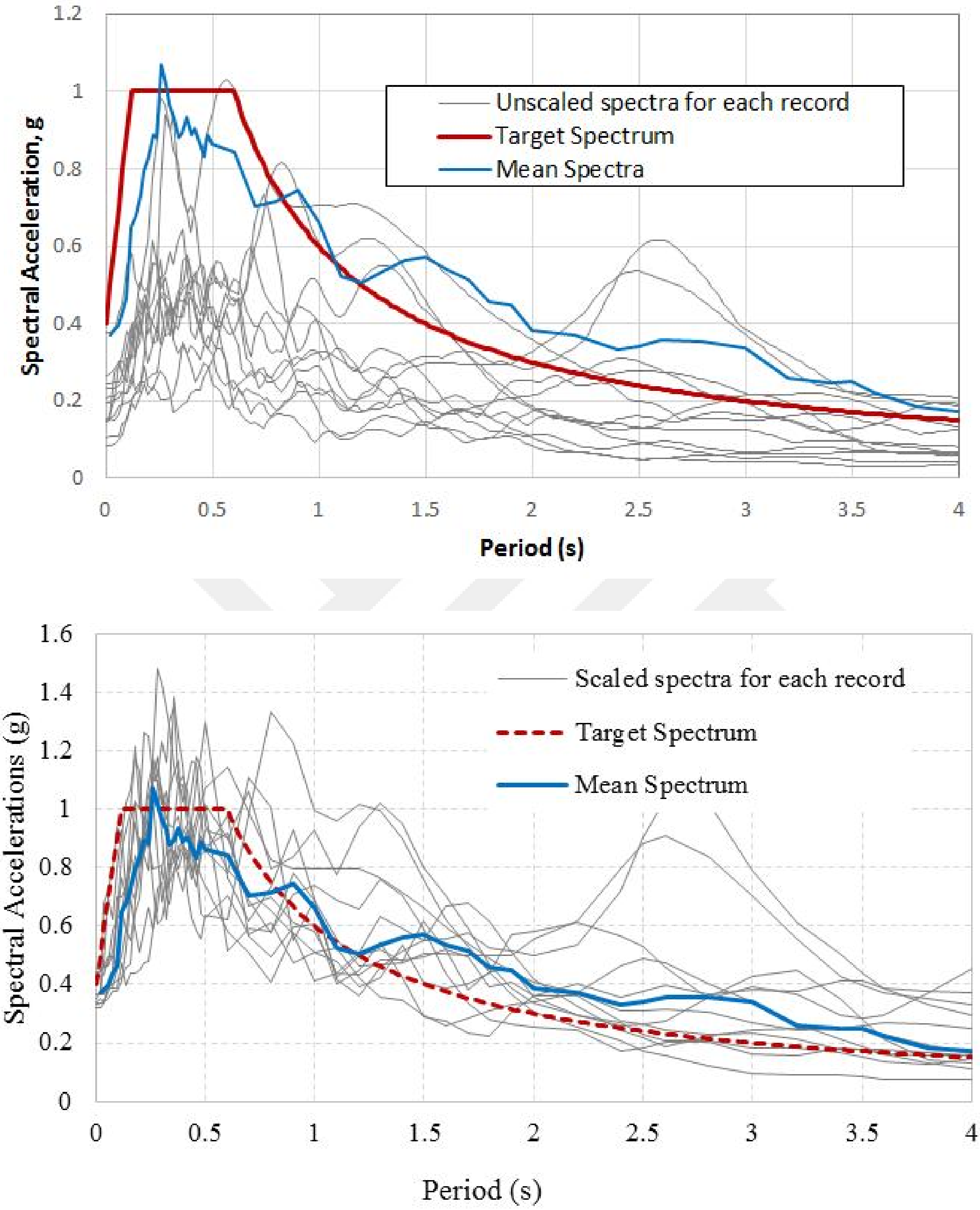

Figure 3.22 : Acceleration response spectra of simulated record.

Multiple earthquake scenarios are created with the simulated accelerations. First multiple earthquake case (Multiple EQ Case-1) is obtained from the combination of Landers - Yermo Fire Station, Darfield New Zealand – Papanui High School and Tabas Iran – Boshrooyeh. The acceleration graph is shown in Figure 3.25.

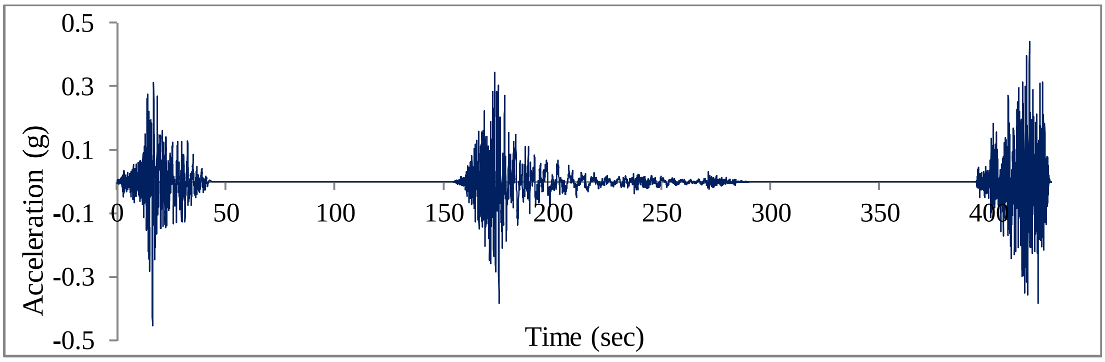

Figure 3.23 : Multiple EQ Case–1

Second multiple earthquake case (Multiple EQ Case-1) is obtained from the combination of Landers - Yermo Fire Station, Darfield New Zealand – Papanui High School and El Mayor Cucapah Mexico – Ejido Saltillo. The acceleration graph is shown in Figure 3.26.

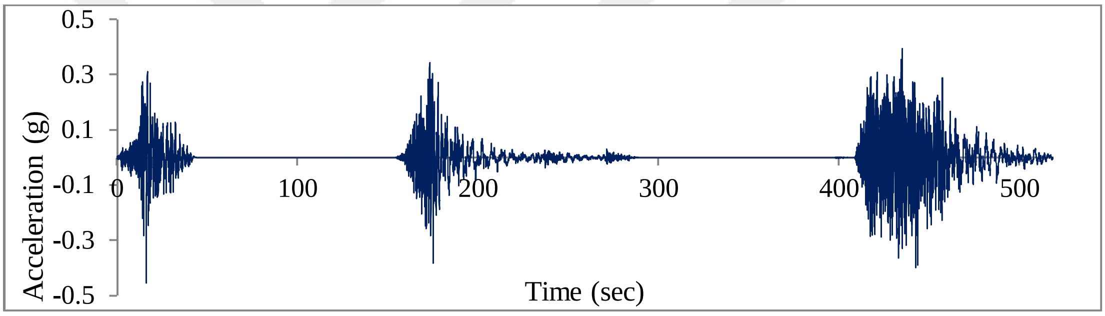

Figure 3.24 : Multiple EQ Case–2

Third multiple earthquake case (Multiple EQ Case-1) is obtained from the combination of Landers - Yermo Fire Station, Cape Mendocino and Darfield New Zealand Christchurch Cathedral College. The acceleration graph is shown in Figure 3.27.

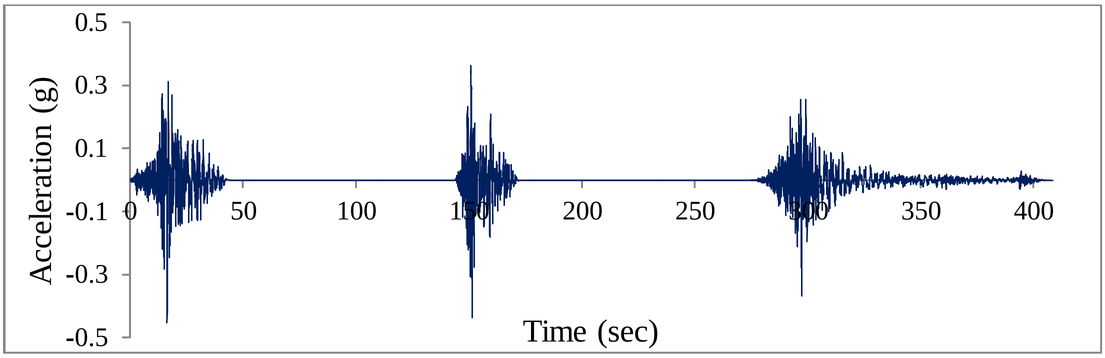

Figure 3.25 : Multiple EQ Case–3

4. ANALYTICAL STUDY

On many previous study, plasticity is assumed to be concentrated on pre-defined plastic hinge regions. This definition includes assumptions that do not exactly correspond to the actual behavior for the definition of plastic hinge regions. In order to avoid this, in the analysis model detailed below, fiber sections are used which allow the definition of distributed plasticity.

4.1 General Information About Studied Building

A school building in the Alaköy settlement of Van Center was examined in the scope of the study. The studied building was used as a school building and the structural system is a reinforced concrete moment frame system. The building, built in 1999, has 3 floors and the total height of the building is 7.95 meters. Axis alyout is represented in Figure 4.1.

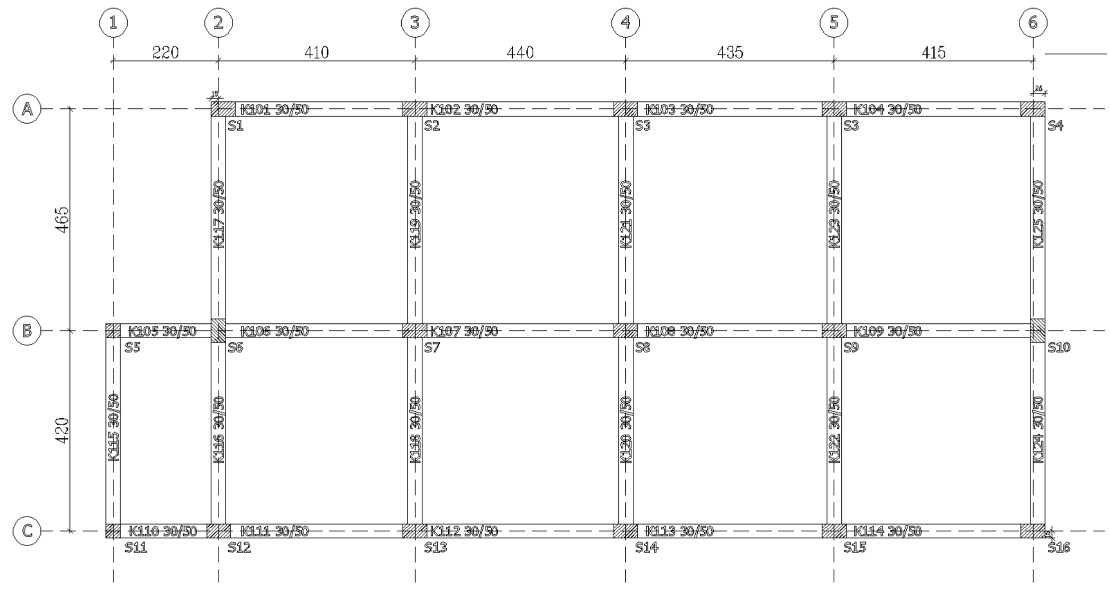

Figure 4.1 : Building typical floor view.

Beams are 30x50 dimensions with 2Φ12 (top) and 6Φ14 (bottom) reinforcement. Type 1 columns are 30x30 dimensions with 4Φ16 reinforcement and type 2 columnsa are 30x50 dimensions with 8Φ16 reinforcement. Column stirrups are Φ8/25. Element dimensions and reinforcement placements are taken from in-situ research. Figure 4.2 represents the damage of the building after earthquakes.

Figure 4.2 : Alaköy school building after earthquake.

Finite element models are obtained using with the frame elements in accordance with the building axis system. Figure 4.3 and Figure 4.4 show that the dimensions of the length of the elements.

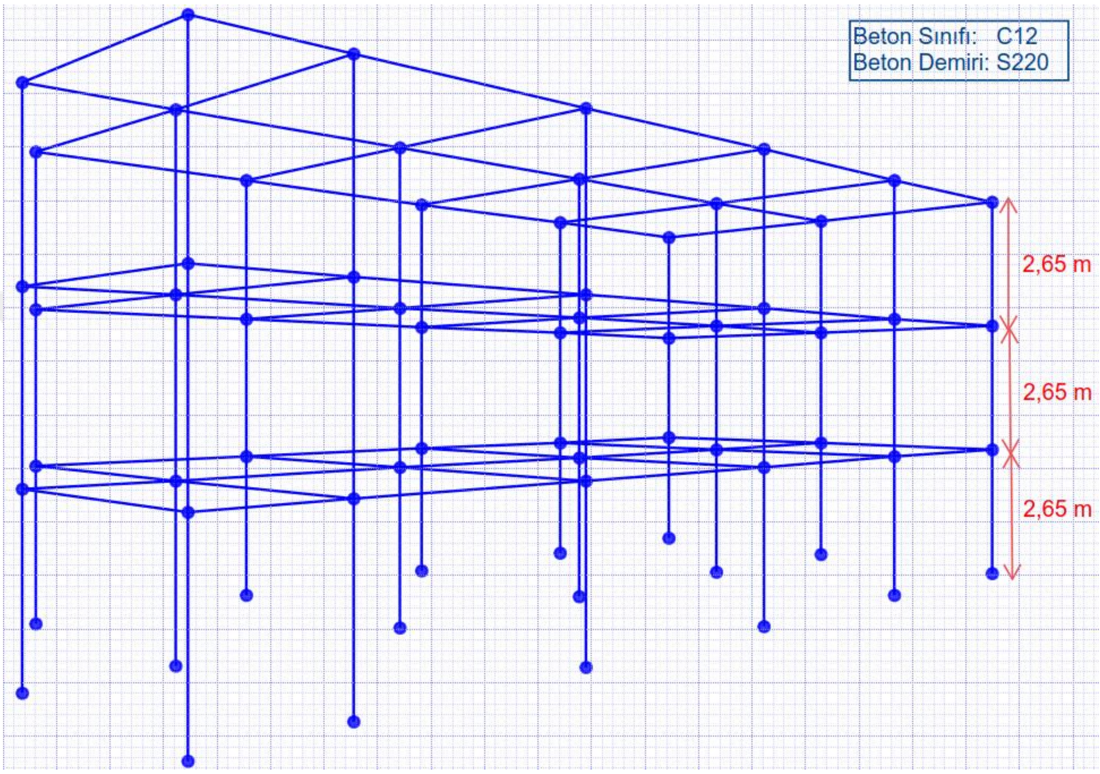

Figure 4.3 : Building general information and floor heights.

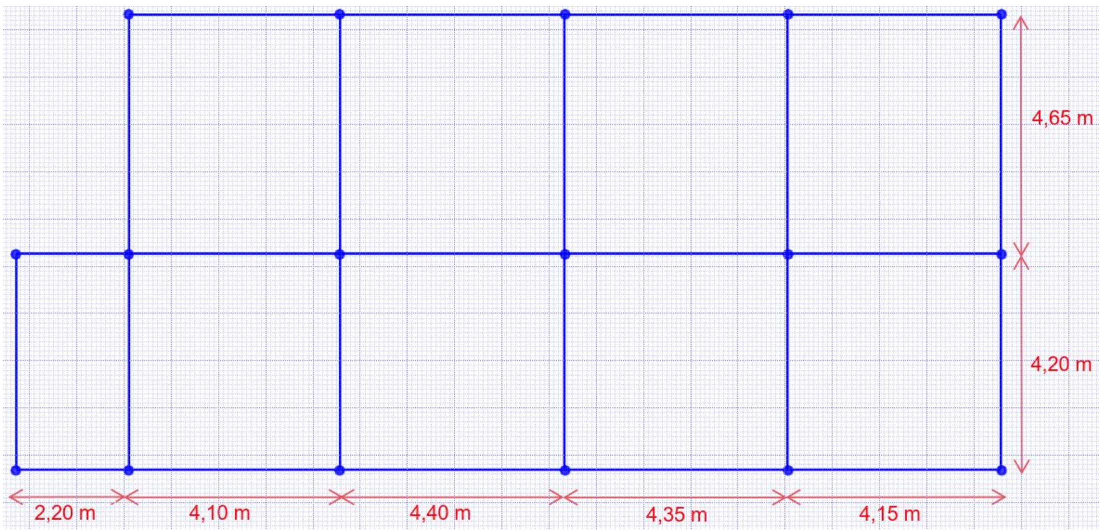

Figure 4.4 : Building plan dimensions.

Structure is modeled with both SAP2000 and ZeusNL with respect to releated dimensions and reinforcement configusations. 3D view of the models created in ZeusNL and SAP2000 are given Figure 4.5 and Figure 4.6 respectively.

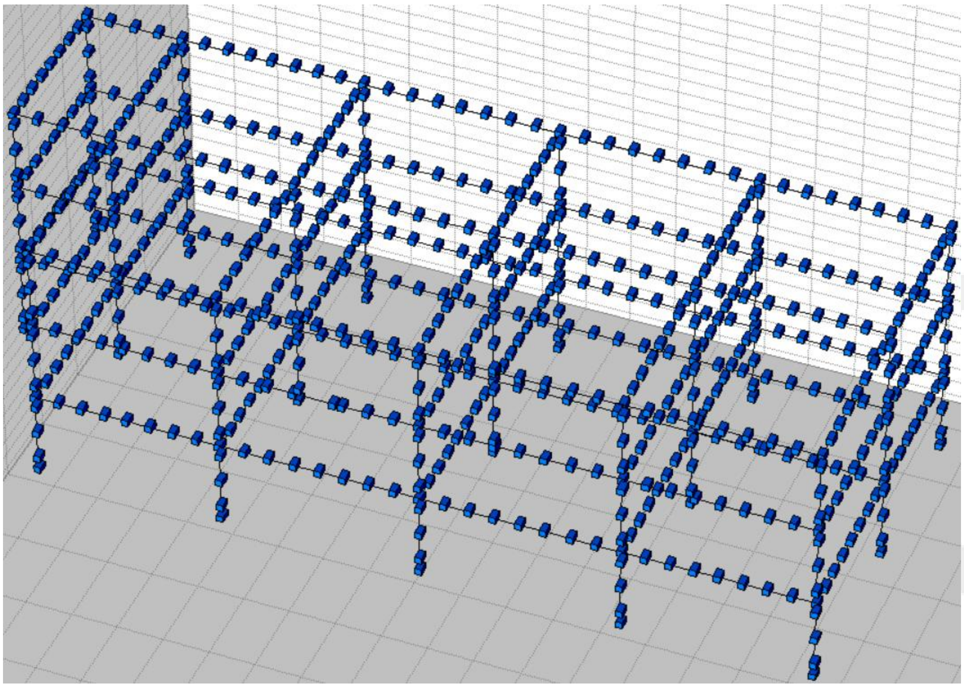

Figure 4.5 : 3D model in ZeusNL.

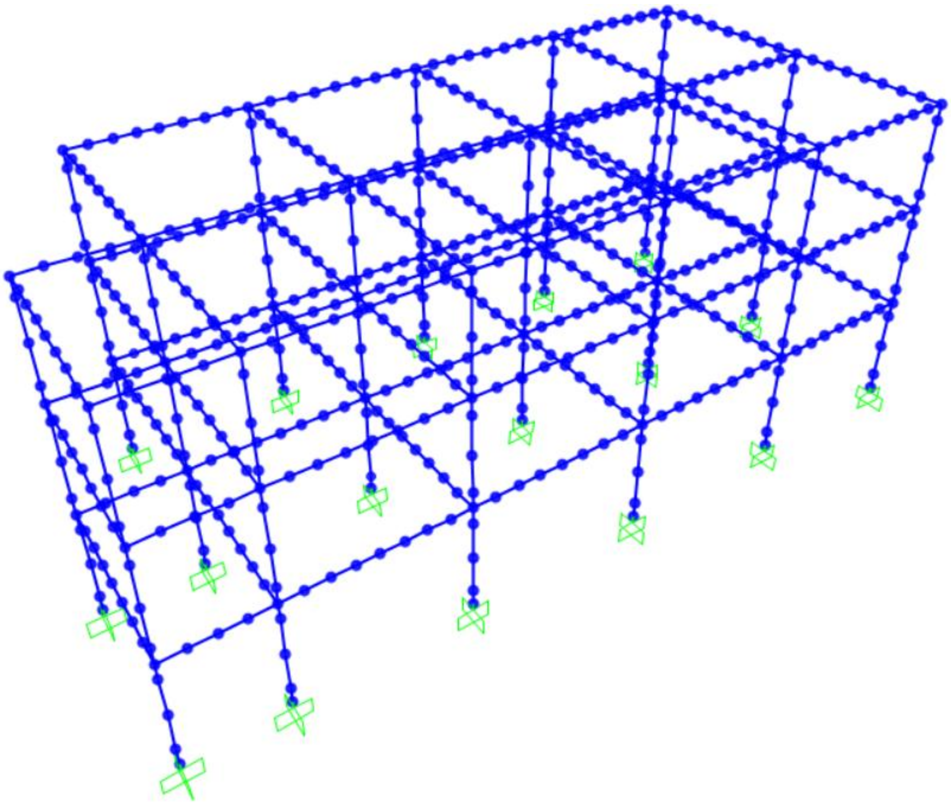

Figure 4.6 : 3D model in SAP2000.

4.2 Loads on Building

The buildings finite element model was built with the SAP2000 and ZeusNL programs. After the geometric properties defined in the programs, the related loads were defined. Accordingly, the weights of the elements are determined by taking the unit weight 25 kN/m^3 of the concrete. The calculated vertical loads are given to the beams as distributed loads. Beam naming used to assign loads are given in Figure 4.7, Figure 4.7 and Figure 4.9. Load values for each beam are submitted in the appendixes as a table.

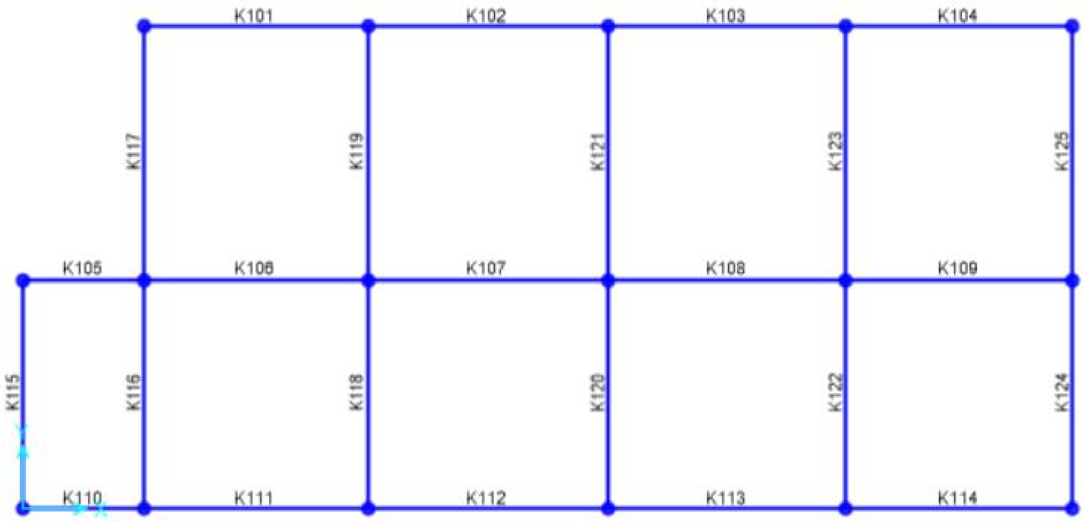

Figure 4.7 : First floor beam names.

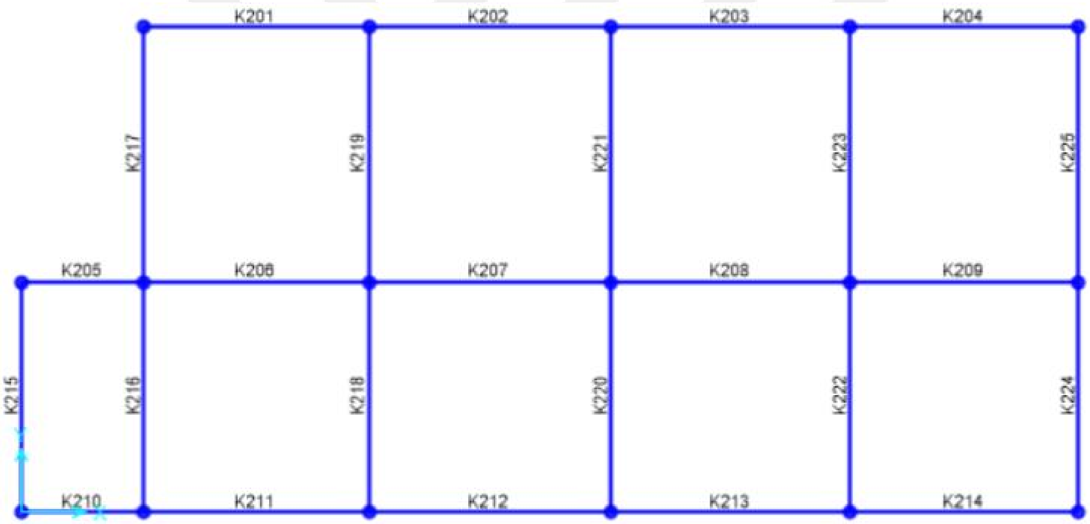

Figure 4.8 : Second floor beam names.

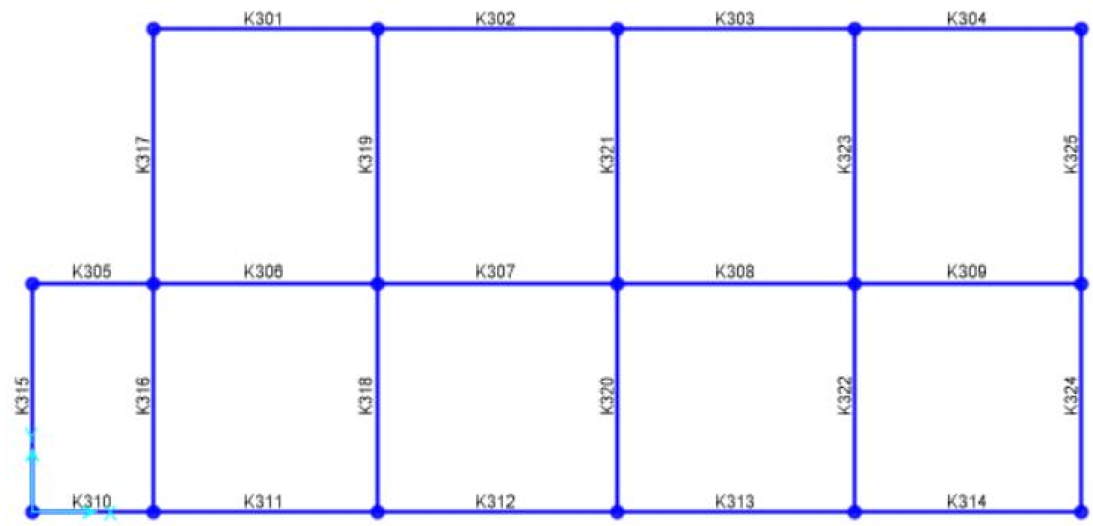

Figure 4.9 : Third floor beam names.

Floor loads are 3 kN/m^2 is taken on all stories. The first and second floor live loads are 3.5 kN/m^2 and the last floor live loads is 1,85 kN/m^2. Alaköy is approximately 20 km away from the center of Van and its altitude is 1700 meters. The snow loads are calculated according to TS 498 for Alaköy. Internal and external wall loads are calculated as 5,035 kN/m depending on floor height.

4.3 Material Models

The finite element model of the studied structure is obtained with both conventinal material model definition and degraded material model definition. The Mander model (Mander et al., 1986) and bilinear steel model is used as the conventional material model. In the second analysis, the stiffness deterioration of concrete (Lee and Fenves, 1998) and the inelastic buckling effect of the longitudinal reinforcement (Gomes and Appleton, 1997) are considered.

4.3.1 Conventional material models

4.3.1.1 Uniaxial confined concrete model

Nonlinear constant confinement concrete model is defined con2 with ZeusNL based on Mander Model (Mander et al., 1986). The main principle of this model is to consider the confinement effect of the transverse reinforcement of the stress-strain relationship of concrete under uniaxial compressive loadings. Confined and unconfined concrete compressive stress and compressive strength curve developed by Mander et al., 19998 is represented in Figure 4.10.

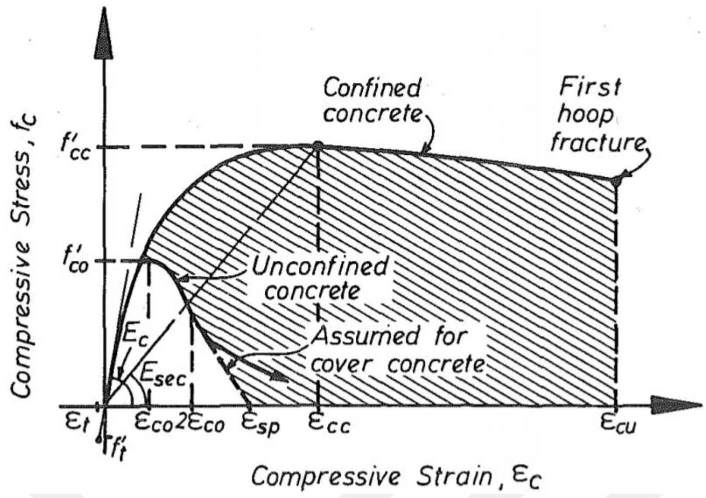

Figure 4.10 : Stress-strain curve for confined and confined concrete (Mander et al., 1998).

4.3.1.2 Bilinear elastoplastic steel model

The bilinear elastic perfectly plastic steel model is defined with stl1 in ZeusNL. This model is defined with the young’s modulus (E), yield strength (σ_y) and the strain-hardening parameter (µ) as follows. Accordingly stress-strain curve remains elastic till yield point. After that point curve values increases with the strain factor. Biliniear elastoplastic steel stress-strain relationship is given in Figure 4.11.

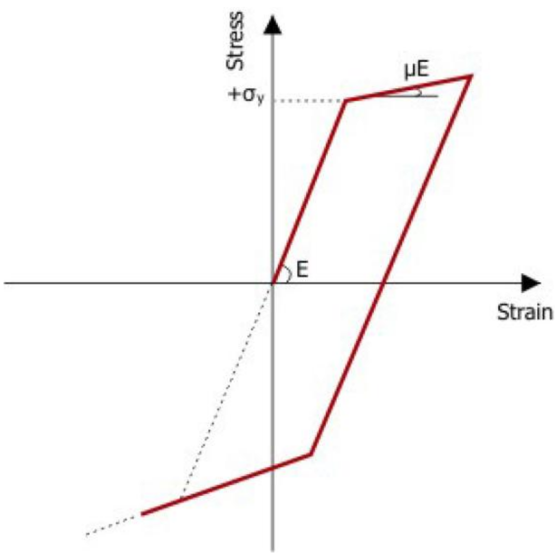

Figure 4.11 : Stress-strain curve for bilinear elastoplastic steel (Zeus, Version 1.9.0).

4.3.2 Degrading material models

4.3.2.1 Plastic-damaged concrete model

A plastic-damaged concrete model is applied to ZeusNL software by Abdelnaby (2012) according to fracture-energy-based damage and stiffness degradation in continuum damage mechanism developed by Lee and Fenves (1998).

Two damage hardening variables are described to calculate different damage states under tensile and compressive stresses. A degradation model was introduced to simulate the effect of damage on elastic stifness and its recovery during carck opening and closure. Strength deterioration was modeled by using the effective stress of cracked concrete to control the progress of the yield surface. Stiffness and strength degradation was defined with the thermodynamically consistent scalar model.

Lee and Fenves compared the numerical solutions of cyclic uniaxial loading with experimental results. This comparison resuslts are represented in Figure 4.12.

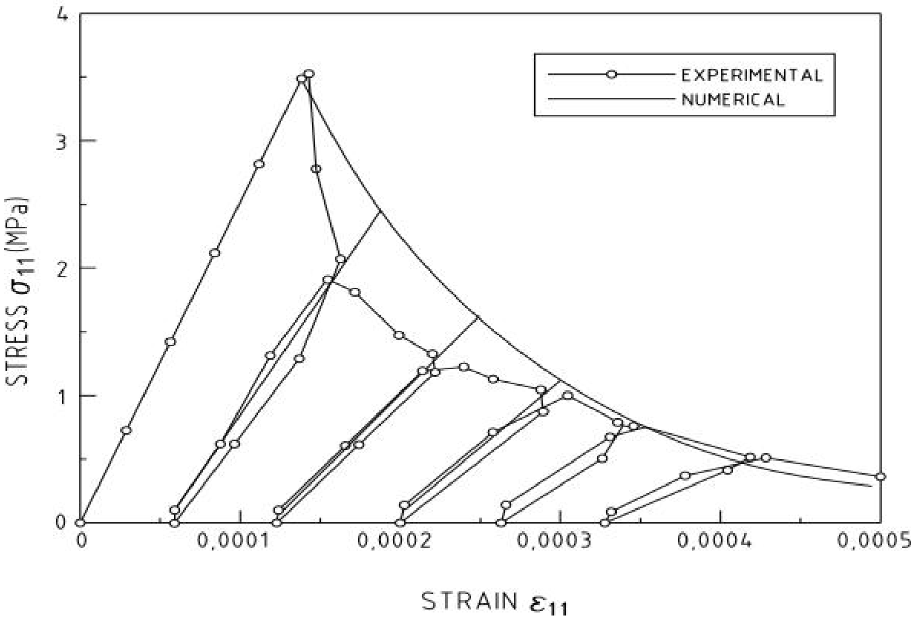

Figure 4.12 : Comparison of numerical and experimental results of the concrete model for tension (Lee and Fenves, 1998).

Abdelnaby (2012) defined the stress-strain curve which considers the stiffness and strength degradation for concrete under cyclic axial, linearly increasing, sinusoidal strain loading in ZeusNL software. Uniaxial stress-strain curve of concrete model developed by Abdelnaby,2012 is shown in Figure 4.13.

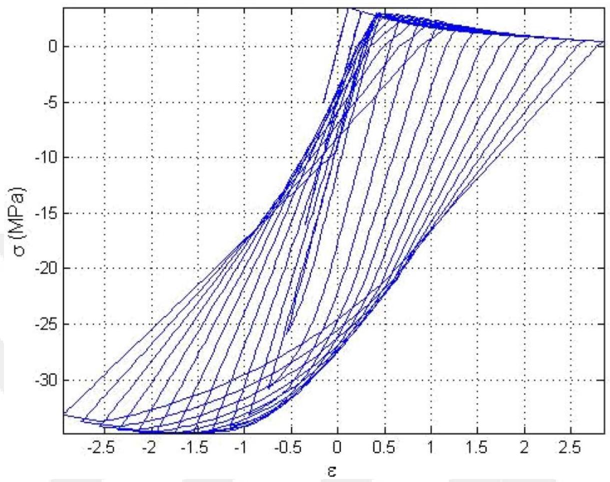

Figure 4.13 : Uniaxial stress-strain response of the concrete model that implemented in the analytical tool under the name of conc5 (Abdelnaby,2012).

In ZeusNL, conventional concrete model and degraded concrete model are defined with names of con2 and con5 respectively. The comparison of these model is given in the Figure 4.14.

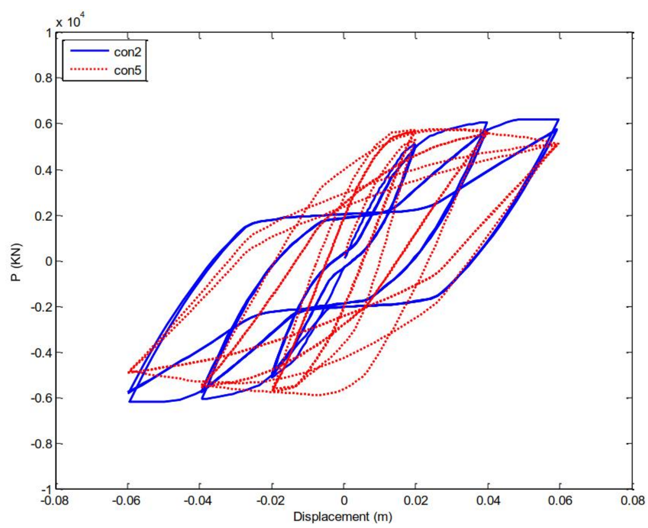

Figure 4.14 : Concrete material models comparison con2 and con5 (Abdelnaby,2012).

4.3.2.2 Modified Menegotto-Pinto model

Gomes and Appleton (1997) made a modification to the cyclic stress-strain relationship of the steel developed by Menegotto-Pinto (1973), taking into account the inelastic buckling effect of the longitudinal reinforcement. Acoording to this model steel stress-strain diagram should have the following properties;

a) First cycle has elastic branch, yield plateau and strain hardening branch
b) Baushinger effect which consist of reduction of the yield stress after a reverse which increases with the enlargement of the plastic strain component of the last excursion and decrease of the curvature in the transition zone between the elastic and the plastic branches
c) Isotropic strain hardening which consists of an increase of the envelope curve, proportional to the plastic strain component of the last excursion
d) Reinforcing bars has inelastic buckling after concrete cover crushing
e) Reinforcing bars fracture after the ultimate strain is exceeded under any cycle

Stress-strain curve of a steel model is shown Figure 4.15.

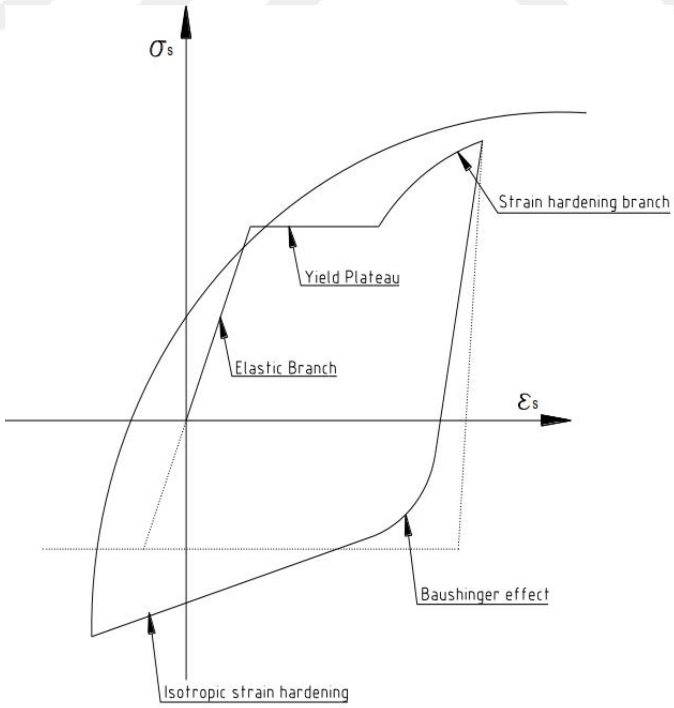

Figure 4.15 : Main characteristics of a steel stress-strain diagram (Gomes and Appleton, 1997).

According to this model, the stresses and strain changes during loading and unloading are determined by following the steps below.

$$\sigma_s^* = \beta\varepsilon_s^* + (1-\beta)\frac{\varepsilon_s^*}{[1+(\varepsilon_s^*)^R]^{1/R}} \tag{3.1}$$

Where,

ε_s* = normalized strain,

σ_s* = normalized stress,

$\beta = E_{s1}/E_s$, ratio between the hardening stiffness E_{s1} and the tangent modulus of elasticity at the origin $E_{s,}$

R = constant taking into account the Baushinger effect.

$$R = R_o - \frac{a_1\xi}{a_2+\xi} \tag{3.2}$$

Where,

ξ = absolute value of the plastic strain of the last cycle

R_0, a_1 and a_2 = material constants.

$$\varepsilon_s^* = \varepsilon_s / \varepsilon_{so} \tag{3.3}$$

$$\sigma_s^* = \sigma_s / \sigma_{so} \tag{3.4}$$

After the first load is reversed by,

$$\varepsilon_s^* = \varepsilon_s - \varepsilon_{sa} / 2\varepsilon_{so} \tag{3.5}$$

$$\sigma_s^* = \sigma_s - \sigma_{sa} / 2\sigma_{so} \tag{3.6}$$

Filippou et al. (1983) improved two modification to the Menegotto-Pinto Model due to it does not take into account isotropic strain hardening.

$$\varepsilon_s^* = \frac{\varepsilon_s - \varepsilon_{sa}}{\varepsilon_{s1} - \varepsilon_{sa}} \tag{3.7}$$

$$\sigma_s^* = \frac{\sigma_s - \sigma_{sa}}{\sigma_{s1} - \sigma_{sa}} \tag{3.8}$$

Hardening envelope is defined by the yield stress (σ_{so}^{e}) after a load reversal.

$$\sigma_{so}^{e} = \sigma_{so} a_3 \left(\frac{\varepsilon_{s\max}}{\varepsilon_{so}} - a_4\right) \quad (3.9)$$

Where,

εsmax = maximum absolute strain value before the load reverse,

a3 and a4 = material constants.

All material constants are defined in the model compatibly with the Gomes and Appleton (1997) and Filippou et al. (1983).

This model is also developed to consider buckling effect of the longitudinal reinforcement bars by calibrating the experimental results. Buckled bars equilibrium is determined by the following formula.

$$P = \frac{2M_p}{w} \quad (3.10)$$

Equilibrium of a buckled longitudinal steel bar is represented in Figure 4.16.

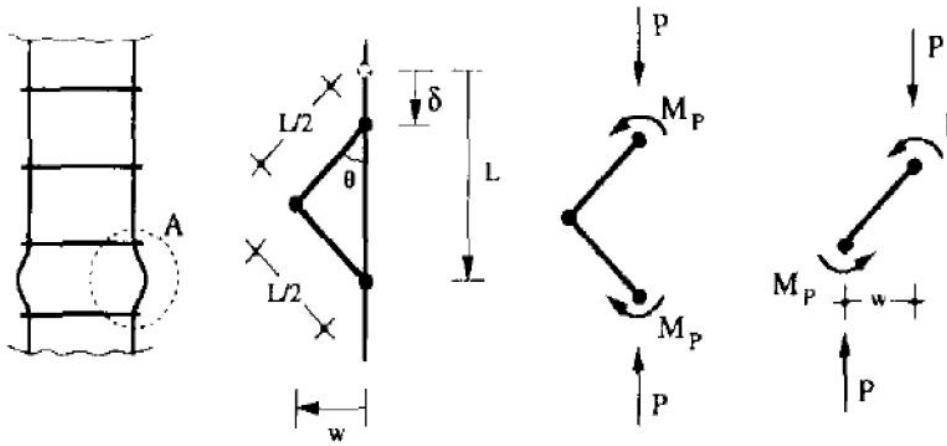

Figure 4.16 : Equilibrium of a buckled longitudinal steel bar (Gomes and Appleton, 1997).

The relation between the transversal displacement w, the longitudinal displacement δ and the rigid body rotation θ are given below.

$$w = L/2\sin\theta \quad (3.11)$$

$$\delta = L(1 - \cos\theta) \quad (3.12)$$

$$w = \sqrt{\frac{\delta L}{2}} \tag{3.13}$$

$$P = \frac{2\sqrt{2}M_p}{\sqrt{L}} \frac{1}{\sqrt{\delta}} \tag{3.14}$$

The average strain between the two transverse bars and the stress in the bar can be calculated as follows.

$$\varepsilon_s = \delta / L \tag{3.15}$$

$$\sigma_s = P / A_s \tag{3.16}$$

$$\sigma_s = \frac{2\sqrt{2}M_p}{\sqrt{L}} \frac{1}{\sqrt{\varepsilon_s}} \tag{3.17}$$

Modified Menegotto-Pinto steel stress-strain curve is defined with a name of stl4 in ZeusNL with the modulus of elasticity, yield strength, yield strain, ultimate strain and R parameter which simulates the Baushinger effect and the material constants. This models parameters and stress-strain relation is represented in Figure 4.17.

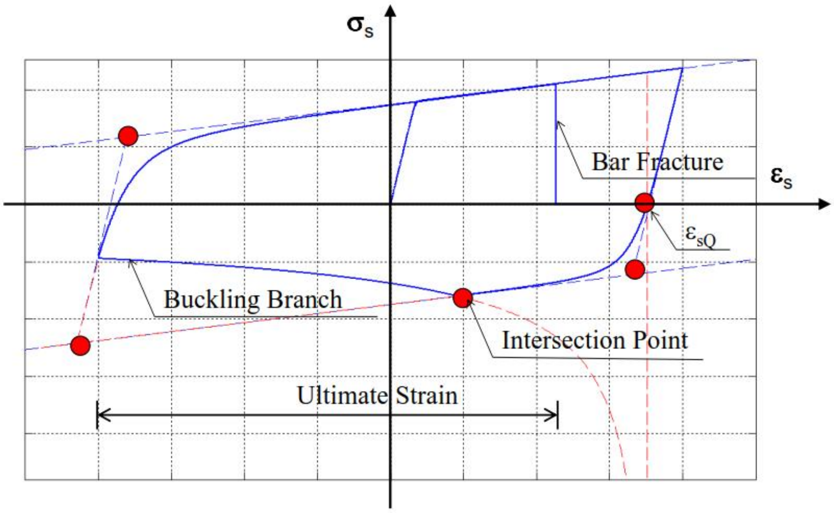

Figure 4.17 : Buckling and fracture implementation in the steel model (Abdelnaby, 2012).

In ZeusNL, conventional steel model and degraded steel model are defined with names of stl2 and stl4 respectively The comparison of these model is given in the Figure 4.18.

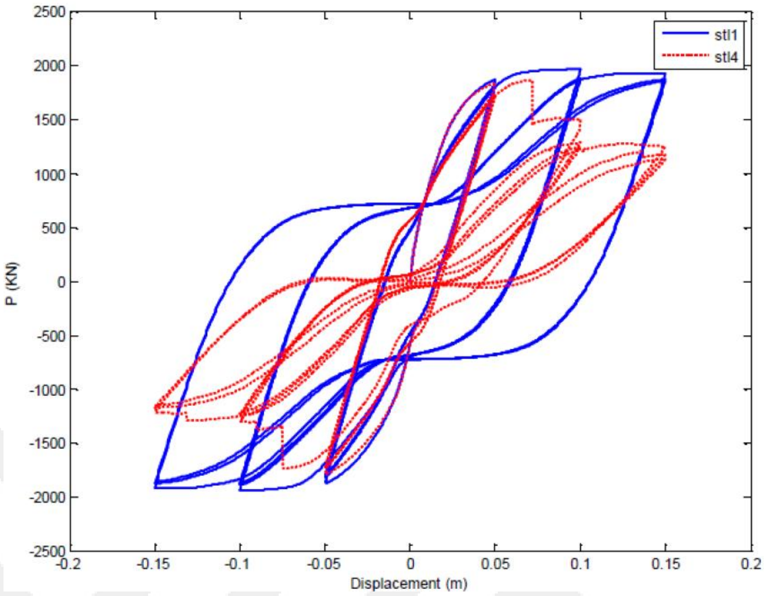

Figure 4.18 : Comparison of the steel models stl1 and stl4 (Abdelnaby, 2012).

4.4 Fiber Section Definition

Fiber-based nonlinear elements allow the distributed plasticity along the member length at certain control points. The cross-section of the elements is discretized into smaller subregions which are fibers. Cyclic stress-strain models are assigned to each fiber related with the material models. The cyclic response of the elements cross-section is obtained from the stress-strain behavior of the discrete fibers.

The main objective of fiber section definition is to obtain flexural hysteretic behavior with stress-strain relationship obtained from material models and section geometry instead of moment-curvature responses. The most critical step for this is the division of element into subdivisions. This process can be done as shown in Figure 4.19 until the division does not affect the result. Difference between lumped plasticity model and distributed model is represented in Figure 4.20.

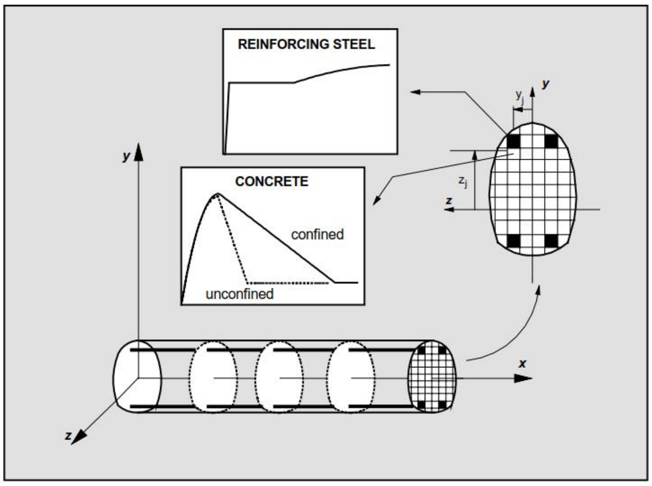

Figure 4.19 : Distribution of control sections and section subdivison into fibers (Taucer et al, 1991).

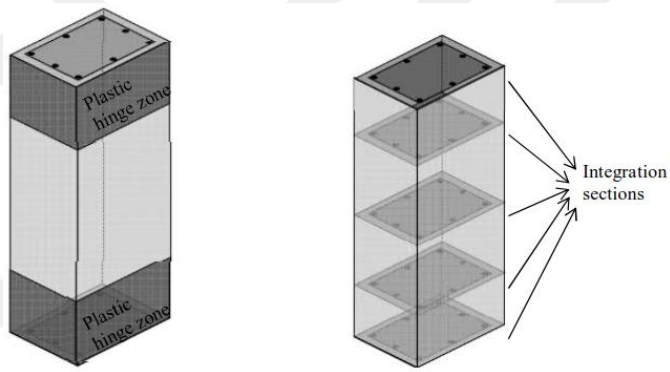

Figure 4.20 : Lumped plasticity (a) and distributed plasticity (b) approaches.

4.5 Damping

One of the parameter that casuses the energy loss during motion is the damping. In the mathemetical models of the building Rayleigh damping is used. Rayleigh damping is proportional mass and stiffness.

$C = a_0m + a_1k$ (Chopra, 2007, 11.4.7)

a_0 and a_1 are calculated to obtain a specified value of damping in any mode with the equation given below;

$a_0 = 2\zeta_i\omega_i$ (Chopra,2007, 11.4.4)

$a_1 = 2\zeta_i / \omega_i$ (Chopra,2007, 11.4.6)

(where ζ is the damping ratio and ω is the circular frequency for related mode)

Stiffness-proportional damping appeals to intuition be because it can be interpreted to model tyhe energy dissipation arising from story deformations. On contrast, mass-proportional damping is difficult to justify physically because tha air damping it can be interpreted to model is negligibly small for most structures (Chopra, 2007). Variation of modal damping ratios with natural frequency is shown in Figure 4.21. First curve is mass-proportional damping and stiffness-proportional damping, second curve Rayleigh damping.

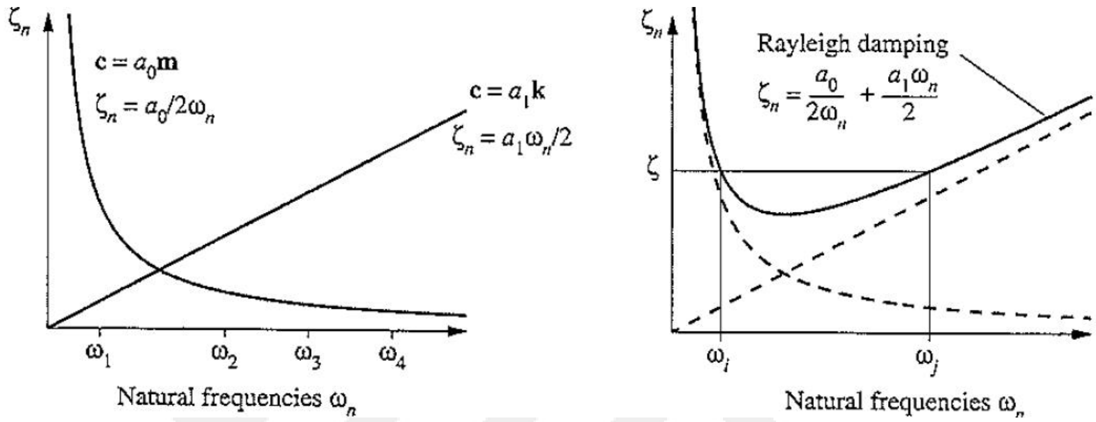

Figure 4.21 : Variation of modal damping ratios with natural frequency (Chopra, 2007).

4.6 Finite Element Programs

The mathematical model of the building is modeled using the SAP2000 analysis program with the geometrical and material properties. Thus, the modal periods of the building are determined. In nonlinear analysis, the ZeusNL program developed by the University of Illinois is used to take into account the degradation of the material. ZeusNL can be used to predict the large displacement bevaior of plane and space frames under static or dynamic loading, taking into account both geometric and material nonlinear behavior. For dynamic analysis process, Newmark integration algorithms is used with ZeusNL. The spread of inelasticity along member length and across section depth is explicitly modeled in ZeusNL allowing or accurate estimation of damage accumulation. This feature sets ZeusNL apart from most of the similar tools that use lamped inelasticity to model the members' nonlinear behavior (Zeus, Version 1.9.0). The mathematical model of the studied building is created in ZesNL as shown in Figure 4.22.

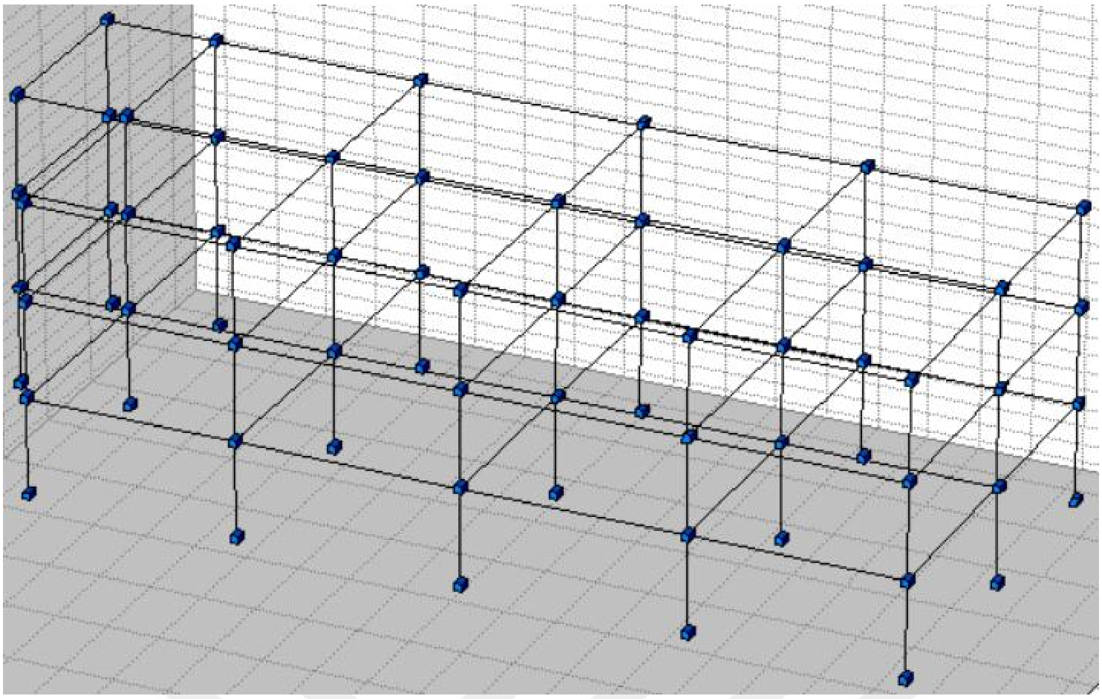

Figure 4.22 : 3D model of building with ZeusNL.

Element models are modeled as a frame systems using with 3D cubic elasto-plastic beam-column elements, with 200 monitoring points in ZeusNL. Each elements have three nodes with Euler-Bernoulli formulation. The elements were divided into subelements to capture the high inelasticity accurately close to the beam-column joints. All beam and column members are divided into 4 sub-elements. The lengths of the elemens are 0.15L near the beam-column joints and 0.35 L other parts, where L is the length of the member. This division procedure is represented in Figure 4.23.

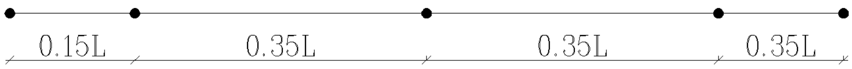

Figure 4.23 : Division of the elements.

Figure 4.23 represents the subdivisions of the elements.

Lumped masses are assigned at the beam nodes' to capture the fundamental periods and vibration modes of the structure. Mass values are calculated with the dead loads (DL) and live loads (LL) with the reduction factor. Reduction factor(n) is determined in accordance with TEC (2007) (DL + 0.6xLL).

Figure 4.23 represents the subdivisions of the elements.

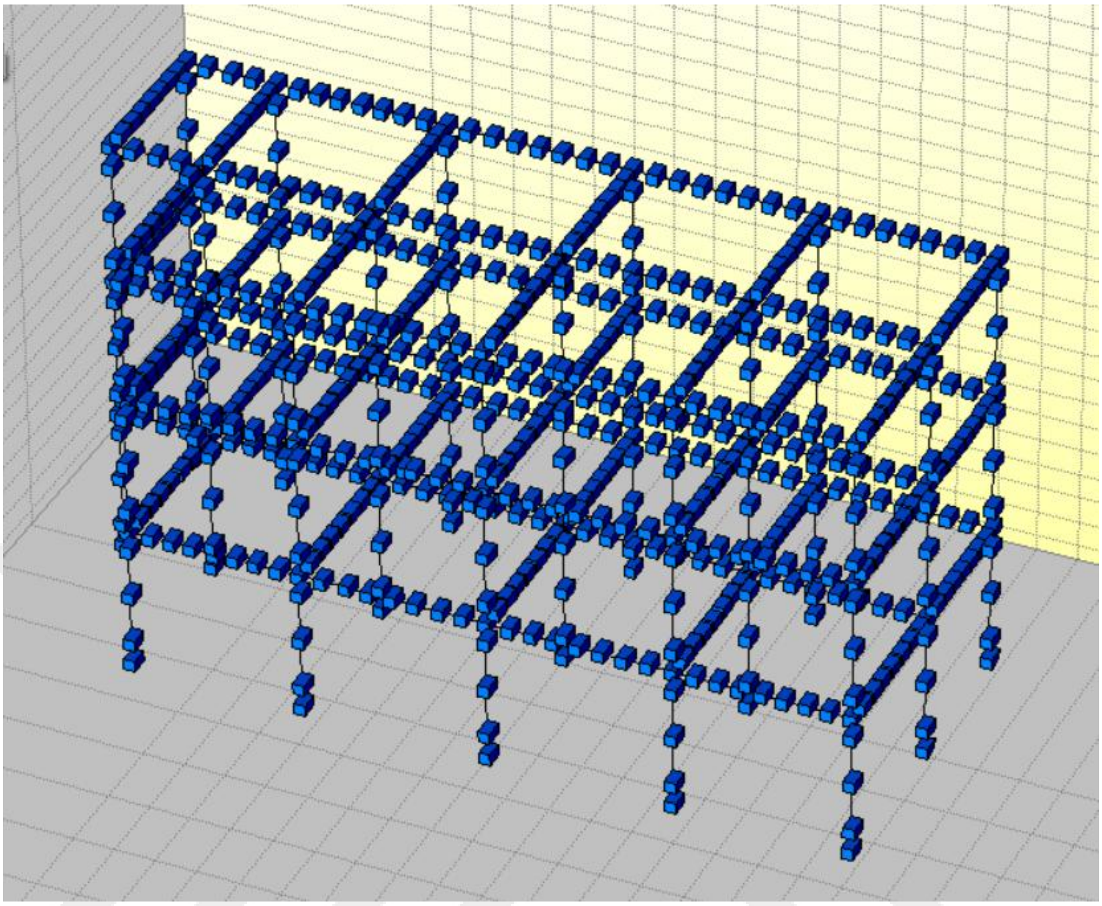

Figure 4.24 : Subdivisions of elements with ZeusNL.

5. DISCUSSIONS AND RESULTS

The finite element models of the building are completed as described in the previous section and eigenvalue analyses are performed with SAP2000 and ZeusNL. Afterwards, dynamic time history analyses are performed to capture the effect of material degradation effect under multiple earthquakes.

5.1 Eigenvalue Analyses

Eigenvalue analyes The mode values obtained in both programs are compared as follows. First three modes results are represented in Figure 4.24, Figure 4.23, Figure 4.24, Figure 4.25, Figure 4.26 and Figure 4.29.

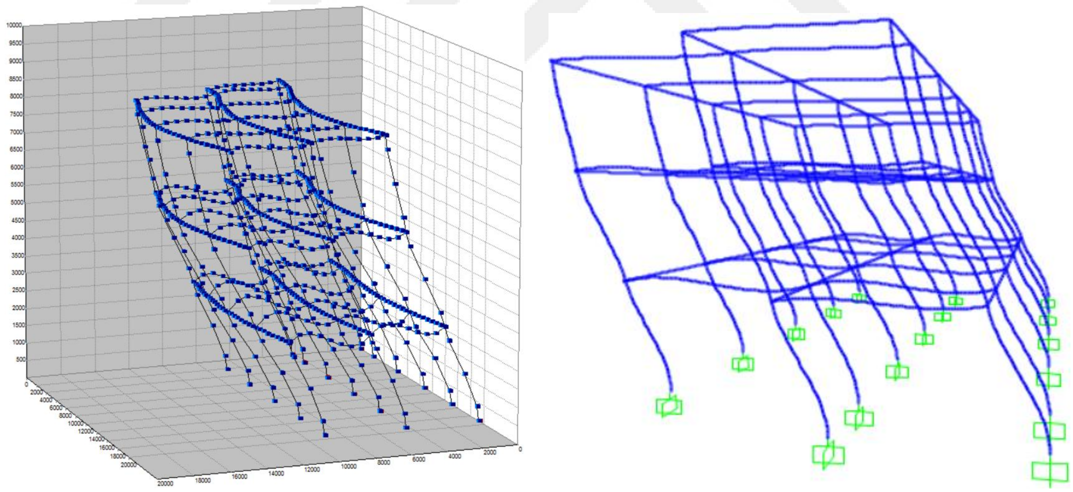

Figure 4.25 : First mode shape (T_{zeus} = 0.427 sec, T_{sap} = 0.444 sec)

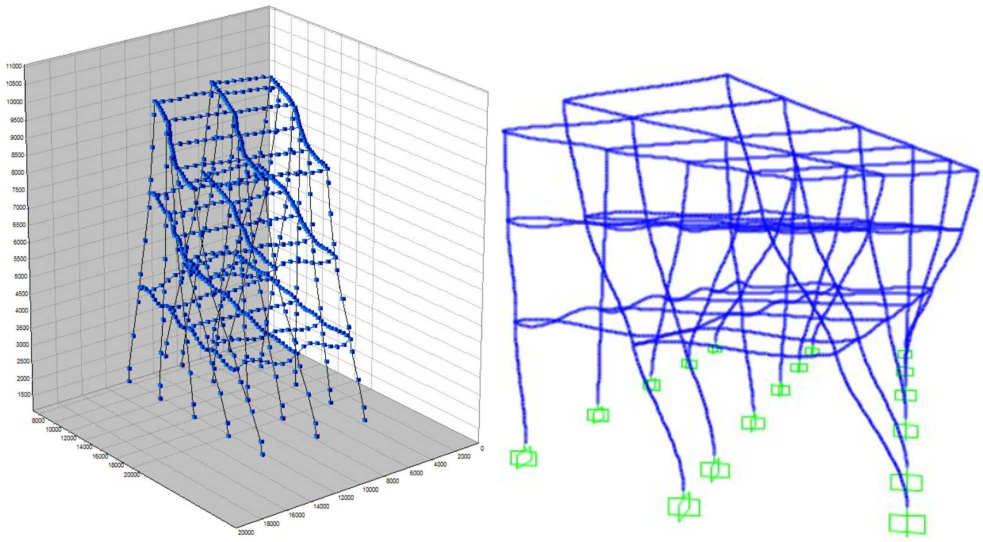

Figure 4.26 : Second mode shape (T_{zeus} = 0.337 sec, T_{sap} = 0.347 sec)

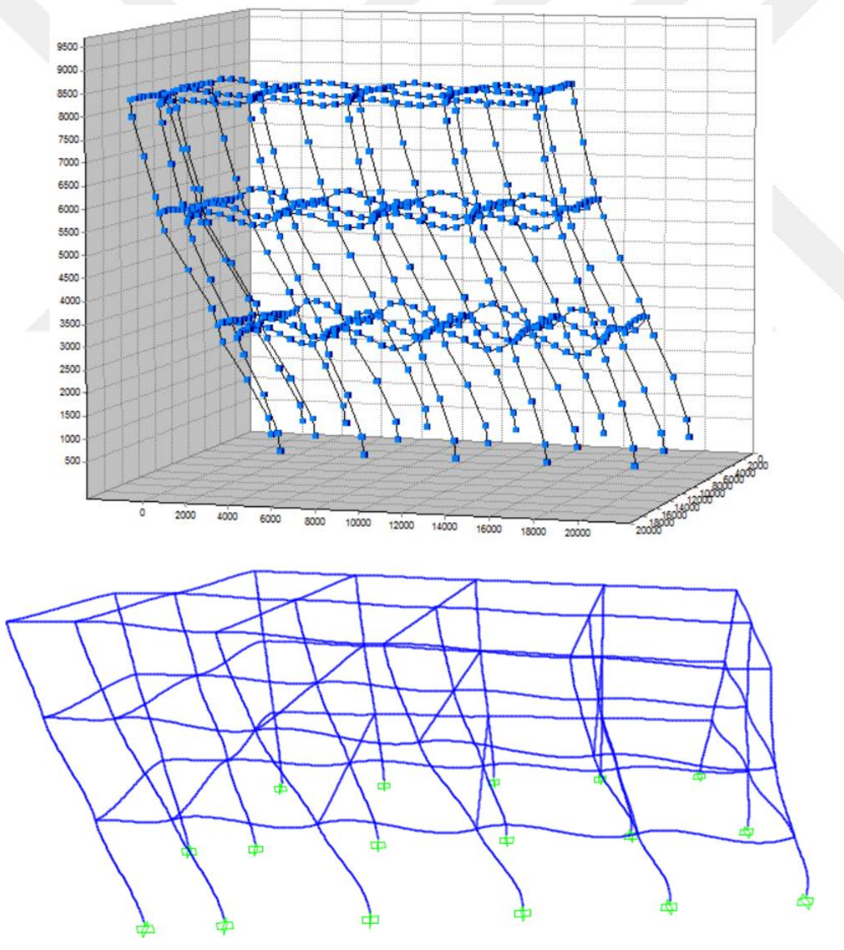

Figure 4.27 : Third mode shape (T_{zeus} = 0.329 sec, T_{sap} = 0.341 sec)

5.2 Dynamic Time-History Analyses

Time-history analyses were performed with the conventional material model using with the Newmark Time Stepping Method according to Chopra, 2007. Analyses were repeated using with the combination of main shock and aftershocks in order to observe the multiple earthquake effects on the degraded material model. Each earthquake scenarios (Multiple EQ Case-1, Multiple EQ Case-2 and Multiple EQ Case-3) were applied to the both conventional material model and degraded material model. Top displacement time-histories were examined and compared. Residual displacements did not occur or very limited in the conventional material models. However, the increment of residual displacements is obtained in degraded models after the aftershocks.

Figure 4.28, Figure 4.29 and Figure 4.30 represent the comparison of conventional material model and degraded material model under multiple earthquakes effects.

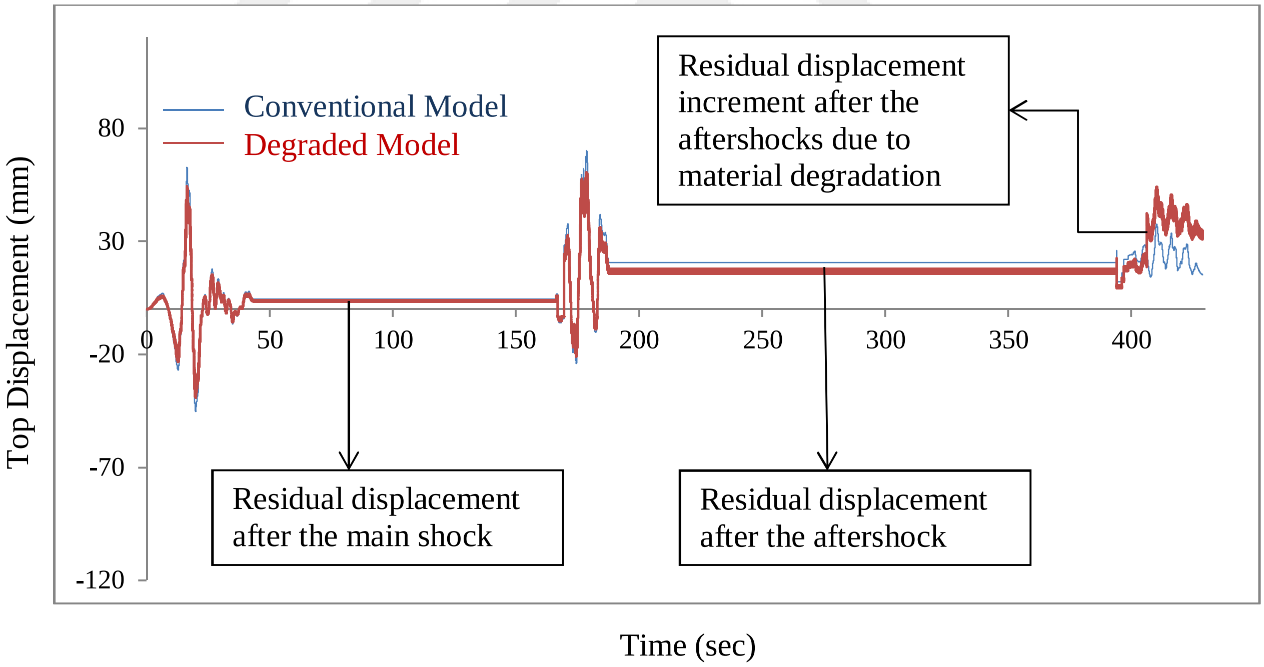

Figure 4.28 : Top displacement time-history (Multiple EQ Case–1 record)

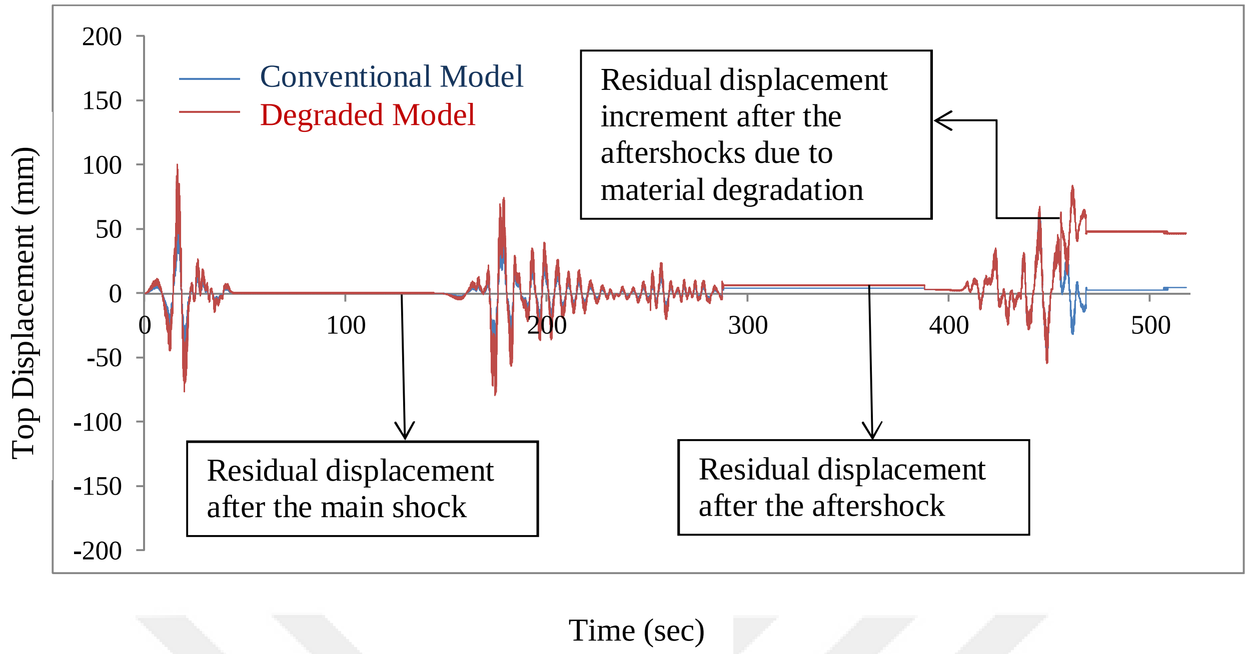

Figure 4.29 : Top displacement time-history (Multiple EQ Case–2 record)

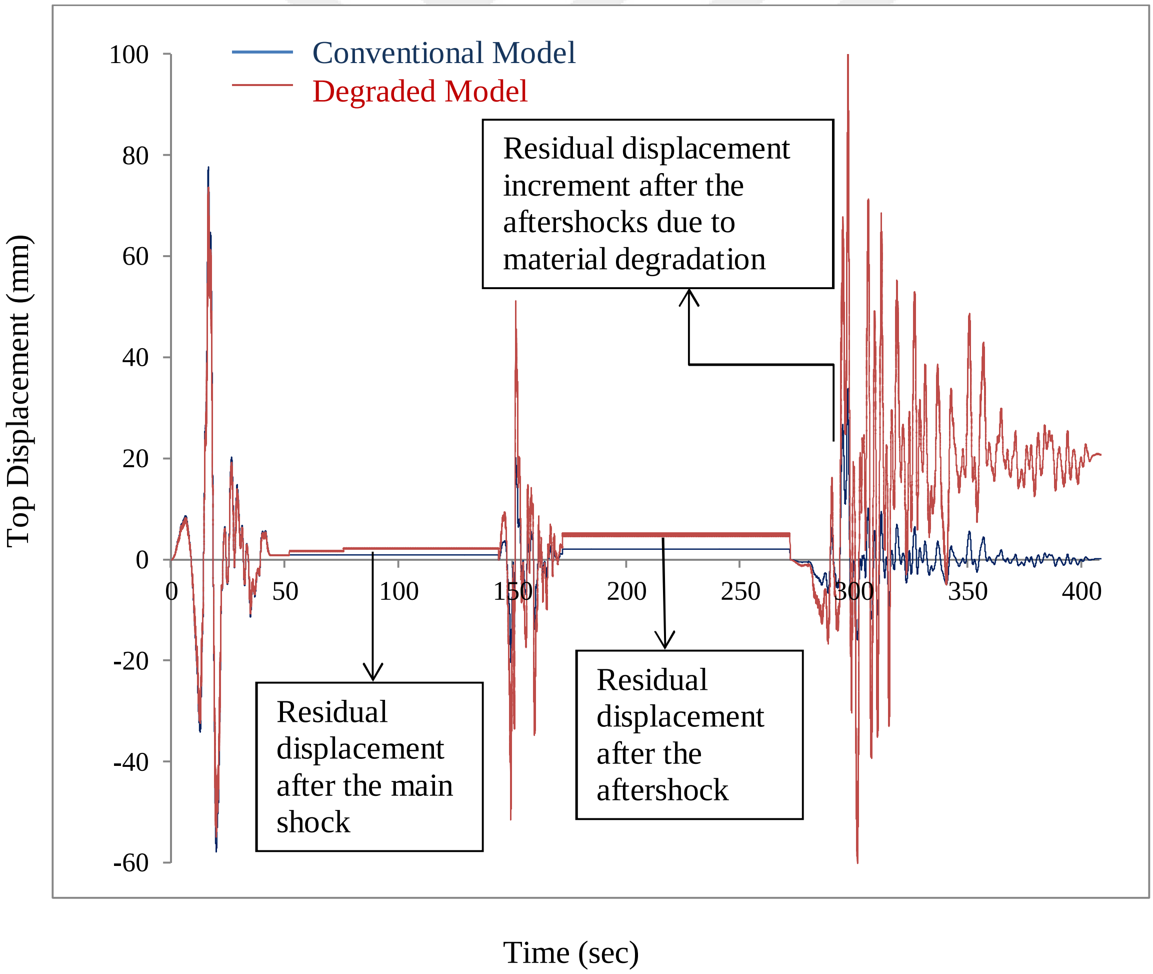

Figure 4.1 : Top displacement time-history (Multiple EQ Case–3 record)

6. CONCLUSION

In this study, material degradation effects under multiple earthquakes on reinforced concrete systems are investigated. In this context, reinforced concrete building is modeled which is damaged in Van Earthquakes in 2011. 7 earthquake recordings were produced according to the location of the building at Van Alaköy. These records were combined to obtain earthquake sequences. The building was modeled in both SAP2000 and ZeusNL finite element programs to capture the material degradation effects. The response of the structure was examined for both conventional material model and degraded material model.

Multiple earthquake effects have a significant influence on structural behavior. These influences cannot be estimated with the current modeling assumptions. Reinforced concrete frame structures behavior under aftershocks are related with the permanent damages occurred after the mainshock. These permanent damages cannot be captured using with the traditional material model definitions. The damaged structure might have worse performance under secondary earthquakes that have less seismic forces. Crushing of concrete, buckling of the longitudinal reinforcement and fracture of reinforcement bars have an important influence on the reinforced concrete structures under repeated loading. Time-history analyses were performed for both conventional material model and degraded material model under multiple earthquake sequences. The results were compared and evaluated.

- The residual displacements obtained in the degraded material model is dramatically much more than the conventional material model.
- In degraded model, maximum top displacement is obtained in mainshock. Even if aftershocks have bigger peak ground acceleration, maximum top displacement value did not go beyond the previous top displacement value due to the stiffness degradation and strength deterioration in the material.

- Under individual ground excitation, conventional material model results are approximately the same with the degraded material model results. Residual displacements are occur. Residual displacements can be clearly observed in multiple earthquakes effect.
- In order to take into account the effects of residual displacement in multiple earthquakes, material degradation should be considered during the design phase.

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APPENDICES

APPENDIX A: Building Loads

APPENDIX B: ZeusNL Inputs

APPENDIX C: Modal Analysis Results

APPENDIX D: Dynamic Time-History Analyses Results

APPENDIX A

Floor loads on beams.

	Load (kN/m^2)	Area (m^2)	Length (m)	Load (kN/m)
K101, K201, K301	3	4.2	4.1	3.073
K102, K202, K302	3	4.84	4.4	3.3
K103, K203, K303	3	4.73	4.35	3.262
K104, K204, K304	3	4.31	4.15	3.116
K105, K205, K305	3	1.21	2.2	1.65
K106, K206, K306	3	8.4	4.1	6.146
K107, K207, K307	3	9.67	4.4	6.593
K108, K208, K308	3	9.46	4.35	6.524
K109, K209, K309	3	8.62	4.15	6.231
K110, K210, K310	3	1.21	2.2	1.65
K111, K211, K311	3	4.2	4.1	3.073
K112, K212, K312	3	4.83	4.4	3.293
K113, K213, K313	3	4.73	4.35	3.262
K114, K214, K314	3	4.31	4.15	3.116
K115, K215, K315	3	3.41	4.2	2.436
K116, K216, K316	3	7.82	4.2	5.586
K117, K217, K317	3	5.33	4.65	3.439
K118, K218, K318	3	8.82	4.2	6.3
K119, K219, K319	3	10.72	4.65	6.916
K120, K220, K320	3	8.82	4.2	6.3
K121, K221, K321	3	10.77	4.65	6.948
K122, K222, K322	3	8.82	4.2	6.3
K123, K223, K323	3	10.72	4.65	6.916
K124, K224, K324	3	4.41	4.2	3.15
K125, K225, K325	3	5.34	4.65	3.445

Live loads on normal floor beams.

	Load (kN/m^2)	Area (m^2)	Length (m)	Load (kN/m)
K101, K201	3.5	4.2	4.1	3.585
K102, K202	3.5	4.84	4.4	3.85
K103, K203	3.5	4.73	4.35	3.806
K104, K204	3.5	4.31	4.15	3.635
K105, K205	3.5	1.21	2.2	1.925
K106, K206	3.5	8.4	4.1	7.171
K107, K207	3.5	9.67	4.4	7.692
K108, K208	3.5	9.46	4.35	7.611
K109, K209	3.5	8.62	4.15	7.27
K110, K210	3.5	1.21	2.2	1.925
K111, K211	3.5	4.2	4.1	3.585
K112, K212	3.5	4.83	4.4	3.842
K113, K213	3.5	4.73	4.35	3.806
K114, K214	3.5	4.31	4.15	3.635
K115, K215	3.5	3.41	4.2	2.842
K116, K216	3.5	7.82	4.2	6.517
K117, K217	3.5	5.33	4.65	4.012
K118, K218	3.5	8.82	4.2	7.35
K119, K219	3.5	10.72	4.65	8.069
K120, K220	3.5	8.82	4.2	7.35
K121, K221	3.5	10.77	4.65	8.106
K122, K222	3.5	8.82	4.2	7.35
K123, K223	3.5	10.72	4.65	8.069
K124, K224	3.5	4.41	4.2	3.675
K125, K225	3.5	5.34	4.65	4.019

Live loads on roof floor beams.

	Load (kN/m^2)	Area (m^2)	Length (m)	Load (kN/m)
K301	1.84	4.2	4.1	1.885
K302	1.84	4.84	4.4	2.024
K303	1.84	4.73	4.35	2.001
K304	1.84	4.31	4.15	1.911
K305	1.84	1.21	2.2	1.012
K306	1.84	8.4	4.1	3.77
K307	1.84	9.67	4.4	4.044
K308	1.84	9.46	4.35	4.001
K309	1.84	8.62	4.15	3.822
K310	1.84	1.21	2.2	1.012
K311	1.84	4.2	4.1	1.885
K312	1.84	4.83	4.4	2.02
K313	1.84	4.73	4.35	2.001
K314	1.84	4.31	4.15	1.911
K315	1.84	3.41	4.2	1.494
K316	1.84	7.82	4.2	3.426
K317	1.84	5.33	4.65	2.109
K318	1.84	8.82	4.2	3.864
K319	1.84	10.72	4.65	4.242
K320	1.84	8.82	4.2	3.864
K321	1.84	10.77	4.65	4.262
K322	1.84	8.82	4.2	3.864
K323	1.84	10.72	4.65	4.242
K324	1.84	4.41	4.2	1.932
K325	1.84	5.34	4.65	2.113

APPENDIX B

ZeusNL inputs:

Node Number	X	Y	Z	Type
1	0	0	4200	structural
178	18162.5	2650	8850	structural
179	18681.25	2650	8850	structural
180	2712.5	2650	4200	structural
181	3225	2650	4200	structural
182	3737.5	2650	4200	structural
183	4250	2650	4200	structural
184	4762.5	2650	4200	structural
185	5275	2650	4200	structural
186	5787.5	2650	4200	structural
187	6850	2650	4200	structural
188	7400	2650	4200	structural
189	7950	2650	4200	structural
18a	0	2252.5	4200	structural
18b	0	1325	4200	structural
18c	0	397.5	4200	structural
190	8500	2650	4200	structural
191	9050	2650	4200	structural
192	9600	2650	4200	structural
193	10150	2650	4200	structural
194	11243.75	2650	4200	structural
195	11787.5	2650	4200	structural
196	12331.25	2650	4200	structural
197	12875	2650	4200	structural
198	13418.75	2650	4200	structural
199	13962.5	2650	4200	structural
19a	0	2252.5	0	structural
19b	0	1325	0	structural
19c	0	397.5	0	structural

2	0	0	0	structural
200	14506.25	2650	4200	structural
201	15568.75	2650	4200	structural
202	16087.5	2650	4200	structural
203	16606.25	2650	4200	structural
204	17125	2650	4200	structural
205	17643.75	2650	4200	structural
206	18162.5	2650	4200	structural
207	18681.25	2650	4200	structural
208	2712.5	2650	0	structural
209	3225	2650	0	structural
20a	2200	2252.5	8850	structural
20b	2200	1325	8850	structural
20c	2200	397.5	8850	structural
210	3737.5	2650	0	structural
211	4250	2650	0	structural
212	4762.5	2650	0	structural
213	5275	2650	0	structural
214	5787.5	2650	0	structural
215	6850	2650	0	structural
216	7400	2650	0	structural
217	7950	2650	0	structural
218	8500	2650	0	structural
219	9050	2650	0	structural
21a	2200	2252.5	4200	structural
21b	2200	1325	4200	structural
21c	2200	397.5	4200	structural
220	9600	2650	0	structural
221	10150	2650	0	structural
222	11243.75	2650	0	structural
223	11787.5	2650	0	structural
224	12331.25	2650	0	structural
225	12875	2650	0	structural

226	13418.75	2650	0	structural
227	13962.5	2650	0	structural
228	14506.25	2650	0	structural
229	15568.75	2650	0	structural
22a	2200	2252.5	0	structural
22b	2200	1325	0	structural
22c	2200	397.5	0	structural
23	6300	2650	8850	structural
230	16087.5	2650	0	structural
231	16606.25	2650	0	structural
232	17125	2650	0	structural
233	17643.75	2650	0	structural
234	18162.5	2650	0	structural
235	18681.25	2650	0	structural
236	550	5300	4200	structural
237	1100	5300	4200	structural
238	1650	5300	4200	structural
239	550	5300	0	structural
23a	6300	2252.5	8850	structural
23b	6300	1325	8850	structural
23c	6300	397.5	8850	structural
240	1100	5300	0	structural
241	1650	5300	0	structural
242	0	5300	525	structural
243	0	5300	1050	structural
244	0	5300	1575	structural
245	0	5300	2100	structural
246	0	5300	2625	structural
247	0	5300	3150	structural
248	0	5300	3675	structural
249	2200	5300	525	structural
24a	6300	2252.5	4200	structural
24b	6300	1325	4200	structural

24c	6300	397.5	4200	structural
250	2200	5300	1050	structural
251	2200	5300	1575	structural
252	2200	5300	2100	structural
253	2200	5300	2625	structural
254	2200	5300	3150	structural
255	2200	5300	3675	structural
256	2200	5300	4781.25	structural
257	2200	5300	5362.5	structural
258	2200	5300	5943.75	structural
259	2200	5300	6525	structural
25a	6300	2252.5	0	structural
25b	6300	1325	0	structural
25c	6300	397.5	0	structural
260	2200	5300	7106.25	structural
261	2200	5300	7687.5	structural
262	2200	5300	8268.75	structural
263	6300	5300	525	structural
264	6300	5300	1050	structural
265	6300	5300	1575	structural
266	6300	5300	2100	structural
267	6300	5300	2625	structural
268	6300	5300	3150	structural
269	6300	5300	3675	structural
26a	10700	2252.5	8850	structural
26b	10700	1325	8850	structural
26c	10700	397.5	8850	structural
270	6300	5300	4781.25	structural
271	6300	5300	5362.5	structural
272	6300	5300	5943.75	structural
273	6300	5300	6525	structural
274	6300	5300	7106.25	structural
275	6300	5300	7687.5	structural

276	6300	5300	8268.75	structural
277	10700	5300	525	structural
278	10700	5300	1050	structural
279	10700	5300	1575	structural
27a	10700	2252.5	4200	structural
27b	10700	1325	4200	structural
27c	10700	397.5	4200	structural
280	10700	5300	2100	structural
281	10700	5300	2625	structural
282	10700	5300	3150	structural
283	10700	5300	3675	structural
284	10700	5300	4781.25	structural
285	10700	5300	5362.5	structural
286	10700	5300	5943.75	structural
287	10700	5300	6525	structural
288	10700	5300	7106.25	structural
289	10700	5300	7687.5	structural
28a	10700	2252.5	0	structural
28b	10700	1325	0	structural
28c	10700	397.5	0	structural
290	10700	5300	8268.75	structural
291	15050	5300	525	structural
292	15050	5300	1050	structural
293	15050	5300	1575	structural
294	15050	5300	2100	structural
295	15050	5300	2625	structural
296	15050	5300	3150	structural
297	15050	5300	3675	structural
298	15050	5300	4781.25	structural
299	15050	5300	5362.5	structural
29a	15050	2252.5	8850	structural
29b	15050	1325	8850	structural
29c	15050	397.5	8850	structural

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301	15050	5300	6525	structural
302	15050	5300	7106.25	structural
303	15050	5300	7687.5	structural
304	15050	5300	8268.75	structural
305	19200	5300	525	structural
306	19200	5300	1050	structural
307	19200	5300	1575	structural
308	19200	5300	2100	structural
309	19200	5300	2625	structural
30a	15050	2252.5	4200	structural
30b	15050	1325	4200	structural
30c	15050	397.5	4200	structural
310	19200	5300	3150	structural
311	19200	5300	3675	structural
312	19200	5300	4781.25	structural
313	19200	5300	5362.5	structural
314	19200	5300	5943.75	structural
315	19200	5300	6525	structural
316	19200	5300	7106.25	structural
317	19200	5300	7687.5	structural
318	19200	5300	8268.75	structural
319	2712.5	5300	8850	structural
31a	15050	2252.5	0	structural
31b	15050	1325	0	structural
31c	15050	397.5	0	structural
320	3225	5300	8850	structural
321	3737.5	5300	8850	structural
322	4250	5300	8850	structural
323	4762.5	5300	8850	structural
324	5275	5300	8850	structural
325	5787.5	5300	8850	structural

326	6850	5300	8850	structural
327	7400	5300	8850	structural
328	7950	5300	8850	structural
329	8850	5300	8850	structural
32a	19200	2252.5	8850	structural
32b	19200	1325	8850	structural
32c	19200	397.5	8850	structural
330	9050	5300	8850	structural
331	9600	5300	8850	structural
332	10150	5300	8850	structural
333	11243.75	5300	8850	structural
334	11787.5	5300	8850	structural
335	12331.25	5300	8850	structural
336	12875	5300	8850	structural
337	13418.75	5300	8850	structural
338	13962.5	5300	8850	structural
339	14506.25	5300	8850	structural
33a	19200	2252.5	4200	structural
33b	19200	1325	4200	structural
33c	19200	397.5	4200	structural
340	15568.75	5300	8850	structural
341	16087.5	5300	8850	structural
342	16606.25	5300	8850	structural
343	17125	5300	8850	structural
344	17643.75	5300	8850	structural
345	18162.5	5300	8850	structural
346	18681.25	5300	8850	structural
347	2712.5	5300	4200	structural
348	3225	5300	4200	structural
349	3737.5	5300	4200	structural
34a	19200	2252.5	0	structural
34b	19200	1325	0	structural
34c	19200	397.5	0	structural

350	4250	5300	4200	structural
351	4762.5	5300	4200	structural
352	5275	5300	4200	structural
353	5787.5	5300	4200	structural
354	6850	5300	4200	structural
355	7400	5300	4200	structural
356	7950	5300	4200	structural
357	8500	5300	4200	structural
358	9050	5300	4200	structural
359	9600	5300	4200	structural
35a	0	4902.5	4200	structural
35b	0	3975	4200	structural
35c	0	3047.5	4200	structural
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36c	0	3047.5	0	structural
370	16606.25	5300	4200	structural
371	17125	5300	4200	structural
372	17643.75	5300	4200	structural
373	18162.5	5300	4200	structural
374	18681.25	5300	4200	structural
375	2712.5	5300	0	structural
376	3225	5300	0	structural

377	3737.5	5300	0	structural
378	4250	5300	0	structural
379	4762.5	5300	0	structural
37a	2200	4902.5	8850	structural
37b	2200	3975	8850	structural
37c	2200	3047.5	8850	structural
380	5275	5300	0	structural
381	5787.5	5300	0	structural
382	6850	5300	0	structural
383	7400	5300	0	structural
384	7950	5300	0	structural
385	8500	5300	0	structural
386	9050	5300	0	structural
387	9600	5300	0	structural
388	10150	5300	0	structural
389	11243.75	5300	0	structural
38a	2200	4902.5	4200	structural
38b	2200	3975	4200	structural
38c	2200	3047.5	4200	structural
390	11787.5	5300	0	structural
391	12331.25	5300	0	structural
392	12875	5300	0	structural
393	13418.75	5300	0	structural
394	13962.5	5300	0	structural
395	14506.25	5300	0	structural
396	15568.75	5300	0	structural
397	16087.5	5300	0	structural
398	16606.25	5300	0	structural
399	17125	5300	0	structural
39a	2200	4902.5	0	structural
39b	2200	3975	0	structural
39c	2200	3047.5	0	structural
400	17643.75	5300	0	structural

401	18162.5	5300	0	structural
402	18681.25	5300	0	structural
403	550	7950	4200	structural
404	1100	7950	4200	structural
405	1650	7950	4200	structural
406	550	7950	0	structural
407	1100	7950	0	structural
408	1650	7950	0	structural
409	0	7950	525	structural
40a	6300	4902.5	8850	structural
40b	6300	3975	8850	structural
40c	6300	3047.5	8850	structural
410	0	7950	1050	structural
411	0	7950	1575	structural
412	0	7950	2100	structural
413	0	7950	2625	structural
414	0	7950	3150	structural
415	0	7950	3675	structural
416	2200	7950	525	structural
417	2200	7950	1050	structural
418	2200	7950	1575	structural
419	2200	7950	2100	structural
41a	6300	4902.5	4200	structural
41b	6300	3975	4200	structural
41c	6300	3047.5	4200	structural
420	2200	7950	2625	structural
421	2200	7950	3150	structural
422	2200	7950	3675	structural
423	2200	7950	4781.25	structural
424	2200	7950	5362.5	structural
425	2200	7950	5943.75	structural
426	2200	7950	6525	structural
427	2200	7950	7106.25	structural

428	2200	7950	7687.5	structural
429	2200	7950	8268.75	structural
42a	6300	4902.5	0	structural
42b	6300	3975	0	structural
42c	6300	3047.5	0	structural
430	6300	7950	525	structural
431	6300	7950	1050	structural
432	6300	7950	1575	structural
433	6300	7950	2100	structural
434	6300	7950	2625	structural
435	6300	7950	3150	structural
436	6300	7950	3675	structural
437	6300	7950	4781.25	structural
438	6300	7950	5362.5	structural
439	6300	7950	5943.75	structural
43a	10700	4902.5	8850	structural
43b	10700	3975	8850	structural
43c	10700	3047.5	8850	structural
440	6300	7950	6525	structural
441	6300	7950	7106.25	structural
442	6300	7950	7687.5	structural
443	6300	7950	8268.75	structural
444	10700	7950	525	structural
445	10700	7950	1050	structural
446	10700	7950	1575	structural
447	10700	7950	2100	structural
448	10700	7950	2625	structural
449	10700	7950	3150	structural
44a	10700	4902.5	4200	structural
44b	10700	3975	4200	structural
44c	10700	3047.5	4200	structural
450	10700	7950	3675	structural
451	10700	7950	4781.25	structural

452	10700	7950	5362.5	structural
453	10700	7950	5943.75	structural
454	10700	7950	6525	structural
455	10700	7950	7106.25	structural
456	10700	7950	7687.5	structural
457	10700	7950	8268.75	structural
458	15050	7950	525	structural
459	15050	7950	1050	structural
45a	10700	4902.5	0	structural
45b	10700	3975	0	structural
45c	10700	3047.5	0	structural
460	15050	7950	1575	structural
461	15050	7950	2100	structural
462	15050	7950	2625	structural
463	15050	7950	3150	structural
464	15050	7950	3675	structural
465	15050	7950	4781.25	structural
466	15050	7950	5362.5	structural
467	15050	7950	5943.75	structural
468	15050	7950	6525	structural
469	15050	7950	7106.25	structural
46a	15050	4902.5	8850	structural
46b	15050	3975	8850	structural
46c	15050	3047.5	8850	structural
470	15050	7950	7687.5	structural
471	15050	7950	8268.75	structural
472	19200	7950	525	structural
473	19200	7950	1050	structural
474	19200	7950	1575	structural
475	19200	7950	2100	structural
476	19200	7950	2625	structural
477	19200	7950	3150	structural
478	19200	7950	3675	structural

479	19200	7950	4781.25	structural
47a	15050	4902.5	4200	structural
47b	15050	3975	4200	structural
47c	15050	3047.5	4200	structural
480	19200	7950	5362.5	structural
481	19200	7950	5943.75	structural
482	19200	7950	6525	structural
483	19200	7950	7106.25	structural
484	19200	7950	7687.5	structural
485	19200	7950	8268.75	structural
486	2712.5	7950	8850	structural
487	3225	7950	8850	structural
488	3737.5	7950	8850	structural
489	4250	7950	8850	structural
48a	15050	4902.5	0	structural
48b	15050	3975	0	structural
48c	15050	3047.5	0	structural
490	4762.5	7950	8850	structural
491	5275	7950	8850	structural
492	5787.5	7950	8850	structural
493	6850	7950	8850	structural
494	7400	7950	8850	structural
495	7950	7950	8850	structural
496	8500	7950	8850	structural
497	9050	7950	8850	structural
498	9600	7950	8850	structural
499	10150	7950	8850	structural
49a	19200	4902.5	8850	structural
49b	19200	3975	8850	structural
49c	19200	3047.5	8850	structural
500	11243.75	7950	8850	structural
501	11787.5	7950	8850	structural
502	12331.25	7950	8850	structural

503	12875	7950	8850	structural
504	13418.75	7950	8850	structural
505	13962.5	7950	8850	structural
506	14506.25	7950	8850	structural
507	15568.75	7950	8850	structural
508	16087.5	7950	8850	structural
509	16606.25	7950	8850	structural
50a	19200	4902.5	4200	structural
50b	19200	3975	4200	structural
50c	19200	3047.5	4200	structural
510	17125	7950	8850	structural
511	17643.75	7950	8850	structural
512	18162.5	7950	8850	structural
513	18681.25	7950	8850	structural
514	2712.5	7950	4200	structural
515	3225	7950	4200	structural
516	3737.5	7950	4200	structural
517	4250	7950	4200	structural
518	4762.5	7950	4200	structural
519	5275	7950	4200	structural
51a	19200	4902.5	0	structural
51b	19200	3975	0	structural
51c	19200	3047.5	0	structural
520	5787.5	7950	4200	structural
521	6850	7950	4200	structural
522	7400	7950	4200	structural
523	7950	7950	4200	structural
524	8500	7950	4200	structural
525	9050	7950	4200	structural
526	9600	7950	4200	structural
527	10150	7950	4200	structural
528	11243.75	7950	4200	structural
529	11787.5	7950	4200	structural

52a	0	7552.5	4200	structural
52b	0	6625	4200	structural
52c	0	5697.5	4200	structural
530	12331.25	7950	4200	structural
531	12875	7950	4200	structural
532	13418.75	7950	4200	structural
533	13962.5	7950	4200	structural
534	14506.25	7950	4200	structural
535	15568.75	7950	4200	structural
536	16087.5	7950	4200	structural
537	16606.25	7950	4200	structural
538	17125	7950	4200	structural
539	17643.75	7950	4200	structural
53a	0	7552.5	0	structural
53b	0	6625	0	structural
53c	0	5697.5	0	structural
540	18162.5	7950	4200	structural
541	18681.25	7950	4200	structural
542	2712.5	7950	0	structural
543	3225	7950	0	structural
544	3737.5	7950	0	structural
545	4250	7950	0	structural
546	4762.5	7950	0	structural
547	5275	7950	0	structural
548	5787.5	7950	0	structural
549	6850	7950	0	structural
54a	2200	7552.5	8850	structural
54b	2200	6625	8850	structural
54c	2200	5697.5	8850	structural
550	7400	7950	0	structural
551	7950	7950	0	structural
552	8500	7950	0	structural
553	9050	7950	0	structural

554	9600	7950	0	structural
555	10150	7950	0	structural
556	11243.75	7950	0	structural
557	11787.5	7950	0	structural
558	12331.25	7950	0	structural
559	12875	7950	0	structural
55a	2200	7552.5	4200	structural
55b	2200	6625	4200	structural
55c	2200	5697.5	4200	structural
560	13418.75	7950	0	structural
561	13962.5	7950	0	structural
562	14506.25	7950	0	structural
563	15568.75	7950	0	structural
564	16087.5	7950	0	structural
565	16606.25	7950	0	structural
566	17125	7950	0	structural
567	17643.75	7950	0	structural
568	18162.5	7950	0	structural
569	18681.25	7950	0	structural
56a	2200	7552.5	0	structural
56b	2200	6625	0	structural
56c	2200	5697.5	0	structural
57a	6300	7552.5	8850	structural
57b	6300	6625	8850	structural
57c	6300	5697.5	8850	structural
58a	6300	7552.5	4200	structural
58b	6300	6625	4200	structural
58c	6300	5697.5	4200	structural
59a	6300	7552.5	0	structural
59b	6300	6625	0	structural
59c	6300	5697.5	0	structural
6	6300	0	8850	structural
12	15050	0	8850	structural

60a	10700	7552.5	8850	structural
60b	10700	6625	8850	structural
60c	10700	5697.5	8850	structural
61a	10700	7552.5	4200	structural
61b	10700	6625	4200	structural
61c	10700	5697.5	4200	structural
62a	10700	7552.5	0	structural
62b	10700	6625	0	structural
62c	10700	5697.5	0	structural
63a	15050	7552.5	8850	structural
63b	15050	6625	8850	structural
63c	15050	5697.5	8850	structural
64a	15050	7552.5	4200	structural
64b	15050	6625	4200	structural
64c	15050	5697.5	4200	structural
65a	15050	7552.5	0	structural
65b	15050	6625	0	structural
65c	15050	5697.5	0	structural
66a	19200	7552.5	8850	structural
66b	19200	6625	8850	structural
66c	19200	5697.5	8850	structural
67a	19200	7552.5	4200	structural
67b	19200	6625	4200	structural
67c	19200	5697.5	4200	structural
68a	19200	7552.5	0	structural
68b	19200	6625	0	structural
68c	19200	5697.5	0	structural
non-1	25000	0	4200	non-structural
non-2	25000	0	0	non-structural
non-3	25000	0	8850	non-structural
4	2200	0	4200	structural
non-4	25000	0	4200	non-structural
5	2200	0	0	structural

non-5	25000	0	0	non-structural
non-56Y	2200	7950	20000	non-structural
non-59Y	6300	7950	20000	non-structural
non-6	25000	0	8850	non-structural
7	6300	0	4200	structural
non-62Y	10700	7950	20000	non-structural
non-65Y	15050	7950	20000	non-structural
non-68Y	19200	7950	20000	non-structural
non-7	25000	0	4200	non-structural
8	6300	0	0	structural
non-8	25000	0	0	non-structural
9	10700	0	8850	structural
non-9	25000	0	8850	non-structural
10	10700	0	4200	structural
non-10	25000	0	4200	non-structural
11	10700	0	0	structural
non-11	25000	0	0	non-structural
non-12	25000	0	8850	non-structural
13	15050	0	4200	structural
non-13	25000	0	4200	non-structural
14	15050	0	0	structural
non-14	25000	0	0	non-structural
15	19200	0	8850	structural
non-15	25000	0	8850	non-structural
16	19200	0	4200	structural
non-16	25000	0	4200	non-structural
17	19200	0	0	structural
non-17	25000	0	0	non-structural
18	0	2650	4200	structural
non-18	25000	2650	4200	non-structural
19	0	2650	0	structural
non-19	25000	2650	0	non-structural
20	2200	2650	8850	structural

21	2200	2650	4200	structural
non-19Y	0	2650	20000	non-structural
non-20	25000	2650	8850	non-structural
non-21	25000	2650	4200	non-structural
22	2200	2650	0	structural
non-22	25000	2650	0	non-structural
non-22Y	2200	2650	20000	non-structural
non-23	25000	2650	8850	non-structural
24	6300	2650	4200	structural
non-24	25000	2650	4200	non-structural
25	6300	2650	0	structural
non-25	25000	2650	0	non-structural
26	10700	2650	8850	structural
29	15050	2650	8850	structural
30	15050	2650	4200	structural
31	15050	2650	0	structural
32	19200	2650	8850	structural
33	19200	2650	4200	structural
34	19200	2650	0	structural
44	10700	5300	4200	structural
45	10700	5300	0	structural
79	0	2650	2625	structural
80	0	2650	3150	structural
81	0	2650	3675	structural
82	2200	2650	525	structural
83	2200	2650	1050	structural
84	2200	2650	1575	structural
85	2200	2650	2100	structural
86	2200	2650	2625	structural
87	2200	2650	3150	structural
88	2200	2650	3675	structural
89	2200	2650	4781.25	structural
90	2200	2650	5362.5	structural

91	2200	2650	5943.75	structural
92	2200	2650	6525	structural
93	2200	2650	7106.25	structural
94	2200	2650	7687.5	structural
95	2200	2650	8268.75	structural
96	6300	2650	525	structural
97	6300	2650	1050	structural
98	6300	2650	1575	structural
99	6300	2650	2100	structural
100	6300	2650	2625	structural
101	6300	2650	3150	structural
102	6300	2650	3675	structural
103	6300	2650	4781.25	structural
104	6300	2650	5362.5	structural
105	6300	2650	5943.75	structural
106	6300	2650	6525	structural
107	6300	2650	7106.25	structural
108	6300	2650	7687.5	structural
109	6300	2650	8268.75	structural
110	10700	2650	525	structural
111	10700	2650	1050	structural
112	10700	2650	1575	structural
113	10700	2650	2100	structural
114	10700	2650	2625	structural
115	10700	2650	3150	structural
116	10700	2650	3675	structural
117	10700	2650	4781.25	structural
118	10700	2650	5362.5	structural
119	10700	2650	5943.75	structural
120	10700	2650	6525	structural
121	10700	2650	7106.25	structural
122	10700	2650	7687.5	structural
123	10700	2650	8268.75	structural

124	15050	2650	525	structural
125	15050	2650	1050	structural
126	15050	2650	1575	structural
127	15050	2650	2100	structural
128	15050	2650	2625	structural
129	15050	2650	3150	structural
130	15050	2650	3675	structural
131	15050	2650	4781.25	structural
132	15050	2650	5362.5	structural
133	15050	2650	5943.75	structural
134	15050	2650	6525	structural
135	15050	2650	7106.25	structural
136	15050	2650	7687.5	structural
137	15050	2650	8268.75	structural
138	19200	2650	525	structural
139	19200	2650	1050	structural
140	19200	2650	1575	structural
141	19200	2650	2100	structural
142	19200	2650	2625	structural
143	19200	2650	3150	structural
144	19200	2650	3675	structural
145	19200	2650	4781.25	structural
146	19200	2650	5362.5	structural
147	19200	2650	5943.75	structural
148	19200	2650	6525	structural
149	19200	2650	7106.25	structural
150	19200	2650	7687.5	structural
151	19200	2650	8268.75	structural
152	2712.5	2650	8850	structural
153	3225	2650	8850	structural
154	3737.5	2650	8850	structural
155	4250	2650	8850	structural
156	4762.5	2650	8850	structural

157	5275	2650	8850	structural
158	5787.5	2650	8850	structural
159	6850	2650	8850	structural
160	7400	2650	8850	structural
161	7950	2650	8850	structural
162	8500	2650	8850	structural
163	9050	2650	8850	structural
164	9600	2650	8850	structural
165	10150	2650	8850	structural
166	11243.75	2650	8850	structural
167	11787.5	2650	8850	structural
168	12331.25	2650	8850	structural
169	12875	2650	8850	structural
170	13418.75	2650	8850	structural
171	13962.5	2650	8850	structural
172	14506.25	2650	8850	structural
173	15568.75	2650	8850	structural
174	16087.5	2650	8850	structural
175	16606.25	2650	8850	structural
176	17125	2650	8850	structural
177	17643.75	2650	8850	structural
non-25Y	6300	2650	20000	non-structural
non-26	25000	2650	8850	non-structural
27	10700	2650	4200	structural
non-27	25000	2650	4200	non-structural
28	10700	2650	0	structural
non-28	25000	2650	0	non-structural
non-28Y	10700	2650	20000	non-structural
non-29	25000	2650	8850	non-structural
non-30	25000	2650	4200	non-structural
non-31	25000	2650	0	non-structural
non-31Y	15050	2650	20000	non-structural
non-32	25000	2650	8850	non-structural

non-33	25000	2650	4200	non-structural
non-34	25000	2650	0	non-structural
35	0	5300	4200	structural
36	0	5300	0	structural
37	2200	5300	8850	structural
38	2200	5300	4200	structural
39	2200	5300	0	structural
40	6300	5300	8850	structural
41	6300	5300	4200	structural
42	6300	5300	0	structural
non-34Y	19200	2650	20000	non-structural
non-35	25000	5300	4200	non-structural
non-36	25000	5300	0	non-structural
non-36Y	0	5300	20000	non-structural
non-37	25000	5300	8850	non-structural
non-38	25000	5300	4200	non-structural
non-39	25000	5300	0	non-structural
non-39Y	2200	5300	20000	non-structural
non-40	25000	5300	8850	non-structural
non-41	25000	5300	4200	non-structural
non-42	25000	5300	0	non-structural
43	10700	5300	8850	structural
non-42Y	6300	5300	20000	non-structural
non-43	25000	5300	8850	non-structural
non-44	25000	5300	4200	non-structural
non-45	25000	5300	0	non-structural
46	15050	5300	8850	structural
47	15050	5300	4200	structural
48	15050	5300	0	structural
50	19200	5300	4200	structural
55	2200	7950	4200	structural
56	2200	7950	0	structural
57	6300	7950	8850	structural

58	6300	7950	4200	structural
59	6300	7950	0	structural
60	10700	7950	8850	structural
61	10700	7950	4200	structural
62	10700	7950	0	structural
63	15050	7950	8850	structural
64	15050	7950	4200	structural
65	15050	7950	0	structural
66	19200	7950	8850	structural
67	19200	7950	4200	structural
68	19200	7950	0	structural
69	550	2650	4200	structural
70	1100	2650	4200	structural
71	1650	2650	4200	structural
72	550	2650	0	structural
73	1100	2650	0	structural
74	1650	2650	0	structural
75	0	2650	525	structural
76	0	2650	1050	structural
77	0	2650	1575	structural
78	0	2650	2100	structural
non-45Y	10700	5300	20000	non-structural
non-46	25000	5300	8850	non-structural
non-47	25000	5300	4200	non-structural
non-48	25000	5300	0	non-structural
49	19200	5300	8850	structural
non-48Y	15050	5300	20000	non-structural
non-49	25000	5300	8850	non-structural
non-50	25000	5300	4200	non-structural
51	19200	5300	0	structural
non-51	25000	5300	0	non-structural
52	0	7950	4200	structural
53	0	7950	0	structural

non-51Y	19200	5300	20000	non-structural
non-52	25000	7950	4200	non-structural
non-53	25000	7950	0	non-structural
54	2200	7950	8850	structural
non-53Y	0	7950	20000	non-structural
non-54	25000	7950	8850	non-structural

Element Number	Element Class	Node Numbers
1a	column-1	19 19a non-2
2a	column-2	22 22a non-5
3a	column-2	25 25a non-8
4a	column-2	28 28a non-11
5a	column-2	31 31a non-14
6a	column-2	34 34a non-17
7a	column-1	18 18a non-1
8a	column-3	21 21a non-4
9a	column-2	24 24a non-7
10a	column-2	27 27a non-10
11a	column-2	30 30a non-13
12a	column-3	33 33a non-16
13a	column-2	20 20a non-3
14a	column-2	23 23a non-6
15a	column-2	26 26a non-9
16a	column-2	29 29a non-12
17a	column-2	32 32a non-15
18a	column-1	36 36a non-19
19a	column-2	39 39a non-22
20a	column-2	42 42a non-25
21a	column-2	45 45a non-28
22a	column-2	48 48a non-31
23a	column-2	51 51a non-34
24a	column-1	35 35a non-18

25a	column-3	38	38a	non-21
26a	column-2	41	41a	non-24
27a	column-2	44	44a	non-27
28a	column-2	47	47a	non-30
29a	column-3	50	50a	non-33
30a	column-2	37	37a	non-20
31a	column-2	40	40a	non-23
32a	column-2	43	43a	non-26
33a	column-2	46	46a	non-29
34a	column-2	49	49a	non-32
35a	column-1	53	53a	non-36
36a	column-2	56	56a	non-39
37a	column-2	59	59a	non-42
38a	column-2	62	62a	non-45
39a	column-2	65	65a	non-48
40a	column-2	68	68a	non-51
41a	column-1	52	52a	non-35
42a	column-3	55	55a	non-38
43a	column-2	58	58a	non-41
44a	column-2	61	61a	non-44
45a	column-2	64	64a	non-47
46a	column-3	67	67a	non-50
47a	column-2	54	54a	non-37
48a	column-2	57	57a	non-40
49a	column-2	60	60a	non-43
50a	column-2	63	63a	non-46
51a	column-2	66	66a	non-49
52	beam	18	69	non-35
53	beam	69	70	non-35
54	beam	70	71	non-35
55	beam	71	21	non-35
56	beam	19	72	non-36
57	beam	72	73	non-36

58	beam	73 74 non-36
59	beam	74 22 non-36
60	beam	19 75 non-36Y
61	beam	75 76 non-36Y
62	beam	76 77 non-36Y
63	beam	77 78 non-36Y
64	beam	78 79 non-36Y
65	beam	79 80 non-36Y
66	beam	80 81 non-36Y
67	beam	81 18 non-36Y
68	beam	22 82 non-39Y
69	beam	82 83 non-39Y
70	beam	83 84 non-39Y
71	beam	84 85 non-39Y
72	beam	85 86 non-39Y
73	beam	86 87 non-39Y
74	beam	87 88 non-39Y
75	beam	88 21 non-39Y
76	beam	21 89 non-39Y
77	beam	89 90 non-39Y
78	beam	90 91 non-39Y
79	beam	91 92 non-39Y
80	beam	92 93 non-39Y
81	beam	93 94 non-39Y
82	beam	94 95 non-39Y
83	beam	95 20 non-39Y
84	beam	25 96 non-42Y
85	beam	96 97 non-42Y
86	beam	97 98 non-42Y
87	beam	98 99 non-42Y
88	beam	99 100 non-42Y
89	beam	100 101 non-42Y
90	beam	101 102 non-42Y

91	beam	102 24 non-42Y
92	beam	24 103 non-42Y
93	beam	103 104 non-42Y
94	beam	104 105 non-42Y
95	beam	105 106 non-42Y
96	beam	106 107 non-42Y
97	beam	107 108 non-42Y
98	beam	108 109 non-42Y
99	beam	109 23 non-42Y
100	beam	28 110 non-45Y
101	beam	110 111 non-45Y
102	beam	111 112 non-45Y
103	beam	112 113 non-45Y
104	beam	113 114 non-45Y
105	beam	114 115 non-45Y
106	beam	115 116 non-45Y
107	beam	116 27 non-45Y
108	beam	27 117 non-45Y
109	beam	117 118 non-45Y
110	beam	118 119 non-45Y
111	beam	119 120 non-45Y
112	beam	120 121 non-45Y
113	beam	121 122 non-45Y
114	beam	122 123 non-45Y
115	beam	123 26 non-45Y
116	beam	31 124 non-48Y
117	beam	124 125 non-48Y
118	beam	125 126 non-48Y
119	beam	126 127 non-48Y
120	beam	127 128 non-48Y
121	beam	128 129 non-48Y
122	beam	129 130 non-48Y
123	beam	130 30 non-48Y

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125	beam	131 132 non-48Y
126	beam	132 133 non-48Y
127	beam	133 134 non-48Y
128	beam	134 135 non-48Y
129	beam	135 136 non-48Y
130	beam	136 137 non-48Y
131	beam	137 29 non-48Y
132	beam	34 138 non-51Y
133	beam	138 139 non-51Y
134	beam	139 140 non-51Y
135	beam	140 141 non-51Y
136	beam	141 142 non-51Y
137	beam	142 143 non-51Y
138	beam	143 144 non-51Y
139	beam	144 33 non-51Y
140	beam	33 145 non-51Y
141	beam	145 146 non-51Y
142	beam	146 147 non-51Y
143	beam	147 148 non-51Y
144	beam	148 149 non-51Y
145	beam	149 150 non-51Y
146	beam	150 151 non-51Y
147	beam	151 32 non-51Y
148	beam	20 152 non-37
149	beam	152 153 non-37
150	beam	153 154 non-37
151	beam	154 155 non-37
152	beam	155 156 non-37
153	beam	156 157 non-37
154	beam	157 158 non-37
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156	beam	23 159 non-37

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160	beam	162 163 non-37
161	beam	163 164 non-37
162	beam	164 165 non-37
163	beam	165 26 non-37
164	beam	26 166 non-37
165	beam	166 167 non-37
166	beam	167 168 non-37
167	beam	168 169 non-37
168	beam	169 170 non-37
169	beam	170 171 non-37
170	beam	171 172 non-37
171	beam	172 29 non-37
172	beam	29 173 non-37
173	beam	173 174 non-37
174	beam	174 175 non-37
175	beam	175 176 non-37
176	beam	176 177 non-37
177	beam	177 178 non-37
178	beam	178 179 non-37
179	beam	179 32 non-37
180	beam	21 180 non-35
181	beam	180 181 non-35
182	beam	181 182 non-35
183	beam	182 183 non-35
184	beam	183 184 non-35
185	beam	184 185 non-35
186	beam	185 186 non-35
187	beam	186 24 non-35
188	beam	24 187 non-35
189	beam	187 188 non-35

190	beam	188 189 non-35
191	beam	189 190 non-35
192	beam	190 191 non-35
193	beam	191 192 non-35
194	beam	192 193 non-35
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197	beam	194 195 non-35
198	beam	195 196 non-35
199	beam	196 197 non-35
200	beam	197 198 non-35
201	beam	198 199 non-35
202	beam	199 200 non-35
203	beam	200 30 non-35
204	beam	30 201 non-35
205	beam	201 202 non-35
206	beam	202 203 non-35
207	beam	203 204 non-35
208	beam	204 205 non-35
209	beam	205 206 non-35
210	beam	206 207 non-35
211	beam	207 33 non-35
212	beam	22 208 non-36
213	beam	208 209 non-36
214	beam	209 210 non-36
215	beam	210 211 non-36
216	beam	211 212 non-36
217	beam	212 213 non-36
218	beam	213 214 non-36
219	beam	214 25 non-36
220	beam	25 215 non-36
221	beam	215 216 non-36
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224	beam	218 219 non-36
225	beam	219 220 non-36
226	beam	220 221 non-36
227	beam	221 28 non-36
228	beam	28 222 non-36
229	beam	222 223 non-36
230	beam	223 224 non-36
231	beam	224 225 non-36
232	beam	225 226 non-36
233	beam	226 227 non-36
234	beam	227 228 non-36
235	beam	228 31 non-36
236	beam	31 229 non-36
237	beam	229 230 non-36
238	beam	230 231 non-36
239	beam	231 232 non-36
240	beam	232 233 non-36
241	beam	233 234 non-36
242	beam	234 235 non-36
243	beam	235 34 non-36
244	beam	35 236 non-52
245	beam	236 237 non-52
246	beam	237 238 non-52
247	beam	238 38 non-52
248	beam	36 239 non-53
249	beam	239 240 non-53
250	beam	240 241 non-53
251	beam	241 39 non-53
252	beam	36 242 non-53Y
253	beam	242 243 non-53Y
254	beam	243 244 non-53Y
255	beam	244 245 non-53Y

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257	beam	246 247 non-53Y
258	beam	247 248 non-53Y
259	beam	248 35 non-53Y
260	beam	39 249 non-56Y
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262	beam	250 251 non-56Y
263	beam	251 252 non-56Y
264	beam	252 253 non-56Y
265	beam	253 254 non-56Y
266	beam	254 255 non-56Y
267	beam	255 38 non-56Y
268	beam	38 256 non-56Y
269	beam	256 257 non-56Y
270	beam	257 258 non-56Y
271	beam	258 259 non-56Y
272	beam	259 260 non-56Y
273	beam	260 261 non-56Y
274	beam	261 262 non-56Y
275	beam	262 37 non-56Y
276	beam	42 263 non-59Y
277	beam	263 264 non-59Y
278	beam	264 265 non-59Y
279	beam	265 266 non-59Y
280	beam	266 267 non-59Y
281	beam	267 268 non-59Y
282	beam	268 269 non-59Y
283	beam	269 41 non-59Y
284	beam	41 270 non-59Y
285	beam	270 271 non-59Y
286	beam	271 272 non-59Y
287	beam	272 273 non-59Y
288	beam	273 274 non-59Y

289	beam	274 275 non-59Y
290	beam	275 276 non-59Y
291	beam	276 40 non-59Y
292	beam	45 277 non-62Y
293	beam	277 278 non-62Y
294	beam	278 279 non-62Y
295	beam	279 280 non-62Y
296	beam	280 281 non-62Y
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298	beam	282 283 non-62Y
299	beam	283 44 non-62Y
300	beam	44 284 non-62Y
301	beam	284 285 non-62Y
302	beam	285 286 non-62Y
303	beam	286 287 non-62Y
304	beam	287 288 non-62Y
305	beam	288 289 non-62Y
306	beam	289 290 non-62Y
307	beam	290 43 non-62Y
308	beam	48 291 non-65Y
309	beam	291 292 non-65Y
310	beam	292 293 non-65Y
311	beam	293 294 non-65Y
312	beam	294 295 non-65Y
313	beam	295 296 non-65Y
314	beam	296 297 non-65Y
315	beam	297 47 non-65Y
316	beam	47 298 non-65Y
317	beam	298 299 non-65Y
318	beam	299 300 non-65Y
319	beam	300 301 non-65Y
320	beam	301 302 non-65Y
321	beam	302 303 non-65Y

322	beam	303 304 non-65Y
323	beam	304 46 non-65Y
324	beam	51 305 non-68Y
325	beam	305 306 non-68Y
326	beam	306 307 non-68Y
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329	beam	309 310 non-68Y
330	beam	310 311 non-68Y
331	beam	311 50 non-68Y
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334	beam	313 314 non-68Y
335	beam	314 315 non-68Y
336	beam	315 316 non-68Y
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338	beam	317 318 non-68Y
339	beam	318 49 non-68Y
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341	beam	319 320 non-54
342	beam	320 321 non-54
343	beam	321 322 non-54
344	beam	322 323 non-54
345	beam	323 324 non-54
346	beam	324 325 non-54
347	beam	325 40 non-54
348	beam	40 326 non-54
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350	beam	327 328 non-54
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352	beam	329 330 non-54
353	beam	330 331 non-54
354	beam	331 332 non-54

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357	beam	333 334 non-54
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362	beam	338 339 non-54
363	beam	339 46 non-54
364	beam	46 340 non-54
365	beam	340 341 non-54
366	beam	341 342 non-54
367	beam	342 343 non-54
368	beam	343 344 non-54
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370	beam	345 346 non-54
371	beam	346 49 non-54
372	beam	38 347 non-52
373	beam	347 348 non-52
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379	beam	353 41 non-52
380	beam	41 354 non-52
381	beam	354 355 non-52
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383	beam	356 357 non-52
384	beam	357 358 non-52
385	beam	358 359 non-52
386	beam	359 360 non-52
387	beam	360 44 non-52

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389	beam	361 362 non-52
390	beam	362 363 non-52
391	beam	363 364 non-52
392	beam	364 365 non-52
393	beam	365 366 non-52
394	beam	366 367 non-52
395	beam	367 47 non-52
396	beam	47 368 non-52
397	beam	368 369 non-52
398	beam	369 370 non-52
399	beam	370 371 non-52
400	beam	371 372 non-52
401	beam	372 373 non-52
402	beam	373 374 non-52
403	beam	374 50 non-52
404	beam	39 375 non-53
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412	beam	42 382 non-53
413	beam	382 383 non-53
414	beam	383 384 non-53
415	beam	384 385 non-53
416	beam	385 386 non-53
417	beam	386 387 non-53
418	beam	387 388 non-53
419	beam	388 45 non-53
420	beam	45 389 non-53

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423	beam	391 392 non-53
424	beam	392 393 non-53
425	beam	393 394 non-53
426	beam	394 395 non-53
427	beam	395 48 non-53
428	beam	48 396 non-53
429	beam	396 397 non-53
430	beam	397 398 non-53
431	beam	398 399 non-53
432	beam	399 400 non-53
433	beam	400 401 non-53
434	beam	401 402 non-53
435	beam	402 51 non-53
436	beam	52 403 non-35
437	beam	403 404 non-35
438	beam	404 405 non-35
439	beam	405 55 non-35
440	beam	53 406 non-36
441	beam	406 407 non-36
442	beam	407 408 non-36
443	beam	408 56 non-36
444	beam	53 409 non-36Y
445	beam	409 410 non-36Y
446	beam	410 411 non-36Y
447	beam	411 412 non-36Y
448	beam	412 413 non-36Y
449	beam	413 414 non-36Y
450	beam	414 415 non-36Y
451	beam	415 52 non-36Y
452	beam	56 416 non-39Y
453	beam	416 417 non-39Y

454	beam	417 418 non-39Y
455	beam	418 419 non-39Y
456	beam	419 420 non-39Y
457	beam	420 421 non-39Y
458	beam	421 422 non-39Y
459	beam	422 55 non-39Y
460	beam	55 423 non-39Y
461	beam	423 424 non-39Y
462	beam	424 425 non-39Y
463	beam	425 426 non-39Y
464	beam	426 427 non-39Y
465	beam	427 428 non-39Y
466	beam	428 429 non-39Y
467	beam	429 54 non-39Y
468	beam	59 430 non-42Y
469	beam	430 431 non-42Y
470	beam	431 432 non-42Y
471	beam	432 433 non-42Y
472	beam	433 434 non-42Y
473	beam	434 435 non-42Y
474	beam	435 436 non-42Y
475	beam	436 58 non-42Y
476	beam	58 437 non-42Y
477	beam	437 438 non-42Y
478	beam	438 439 non-42Y
479	beam	439 440 non-42Y
480	beam	440 441 non-42Y
481	beam	441 442 non-42Y
482	beam	442 443 non-42Y
483	beam	443 57 non-42Y
484	beam	62 444 non-45Y
485	beam	444 445 non-45Y
486	beam	445 446 non-45Y

487	beam	446 447 non-45Y
488	beam	447 448 non-45Y
489	beam	448 449 non-45Y
490	beam	449 450 non-45Y
491	beam	450 61 non-45Y
492	beam	61 451 non-45Y
493	beam	451 452 non-45Y
494	beam	452 453 non-45Y
495	beam	453 454 non-45Y
496	beam	454 455 non-45Y
497	beam	455 456 non-45Y
498	beam	456 457 non-45Y
499	beam	457 60 non-45Y
500	beam	65 458 non-48Y
501	beam	458 459 non-48Y
502	beam	459 460 non-48Y
503	beam	460 461 non-48Y
504	beam	461 462 non-48Y
505	beam	462 463 non-48Y
506	beam	463 464 non-48Y
507	beam	464 64 non-48Y
508	beam	64 465 non-48Y
509	beam	465 466 non-48Y
510	beam	466 467 non-48Y
511	beam	467 468 non-48Y
512	beam	468 469 non-48Y
513	beam	469 470 non-48Y
514	beam	470 471 non-48Y
515	beam	471 63 non-48Y
516	beam	68 472 non-51Y
517	beam	472 473 non-51Y
518	beam	473 474 non-51Y
519	beam	474 475 non-51Y

520	beam	475 476 non-51Y
521	beam	476 477 non-51Y
522	beam	477 478 non-51Y
523	beam	478 67 non-51Y
524	beam	67 479 non-51Y
525	beam	479 480 non-51Y
526	beam	480 481 non-51Y
527	beam	481 482 non-51Y
528	beam	482 483 non-51Y
529	beam	483 484 non-51Y
530	beam	484 485 non-51Y
531	beam	485 66 non-51Y
532	beam	54 486 non-37
533	beam	486 487 non-37
534	beam	487 488 non-37
535	beam	488 489 non-37
536	beam	489 490 non-37
537	beam	490 491 non-37
538	beam	491 492 non-37
539	beam	492 57 non-37
540	beam	57 493 non-37
541	beam	493 494 non-37
542	beam	494 495 non-37
543	beam	495 496 non-37
544	beam	496 497 non-37
545	beam	497 498 non-37
546	beam	498 499 non-37
547	beam	499 60 non-37
548	beam	60 500 non-37
549	beam	500 501 non-37
550	beam	501 502 non-37
551	beam	502 503 non-37
552	beam	503 504 non-37

553	beam	504 505 non-37
554	beam	505 506 non-37
555	beam	506 63 non-37
556	beam	63 507 non-37
557	beam	507 508 non-37
558	beam	508 509 non-37
559	beam	509 510 non-37
560	beam	510 511 non-37
561	beam	511 512 non-37
562	beam	512 513 non-37
563	beam	513 66 non-37
564	beam	55 514 non-35
565	beam	514 515 non-35
566	beam	515 516 non-35
567	beam	516 517 non-35
568	beam	517 518 non-35
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570	beam	519 520 non-35
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572	beam	58 521 non-35
573	beam	521 522 non-35
574	beam	522 523 non-35
575	beam	523 524 non-35
576	beam	524 525 non-35
577	beam	525 526 non-35
578	beam	526 527 non-35
579	beam	527 61 non-35
580	beam	61 528 non-35
581	beam	528 529 non-35
582	beam	529 530 non-35
583	beam	530 531 non-35
584	beam	531 532 non-35
585	beam	532 533 non-35

586	beam	533 534 non-35
587	beam	534 64 non-35
588	beam	64 535 non-35
589	beam	535 536 non-35
590	beam	536 537 non-35
591	beam	537 538 non-35
592	beam	538 539 non-35
593	beam	539 540 non-35
594	beam	540 541 non-35
595	beam	541 67 non-35
596	beam	56 542 non-36
597	beam	542 543 non-36
598	beam	543 544 non-36
599	beam	544 545 non-36
600	beam	545 546 non-36
601	beam	546 547 non-36
602	beam	547 548 non-36
603	beam	548 59 non-36
604	beam	59 549 non-36
605	beam	549 550 non-36
606	beam	550 551 non-36
607	beam	551 552 non-36
608	beam	552 553 non-36
609	beam	553 554 non-36
610	beam	554 555 non-36
611	beam	555 62 non-36
612	beam	62 556 non-36
613	beam	556 557 non-36
614	beam	557 558 non-36
615	beam	558 559 non-36
616	beam	559 560 non-36
617	beam	560 561 non-36
618	beam	561 562 non-36

619	beam	562 65 non-36
620	beam	65 563 non-36
621	beam	563 564 non-36
622	beam	564 565 non-36
623	beam	565 566 non-36
624	beam	566 567 non-36
625	beam	567 568 non-36
626	beam	568 569 non-36
627	beam	569 68 non-36
1b	column-1	19a 19b non-2
1c	column-1	19b 19c non-2
1d	column-1	19c 2 non-2
2b	column-2	22a 22b non-5
2c	column-2	22b 22c non-5
2d	column-2	22c 5 non-5
3b	column-2	25a 25b non-8
3c	column-2	25b 25c non-8
3d	column-2	25c 8 non-8
4b	column-2	28a 28b non-11
4c	column-2	28b 28c non-11
4d	column-2	28c 11 non-11
5b	column-2	31a 31b non-14
5c	column-2	31b 31c non-14
5d	column-2	31c 14 non-14
6b	column-2	34a 34b non-17
6c	column-2	34b 34c non-17
6d	column-2	34c 17 non-17
7b	column-1	18a 18b non-1
7c	column-1	18b 18c non-1
7d	column-1	18c 1 non-1
8b	column-3	21a 21b non-4
8c	column-3	21b 21c non-4
8d	column-3	21c 4 non-4

9b	column-2	24a 24b non-7
9c	column-2	24b 24c non-7
9d	column-2	24c 7 non-7
10b	column-2	27a 27b non-10
10c	column-2	27b 27c non-10
10d	column-2	27c 10 non-10
11b	column-2	30a 30b non-13
11c	column-2	30b 30c non-13
11d	column-2	30c 13 non-13
12b	column-3	33a 33b non-16
12c	column-3	33b 33c non-16
12d	column-3	33c 16 non-16
13b	column-2	20a 20b non-3
13c	column-2	20b 20c non-3
13d	column-2	20c 3 non-3
14b	column-2	23a 23b non-6
14c	column-2	23b 23c non-6
14d	column-2	23c 6 non-6
15b	column-2	26a 26b non-9
15c	column-2	26b 26c non-9
15d	column-2	26c 9 non-9
16b	column-2	29a 29b non-12
16c	column-2	29b 29c non-12
16d	column-2	29c 12 non-12
17b	column-2	32a 32b non-15
17c	column-2	32b 32c non-15
17d	column-2	32c 15 non-15
18b	column-1	36a 36b non-19
18c	column-1	36b 36c non-19
18d	column-1	36c 19 non-19
19b	column-2	39a 39b non-22
19c	column-2	39b 39c non-22
19d	column-2	39c 22 non-22

20b	column-2	42a 42b non-25
20c	column-2	42b 42c non-25
20d	column-2	42c 25 non-25
21b	column-2	45a 45b non-28
21c	column-2	45b 45c non-28
21d	column-2	45c 28 non-28
22b	column-2	48a 48b non-31
22c	column-2	48b 48c non-31
22d	column-2	48c 31 non-31
23b	column-2	51a 51b non-34
23c	column-2	51b 51c non-34
23d	column-2	51c 34 non-34
24b	column-1	35a 35b non-18
24c	column-1	35b 35c non-18
24d	column-1	35c 18 non-18
25b	column-3	38a 38b non-21
25c	column-3	38b 38c non-21
25d	column-3	38c 21 non-21
26b	column-2	41a 41b non-24
26c	column-2	41b 41c non-24
26d	column-2	41c 24 non-24
27b	column-2	44a 44b non-27
27c	column-2	44b 44c non-27
27d	column-2	44c 27 non-27
28b	column-2	47a 47b non-30
28c	column-2	47b 47c non-30
28d	column-2	47c 30 non-30
29b	column-3	50a 50b non-33
29c	column-3	50b 50c non-33
29d	column-3	50c 33 non-33
30b	column-2	37a 37b non-20
30c	column-2	37b 37c non-20
30d	column-2	37c 20 non-20

31b	column-2	40a 40b non-23
31c	column-2	40b 40c non-23
31d	column-2	40c 23 non-23
32b	column-2	43a 43b non-26
32c	column-2	43b 43c non-26
32d	column-2	43c 26 non-26
33b	column-2	46a 46b non-29
33c	column-2	46b 46c non-29
33d	column-2	46c 29 non-29
34b	column-2	49a 49b non-32
34c	column-2	49b 49c non-32
34d	column-2	49c 32 non-32
35b	column-1	53a 53b non-36
35c	column-1	53b 53c non-36
35d	column-1	53c 36 non-36
36b	column-2	56a 56b non-39
36c	column-2	56b 56c non-39
36d	column-2	56c 39 non-39
37b	column-2	59a 59b non-42
37c	column-2	59b 59c non-42
37d	column-2	59c 42 non-42
38b	column-2	62a 62b non-45
38c	column-2	62b 62c non-45
38d	column-2	62c 45 non-45
39b	column-2	65a 65b non-48
39c	column-2	65b 65c non-48
39d	column-2	65c 48 non-48
40b	column-2	68a 68b non-51
40c	column-2	68b 68c non-51
40d	column-2	68c 51 non-51
41b	column-1	52a 52b non-35
41c	column-1	52b 52c non-35
41d	column-1	52c 35 non-35

42b	column-3	55a 55b non-38
42c	column-3	55b 55c non-38
42d	column-3	55c 38 non-38
43b	column-2	58a 58b non-41
43c	column-2	58b 58c non-41
43d	column-2	58c 41 non-41
44b	column-2	61a 61b non-44
44c	column-2	61b 61c non-44
44d	column-2	61c 44 non-44
45b	column-2	64a 64b non-47
45c	column-2	64b 64c non-47
45d	column-2	64c 47 non-47
46b	column-3	67a 67b non-50
46c	column-3	67b 67c non-50
46d	column-3	67c 50 non-50
47b	column-2	54a 54b non-37
47c	column-2	54b 54c non-37
47d	column-2	54c 37 non-37
48b	column-2	57a 57b non-40
48c	column-2	57b 57c non-40
48d	column-2	57c 40 non-40
49b	column-2	60a 60b non-43
49c	column-2	60b 60c non-43
49d	column-2	60c 43 non-43
50b	column-2	63a 63b non-46
50c	column-2	63b 63c non-46
50d	column-2	63c 46 non-46
51b	column-2	66a 66b non-49
51c	column-2	66b 66c non-49
51d	column-2	66c 49 non-49
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mass569	mass569	569

APPENDIX C

Eigenvalue analysis results obtained from SAP2000.

LOAD CASE	Period [sec]	UX	UY	SumUX	SumUY
MODE-1	0.445	1.80E-05	0.87037	1.80E-05	0.8704
MODE-2	0.347	0.40588	0.00033	0.4059	0.8707
MODE-3	0.341	0.45468	0.00012	0.86058	0.8708
MODE-4	0.148	2.00E-06	0.098	0.86058	0.9688
MODE-5	0.114	0.01006	2.10E-05	0.87064	0.9688
MODE-6	0.112	0.09435	4.00E-07	0.965	0.9688
MODE-7	0.096	2.30E-07	0.0203	0.965	0.9891
MODE-8	0.072	6.80E-06	1.60E-06	0.96501	0.9891
MODE-9	0.07	0.02405	7.10E-10	0.98906	0.9891
MODE-10	0.06	3.7E-09	4.30E-06	0.98906	0.9891
MODE-11	0.058	4.70E-09	0.0001	0.98906	0.9892
MODE-12	0.058	1.2E-08	1.80E-06	0.98906	0.9893

Joint reactions obtained from SAP2000 (where G is the dead loads, Q is the live loads and n is the live load reduction factor).

Joint	Combination	F1 [kN]	F2 [kN]	F3 [kN]
1	G+nQ	0.71	-2.37	116.04
2	G+nQ	0.47	2.70	113.06
3	G+nQ	3.03	-3.98	185.76
4	G+nQ	2.49	-0.24	366.30
5	G+nQ	2.44	4.10	234.65
6	G+nQ	0.87	-5.60	303.74
7	G+nQ	0.85	1.16	502.62
8	G+nQ	0.71	4.23	286.07
9	G+nQ	0.10	-5.69	312.30
10	G+nQ	0.04	1.22	510.32
11	G+nQ	0.10	4.22	291.88
12	G+nQ	-0.06	-5.62	305.39
13	G+nQ	0.10	1.18	503.88
14	G+nQ	-0.05	4.18	285.90
15	G+nQ	-3.96	-3.98	185.08
16	G+nQ	-3.89	1.35	305.18
17	G+nQ	-3.96	3.14	173.94

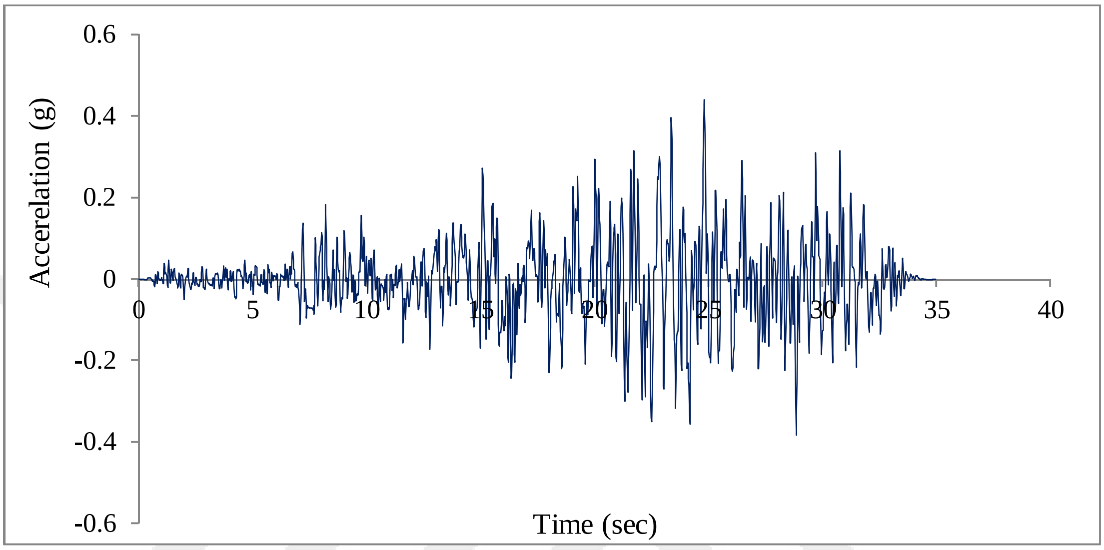
Mass reactions obtained from SAP2000.

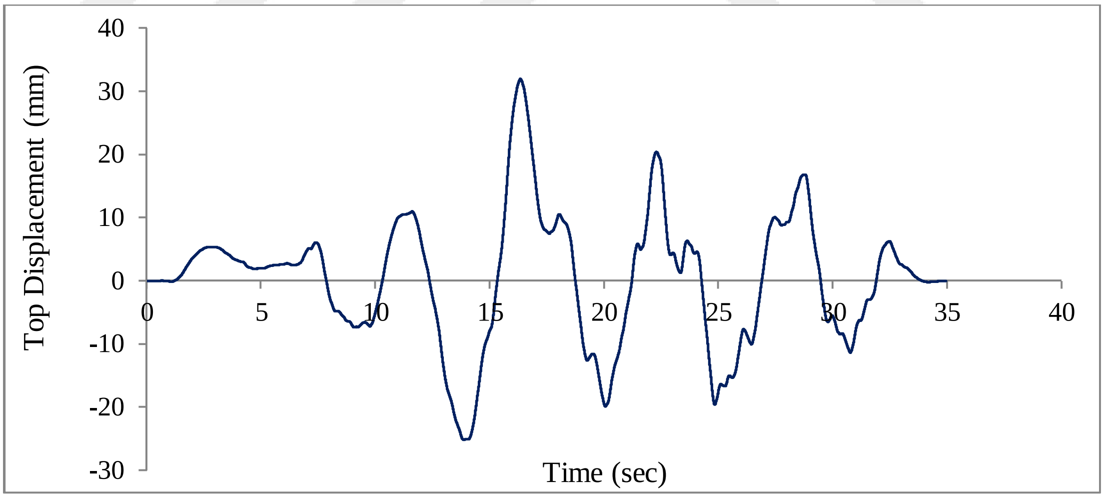
Joint	CASE	F1 [kN]	F2 [kN]	F3 [kN]
1	MASS	0.713	-2.366	116.043
2	MASS	0.47	2.701	113.064
3	MASS	3.034	-3.975	185.763
4	MASS	2.489	-0.237	366.3
5	MASS	2.443	4.098	234.65
6	MASS	0.87	-5.604	303.742
7	MASS	0.854	1.162	502.62
8	MASS	0.712	4.225	286.068
9	MASS	0.103	-5.692	312.299
10	MASS	0.039	1.218	510.318
11	MASS	0.099	4.218	291.881
12	MASS	-0.06	-5.615	305.392
13	MASS	0.103	1.181	503.884
14	MASS	-0.052	4.18	285.903
15	MASS	-3.964	-3.982	185.079
16	MASS	-3.893	1.35	305.182
17	MASS	-3.96	3.139	173.938

APPENDIX D

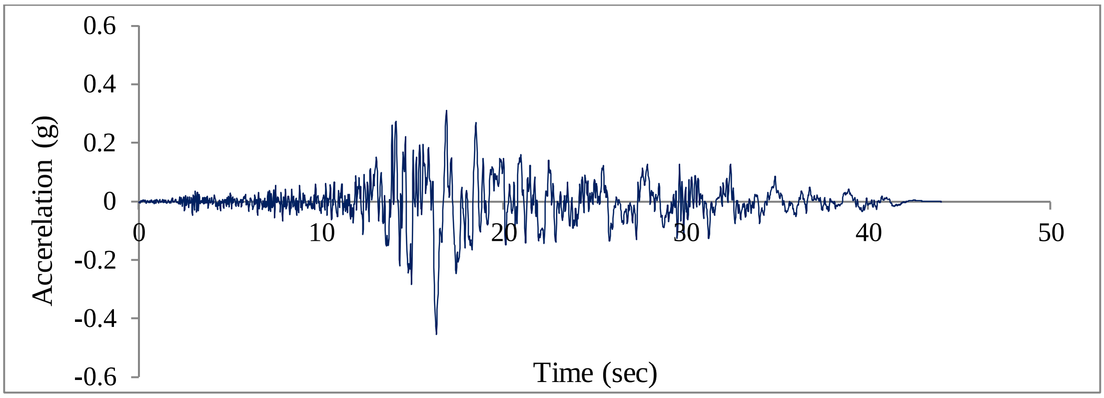
Time-history results for conventional material model under individual earthquakes are represented below.

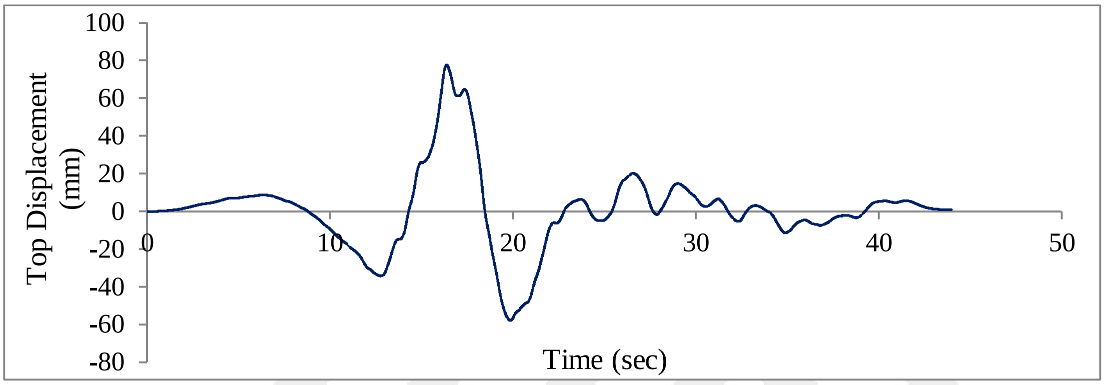
Tabas-Iran Earthquake (Boshrooyeh Station):



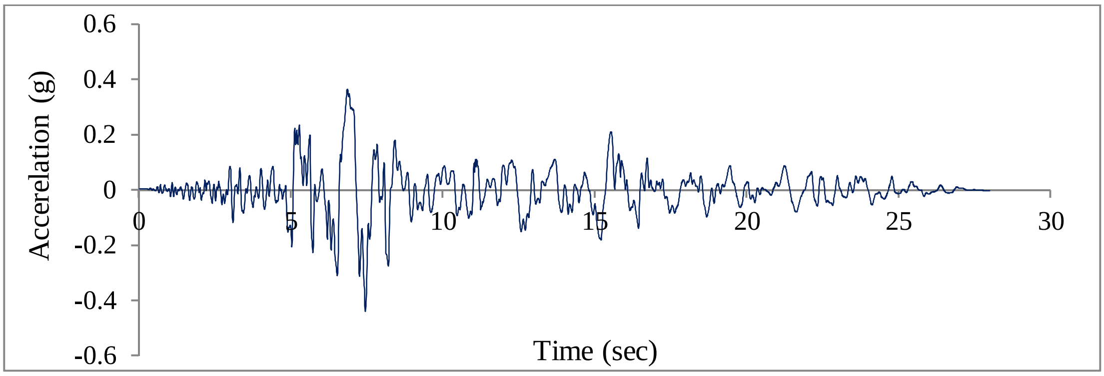


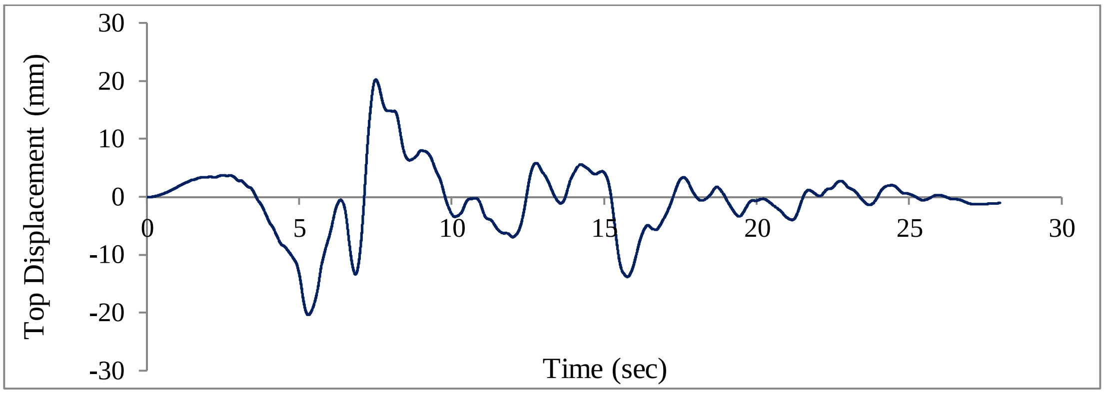
Landers Earthquake (Yermo Fire Station):



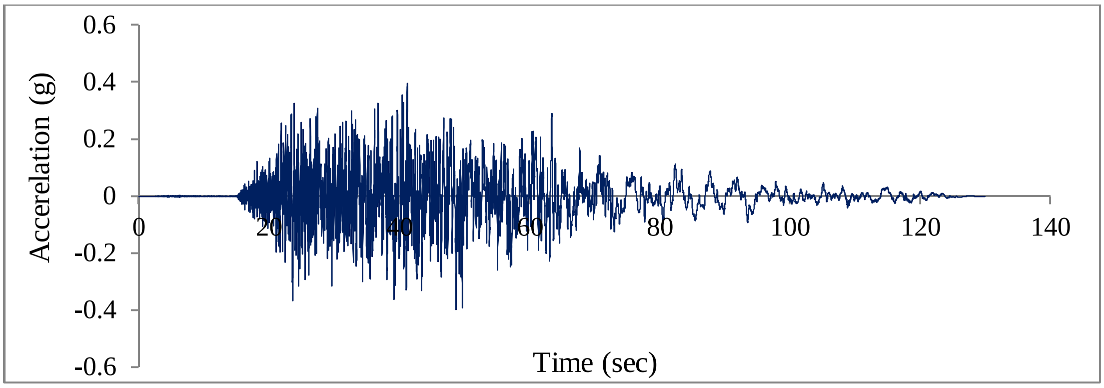


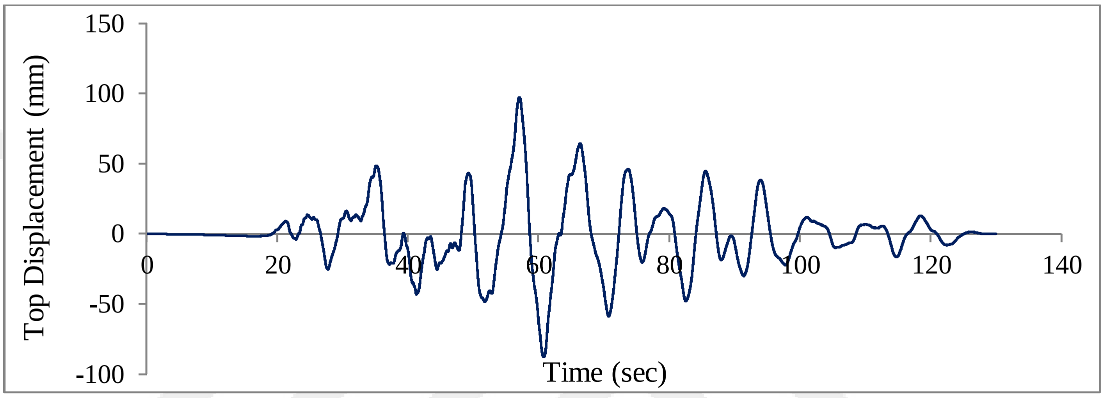
Cape Mendocino Earthquake (Ferndale Fire Station):



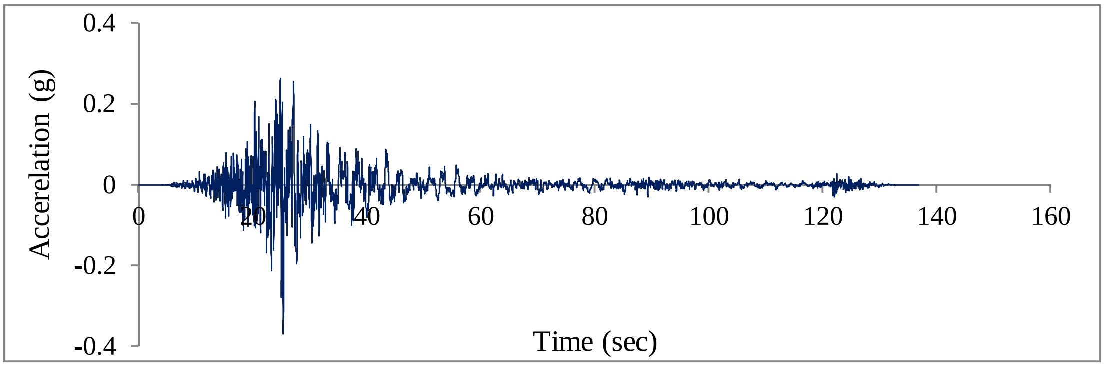


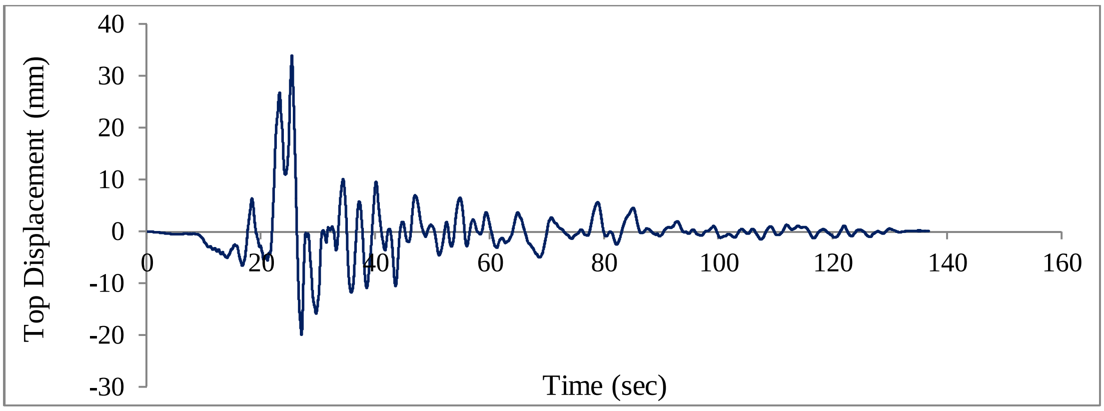
El Mayor-Cucapah_Mexico Earthquake (Ejido Saltillo Station):



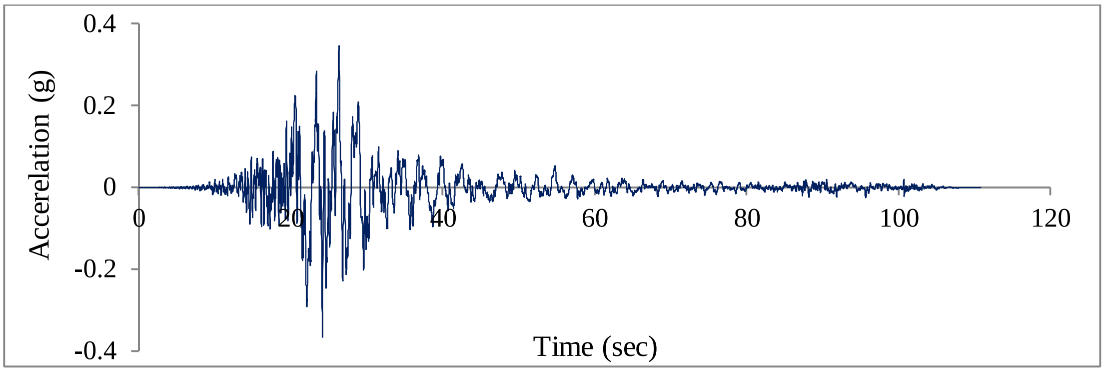


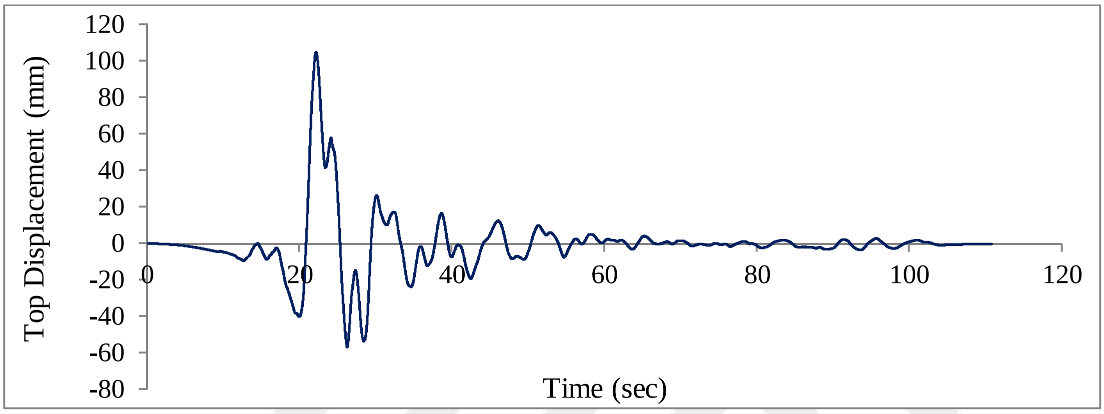
Darfield_New Zealand (Christchurch Cathedral College Station):



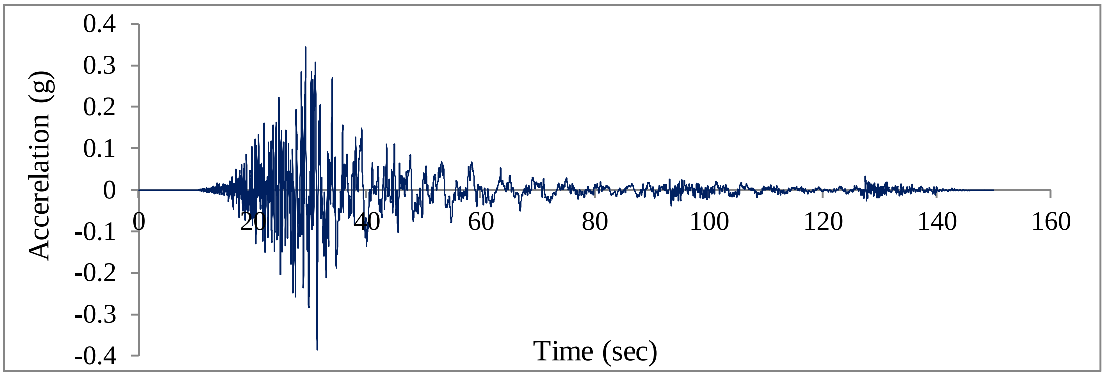


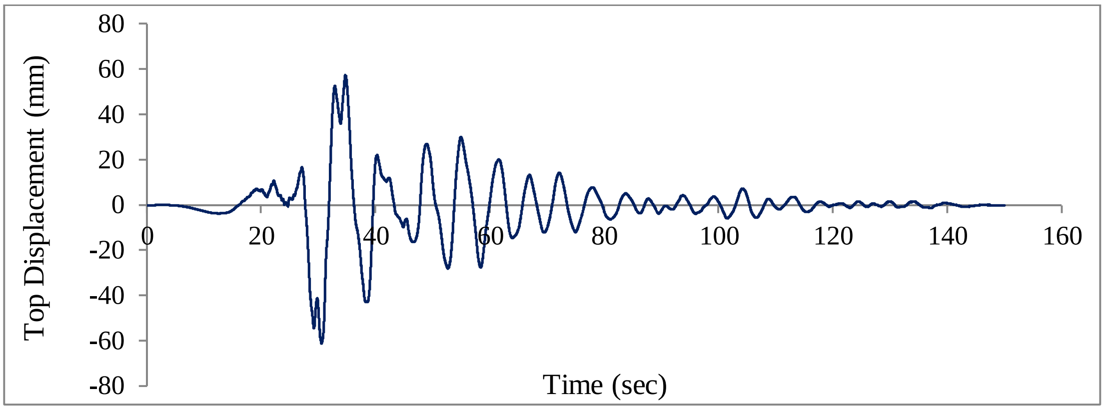
Darfield_New Zealand (Christchurch Hospital Station):



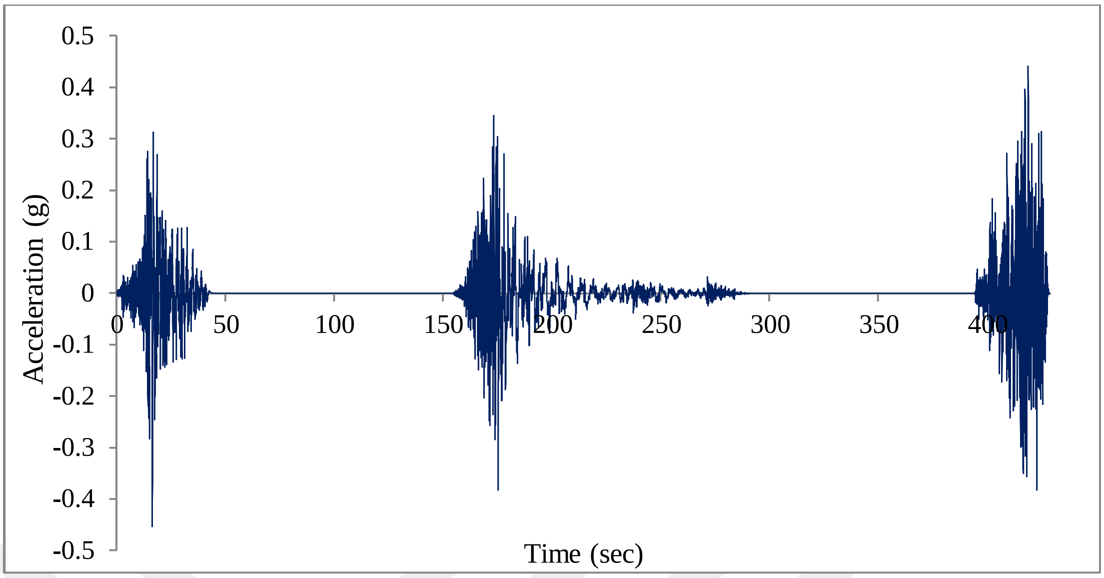


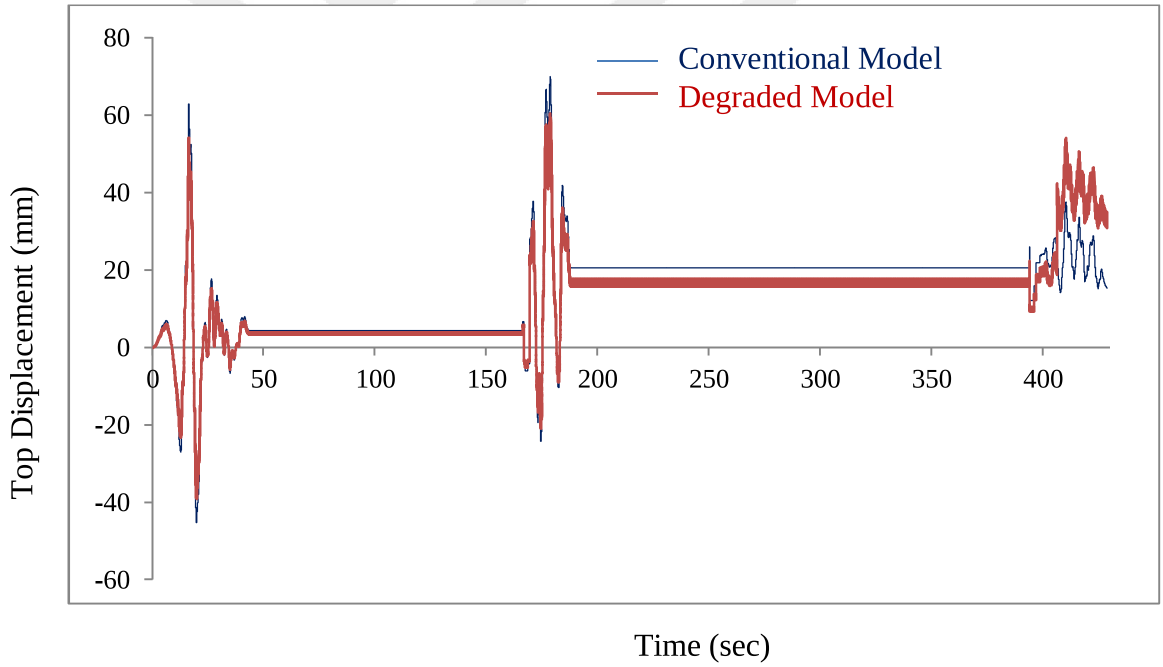
Darfield_New Zealand (Papanui High School Station):



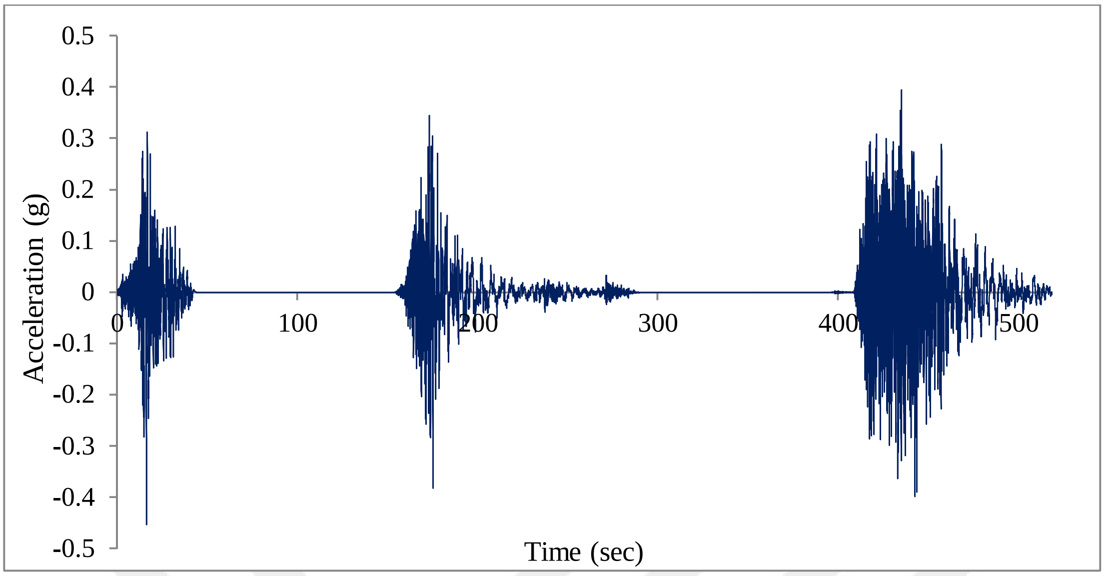


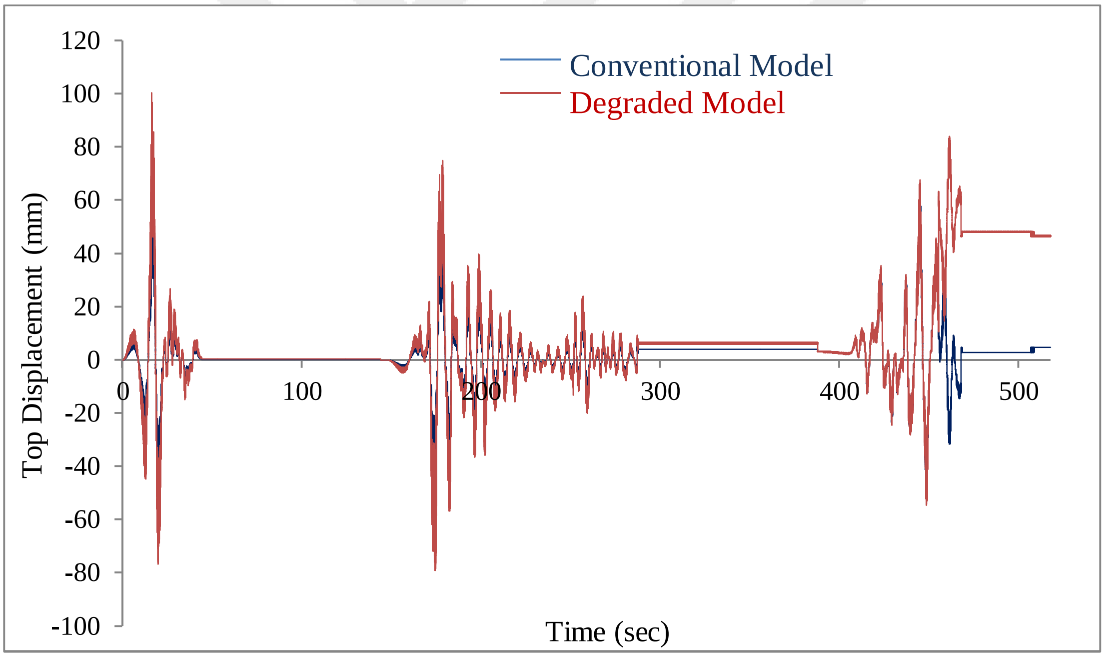
Multiple EQ Case–1:



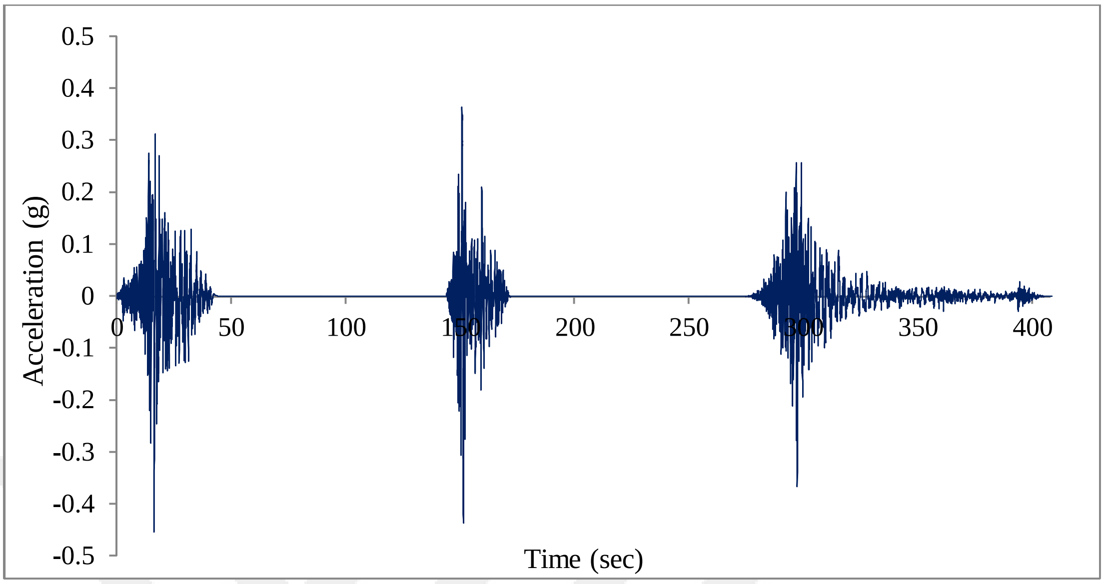


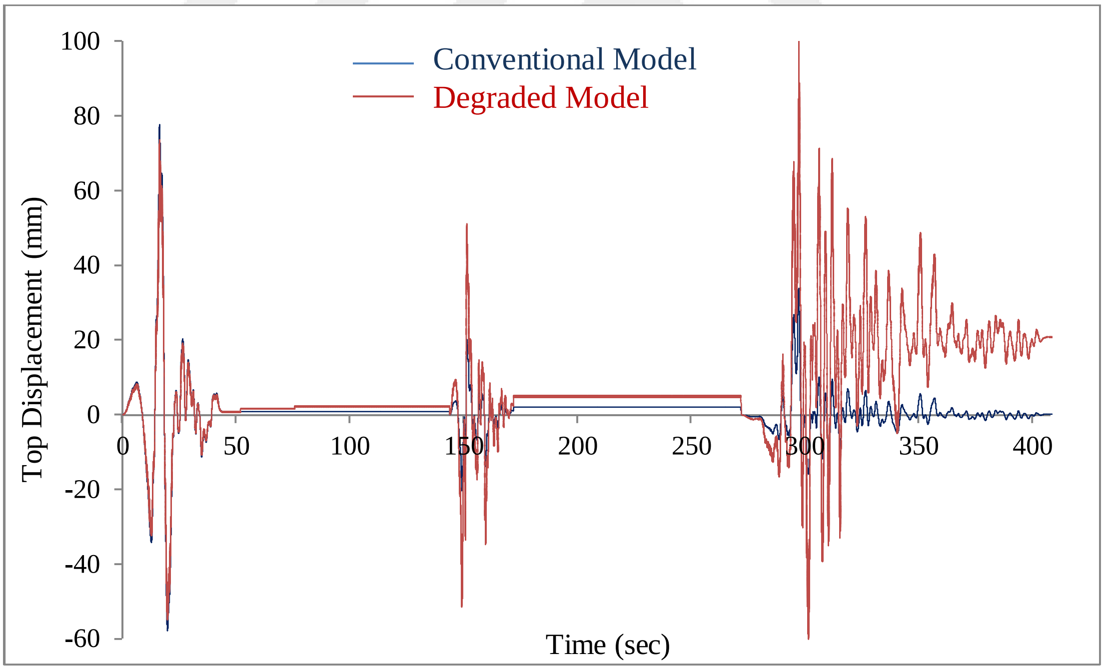
Multiple EQ Case–2:





Multiple EQ Case–3:





CURRICULUM VITAE

Name Surname : **Menelşe CANATAN**

Place and Date of Birth : **Ankara/1989**

E-Mail : **menekse.cntn @gmail.com**

EDUCATION

B.Sc. : **2011, Karadeniz Teknik Üniversitesi, Mühendislik ve Mimarlık Fakültesi, İnşaat Mühendisliği Anabilim Dalı**