

University of Bahrain

College of Engineering



**Department of
Civil Engineering**

**ASSESSMENT OF SEISMIC RESPONSE OF REINFORCED
CONCRETE (RC) 3D BUILDINGS USING NON-LINEAR
FINITE ELEMENT ANALYSIS (FEA)**

**A Thesis Submitted in Partial Fulfilment of the Requirements for the
M.Sc. Degree in Civil Engineering**

**Submitted by
Zainab Khalid Hussain Ali
20122371**

**Supervised by
Dr. Md Shah Alam**

February 2024

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Abstract

This research aims to investigate the effects of earthquakes on structural buildings, focusing on understanding the causes of building collapse. The study seeks to identify the specific locations and reasons for the initial failure of building members, which subsequently lead to the collapse of the entire structure. The goal is to mitigate or prevent building collapses during or after earthquakes, thereby minimizing loss of life and property damage.

Recent events highlight a significant gap in the application and understanding of earthquake resistant methods in the design, monitoring, and investigation of buildings. This deficiency has resulted in loss of life and property damage, placing a burden on the state for repairs and emergency response efforts. It's crucial to address these shortcomings to ensure better resilience against earthquakes and their associated risks. This report outlines the process of designing a building according to the BS8110 code, followed by the application of a performance-based analysis method. Two types of analyses will be employed: fiber modeling and the Plastic Hinge Approach. Firstly, the Fiber Modeling Method will be utilized for reinforced columns and shear walls. This involves categorizing the materials (concrete or reinforcement) into three levels: Immediate Occupancy (IO), Life Safety (LS), and Collapse Prevention (CP). Sections of columns and walls will be subdivided into smaller parts to study the effects of movement on them.

Secondly, the Plastic Hinge Approach will be employed for reinforced beam sections. Beams will be divided into smaller parts based on their geometry, following the guidelines of the ASCE41-17 code, and analyzed accordingly.

Subsequently, the entire building will undergo nonlinear analysis using two methods: Push-Over Nonlinear Dynamic Analysis and Nonlinear Time History Analysis. The pushover dynamic analysis entails applying horizontal displacement gradually until collapse is reached. The Nonlinear Time History Analysis involves subjecting the building to simulated seismic events. Finally, a comprehensive review of the results obtained from these two analytical processes will be presented.

By analyzing the obtained results, the causes of building collapse during earthquakes will be anticipated, on this research two results obtained from two different analysis are going to be presented, compared and studied as it is shown in chapter 4. When the case

of failure is known, and the elements that failure first are known, a redesign of building to withstand these loads is required. Then the building will gain the ability to withstand earthquakes for a determined period, which it can be estimate. Furthermore, this report examines various factors over time, such as horizontal displacement of floors and shear forces throughout the earthquake event. These analyses provide insights into the dynamic behavior of the structure during seismic events, aiding in the development of effective earthquake-resistant strategies.

Dedication

This research paper is dedicated to my dear father, who has been nicely my supporter until my research was fully finished, and my beloved mother who, for months past, has encouraged me attentively with her fullest and truest attention to accomplish my work with truthful self and confidence.

This work is also dedicated to my brother and sisters, who have always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve.

I am truly thankful for having them in my life.

Acknowledgements

Words cannot express my gratitude to the professor and chair of my committee for their invaluable patience and feedback. I also could not have undertaken this journey without my defense committee, who generously provided knowledge and expertise. Additionally, this endeavor would not have been possible without the generous support from My supervisor Dr. Md Shah Alam, this endeavor would not have been possible without the generous support from him.

I am also grateful to my classmates and cohort members, especially my office mates, for their moral support. Thanks, should also go to the librarians, research assistants, and study participants from the university, who impacted and inspired me.

Lastly, I would be remiss in not mentioning my family, especially my parents, My Siblings, my grandfather, and my grandmother. Their belief in me has kept my spirits and motivation high during this process.

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Chapter One

Introduction

1.1 Overview

In this project, a six-story reinforced concrete building are going to be analyzed, design based on British code (BS 8110-1997 for Concrete and BS 6399 – Part 1 for reinforcements) first as a linear elastic design, then a nonlinear modeling and design will be followed.

The building is residential building contained of 2 flats at each floor and it is located at Gaziantep city in turkey to study the catastrophic earthquake effect happed on turkey and Syria on 6th Feb 2023. Which caused 50,783 deaths, 107,204 injured, 297 missing in Turkey and 8,476 deaths, 14,500 injured in Syria.

The goal of this research is to study the response of buildings to earthquakes, find out the causes of their collapse and how to reduce the loss of life and property at the individual level, in addition to the losses of repair work and the resulting effects at the state level.

Let's take a look at what the The Council on Tall Buildings and Urban Habitat (CTBUH) newspaper wrote about the devastating earthquake in Turkey, and the reactions of political leaders in Turkey, which shows that the risk of building collapse during earthquakes is a significant problem in addition to an engineering problem.

“Turkish President Pledges to Increase Building Seismic Resilience

The Turkish President has made a promise to rebuild the country’s southern region that was heavily damaged by an earthquake on 6 February, 2023.

Over 50,000 people died from the 7.7 and 7.6 earthquakes that struck 11 Turkish provinces. A few weeks later, another two earthquakes occurred. President Erdogan has said he will prepare the city better for future disasters. Over 13.5 million people have been affected by the earthquakes. Projections made in 2021 stated that 200,000 buildings in the nation's capital stand with a medium to high-level risk of collapsing. An investigation into an earlier earthquake in 1999 also found that many buildings in the city did not meet design requirements and were not earthquake resistant even. They did not meet design requirements and were not in compliance with regulations. For more information refer to reference 48). “

1.2 Background of the study

This report was based on backgrounds, the most important of which were theoretically based on the principles of static engineering during the design of the building, and then on studying the effect of movement on the two components of the structure through knowledge of the dynamic nature or movement of materials. This was the basic background for the research, as well as albumin records around the world in general, Records of earthquakes close to the earthquake studied in this research gave the research more realism.

Due to the large number of earthquakes recently and the many losses of life, the need to understand structures during earthquakes has become an urgent and important necessity.

1.3 Problem statement

The Earthquake's problems

Earthquake event starts from seismic sources, and an epicenter initiated at earth level at the same location of hypocenter, the seismic waves starting from the source reach to the site, this attenuation increase the energy of those seismic waves as well as modification in frequency quantitate. Once this wave reaches close to the site, the local soil of the site has role to amplify or de amplify the ground motions, ultimately it reach to the base of the structure as it is shown in figure 1.1 below. The process of estimating this future ground shaking and the actual dynamic shaking of the ground cannot be exactly estimated, only some peak number in propylitic manner through prosses called' probabilistic seismic hazard assessment (PSHA) can be estimated. Also, by using site responded analysis to know wither the local soil site condition will amplify or de amplify the seismic waves before its reach to the soil of the structure, so (future ground shaking can be represented by peak ground accretion or peak speedread accretionary spectral accretion values corresponding to different time period of different properties of structure.

The structure on the other hand is converted to linear/non-linear analyses model, which is a computer model created for linear/nonlinear analysis is compromise between a real structure and its mathematical representation, followed by application of estimated ground shaking to the model, and then come up with estimation of seismic demands, those demand could be:

Global level responses (which mean story level)

Inter Story responses (Inter story grids)

Component level responses (individual column or beam or any other component)

The scope of this report will be from structural idealization, analysis and the final performance assessment.

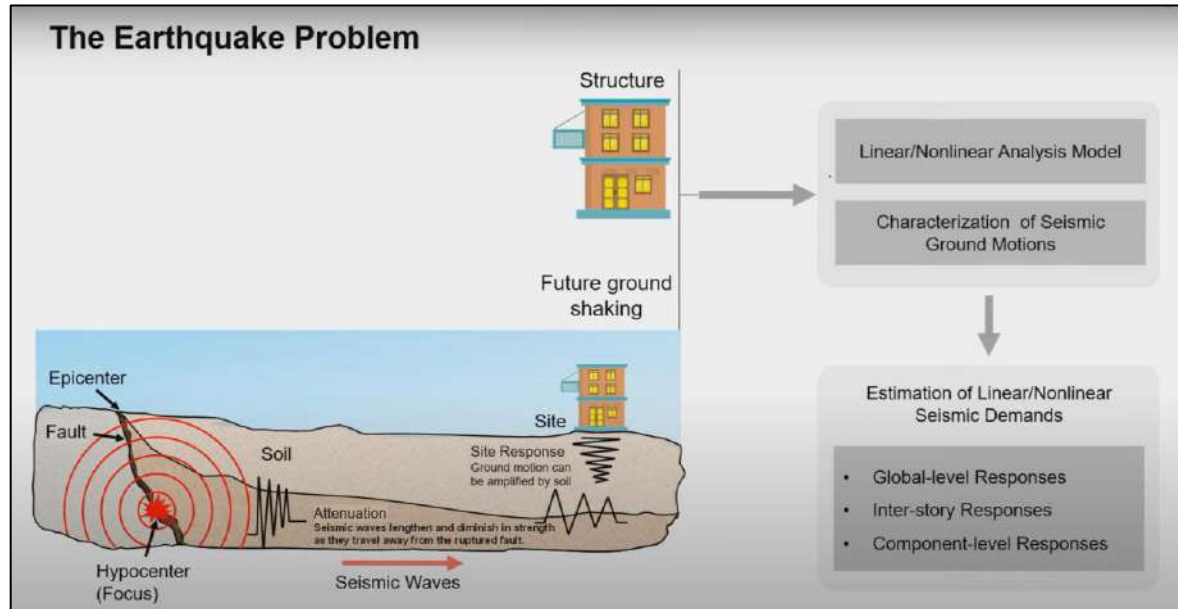


Figure (1.1): The earthquake problems

Some countries have their own institute to ensure the safety during the earthquakes. America for example has the Federal Emergency Management Agency (FEMA) employs more than 20,000 people nationwide, it has 10 regional offices located across the country to make sure America is equipped to prepare for and respond to disasters. Refer to reference No. 21.

1.4 Objective of the study.

“To reduce risk of disaster and increase safety, one need to estimate hazard properly and reduce Vulnerability” [31].

The main goal of the research is to avoid the danger of building collapses at the time of earthquakes or severe horizontal displacements, and thus reduce the loss of life and property. The research also has other goals, which are determining the design goal, or in other words, the design is

based on specific levels that depend on the budget or the expected lifespan, for the building to be constructed, for example, the owner can determine the time at which the building will collapse from the time of the earthquake, such as an hour, half an hour, and so on. He can also determine the expected size of destruction such that the earthquake affected non-structural elements only. Another goal that the research addresses is to study the mechanical nature of the building from a kinetic or dynamic perspective, and thus know the nature of materials and their response to various forces.

1.5 Research questions.

In this research, the following questions will be answered:

1. The cause of building collapses during earthquakes.
2. How to predict when a building will collapse?
3. How to know which element collapsed first and which caused successive collapses of other?
4. How to avoid the collapse of the building and limit the destruction to non-structural elements?

Chapter Two

Literature Review

2.1 Introduction

Some of the important concepts of performance based seismic design and how to use the nonlinear modeling and analysis to come up with detailed performance assessment of structures are shown in detail in this section.

The observable part of this report will be applied of nonlinear modeling of structure by using ETABS 2020.

Starting with the basic of performance based seismic design, reason of using nonlinear modeling and analysis of structures, then the major nonlinear modeling approach, which will be used in nonlinear analysis of structures, then a nonlinear dynamic analysis which mean the nonlinear responds analysis, the selection of ground motions, the modifications of ground motions required for dynamic analysis will be discussed, along with a nonlinear static analysis procedure of pushover analysis and how to interpolate the result of nonlinear analysis to assist the structural performance or behavior of the building structure.

By looking at the historical seismic data of all the world, the map in Figure 2.1 shows the location of all major earth quicks in last 67 years, several observations can be made from this historical seismic data, such that earthquakes do not occur everywhere, they only occur at certain places on the world, and those places basically corresponds to the boundary between two tectonic plates, so some countries which lay on the area close to the boundary of tectonic plates are most probable to earthquakes that other country away from these boundary. In Bahrain according to Think hazard website (Refer to reference No.51), Bahrain's earthquake hazard classified as very low, which means there is less than 2% chance of potentially

damaging earthquakes in the next 50 years, while its high-hazard level in Iraq, a chance of 10% potentially damaging earthquake shaking in the next 50 years.

Think Hazard provides a general view of the hazards, for a given location, that should be considered in project design and implementation to promote disaster and climate resilience. The tool highlights the likelihood of different natural hazards affecting project areas (very low, low, medium and high), provides guidance on how to reduce the impact of these hazards, and where to find more information. The hazard levels provided are based on published hazard data, provided by a range of private, academic and public organizations. Refer to reference 41.

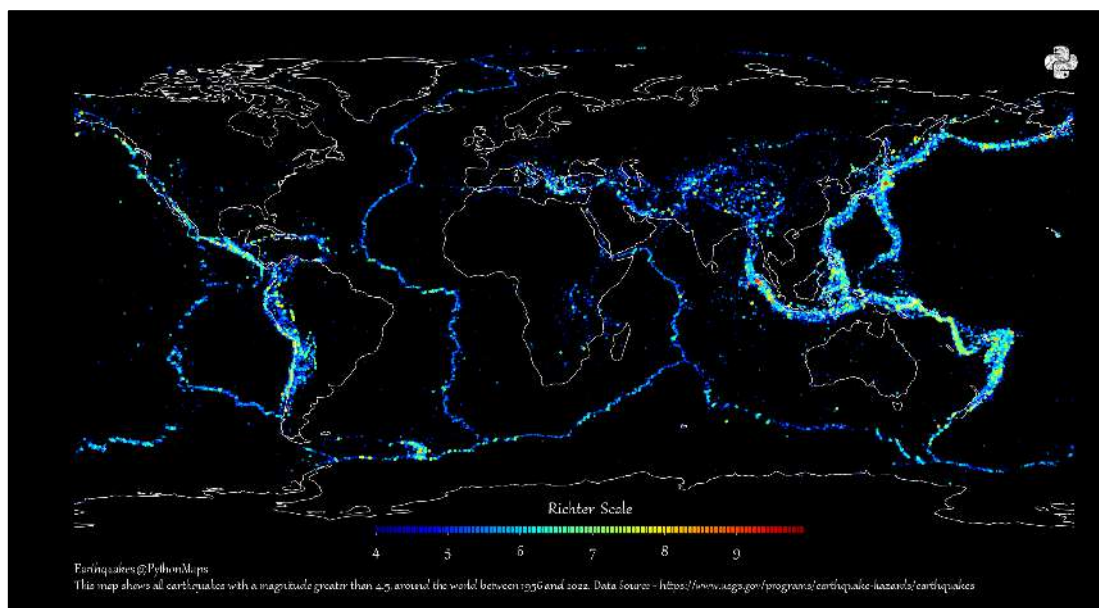


Figure (2.1): The world's major earthquakes from 1956–2022, source: mapping the world's major earthquakes from 1956–2022 (visualcapitalist.com).

From the Figure 2.2 below its shown that the Arab countries lay between 4 tectonic plates (Eurasian, Arabian, African & Somali pleats).

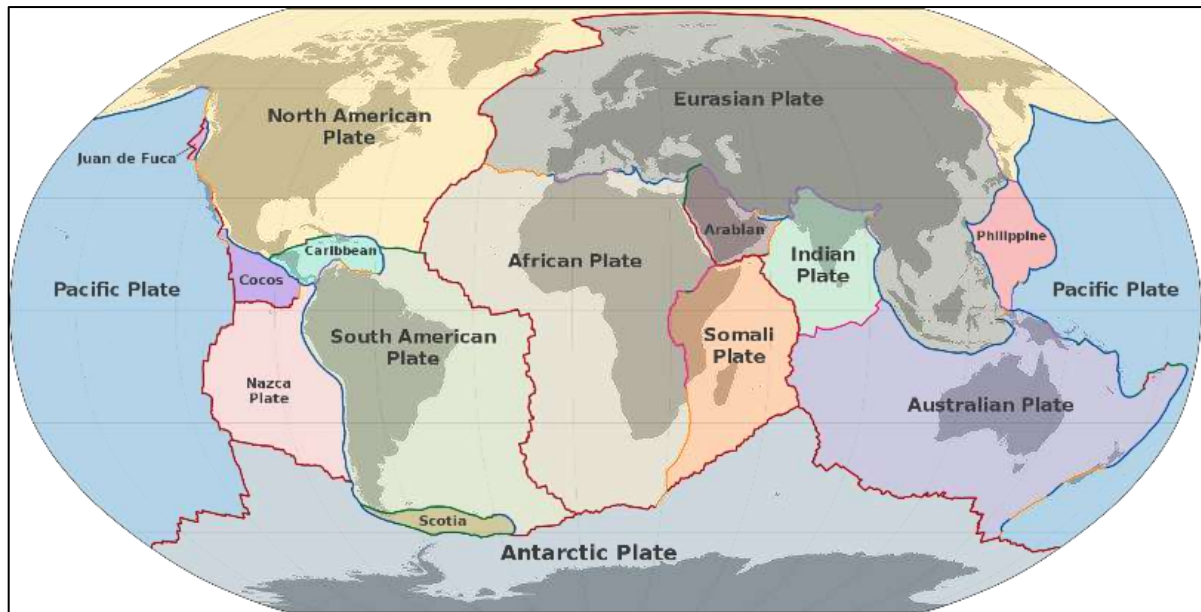


Figure (2.2): Map of earth's 16 principal tectonic plates divergent, source: new maps of global geological provinces and tectonic plates (phys.org).

USGS for example, provide science about the natural hazards that threaten lives and livelihoods, the water, energy, minerals, and other natural resources we rely on, the health of our ecosystems and environment, and the impacts of climate and land-use change. Our scientists develop new methods and tools to enable timely, relevant, and useful information about the Earth and its processes. Created by an act of Congress in 1879, the USGS provides science for a changing world, which reflects and responds to society's continuously evolving needs. As the science arm of the Department of the Interior, the USGS brings an array of earth, water, biological, and mapping data and expertise to bear in support of decision-making on environmental, resource, and public safety issues. Refer to reference No.19.

Also, Earth Scope is a global community of hundreds of employees and tens of thousands of scientists, scholars, and educators. their goal is to advance human understanding of the Earth and its physical systems by democratizing access to geophysical observations and practices. Refer to reference 22.

2.2 Performance based seismic design of structure.

2.2.1 An Overview of the Performance based seismic design Process

It is generally goes beyond the code-based design. The code-based design serves as an input to performance base design. As it's shown in figure 2.3 below, the first step is analysis and design structure must be done based on code (a linear elastic model). That gives the initial design (Such as member section and reinforcement details). From that information members capacity can be obtained. And then perform and formulate the nonlinear model (the more realistic Model), that will give a real seismic demand and the actual damage of the structure. (Refer to reference No.45 and 46).

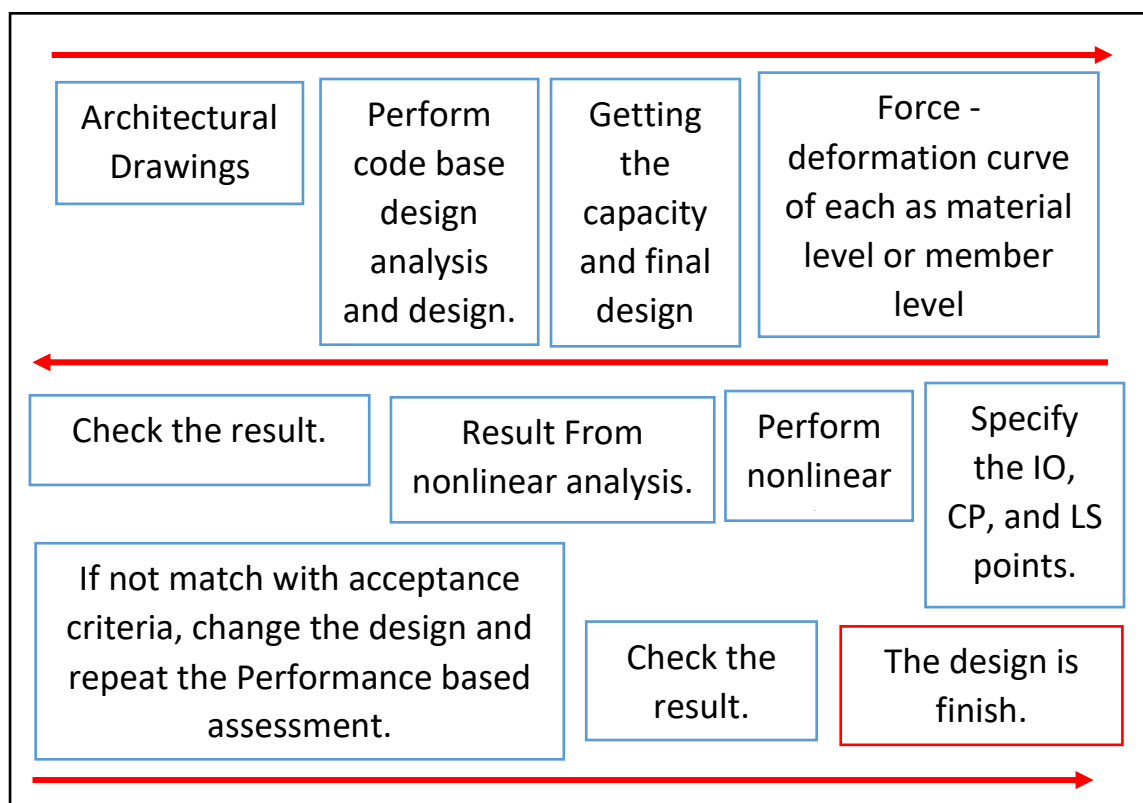


Figure (2.3): Performance based process diagram.

As it is shown in the figure 2.3 above, structural design starts with finalizing of architectural drawings. This drawing will be analyzed, and design Based on code which is on our research is the British court. Once the analyze and design is finish. That's mean the cross section and reinforcement details has been finalized, member capacities are known (e.g., yield moment, axial moment force). Enables to draw Force - deformation curve as a material level or as sectional level, with construction of the force-deformation curve, it can easily detect the safety of the member since the applied load will not go beyond the linear elastic slope on the graph, this can be defined as IO (i.e., immediate occupancy level). By increasing the force applied and at the capacity increase to the ultimate point this is considered as LS point. Then at degradation of the material strength or at the ultimately Failure, this is considered as CB level. These curves and the criteria IO, LS & CP is considered as an input to the nonlinear analysis. After performing the nonlinear analysis, results must be checked whether the results match the given acceptable criteria which have been set before as IO, LS & CP, otherwise, design must be changed and repainting the same process are required. (Refer to reference No.42).

2.2.2 Performance based design guidelines

There are some special purpose guidelines for performance-based design, that should be followed as shown in figure 2.4. They are not building codes, or something which it should followed legally as part of the conventional design or part of the legal requirement. They are guidelines and they can be used as instructions and directions, some are represented in figure 2.5.



Figure (2.4): Special purposes guidelines.

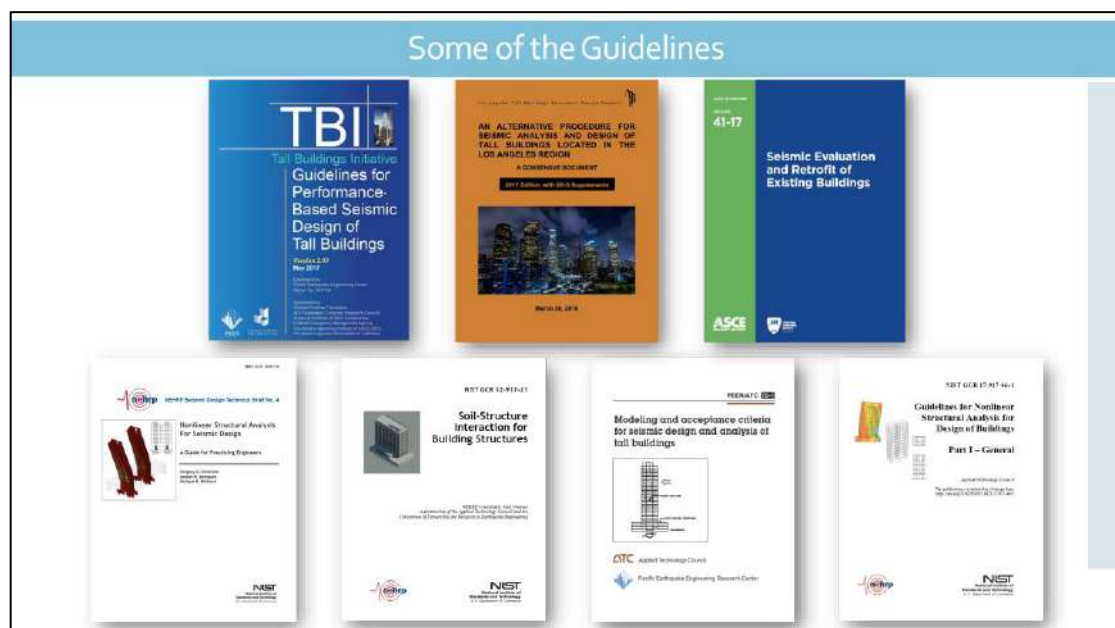


Figure (2.5): Examples of reference seismic design guidelines.

2.2.3 Judgment of Performance Acceptability

Acceptance criteria are indicators of whether the predicted performance is adequate for

- i. Local (component based), Example: Drift ratio, structural component deformation.

ii. Global (overall structure-based) Example: Roof drift, base shear.

For more information regarding Acceptance criteria, refer to reference 29, PEER/ATC-72-1 (2011): Modeling and Acceptance Criteria for Tall Buildings, USA Guidelines.

2.2.4 Performance Levels

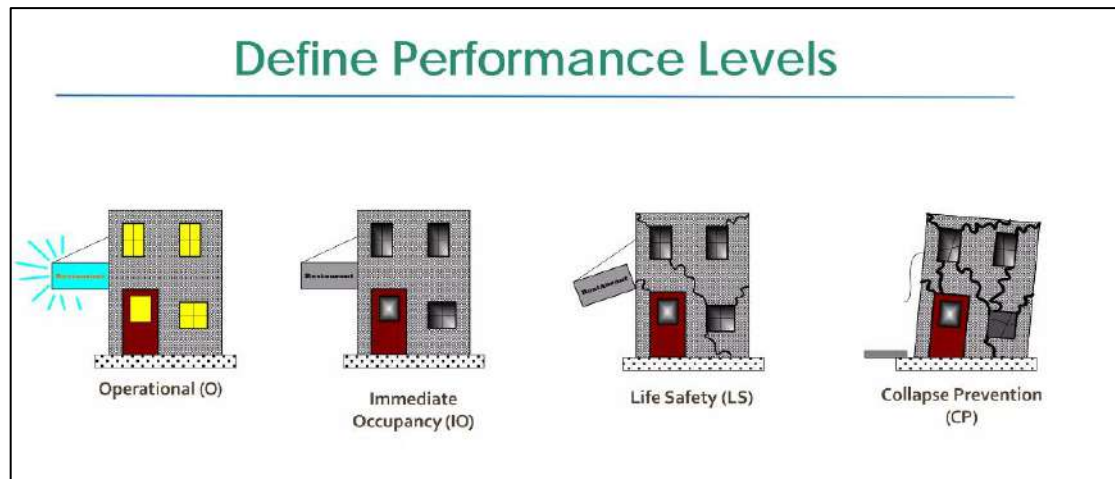


Figure (2.6): Definition of performance levels.

According to FEMA 356 (2000): Pre-Standard and Commentary for the /seismic Rehabilitation of Buildings., reference 16:

“Building performance can be described qualitatively in terms of the safety afforded building occupants during and after the event; the cost and feasibility of restoring the building to pre-earthquake condition; the length of time the building is removed from service to effect repairs; and economic, architectural, or historic impacts on the larger community. These performance characteristics are directly related to the extent of damage that would be sustained by the building.”

There are some standard performance levels which are used in the context of performance-based design approach, as shown in figure 2.5 and they are defined descriptively in different standards. The four standard performance

level are operational(O), Immediate occupancy (IO), life safety (LS) and collapse prevention (CP), which are used in meaningful discussion with the decision maker or the primary stakeholder. sometime owner requests that structure is not allowed to have any damage, or it will remain exactly intact. Immediate occupancy (O) means that it will have some damage, maybe some minor damage, but it will be able to occupy it immediately after the earthquake, this will become immediate occurrence actions almost more than life safety means that there can be some damage, but there will be no loss of life. Collapse prevention (CP) means that there can be significant damage, but the structure should not collapse, it should remain standing. These four performance levels are widely used nowadays to describe different performances of a structure under different loads. Owner can request from designer to design a building that has 10% probability of exceedance in 50 years of earthquake. While at 2% probability in 50 years of exceedance, which means for a very low probability earthquake, very rare event, it may allow another performance level. As shown in figure 2.10, this will become the performance object. Definition of a hazard level and the description of the damage (The performance level), this combined will become the performance/design objective.



Figure (2.7): Define performance level for specific hazard level.

i. Operational Level (O):

Which mean, negligible structural and nonstructural damage, so it can be occupied safely during event, the utilities and facility are available for immediate re-use (some cleanup required). The loss $< 5\%$ of replacement value. As it is shown in Figure 2.8

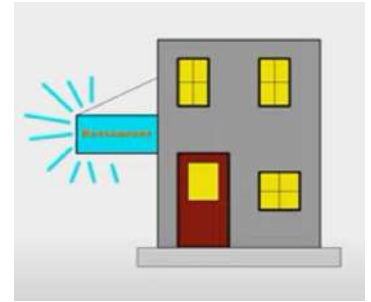


Figure (2.8): Operational level (O).

ii. Immediate Occupancy Level (IO):

That described negligible structural damage. Occupants safe during event, only minor nonstructural damage. The building is safe to occupy but may not function, limited interruption of operations. The losses $< 15\%$. As it is shown in Figure 2.9

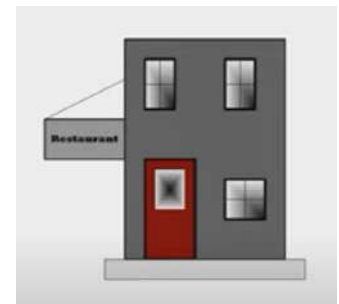


Figure (2.9): Immediate occupancy level (IO).

iii. Life Safety Level (LS):

When the structure significantly damaged. Some injuries may occur. Extensive nonstructural damage. Building not safe for re-occupancy until repaired. Losses $< 30\%$. As it is shown in Figure 2.10



Figure (2.10): Life safety level (LS).

iv. Collapse Prevention Level (CP)

Represent the case when Extensive (near complete) structural and nonstructural damage, and significant potential for injury but not wide scale loss of life, extended loss of use. And repair may not be practical. Loss $>> 30\%$. As it is shown in Figure 2.11.

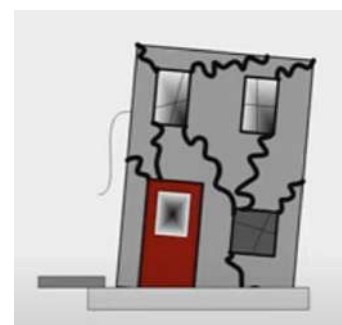


Figure (2.11): Collapse prevention level (CP).

We quote from reference No.4. 4. ASCE/SEI 41-13 (2014): Seismic Rehabilitation of Existing Buildings Guidelines (ASCE/SEI 41-13).

“The committee agreed that the philosophy of permitting existing buildings to be evaluated, and even upgraded, to a lower hazard should be retained. There are a number of reasons for this, which are discussed in detail in the ASCE 41-13 Chapter 2 commentary. They are:

- Permitting buildings recently built to not be immediately rendered deficient when there are minor changes to the new design standards.
- The increased risk due to the lower hazard is acceptable because of the presumption that an existing building has a shorter remaining life than a new building.
- The cost of retrofitting to achieve commensurate performance can be disproportional to the increased benefit as opposed to doing something to make the building better by mitigating the most egregious deficiencies”

Once the structural damage classification under the four is decided, damage can be related to any other loss, for example economic loss, repair cost and how much repair time will be required in the facility will be shut down.

As an example, graph or relationship can be drawn as hazard measure (or the loading severity) in Y-axis and the structural displacements (or deformations) on X-axis and put these performance levels on this curve as it is shown in figure 2.11, That means these four performance levels can be related to the demand side of the analysis (the demand and capacity), all can be related to these four performances. If someone says collapse prevention of the structure, it should be known clearly that it is somewhere towards the end of force-deformation behavior or the loading security versus structural deformation.

Performance-Based Structural Design: What Is It?

By Naveed Anwar, Vice President for Knowledge Transfer, Asian Institute of Technology. In reference 33:

“How to link design decisions with performance indicators?”

Many of the disciplines use key performance indicators (KPIs) or a performance-based approach in management, evaluation, and monitoring. Employees in a company have KPIs that sets expected targets for them. In some traditional companies, employees only have to spend eight hours in the office but that is not useful for examining performance, however, what is useful in determining the output during those eight hours. Similar was the case for earthquake loading which made seismic structural design the catalyst for starting performance-based design. When we have earthquake effects on the structures, we expect the structures to remain standing and not to be damaged severely but how to ensure that?”

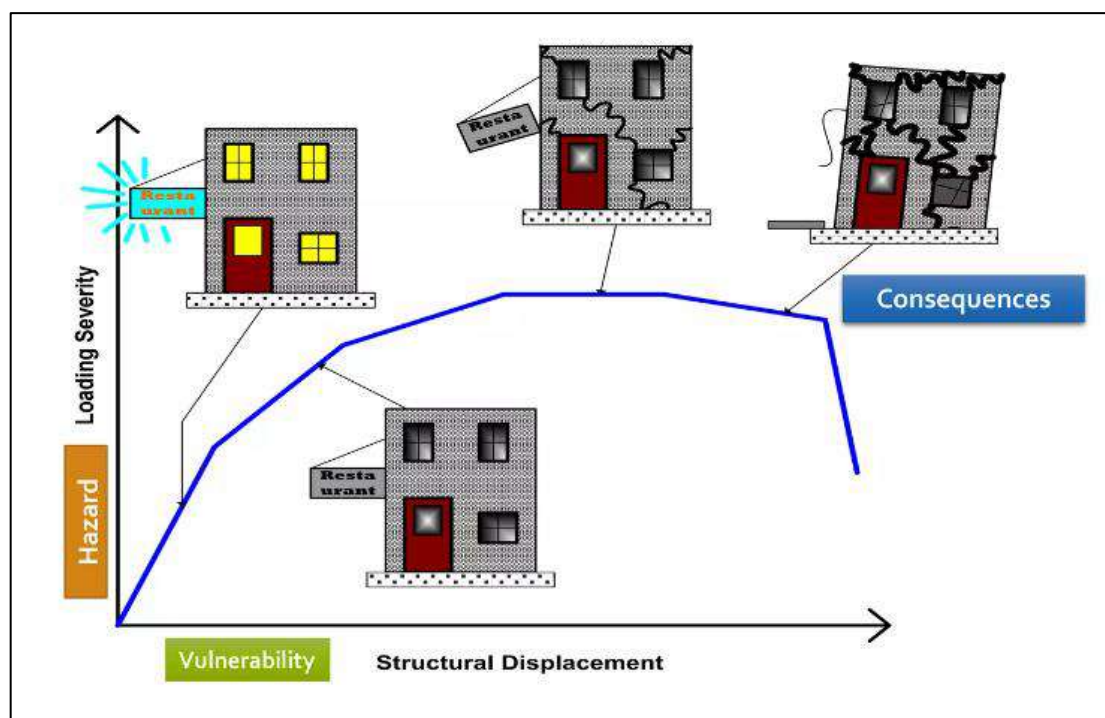


Figure (2.12): Link the damage to performance levels.

This is the idea, the damage already expected or concluded by the nonlinear analysis or predicted by the nonlinear model, can be converted to any other

loss like number of casualties expected during that earthquake as shown in figure 2.12 above and figure 2.13 below. Models are available to convert structural analysis results into the expected number of casualties or injuries, also, convert structure analysis results into downtime or rehabilitation time. As an example, the rehabilitation cost or the required cost to restore after an earthquake can be calculated.

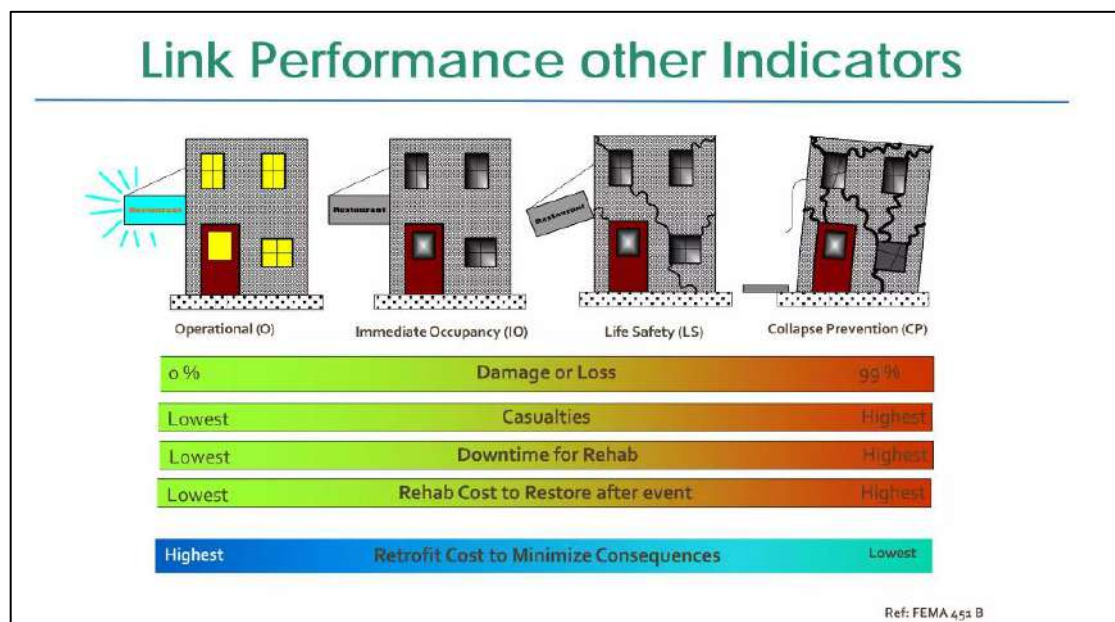


Figure (2.13): Link performance level to other indicators

Series of video records presented by Dr. Graham Powell explains the Performance Based Design, applications and software. Reference 32.

Another useful reference is International Seminar and Workshop on Performance Based Design of Reinforced Concrete Buildings - 27-28 August 2013 - Hosted by the Asian Center for Engineering Computations and Software (ACECOMS) in collaboration with AIT Consulting. Refer to reference 43.

Chapter Three

Research Methodology

As discussed above, the first step of performance-based analysis is design the building based on construction code which is in this research is British code BS8110 as a linear analysis (In the other words Elastic analysis), and once the member section dimensions are finalize, two analysis to be applied (fiber hinge analysis and Plastic hinge analysis) making the model ready to start nonlinear (inelastic) analysis.

Elastic/linear analysis will start by converting the architectural drawings to DXF file as a base for start ETABS modeling by defining materials, elements such as beams, columns, slabs, and foundation type, then defining loads and load combinations. Ending the steps by run, analysis and design the model. Designing the model means that the sections of building elements are capable to carry out the load applied withing the elastic region. Then, the same design will be used for inelastic-plastic -nonlinear analysis.

3.1 Structural design of multi-story building using ETABS – British Codes

As discussed in overview of the performance-based design process, the first step is designing the building as per the architectural drawings based on Building code, in this research a five-story residential building will be designed based on British code BS8110 as shown in figure 3.1 below.

Reference No.9 provide Video Tutorials for ETABS modeling and analysis.

3.1.1 Architectural Drawings

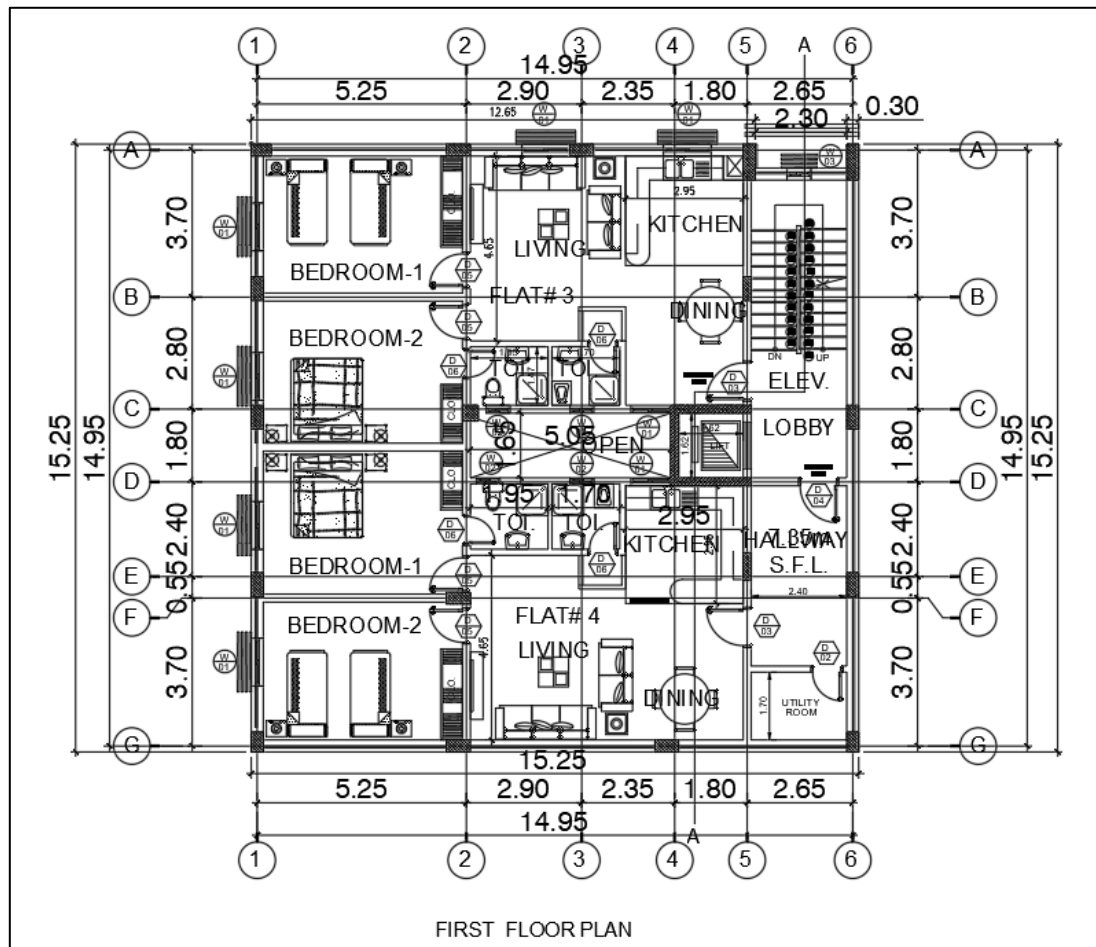


Figure (3.1): Typical floor plan – Architectural drawing

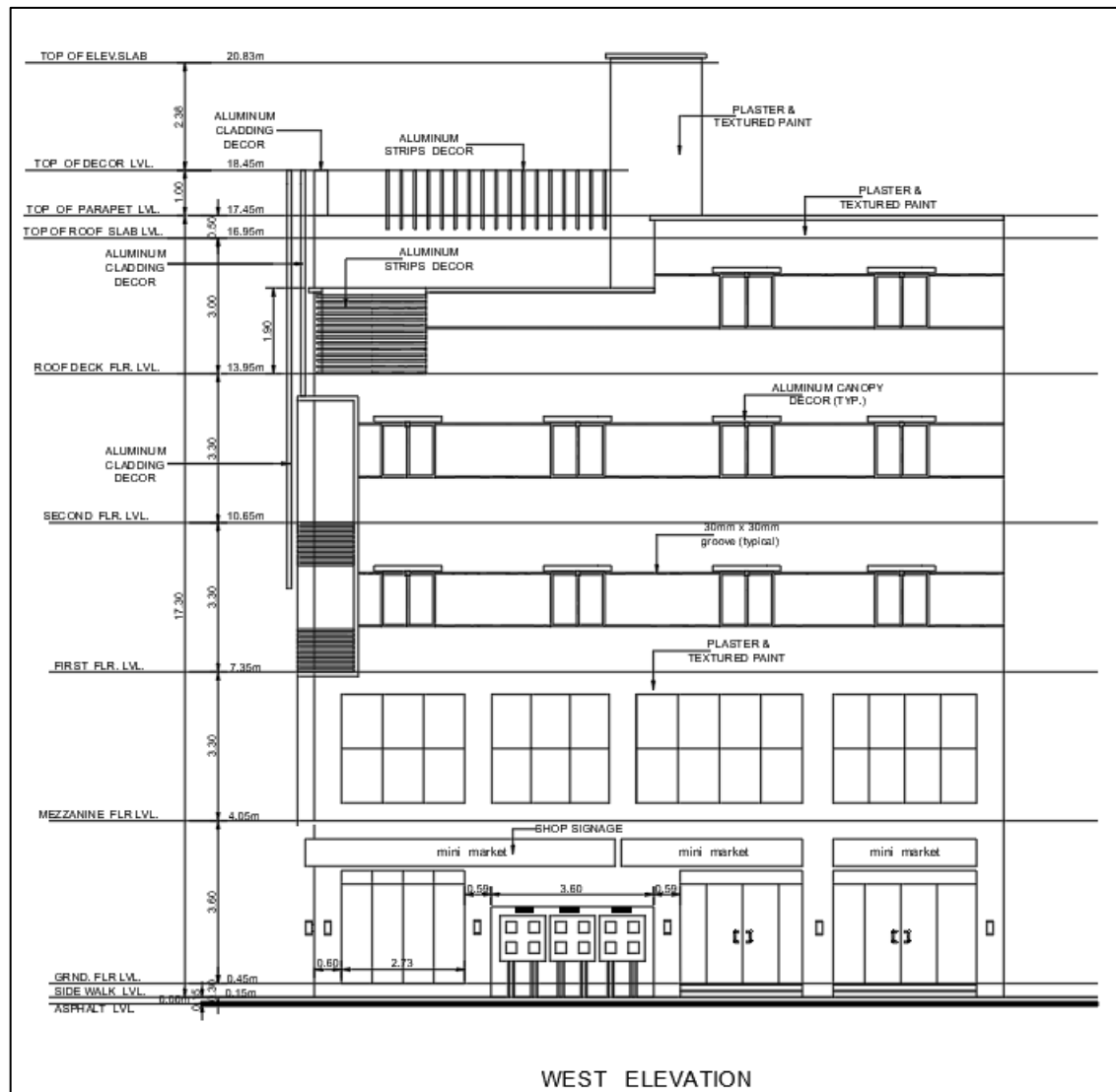


Figure (3.2): West elevation – Architectural drawing

3.1.2 Perpetration of DXF file

Converting the AUTOCAD file of architectural drawings to DXF file by converting the beams and columns to a single line, and converting slab and shear wall to polylines, enabling to be transfer to ETABS.

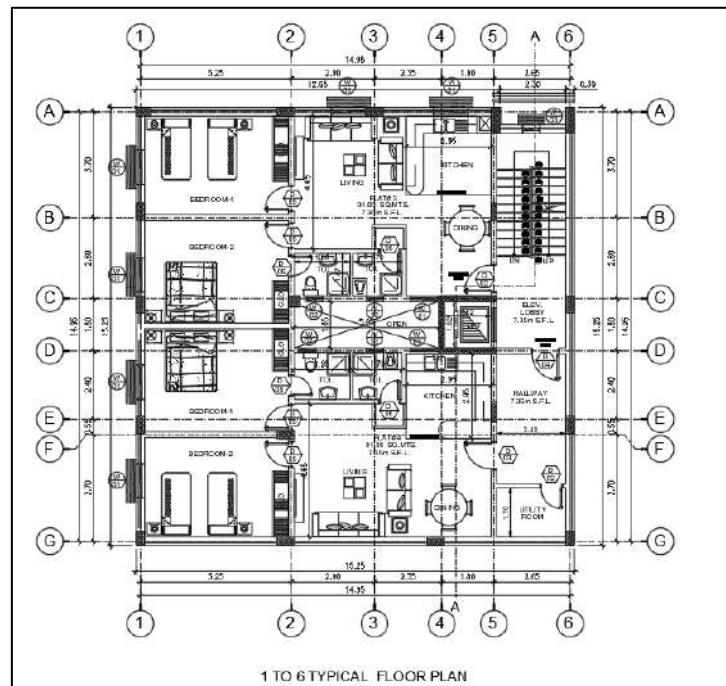


Figure (3.3): Original plan

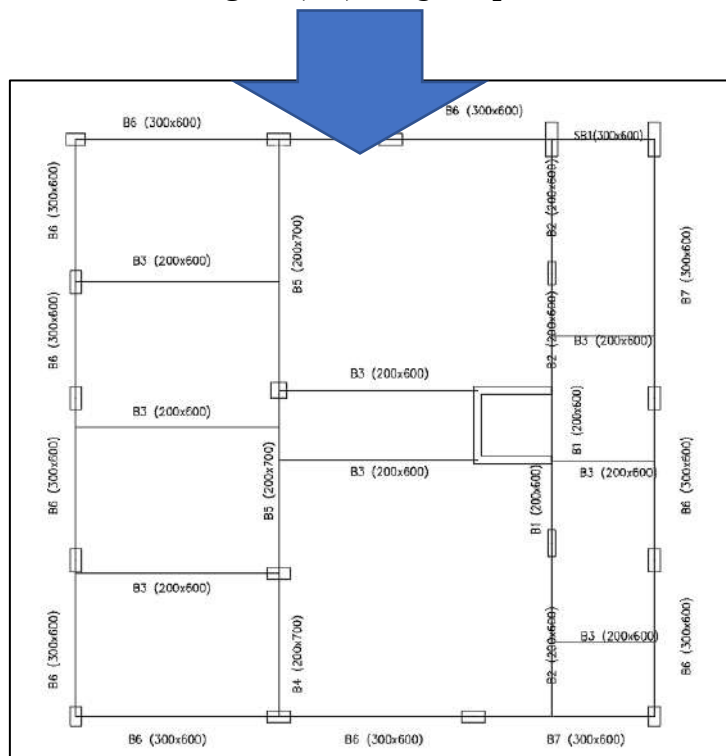


Figure (3.4): DXF file

3.1.3 Model the building in ETABS

Molding of the structure in ETABS start by importing the previously prepared DXF file and defining the materials of concrete and reinforcement and drawing the structural members as it is shown in figure 3.5 and figure 3.6. For details refer to appendix (1) which detailed the structural calculation. (Refer to reference No.43 and 44).

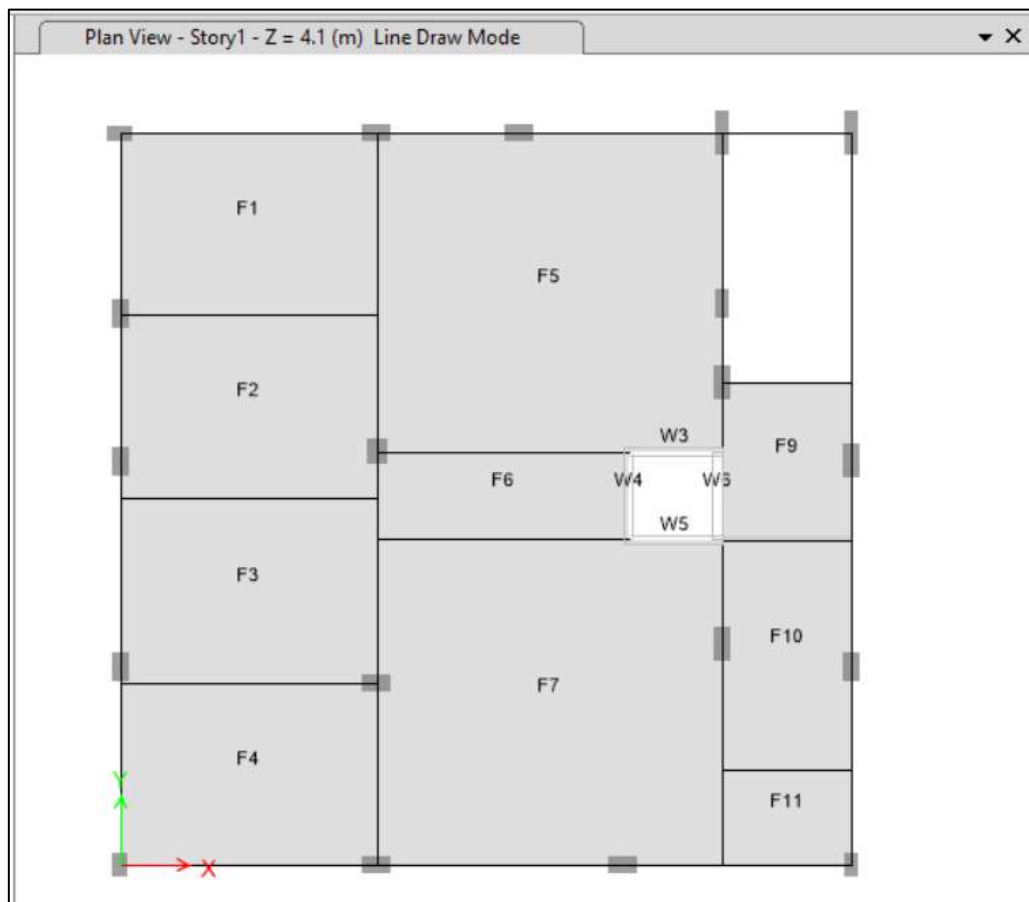


Figure (3.5): Modeling of beam, columns and slabs using ETABS 20

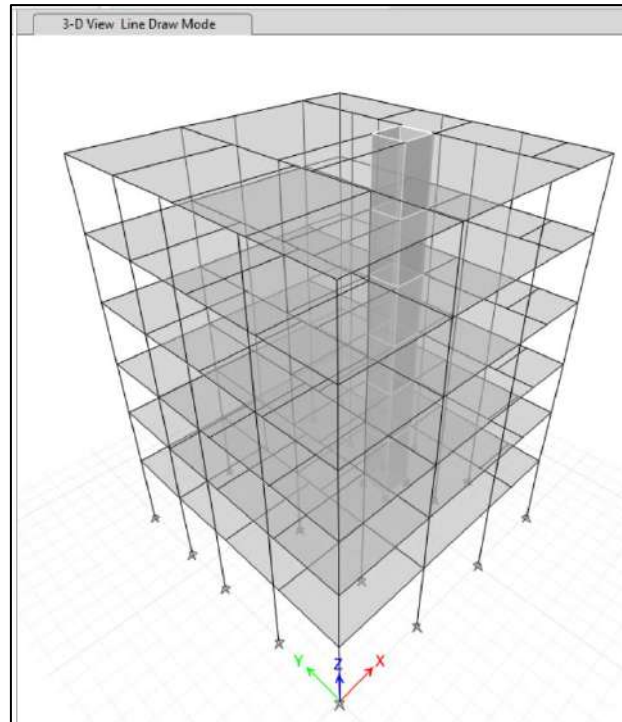


Figure (3.6):3D view of the building modeling

3.1.4 Structural design of the building

i. Structure design input.

1. Introduction

Proposed six story building at Gaziantep in turkey building consists of 6 typical stories. The conceptual general arrangement for the structural system consists of solid concrete slabs, RCC columns, RCC beams supported by isolated footing foundation. (Refer to reference No.6,7,9 to 13).

2. Purpose of this document

The purpose of the section is to present the loading considered for modeling.

3. Reference

3.1 Codes and standards

For the applicable codes and standards for this project reference is made to:

BS 8110-1997 Structural Use of Concrete

BS 6399 – Part 1 Loading for Buildings - Code of Practice for dead and imposed load

For more information regarding the specifications and characteristics of concrete, steel and reinforced concrete, refer to references 4,5,17,24,25,37 and 45.

4. Materials

4.1 Concrete compressive strength in (Mpa):

Concrete compressive strength used depends on elements location as shown in table 3.1 below. (Refer to reference No.1 for concrete specifications).

Table (3.1): Concrete grade for different structural elements

<i>Element</i>	<i>Grade</i>
Foundation	45
Columns	35
Beams Top & Bottom	35
Cast in-situ slab	35

4.2 Concrete cover to reinforcement in (mm) are as follows.

Table 3.2 shows concrete cover for each element.

Table (3.2): Concrete cover for different structural elements

LOCATION	COVER FOR CONCRETE
SUBSTRUCTURE (FACING SOIL OR WATER)	75
EXPOSED EXTERNAL SURFACES (SUBSTRUCTURE)	50
BEAMS EXPOSED TO WEATHER	
UNCLAD (BOTTOM AND SIDE)	40
COLUMNS, SHEAR WALLS EXTERNAL	40
CONCRETE NOT EXPOSED TO WEATHER:	
SOLID SLABS ON GROUND	
TOP	30
BOTTOM	50
SOLID SLABS, ABOVE GROUND FLOOR	30
BEAMS BOTTOM AND SIDE	30
(TOP WITH MIN. 50 FINISHES)	30
COLUMNS, SHEAR WALLS INTERNAL	40

- Concrete compressive strength is taken as 35 N/mm^2 (f_{ck}) for superstructure and 45 N/mm^2 (f_{ck}) for substructure.
- Modulus of elasticity for $35 \text{ N/mm}^2 = 4800 \times \sqrt{f_{ck}} = 28397.183 \text{ N/mm}^2$
- Modulus of elasticity for $45 \text{ N/mm}^2 = 4800 \times \sqrt{f_{ck}} = 32199.38 \text{ N/mm}^2$

For more Concrete material research refer to reference 28. 28. Magazine of Concrete Research, ICE, Edited by: Peter C Hewlett, BSc, PhD, LLD, CChem, CSci, FRSC, FIM, FICT, FConcSoc, Professor, University of Dundee, UK

4.3 Reinforcement

All reinforcing bars strength is considered in accordance with BS 4449

HYSD bars $f_y = 460 \text{ N/mm}^2$

Modulus of Elasticity $E = 200 \text{ kN/mm}^2$

For detailed design steps and calculation refer to Appendix (1)

Detailed structural calculation and design represented in appendix (1).

For reinforcement design calculation and procedure refer to reference No.3. Arthur H. Nilson, David Darwin, Charles W. Dolan (2005): Design of Concrete Structures **Book**, 13th Edition.

iii. Structural design Report

After applying the assigned load and run the analysis, model must be design and then checked to come up with final design (i.e., final cross section and reinforcements ratio for structural elements). Project report can then be downloaded as shown in figure 3.7, figure 3.8 and figure 3.9. Refer to Appendix (2) for full structural report obtained after running the analysis from ETABS.

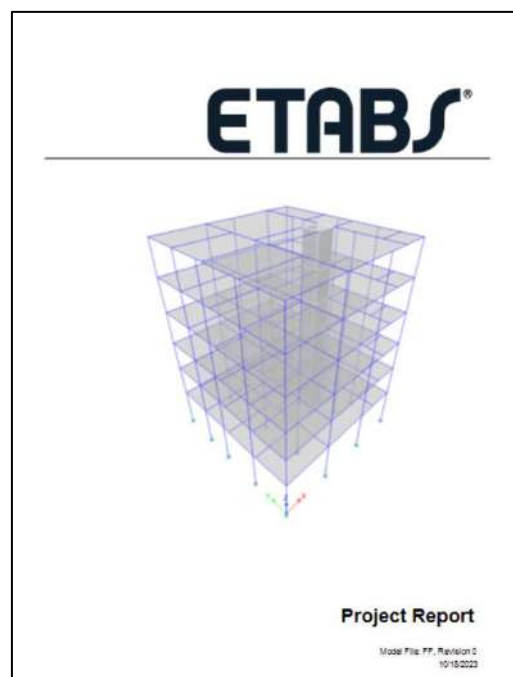


Figure (3.7): Structural project report

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Figure (3.8): Structural project report list

Structure Data

10/18/2023

1 Structure Data

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

1.1 Story Data

Table 1.1 - Story Definitions

Tower	Name	Height m	Marker Story	Marker To	Marker From	Color
T1	Story1	3.3	10	None	10	Cyan
T1	Story2	3.3	10	None	10	Cyan
T1	Story3	3.3	10	None	10	Cyan
T1	Story4	3.3	10	None	10	Cyan
T1	Story5	3.3	10	None	10	Cyan
T1	Story6	3.3	10	None	10	Cyan
T1	Story7	3.3	10	None	10	Cyan

1.2 Grid Data

Table 1.2 - Grid Definitions - General

Tower	Name	Type	U1 m	U2 m	R2 deg	Story Range	Bubble Size mm	Color
T1	G1	General	0	0	0	Default	100	Gray

1.3 Point Coordinates

Table 1.3 - Point Data

Layer	N	W	X	Y	Offset m
1	10	10	0.0	0.0	0
2	10	10	0.0	0.705	0
3	10	10	0.0	0.000	0
4	10	10	0.0	0.00	0
5	10	10	0.0	0	0
6	10	10	0.0	0.000000	0
7	10	10	0.0	0.000	0
8	10	10	0.00	0.000	0
9	10	10	0.00	0.0000	0
10	10	10	0.00	0.00000	0
11	10	10	0	0.000000	0
12	10	10	0.00	0.0000	0
13	10	10	0	0.0000	0
14	10	10	0.0000	0.00	0
15	10	10	0.00	0.00	0
16	10	10	0.00	0.00	0
17	10	10	0.00	0.00	0
18	10	10	0.00	0.00000	0
19	10	10	0	0.00000	0
20	10	10	0.00	0.000	0
21	10	10	0.00	0.00	0

STAB3-120.0.0

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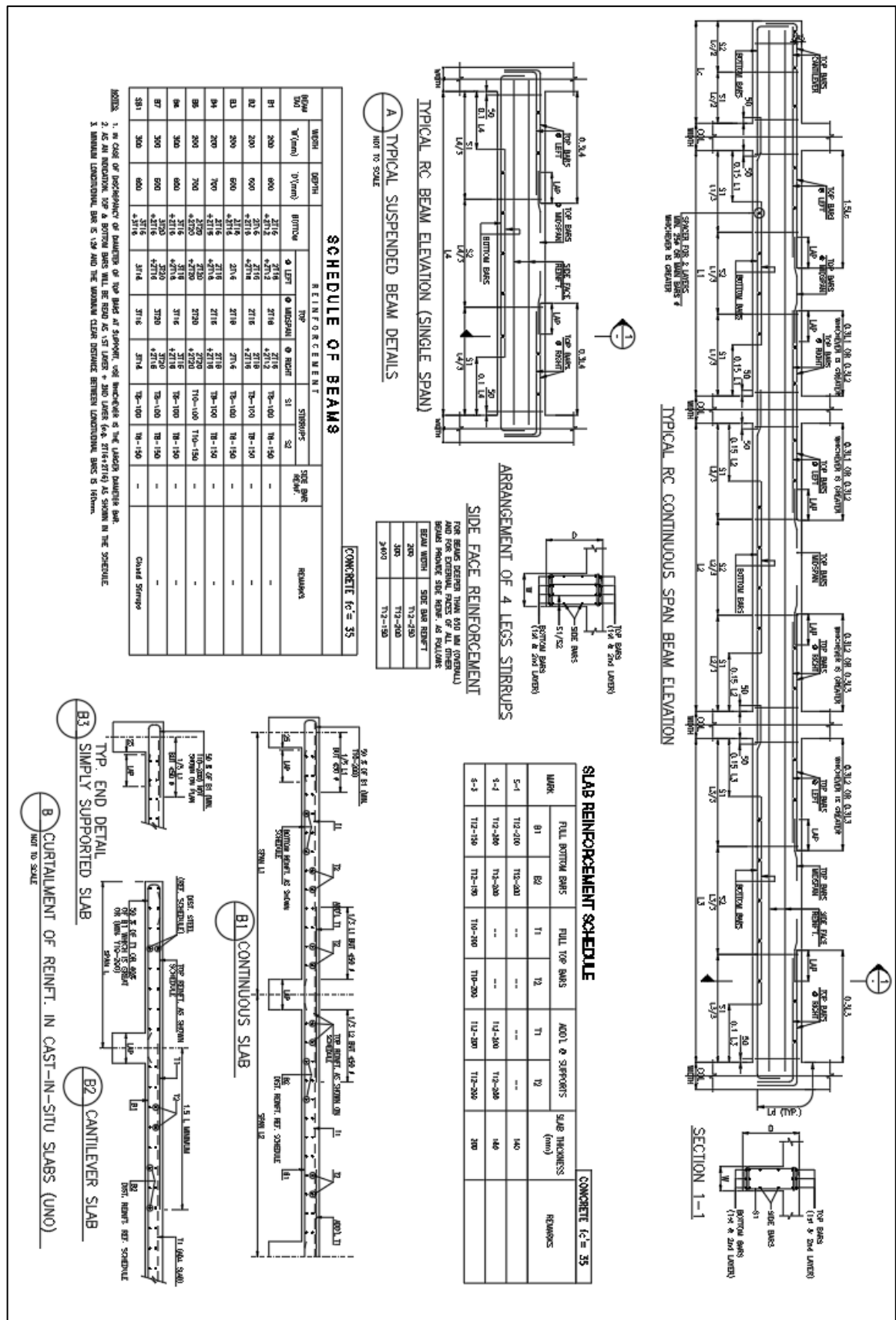


Figure (3.10): Structural drawing

For bigger size, please refer to Appendix 3.

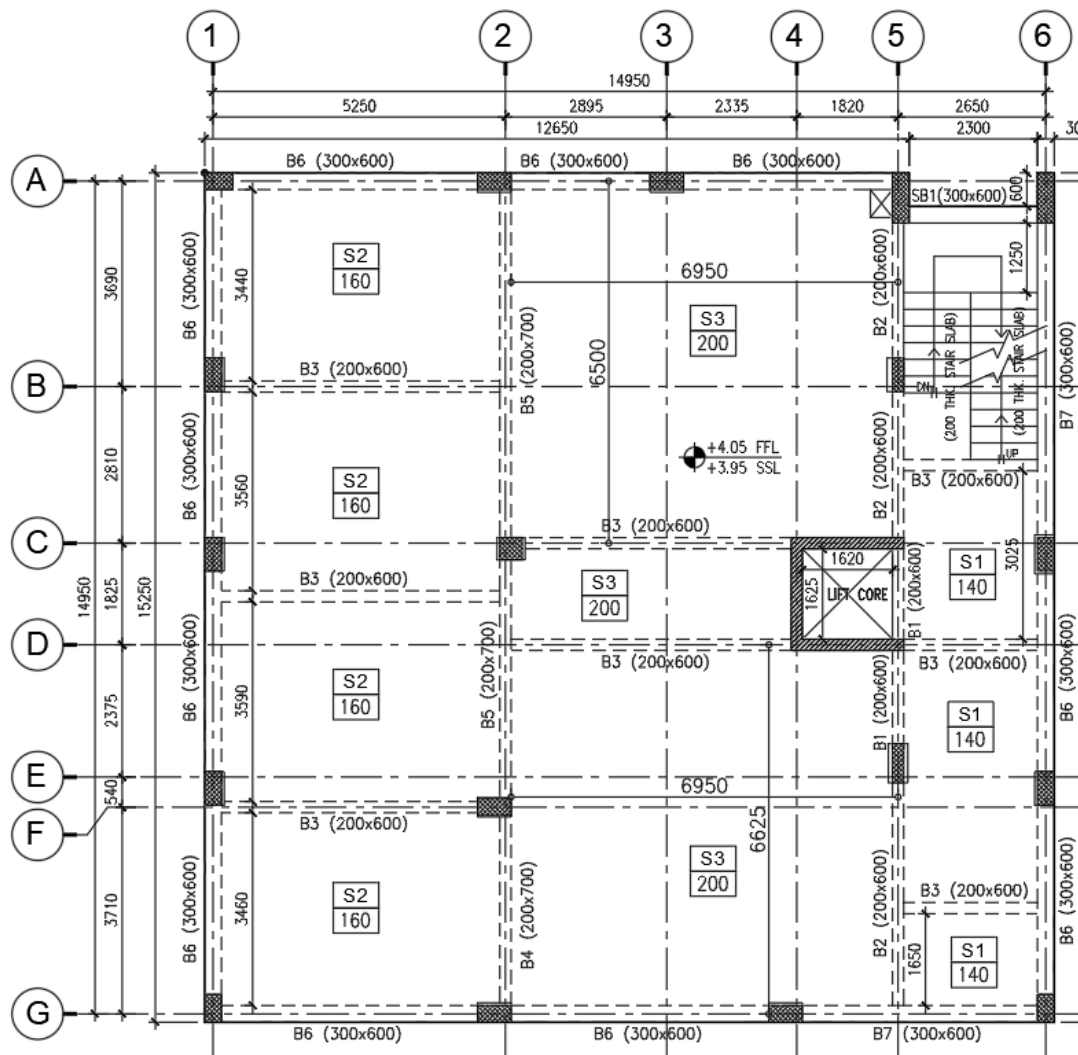
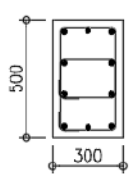
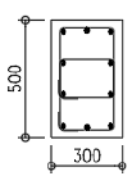
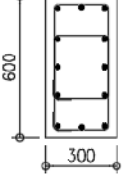
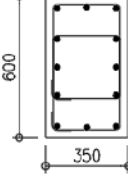
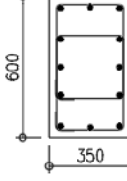
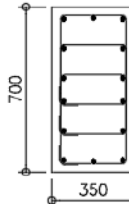
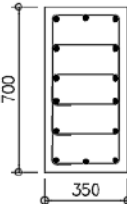
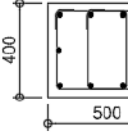
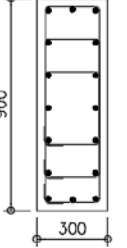


Figure (3.12): Slab and beam design

For bigger size, please refer to Appendix 3.

					
SIZE	300 x 500	300 x 500	300 x 600	350 x 600	350 x 600
REBAR	10T16	10T16	12T16	12T16	12T16
LINKS	T10-150	T10-150	T10-150	T10-150	T10-150
COLUMN REFERENCE	C1	C1A	C2	C3	C3A
					
SIZE	350 x 700	350 x 700	400 x 500	300 x 900	
REBAR	14T16	14T16	10T16	16T16	
LINKS	T10-150	T10-150	T10-150	T10-150	
COLUMN REFERENCE	C4	C5	C6	C7	

NOTES: – COLUMN STEEL BARS FLOOR TO FLOOR LAPPING SHALL BE 40 ϕ .
– LINKS SHOULD BE CONCENTRATED (T10-100) AT 1.2M ABOVE AND BELOW SLAB LEVEL.
– CONCRETE COVER OF COLUMNS BELOW GROUND FLOOR LEVEL SHOULD BE INCREASED TO 75 MM.
– IT IS NOT ALLOWED TO PATH ANY PIPE INSIDE THE COLUMNS.

Figure (3.13): Column design

For bigger size, please refer to Appendix 2.

3.2 Fiber hinge approach - material nonlinearity

3.2.1 Application of Fiber Nonlinear Modeling of Materials using CSI ETABS

In this section fiber modeling approach will be applied for columns and shear walls. For beams other approach will be used which called plastic hinge approach and it is explained later in the next chapter.

Refer to reference 23. This document or manual compiles the basic concepts of inelastic computer modelling and nonlinear analysis of building structures. It also presents a step-by-step methodology to construct the nonlinear computer models of RC building structures (for their detailed performance evaluation) using CSI ETABS 2016.

3.2.2 Fiber Modeling of Reinforced Columns:

After designing the structure based on building codes, (i.e. elastic model analysis) and all cross-section details is finalized, now it is the time to convert it to inelastic model using fiber modeling approach, (Refer to reference No.41), the steps are described as following:

1. Define material Nonlinearity Stress-Strain Curve:

First Concrete Material

As shown in figure 3.14. Go to Define>Material Properties>select the concrete material as defined before” Con 35MPA” >Modify>In the Advance Material properties select “Nonlinear Material Data” as it shown below.

General Data

Material Name
Con35MPA

Material Type
Concrete

Directional Symmetry Type
Isotropic

Material Display Color
Change...

Material Notes
Modify/Show Notes...

Material Weight and Mass

☒ Specify Weight Density
☐ Specify Mass Density

Weight per Unit Volume
23
kN/m³

Mass per Unit Volume
2345.347
kg/m³

Mechanical Property Data

Modulus of Elasticity, E
26030.75
MPa

Poisson's Ratio, U
0.2

Coefficient of Thermal Expansion, A
0.0000099
1/C

Shear Modulus, G
10846.15
MPa

Material Name and Type

Material Name
Con35MPA

Material Type
Concrete, Isotropic

Acceptance Criteria Strains

	Tension	Compression	
IO	0.01	-0.003	mm/mm
LS	0.02	-0.006	mm/mm
CP	0.05	-0.015	mm/mm

☒ Ignore Tension Acceptance Criteria

Parametric Strain Data

Strain at Unconfined Compressive Strength, f_c
0.002219

Ultimate Unconfined Strain Capacity
0.005

Final Compression Slope (Multiplier on E)
-0.1

Miscellaneous Parameters

Hysteresis Type
Concrete

Modify/Show Hysteresis Parameters...

Drucker-Prager Parameters

Friction Angle
0
deg

Dilatational Angle
0
deg

Stress Strain Curve Definition Options

☒ Parametric
Mander

Convert to User Defined

☐ User Defined

Figure (3.14): Define concrete material nonlinearity stress-strain curve

Three important Input must be provided:

1. The Acceptance criteria strains for every performance level at tension and compression, enter the performance criteria decided.
2. Stress-Strain Curve parametric shape> select Mander>Convert to user Define > enter f'_c , E values as shown above.

Accordingly, the program will draw the stress-strain curve as shown in figure 3.15.

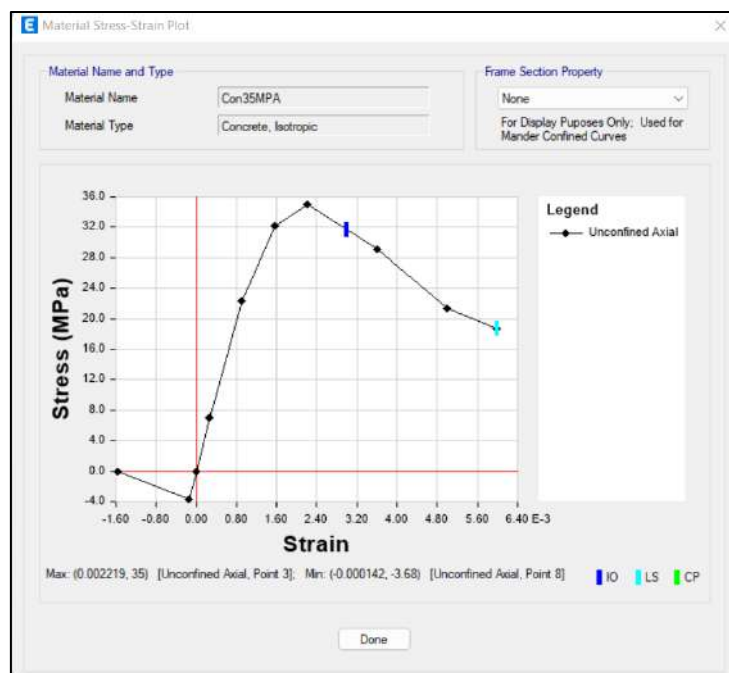


Figure (3.15): Concrete stress-strain curve

3. Hysteresis Type, as shown in figure 3.16
select concrete> Energy Degrading factor =0.5.

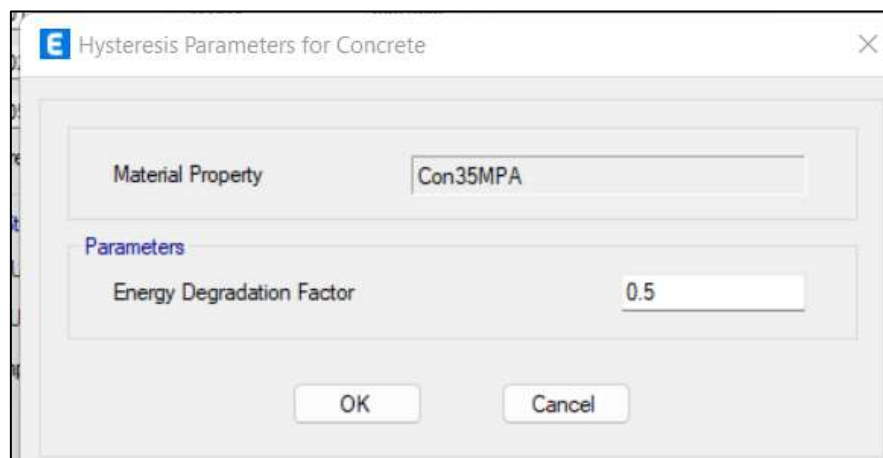


Figure (3.16): Concrete energy degrading factor

Second Steel (Rebar) Material

As shown in figure 3.17. Go to Define>Material Properties>select the concrete material as defined before” G460” >Modify>In the Advance Material properties select “Nonlinear Material Data” as it shown below.

General Data

Material Name	G460
Material Type	Rebar
Directional Symmetry Type	Uniaxial
Material Display Color	 Change...
Material Notes	Modify/Show Notes...

Material Weight and Mass

☒ Specify Weight Density ☐ Specify Mass Density

Weight per Unit Volume	76.9729	kN/m ³
Mass per Unit Volume	7849.047	kg/m ³

Mechanical Property Data

Modulus of Elasticity, E	199947.98	MPa
Coefficient of Thermal Expansion, A	0.0000117	1/C

Material Name and Type

Material Name	G460
Material Type	Rebar, Uniaxial

Miscellaneous Parameters

Hysteresis Type	Kinematic
-----------------	-----------

Acceptance Criteria Strains

	Tension	Compression	
IO	0.01	-0.005	mm/mm
LS	0.02	-0.01	mm/mm
CP	0.05	-0.02	mm/mm

Stress Strain Curve Definition Options

☒ Parametric Simple Convert to User Defined

☐ User Defined

Parametric Strain Data

Strain at Onset of Strain Hardening	0.01
Ultimate Strain Capacity	0.09
Final Slope (Multiplier on E)	-0.1

Figure (3.17): Define steel material nonlinearity stress-strain curve

Three important Input must be provided:

1. The Acceptance Criteria Strains for every performance level at Tension and compression, enter the performance criteria decided.
2. Stress-Strain Curve parametric shape> select Park>Convert to user Define > enter parametric stain data as above. As shown in figure 3.18.

Accordingly, the program will draw the stress-strain curve as shown in figure.

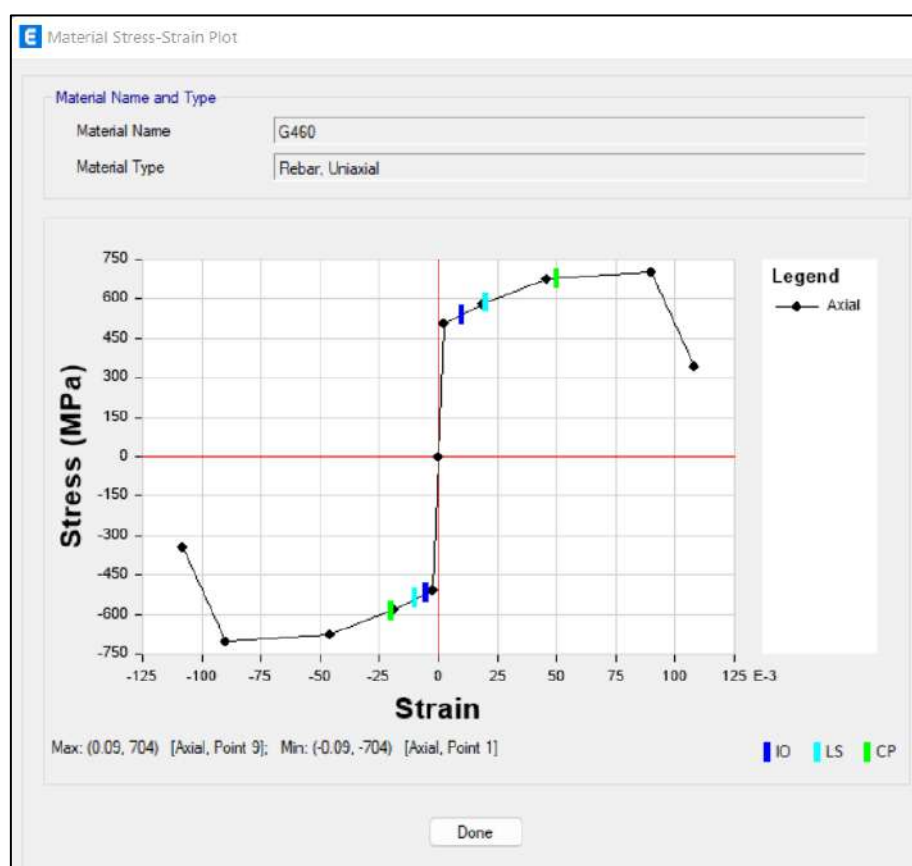


Figure (3.18): Steel stress -strain curve

3. Hysteresis Type, select Kinematic.

2. Divination of the material section to fiber sections

- Reinforced Concrete Columns

As shown in figure 3.19. Go to Define>Section Properties>Frame/wall Nonlinear Hinges>Add New Property>Concrete.

Change the Hinge Name to (concrete Fiber Hinge)

Hinge type to (Deformation Controlled Ductile)

Select Fiber (P-M2-M3)

Select (Default from Frame Section)

Hinge length = $0.1 \times$ Relative length (that is mean it will take the 10% of each column length and apply it at each columns ends to apply the fiber hinge)

Defined Hinge Props

Name
Column Fiber Hing

Click to:

Add New Property...

Add Copy of Property...

Modify/Show Property...

Delete Property

☐ Show Hinge Details

☐ Show Generated Props

Hinge Property Name

Column Fiber Hing

Hinge Type

☐ Force Controlled (Brittle)

☒ Deformation Controlled (Ductile)

Fiber P-M2-M3

Modify/Show Hinge Property...

Fiber Definition Options

☒ Default From Frame Section

☐ User Defined

Hinge Length

Hinge Length 0.1

☒ Relative Length

Figure (3.19): Define column fiber hinge.

Now the program will automatically divide the column section into small concrete and rebar sections as defined before based on the design cross section and reinforcements provided on elastic analysis.

To Assign the defined hinge above, Select the columns > Assign>Frame >Hinges>as shown in figure 3.20 below.

Frame Hinge Assignment Data				
Hinge Property	Location Type	Relative Distance	Distance from End m	
Column Fiber Hing	Relative to clear length	1		Add Modify Delete
Column Fiber Hing	Relative to clear length	0		
Column Fiber Hing	Relative to clear length	1		

Figure (3.20): Assign column fiber hinge

Add the Column fiber hinges defined before as 0 and 1 Relative distance, that means the program will assign it at the ends of each column.

Figure 3.21 shows that the program has added the hinges for each column ends.

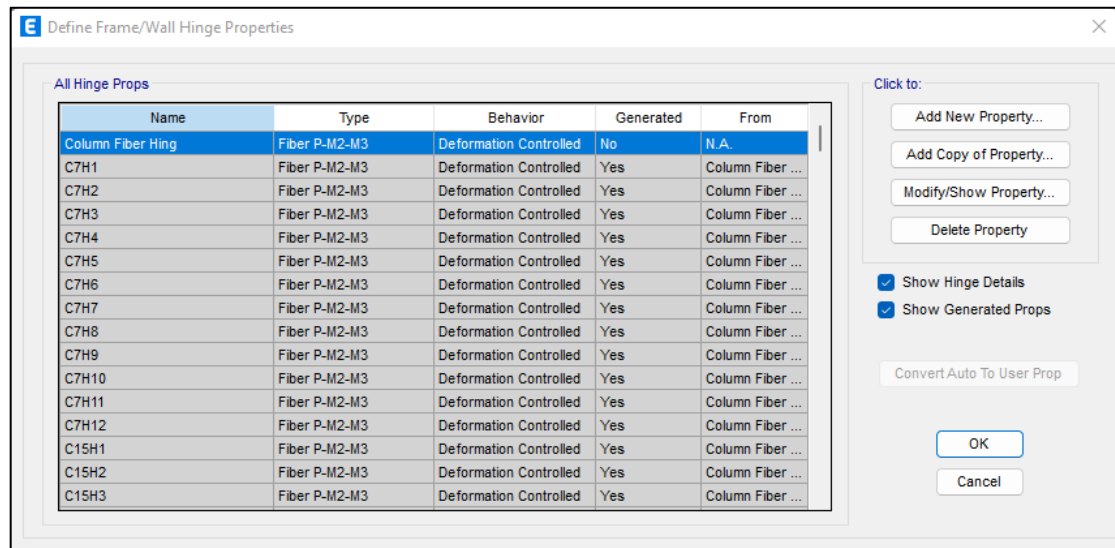


Figure (3.21): List of column fiber hinge at each end

To display the fiber divisions of one column section as an example refer to figure 3.22 to understand how the program has generated the divisions.

Select for example column No. C15, and then hinge No.1 >Go to Show properties>show fiber>

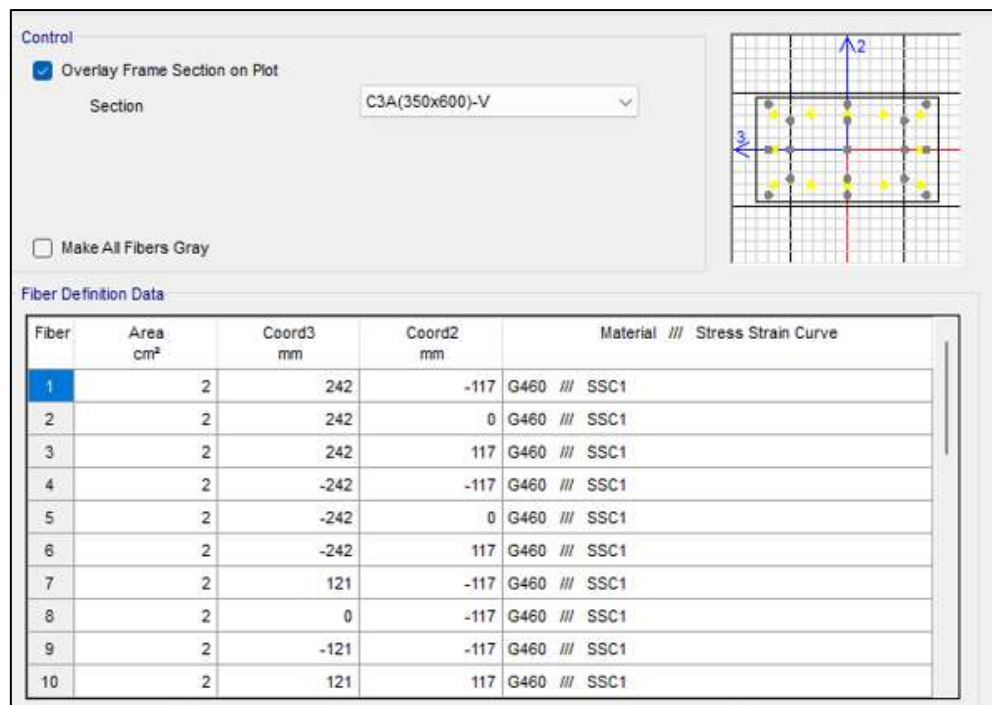


Figure (3.22): Cross section division of fiber

As shown in figure 3.23, the section has been divided into concrete fibers in gray color (some on them are inside the cover zone, and the other in the core of section), while the yellow dots represent the rebars. The dots represent the center of each division sections.

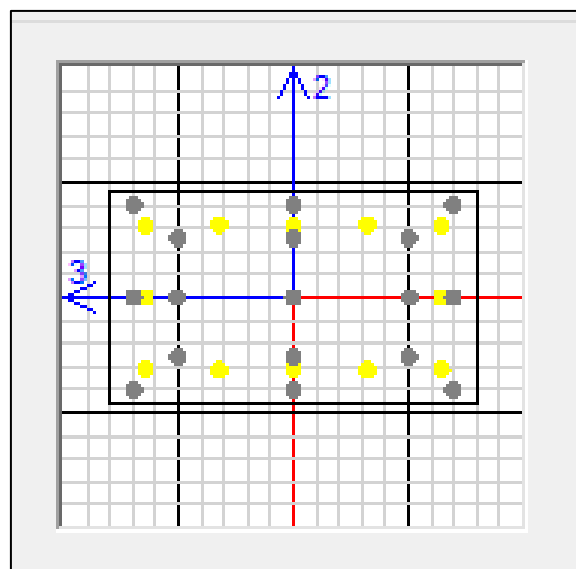


Figure (3.23): Fiber hinge section details

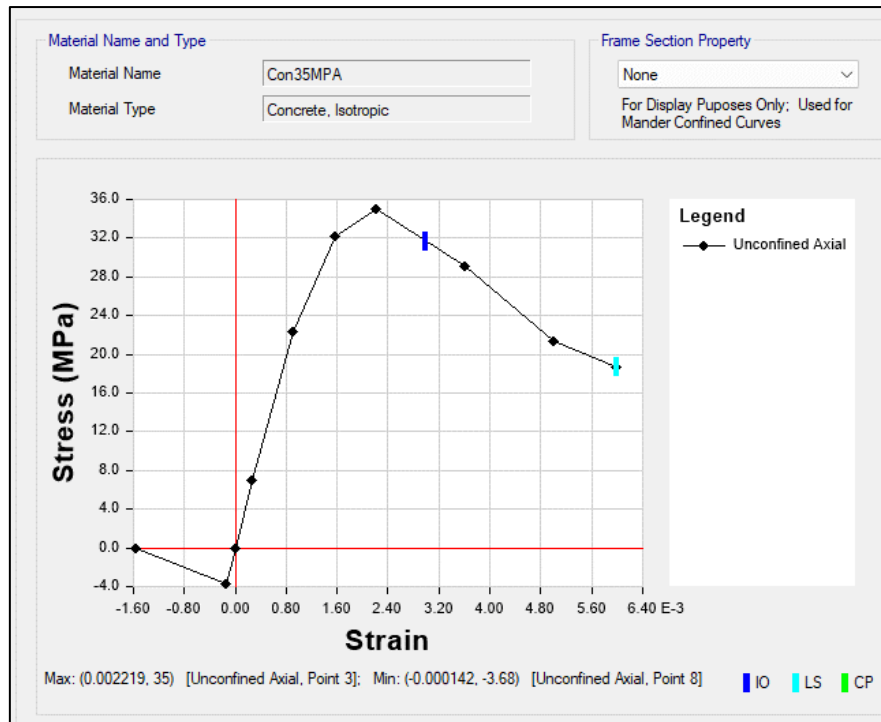


Figure (3.24): Acceptance criteria of columns

The Stress-strain Curve shown in figure 3.24 represent the shows the performance values of the selected columns, any column can be selected, for example C1> the stress-stain for particular cross section can be presented as figure 3.25 below.

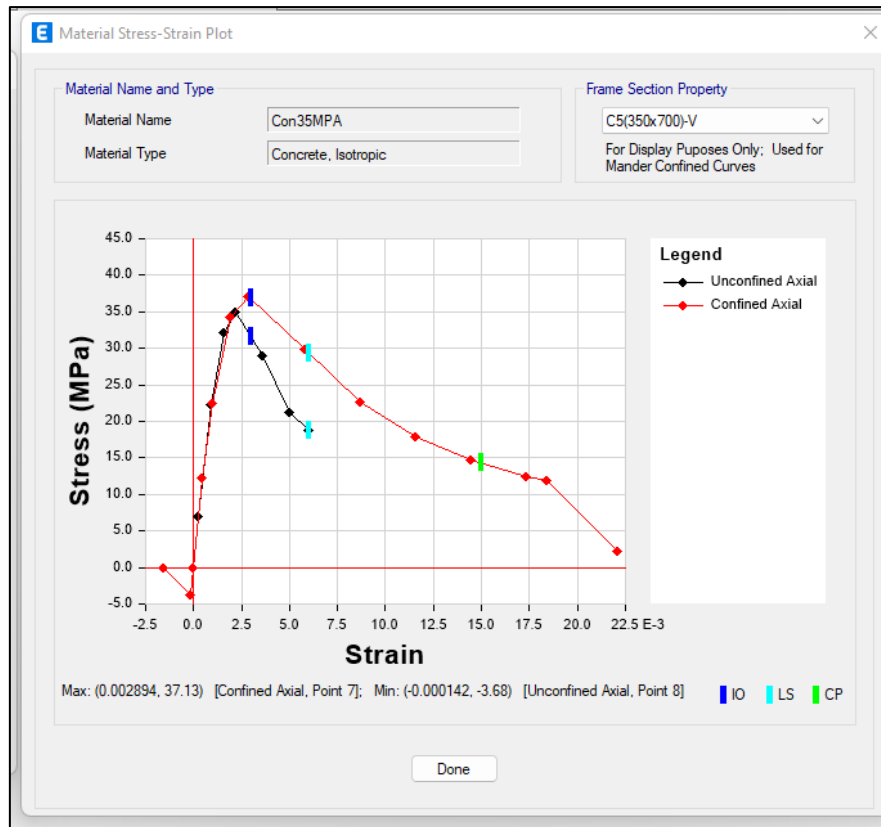


Figure (3.25): Column specific stress-strain curve

3.2.3 Fiber Modeling of Reinforced Concrete Shear Wall

As it has been done for columns, fiber model will be applied for shear walls. By Selecting show the shear wall only > select all shear walls>Assign>Shell>Reinforcements for Wall Hinge>From Current Design (as shown in figure 3.26), then (the program will automatically divide each wall section to fibers).

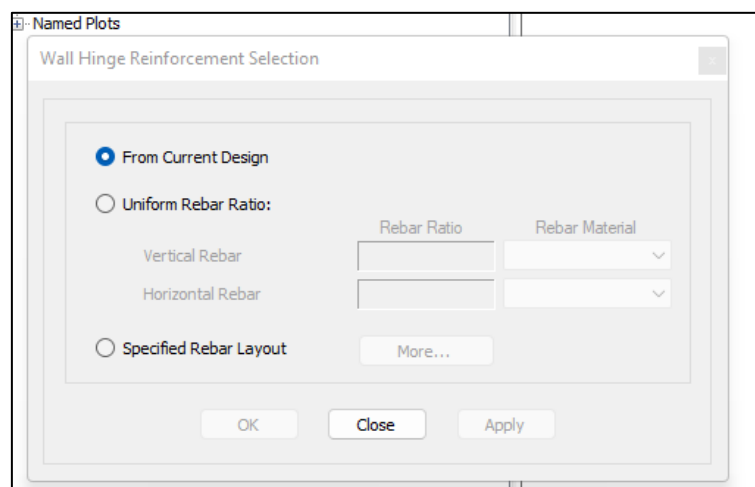


Figure (3.26): Wall Fiber Hinge

Figure 3.27 shows the procedure of assigning auto by select >hinges Assign>Shell> Wall Hinge> select Auto Fiber P-M3 (generated automatically by the program from the previous step)>Add>Apply.

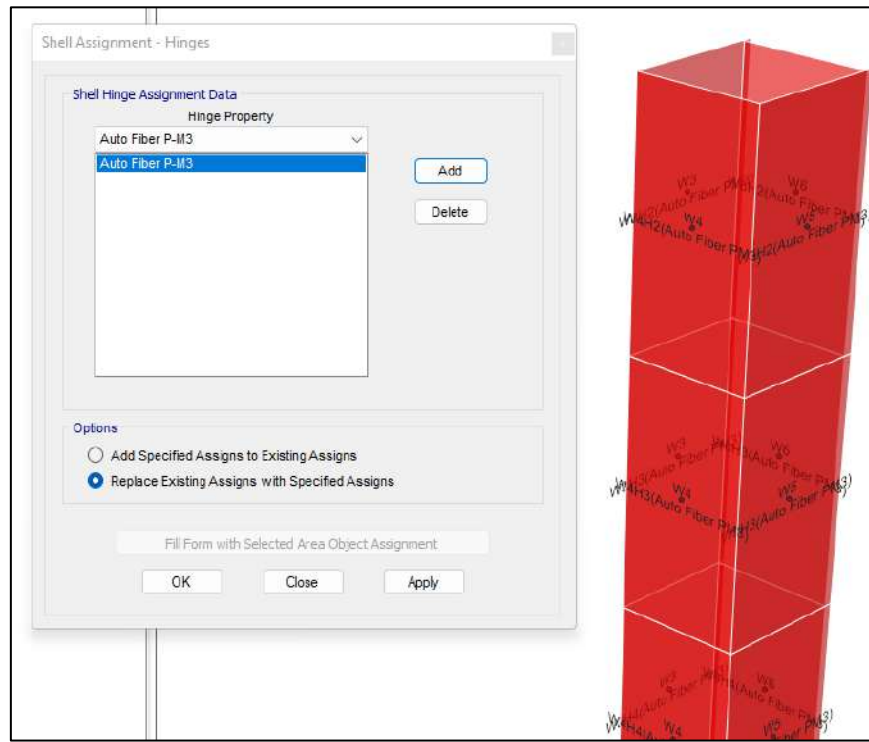


Figure (3.27): Assigning wall fiber hinge

From figure 3.27, it can be noticed that the Automatic fiber section have been assigned to all shear walls. To find out how the program has divide the walls hinges,

Go to Define>Section Properties>Frame/Wall nonlinear Hinges>Select any wall for example W6H5> as shown in figure 3.28. It's clearly shows at right-hand side the program has divide the wall into concrete and reinforcement fibers.

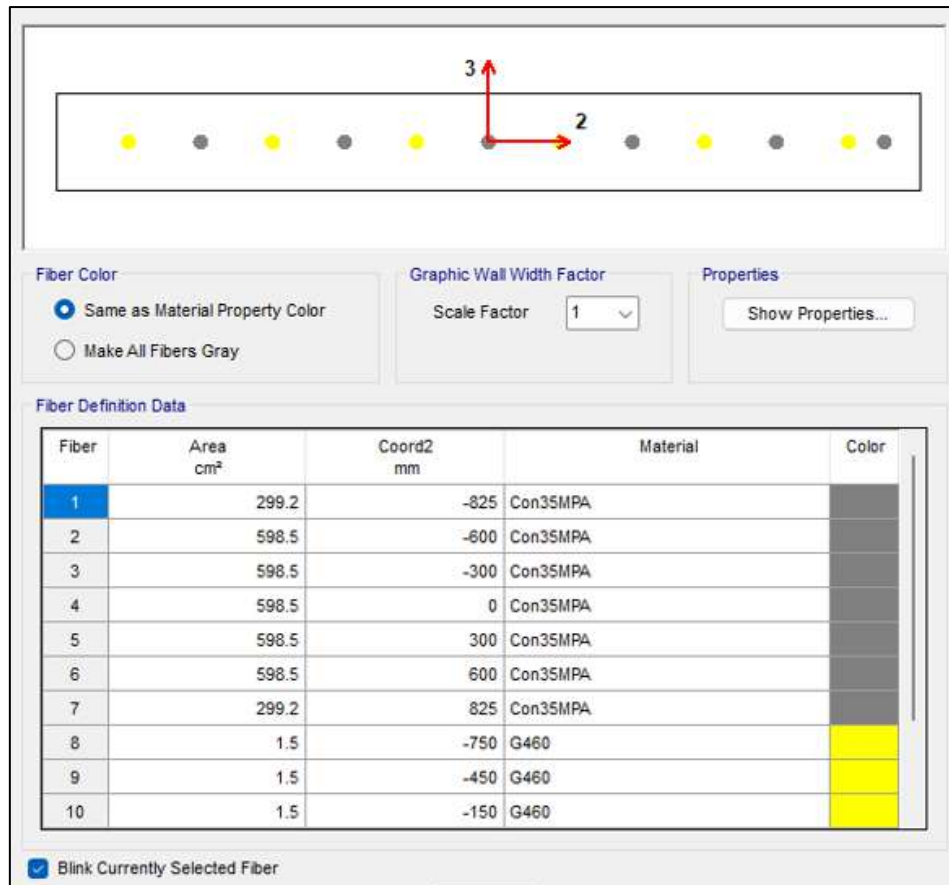


Figure (3.28): List and details of all wall hinge created

Beam:

For beams, no automatic option available in ETABS for dividing the cross section of beam to fibers, as it was done for columns and walls. It can be applied only be manual divisions of fiber sections which is very long process, since it's required to divide each beam into 3 x 3 total 9 concrete sections and at least 6 fibers for reinforcement depends on their diameters. Making 15 sections for only one cross section of beam and repeating the same for other beam that have different dimensions so difficult and long prosses.

For that reason, another approach will be used for modeling the beams as nonlinear elements which called the plastic approach and that will be discussed in the next part of the chapter.

3.3 Plastic hinge approach - geometric nonlinearity

Moment Rotation Type Plastic Hinge Modeling of RC Beams

In the same model used in demonstration of fiber hinge for columns and shear wall, defining of plastic -uncoupled concentrated hinge for beams will be applied. (Refer to reference No.1 to 5 and 8).

Two options are available for applying the same:

1. Manual (by define each beam separately and then assign each hinge in both ends of each beam.
2. Automatic (by add the reinforcement design of beam, and let the program calculate the yield moments)

The procedure of each method sing ETABS are illustrated as followings:

1. Manual

As shown in figure 3.29. Go to Define > Section properties > Frame/Wall Nonlinear Hinges

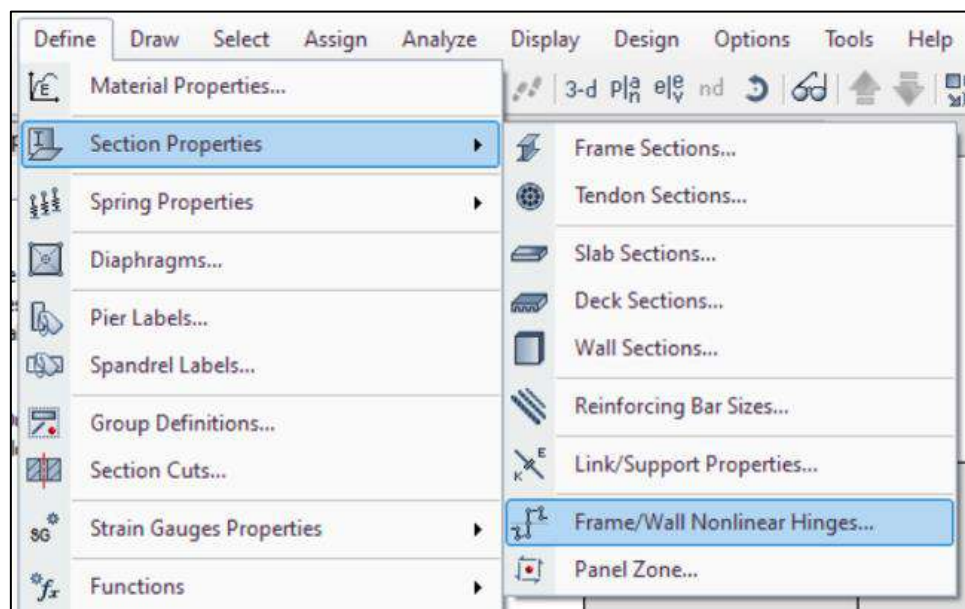


Figure (3.29): Define plastic hinge for beam

Then concrete fiber hinge must be defined as shown in figure 3.30. Add new properties> concrete>ok

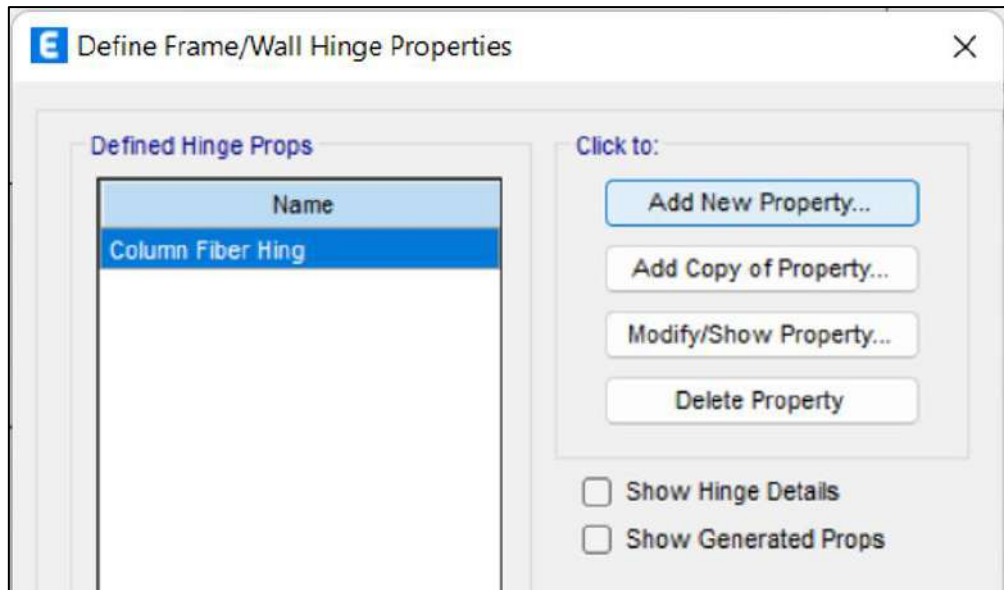


Figure (3.30): Add new hinge type.

Select Concrete, same as Figure 3.31.

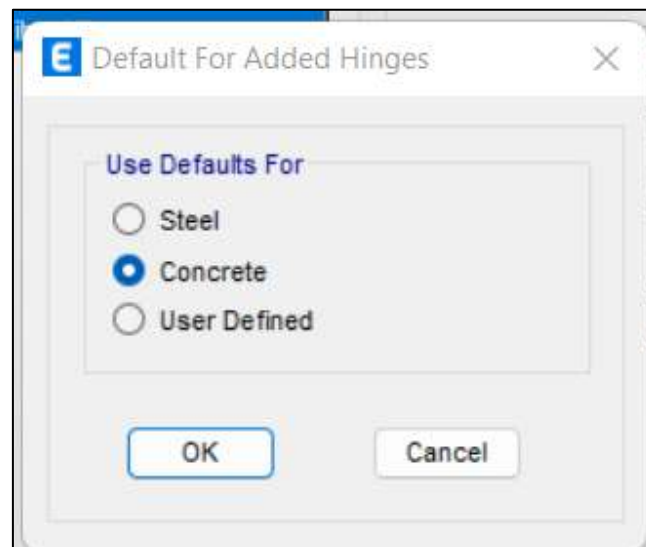


Figure (3.31): Concrete plastic hinge

As shown in figure 3.32. Change the name to “PH1” > select Deformation controlled (Ductile)>Moment M3

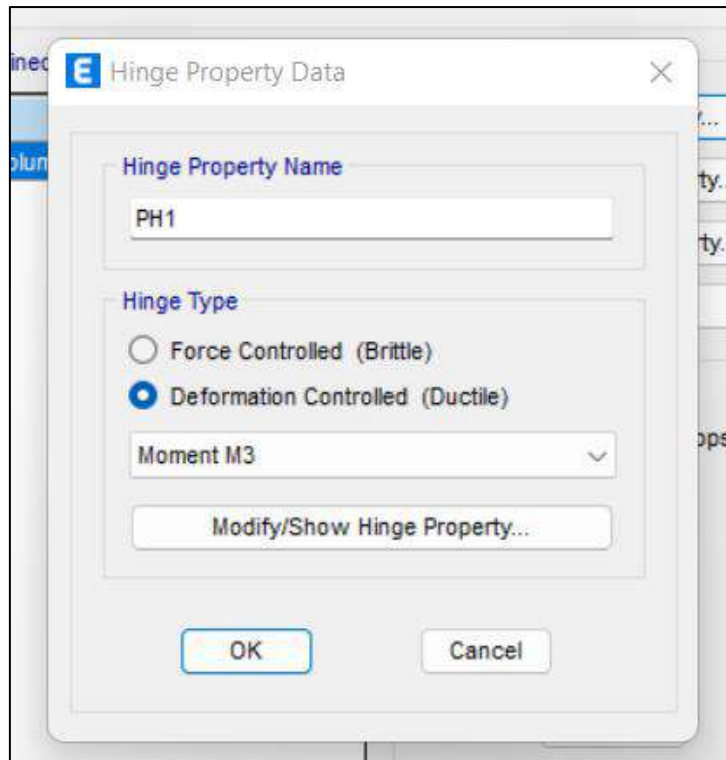


Figure (3.32): Plastic hinge type as ductile

Same as figure 3.33, select Modify/Show Hinge Property>add the section moment – rotation values> change the Hysteresis Type to Takeda> enter the acceptance criteria IO, LS and CP values.

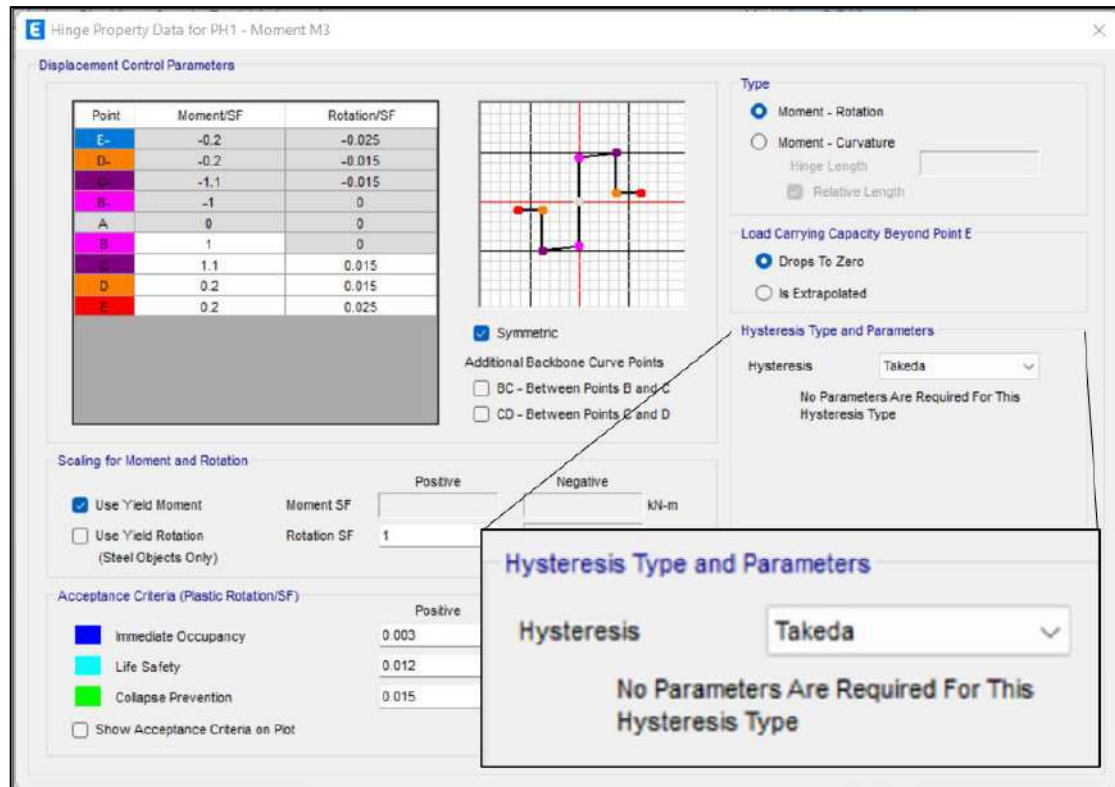


Figure (3.33): Hinge properties data

For assigning the hinges to the beams, as shown in figure 3.34>select the beam > Assign>Frame>Hinges.

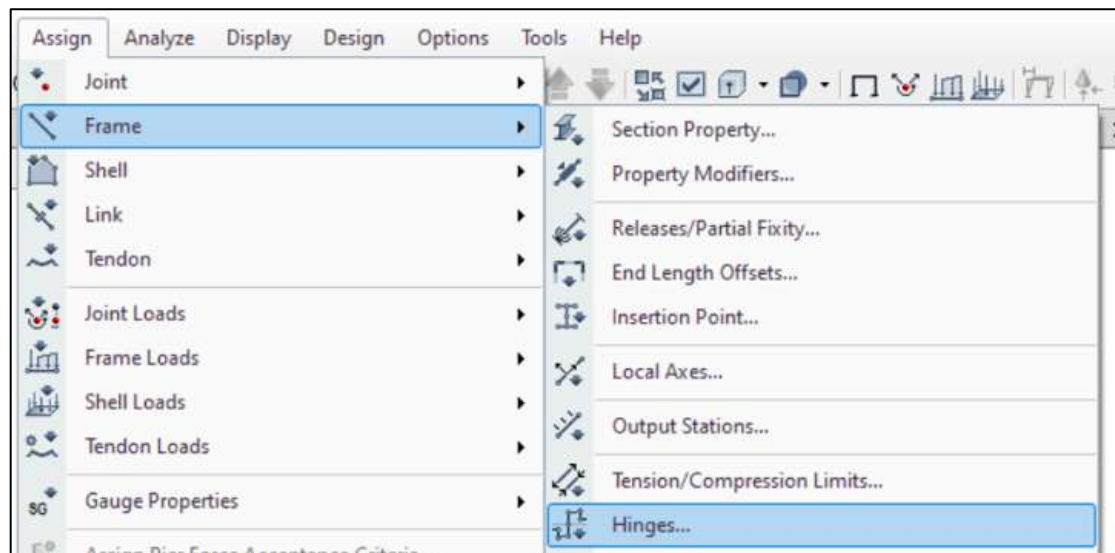


Figure (3.34): Assign beam plastic hinge

Add the last created plastic hinge (PH1) to a relative distance 0 and 1 (considering both ends of the beam 0 will be assigned at the start of the beam, end will be assigned at the end)>ok

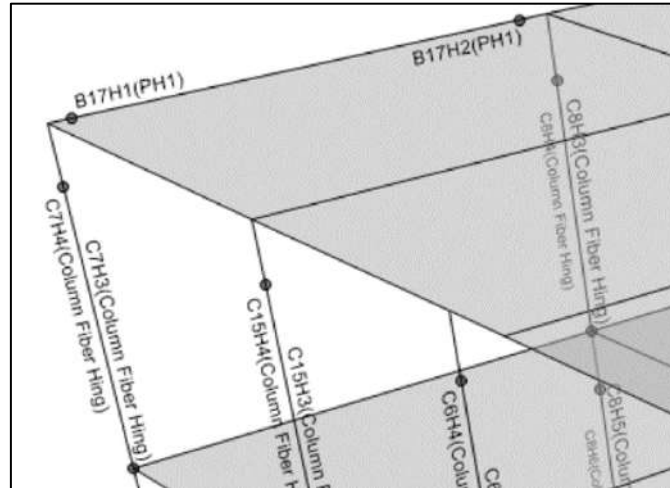


Figure (3.35): The assigned plastics hinge on the beam

As it is shown in figure 3.35, the PH1 have been assigned to the selected beam , but the issue of manual assigning of plastic hinge, that required to enter section moment – rotation values and acceptance criteria IO, LS and CP values for each beam section that has different reinforcement quantities or arrangement, which is make is very long procedure, the other procedure is the Automatic option, and is shown below:

1. Calculate the reinforcement area (mm^2) at top and bottom of each beam section, refer to tabulated data in table 3.3:

Table (3.3): Beam's reinforcements area calculation

	Bottom (mm^2)	Top(mm^2)
B1	628.3185	628.3185
B2	804.2477	804.2477
B3	804.2477	402.1239
B4	804.2477	804.2477
B5	1256.637	1256.637
B6	1005.31	1005.31
B7	1344.602	1344.602
SB1	1206.372	603.1858

Select all beam section, same as figure 3.36.

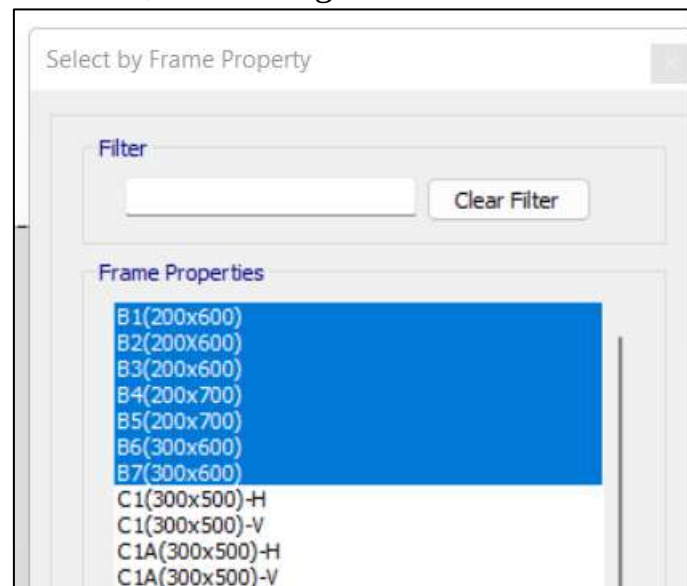


Figure (3.36): Beams selection

Assign the hinges same as figure 3.37, by selecting the beam > Assign>Frame>Hinges

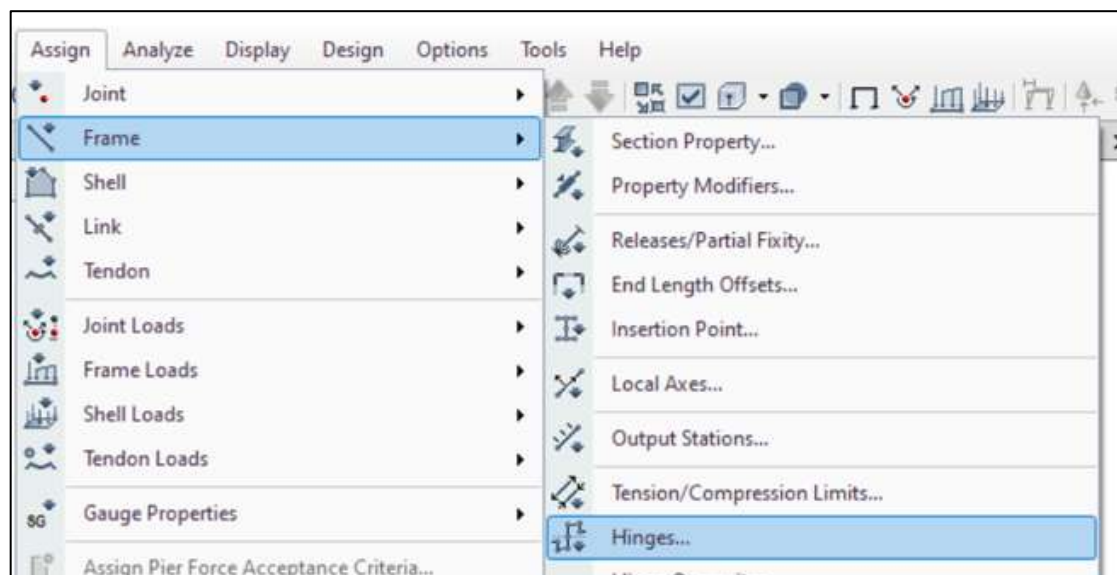


Figure (3.37): Assigning of automatic beam hinge

Add Auto in 0 and 1 >modify the hinge type to “from Table ASCE41-17” > and select find. As shown in figure 3.38 and figure 3.39 below.

Existing Assignments

Warning: Assignments may already exist on some selected line objects.

☐ Add Specified Assigns To Existing Assigns
☒ Replace Existing Assigns With Specified Assigns

Frame Hinge Assignment Data

Hinge Property	Location Type	Relative Distance	Distance from End m
Auto	Relative to clear length	0	
Auto M3	Relative to clear length	0	
Auto M3	Relative to clear length	1	

Add

Modify

Figure (3.38): Frane assignment hinges

Auto Hinge Type

From Tables In ASCE 41-17

Select a Hinge Table

Table 10-7 (Concrete Beams - Flexure) Item i

Degree of Freedom

☐ M2
☒ M3

Hysteresis Type: Isotropic Modify/Show

Transverse Reinforcing

☒ Transverse Reinforcing is Conforming

V Value From

☒ Case/Combo: Dead
☐ User Value

Reinforcing Ratio $(p - p') / p_{balanced}$

☒ From Current Design
☐ User Value (for positive bending)

Deformation Controlled Hinge Load Carrying Capacity

☒ Drops Load After Point E
☐ Is Extrapolated After Point E

Figure (3.39): Hinge data

Chapter Four

Analysis and Discussion

4.1 Nonlinear Static (Pushover) & Dynamic Analysis

The Pushover analysis as its clear form its name, a procedure of trying to push the building to a certain displacements gradually to study the building behavior along the displacements till its reaches to the maximum displacements and failure/collapse of the building, the steps of pushover analysis start with defining the models that cause the maximum displacement in x and y directions by the building Mass Participation, then defining the gravity nonlinear load, which is the building mass load and by selection of any node on the building, then study the movement of the building based on the selected node. Pushover load will apply gradually to multi steps, the results of the same will be discussed at the end of this section.

For more information regarding dynamic analysis of structures, refer to reference No. 2 (Dynamics of Structures: Theory and Applications to Earthquake Engineering), Reference 12 Earthquake Engineering & Structural Dynamics, Wiley online library, Edited By: Anil K. Chopra, Peter Fajfar, Masayoshi Nakashima, Reference 13, Edward L. Wilson (2000): Three-Dimensional Static and Dynamic Analysis of Structures Book, Computers & Structures Inc

4.1.1 Pushover analysis procedure

To find out the maximum displacement in x and y direction, let us check first, the maximum displacement accrues due to the structure mass itself, as Shown from figure 4.1, steps are as follows:

1. Define the maximum x and y modal direction:

Do to Display>Show tables>Analysis>Result>Modal Results>select the following.

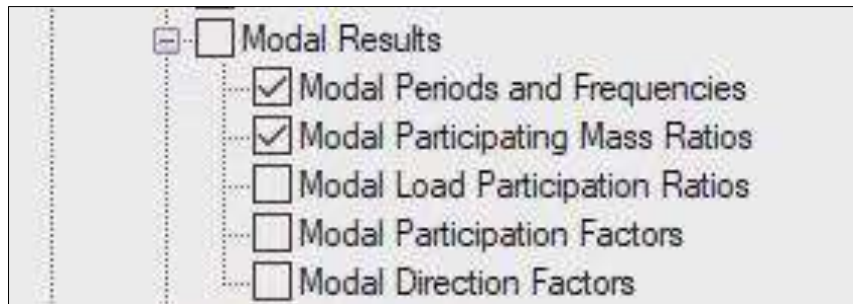


Figure (4.1): Display model result

From figure 4.2 below, it can be noticed that the maximum UX (Mass Participation) value occur in Modal No.2, similarity modal No.3 is the maximum in y direction.

Modal Participating Mass Ratios					
File Edit Format-Filter-Sort Select Options					
Units: As Noted Hidden Columns: No Sort: None					
Filter: None					
	Case	Mode	Period sec	UX	UY
▶	Modal	1	0.824	0.0099	0.3555
	Modal	2	0.674	0.7423	0.0057
	Modal	3	0.507	2.899E-05	0.4305
	Modal	4	0.247	0.0012	0.0426
	Modal	5	0.173	0.1592	0.0002
	Modal	6	0.142	0.0002	0.0556
	Modal	7	0.128	0.0005	0.0489
	Modal	8	0.089	4.631E-05	0.0004
	Modal	9	0.077	0.0523	0.0001
	Modal	10	0.064	0	0.0003
	Modal	11	0.063	4.932E-05	0.0354
	Modal	12	0.052	1.646E-06	0.0001

Figure (4.2): Model mass participation

2. Define Nonlinear Gravity load.

Since the weight of the structure play a major role in its behavior during the earthquake, gravity nonlinear load must be defined as shown in figure 4.3 using the information given in table 4.1.

Define>Load case>add now load case> enter the following.

Table (4.1): Define nonlinear gravity load.

Name	Gravity Nonlinear
Type	Nonlinear static
Initial Condition	Zero-Start from unstressed state
Dead	1
Live	0.25
Geometric	P-Delta
Load Application	Full load
Results saved	Final State Only

Figure (4.3): Define pushover load case.

Since the main aim of gravity load is to involve the building weight in the analysis, multi states result is not required. Only final state to be selected, as shown in figure 4.4.

Figure (4.4): Result saved as final stage.

3. Define Load Cases

- At X direction

As shown in figure 4.5. Add New load Case> Enter the information in table 4.2.

Table (4.2): Define load cases for pushover

Name	Pushover_mode 2 - X direction
Type	Nonlinear static
Mass Source	Mass Source
Initial Condition	Continue from state at End of nonlinear case
Nonlinear Case	Gravity Nonlinear
Load type	Mode 2
Geometric	P-Delta
Load Application	Full load
Results saved	Final State Only

General

Load Case Name: Pushover_mode 2 - X direction [Design...]

Load Case Type: Nonlinear Static [Notes...]

Mass Source: Mass Source

Analysis Model: Default

Initial Conditions

☐ Zero Initial Conditions - Start from Unstressed State

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

Nonlinear Case: Gravity Nonlinear

Loads Applied

Load Type	Load Name	Scale Factor
Mode	2	1

[Add] [Delete]

Other Parameters

Modal Load Case: Modal

Geometric Nonlinearity Option: P-Delta

Load Application: Full Load [Modify/Show...]

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

Floor Cracking Analysis: No Cracked Analysis [Modify/Show...]

Nonlinear Parameters: Default - Iterative Event-to-Event [Modify/Show...]

Figure (4.5): Load case data

Refer also to reference No.5, ASCE 7-16 (2017) Guidelines: Minimum Design Loads and Associated Criteria for Buildings and -Other Structures (ASCE/SEI 7-16)

Standard 7-22 Minimum Design Loads and Associated Criteria for Buildings and Other Structures Chapter 1.

“Structural and nonstructural components and their connections designed with performance-based procedures shall be demonstrated by analysis in accordance with Section 2.3.5 or by analysis procedures supplemented by testing to provide a reliability that is generally consistent with the target reliabilities stipulated in this section. Structural and nonstructural components subjected to dead, live, environmental, and other loads except earthquake, tsunami, and loads from extraordinary events shall be based on the target reliabilities in Table 1.3-1. Structural systems subjected to earthquake shall be based on the target reliabilities in Table 1.3-2 and 1.3-3.”

4. Select control Node:

By selecting any node in the structure, to study its displacement, for example, the node shown in the figure 4.6 below, that is in story 6, label 17 has unique Name 93.

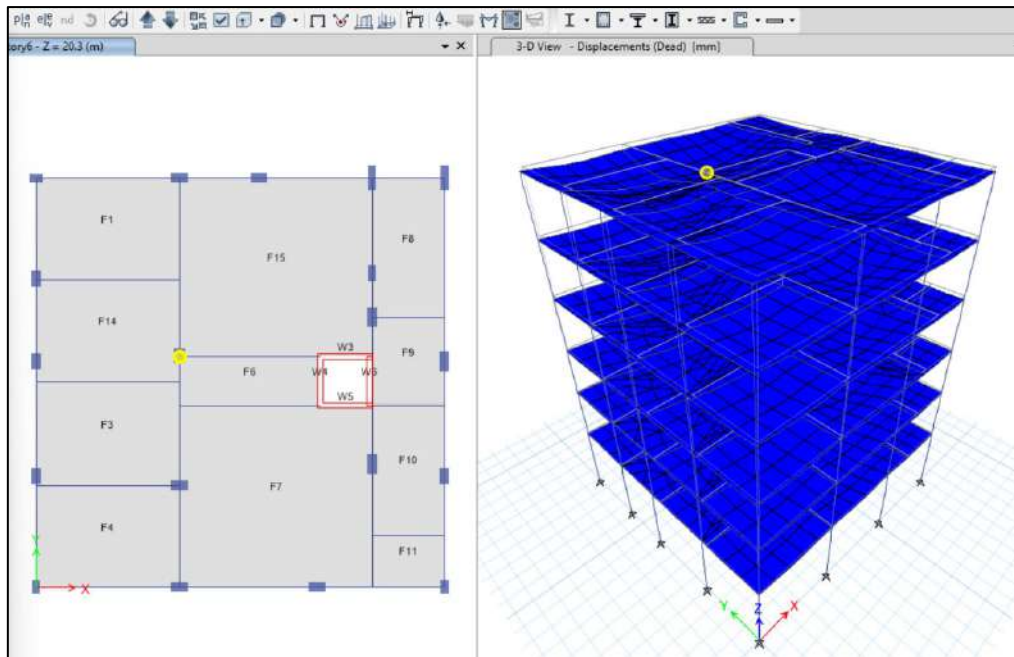


Figure (4.6): Select control node.

Enter the selected node details to “Pushover_mode 2 - X direction” as a Displacement Control, as shown in figure 4.7.

Go to load application > select use monitored displacement and enter the selected joint above>U1>Story6>17.

Load Application Control

☐ Full Load
☒ Displacement Control
☐ Quasi-Static (run as time history)

Control Displacement

☐ Use Conjugate Displacement
☒ Use Monitored Displacement
 Load to a Monitored Displacement Magnitude of mm

Monitored Displacement

☒ DOF/Joint
☐ Generalized Displacement

Figure (4.7): Load application control as displacement control

In the results saved enter multiple stages as shown in figure 4.8, since tracking the behavior of the selected node is required.

Results Saved

☐ Final State Only ☒ Multiple States

For Each Stage

Minimum Number of Saved States: 10

Maximum Number of Saved States: 100

☒ Save positive Displacement Increments Only

Figure (4.8): Results saved as multiple states.

Similarity, same procedure to be applied for y-direction as shown in figure 4.9.

- At Y direction

General

Load Case Name: Pushover_mode 3 -Y direction

Load Case Type: Nonlinear Static

Mass Source: Mass Source

Analysis Model: Default

Initial Conditions

☐ Zero Initial Conditions - Start from Unstressed State

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

Nonlinear Case: Gravity Nonlinear

Loads Applied

Load Type	Load Name	Scale Factor
Mode	3	1

Other Parameters

Modal Load Case: Modal

Geometric Nonlinearity Option: P-Delta

Load Application: Displacement Control

Results Saved: Multiple States

Floor Cracking Analysis: No Cracked Analysis

Nonlinear Parameters: Default - Iterative Event-to-Event

Figure (4.9): Define load case for y direction.

The only different between x and y direction is in the load application while entering the data of the control node, select U2 instead of U1,

corresponding to the y direction and name is as “Pushover_mode 3 - y direction”. As shown in figure 4.10.

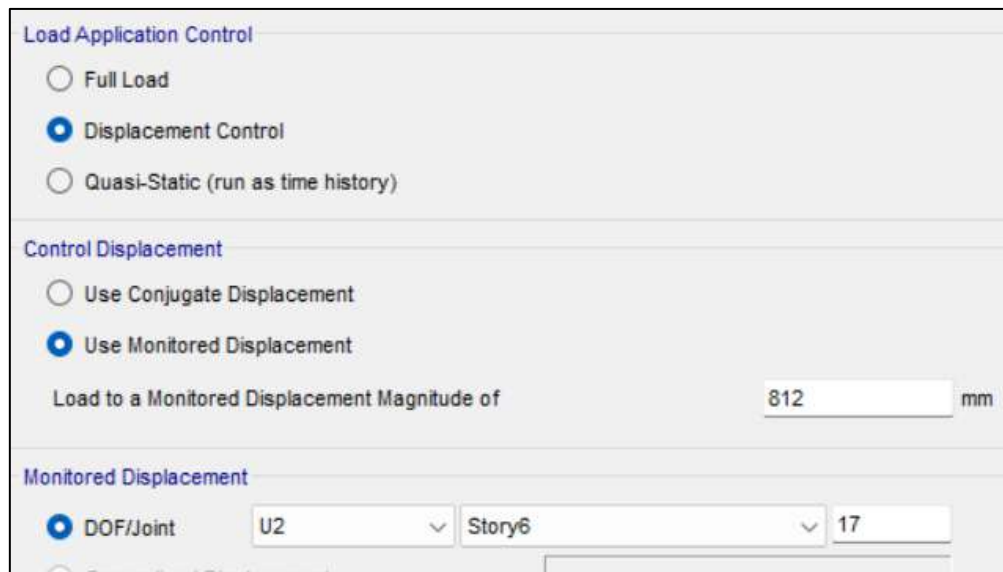


Figure (4.10): Load application control as displacement control

Now, after defining two Pushover load in x and y direction, Run the analysis.

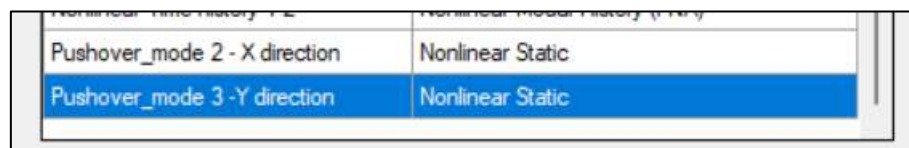


Figure (4.11): Running the x and y pushover load.

Go to Analysis>Set Load Cases to Run> select the last 2 load defined> Run Now.

4.1.2 Push Over Analysis Results:

i. Base shear Vs Displacements

After running the analysis> go to Display >static push over curve>it will show a graph between the monitored displacements Vs base shear same as shown in figure 4.12 and figure 4.13 below. (Monitored displacements mean the reference or control selected which was story 6, label 17 has unique Name 93) at x direction and y direction.

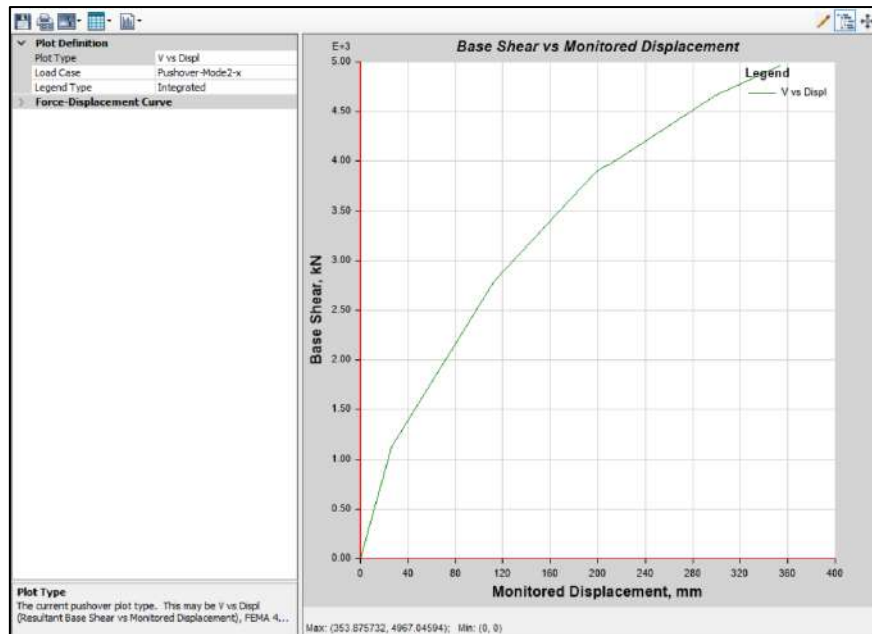


Figure (4.12): Pushover result - base shear vs displacements curve at x direction

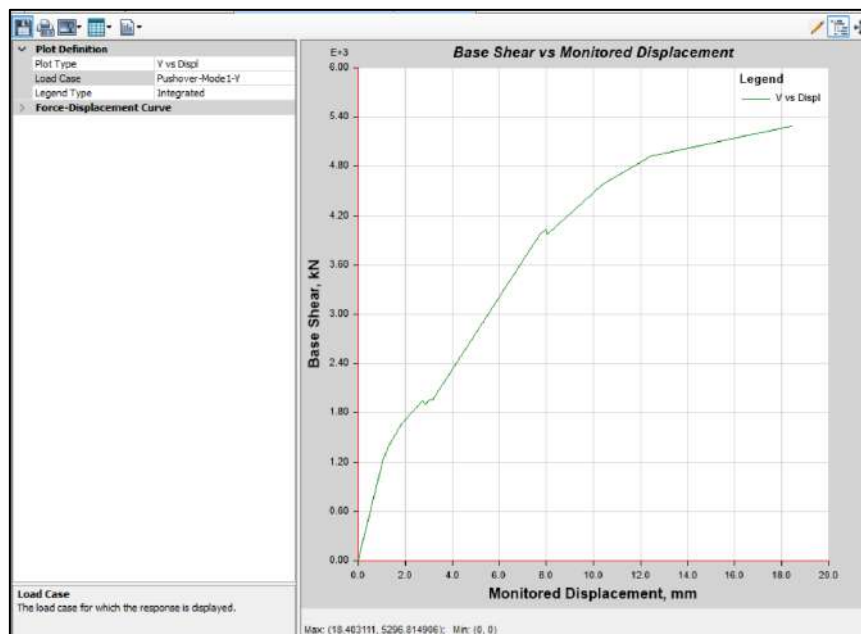


Figure (4.13): Pushover result - base shear vs displacements curve at y direction

The results can be represented in tabular form as it is shown in figure 4.14 and table 4.3.

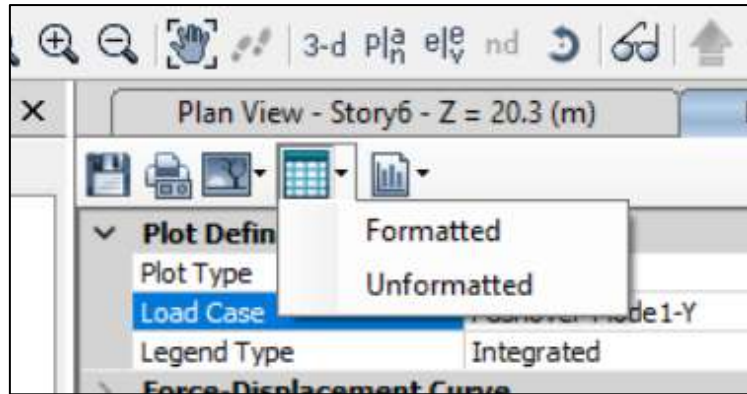


Figure (4.14): Display the results as a formatted table.

Table (4.3): Table of base shear vs monitored displacement.

Base Shear vs Monitored Displacement													
	Step	Monitored Displ mm	Base Force kN	A-B	B-C	C-D	D-E	>E	A-I0	I0-LS	LS-CP	>CP	Total
	0	0	0	588	0	0	0	0	588	0	0	0	588
	1	1.054	1216.3882	587	1	0	0	0	588	0	0	0	588
	2	1.347	1433.1746	579	9	0	0	0	588	0	0	0	588
	3	1.834	1669.4712	577	11	0	0	0	588	0	0	0	588
	4	2.723	1943.8548	576	12	0	0	0	588	0	0	0	588
	5	2.849	1906.265	575	13	0	0	0	588	0	0	0	588
	6	3.006	1959.3899	574	14	0	0	0	588	0	0	0	588
	7	3.18	1963.6773	574	14	0	0	0	588	0	0	0	588
	8	7.729	3971.9994	437	151	0	0	0	582	6	0	0	588
	9	7.986	4044.7698	429	159	0	0	0	579	9	0	0	588
	10	8.03	3982.3146	419	169	0	0	0	579	9	0	0	588
	11	8.051	3980.7193	418	170	0	0	0	578	10	0	0	588
	12	10.379	4581.3088	370	216	2	0	0	556	30	2	0	588

ii. Deformation Shape

To display the deformation as a function of time, as shown in figure 4.15. Go to display>deformed shape>select “Pushover_mode 2 - X direction” > Steps> Apply.

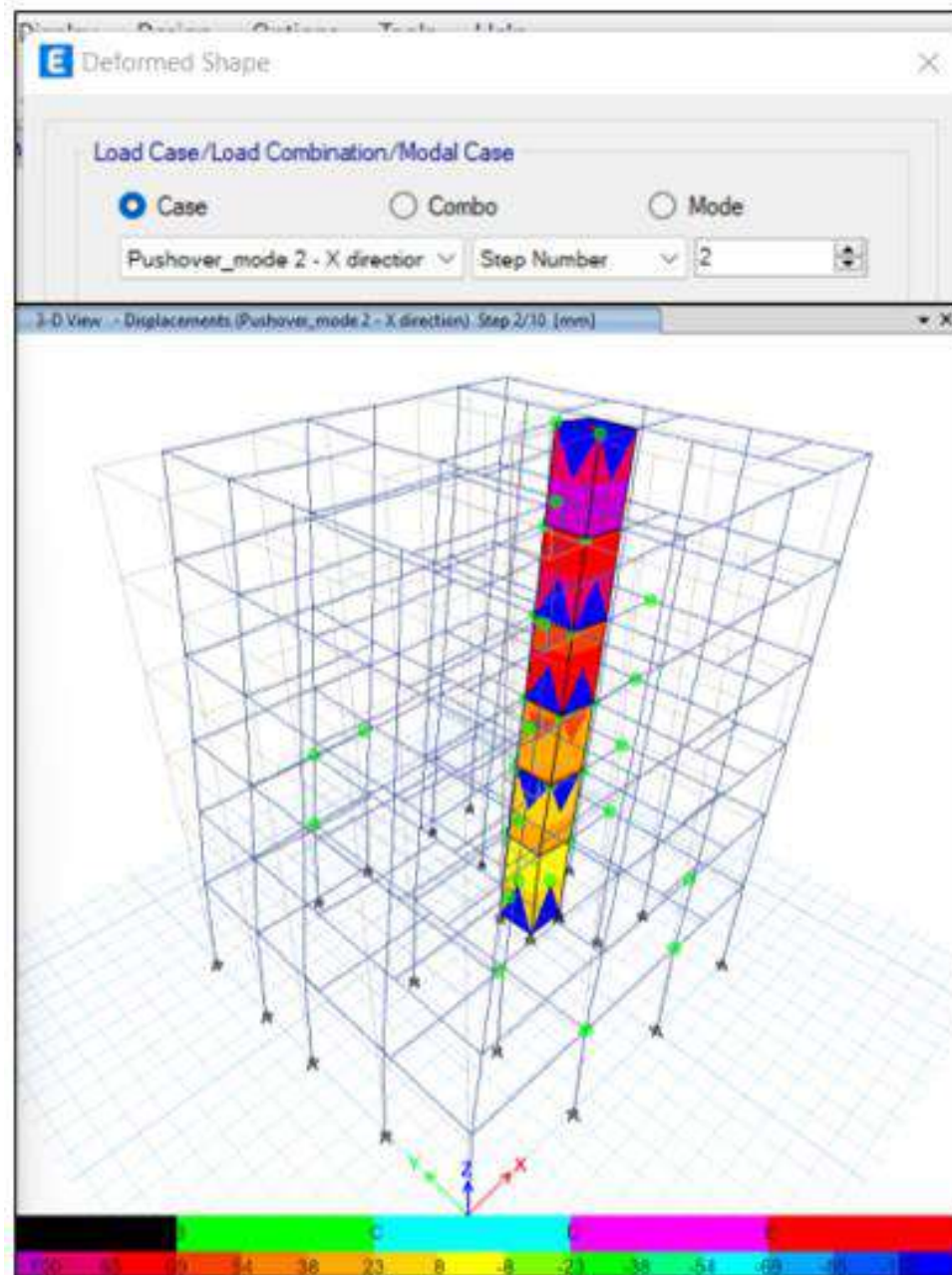


Figure (4.15): Pushover deformed shape mode 2.

By increasing the steps till reaching to a failure of the member as represented in red dot in figure 4.16. Detailed information of this member using graph or table can be displaced as shown in table 4.17 to fine out the reason of failure at that step (e.g., base shear force, displacements).

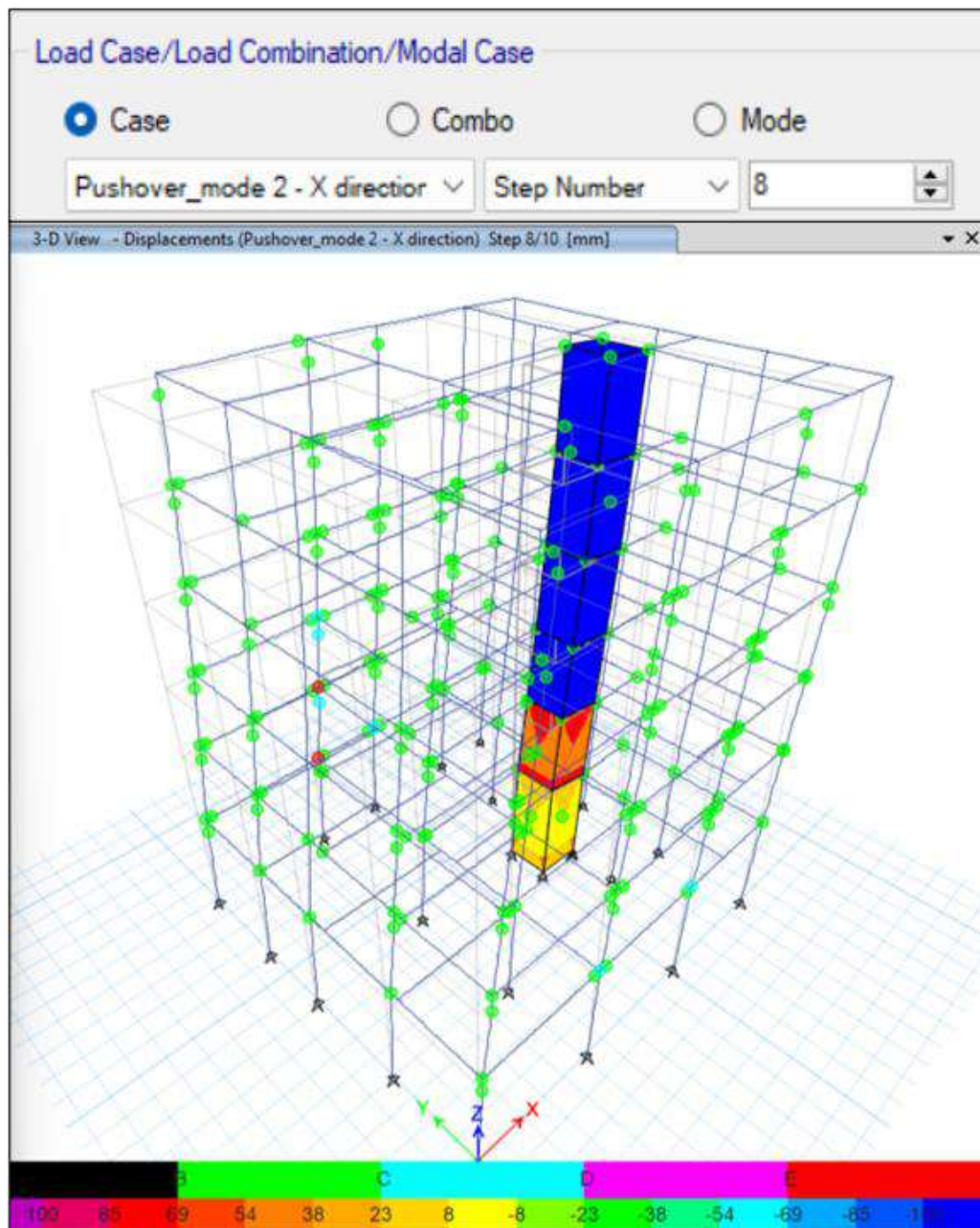


Figure (4.16): Pushover deformed shape mode 8.

From figure 4.16 it is noted that at step No.8, a red node has been displaced, by going back to the base shear-displacements curve or the tabulated values to find out what is the roof displacements corresponds to step No. 8 which is shown table 4.17 below.

Step	Monitored Displ mm	Base Force kN	A-B	B-C	C-D	D-E	>E	A-I/O	I/O-LS	LS-CP	>CP	Total
0	0	0	588	0	0	0	0	588	0	0	0	588
1	26.029	1124.8728	587	1	0	0	0	588	0	0	0	588
2	112.659	2794.7937	549	39	0	0	0	588	0	0	0	588
3	198.796	3895.0978	442	146	0	0	0	583	5	0	0	588
4	203.957	3941.3764	436	152	0	0	0	582	6	0	0	588
5	208.063	3956.619	429	159	0	0	0	580	8	0	0	588
6	208.175	3956.8747	428	160	0	0	0	579	9	0	0	588
7	208.625	3959.4733	427	161	0	0	0	579	9	0	0	588
8	299.307	4666.3601	366	219	1	0	2	547	39	2	0	588
9	353.876	4967.0459	328	249	5	0	6	514	65	9	0	588

Figure (4.17): displacements correspond to step No. 8

The Failure have been shown as force deformation shape or by acceptance criteria. The same can be repeated to any steps and at x and y directions.

iii. Hinge Result.

The result of fiber and plastic hinge analysis discussed earlier in chapter 3, can be displaced as following.

By going to display>Hinge Result.

To display the deformation as a function of axial load as shown in figure 4.18.

For example, let us select story 4, column, Fiber hinge at column C1.

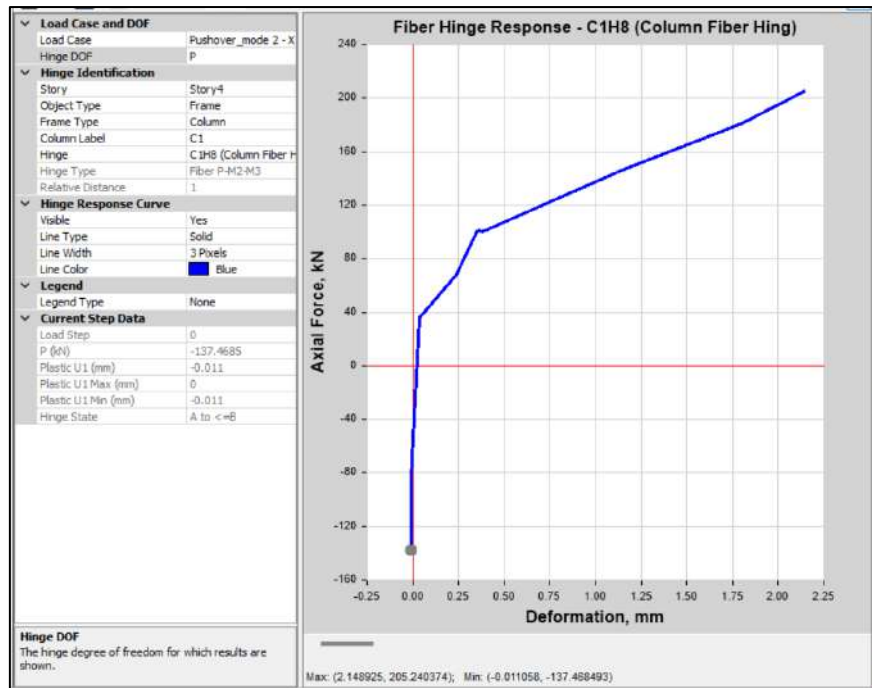


Figure (4.18): Axial force vs deformation curve for column 1 at story 4

The same can be done for the moment vs rotation for column C1 as shown in figure 4.19.

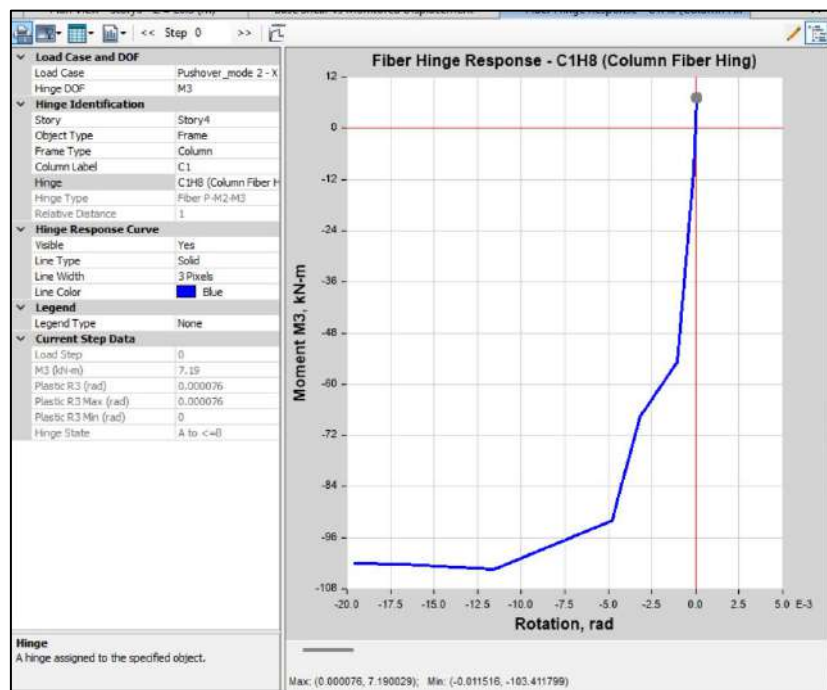


Figure (4.19): Moment M3 vs rotation for column 1 at story 4

Stress-strain curve for specific fiber number in the column C1 itself can be displayed as shown in figure 4.20.



Figure (4.20): Stress-strain curve for fiber 13 of column C1

The red line represents in curve refer to the input values, while the blue line represents demand or applied pushover load stress-strain curve as a result.

iv. Story response plot

Other result can be displayed is the story response plot, as it's shown in figure 4.21, which is a relationship between displacements and stories.

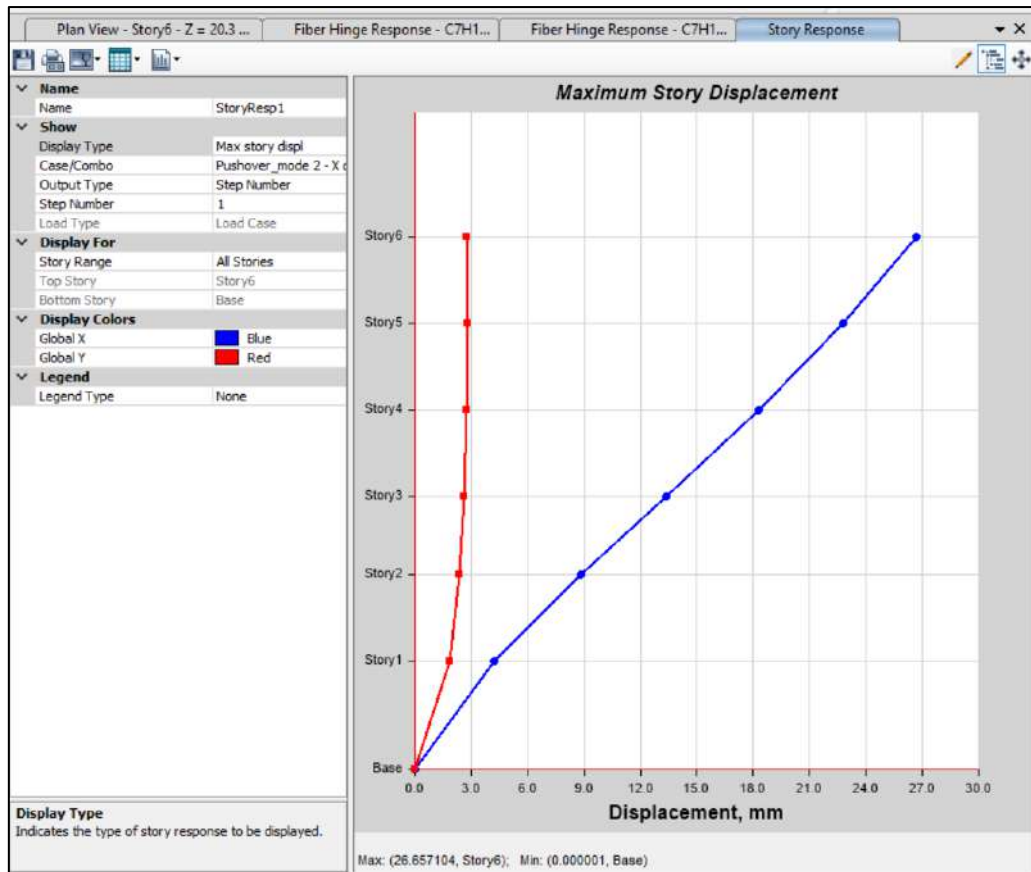


Figure (4.21): Pushover result-maximum story displacement

v. Combined Response Plot

Which is consider the response of the stories level with respect to displacements, drift, shear and overturning, as it is shown in figure 4.22.

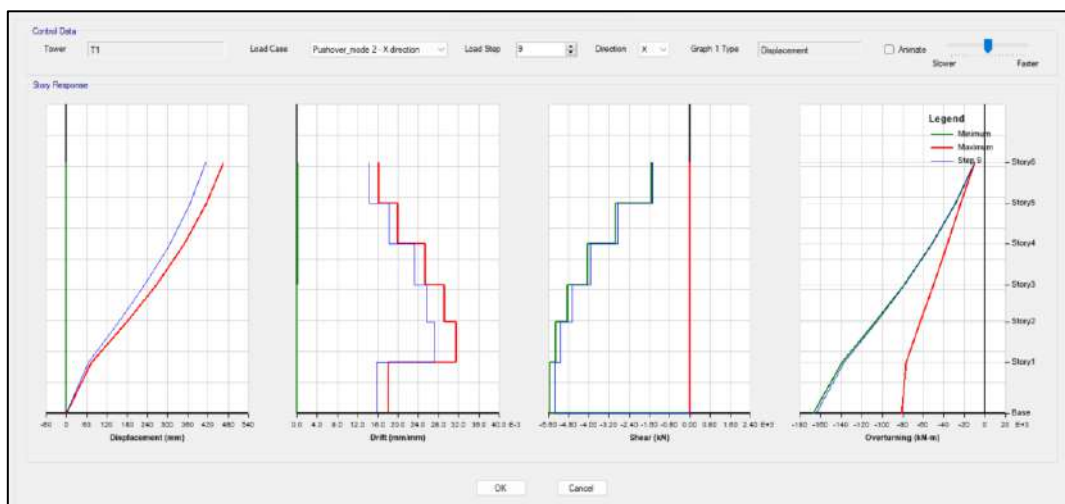


Figure (4.22): Combined response plot

vi. Plots Function (Base reaction vs Steps)

Plot any two results, for example, Base reaction vs Steps as shown in figure 4.23.

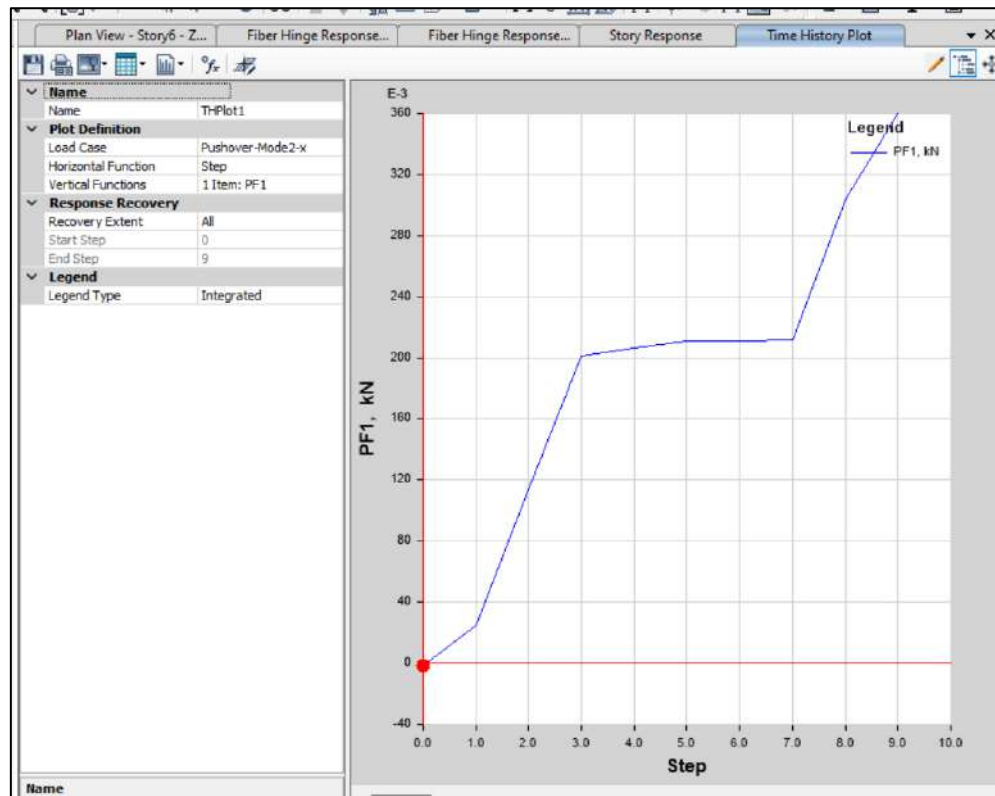


Figure (4.23): Pushover result - base reaction vs steps

4.1.3 Pushover analysis for beam - plastic hinge results

After applying the plastic hinge of beams, and run the nonlinear static (i.e., dynamic analysis), now hinge result of beam can be obtained as followings:

By pressing Display>deformed Shape> select the load case “Pushover-model 2-x “which is for x-direction >Apply, as it is shown in figure 4.24 , the same will be applied at y direction as it is shown in figure 4.26.

By entering any specific time that needs to know the deformation shape of the building, displacement will show as figure 4.25 for x direction and figure 4.27 for y direction below.

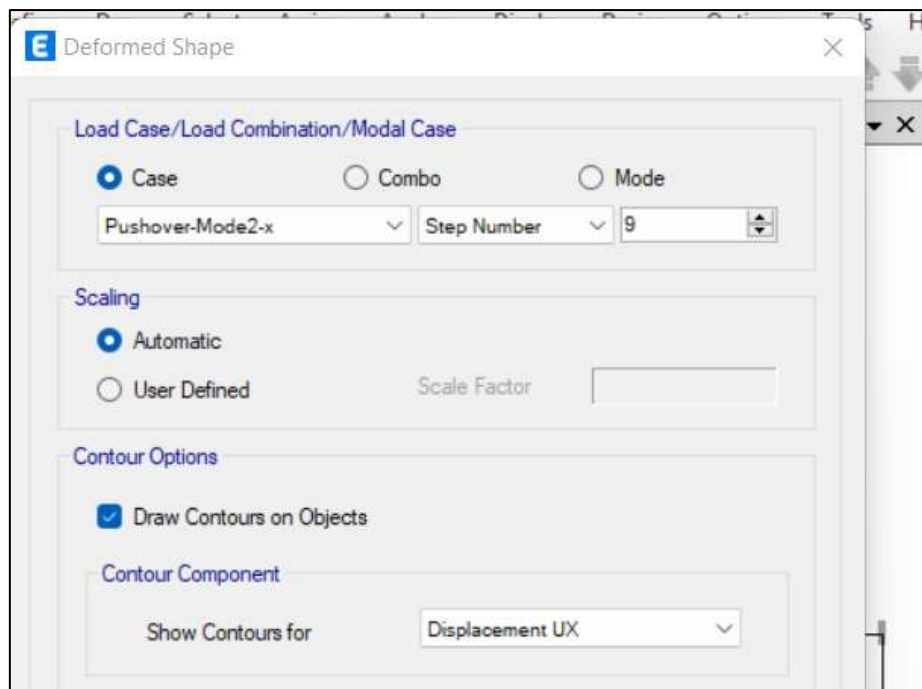


Figure (4.24): deformed shape displacement for x direction

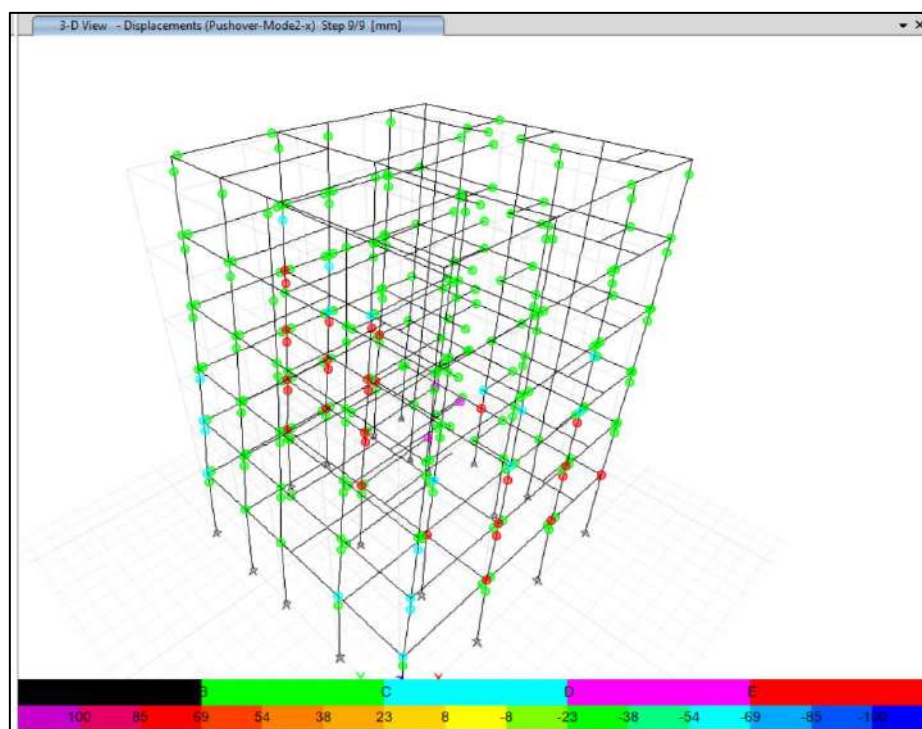


Figure (4.25): 3D view of the shape displacement for x direction

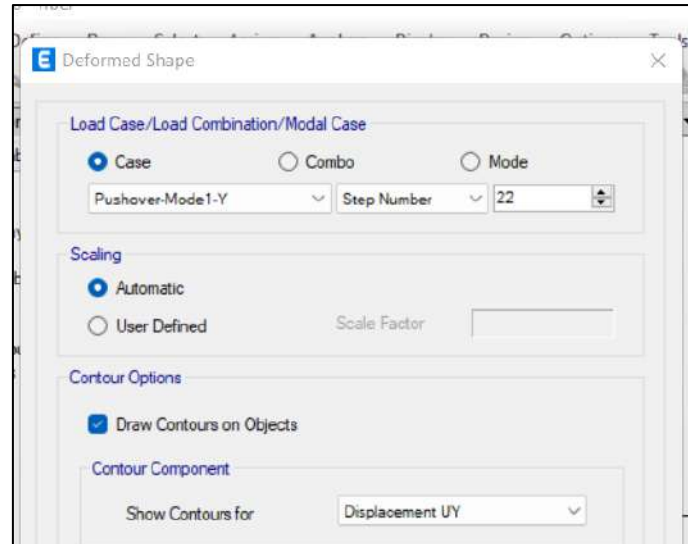


Figure (4.26): deformed Shape displacement for y direction

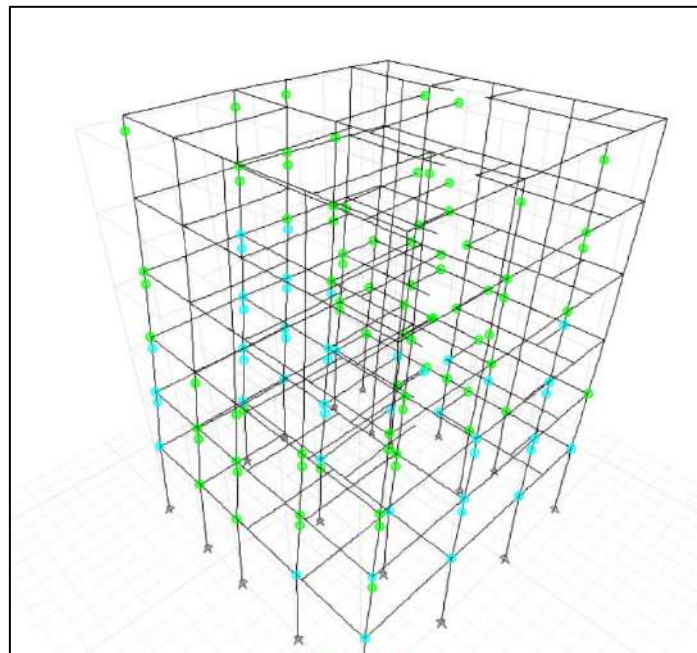


Figure (4.27): 3D view of the Shape displacement for y direction

The colors shown in figure 4.27 are either be indicated by Moment-Rotation values of individual member as shown in figure 4.28 or by acceptance Criteria as shown in figure 4.29.

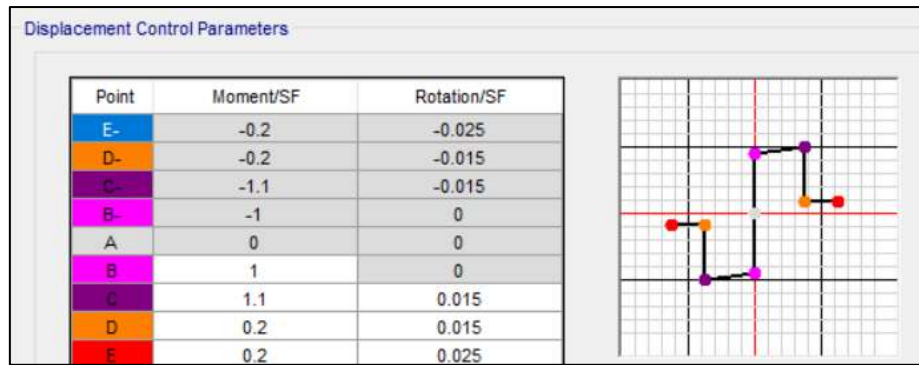


Figure (4.28): Moment-rotation values



Figure (4.29): Acceptance criteria

Another important result its obtained from plastic hinge analysis, which is the engine dissipation graph, as it is shown in figure 4.30 at x direction and figure 4.31 at y direction.

By going to display > cumulative engorge components.

Figure 4.30 shows the amounts of applied force that have been dissipated by components of the structure.

At x direction

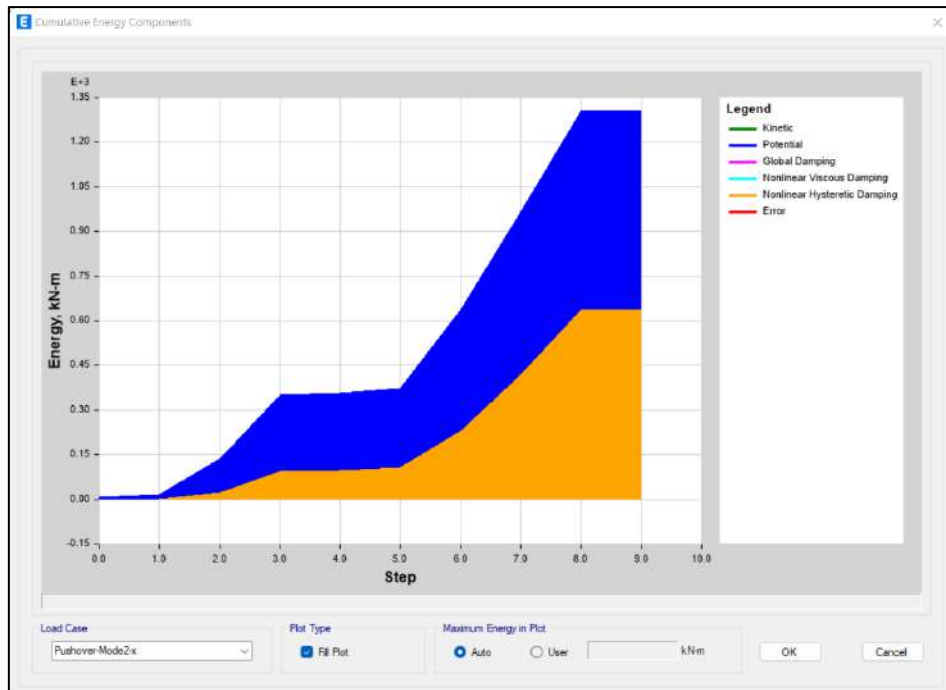


Figure (4.30): Cumulative energy components due to pushover of x direction.

And at y direction



Figure (4.31): Cumulative energy components due to pushover of y direction.

4.1.4 Pushover analysis for column and shear wall- Fiber hinge results

Same process can be applied to display the fiber hinge results for column and shear walls. Figure 4.32 below is one example of applying the same for columns and tabulated in table 4.4.

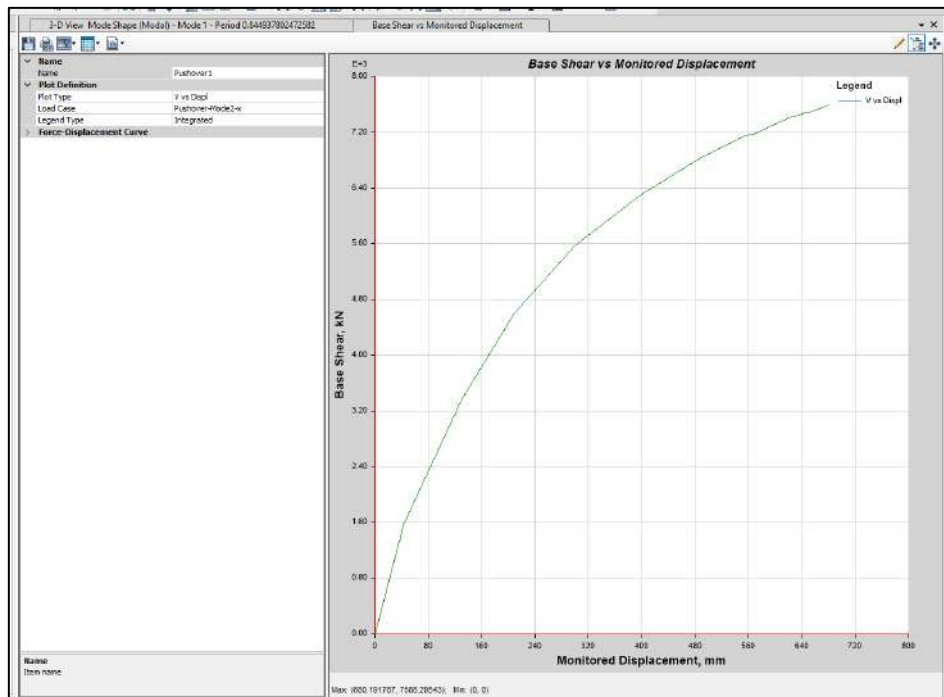


Figure (4.32): Base shear vs displacements curve as a result of pushover analysis

Table (4.4): Tabulated data of base shear vs displacements as a result of pushover analysis

Step	Monitored Displ mm	Base Force kN	A-B	B-C	C-D	D-E	>E	A+D	D+LS	LS+CP	>CP	Total
0	0	0	240	0	0	0	0	240	0	0	0	240
1	3	1938.953	240	0	0	0	0	240	0	0	0	240
2	10.608	4868.4399	150	90	0	0	0	229	11	0	0	240
3	11.958	5176.4559	136	102	2	0	0	221	18	1	0	240
4	18.598	6170.7724	93	121	11	0	15	162	55	23	0	240
5	22.216	6507.4962	80	115	17	0	28	137	68	35	0	240
6	23.812	6591.9452	77	116	16	0	31	133	63	44	0	240
7	26.151	6653.6179	75	115	16	0	34	129	66	45	0	240
8	34.612	7264.1019	54	90	29	0	67	98	53	82	7	240
9	34.614	7264.1933	54	90	29	0	67	98	53	82	7	240
10	34.715	7274.8861	54	90	29	0	67	98	53	82	7	240
11	35.045	7295.2729	53	90	29	0	68	98	53	82	7	240
12	35.048	7299.2907	52	89	31	0	68	97	53	83	7	240

As a summary of above, the results show that when the building is pushed over, the first failure happened due to column at first floor in x-direction. The

applied shear force on the base foundation was 4666 kN and the x displacements of the selected joint as a reference was 299 mm. at mode 8. Once the members in known, a detail of load and moments applied can be studied, which is in the column was as followings:

Applied axial force= -505.325 kN

Shear at x direction = 4.2254 kN

Shear at y direction = 23.2716 kN

Maximum Moment at x direction = +41.4911 kN

Maximum Moment at y direction = +7.3601 kN

that's means to avoid building failure due to this column collapse, redesign of this column is required to resist the shear force of 4666 kN and 299 mm displacement must be carryout. To study the behavior of column (or beam and shear wall) since it's the first elements failed, fiber hinge analysis must be applied to show in detail the reason of collapse, for example, shown the displacement-shear curve of this particular column, or moment-rotation curve and stress-strain diagram of this column comparing with its original stress-strain curve.

Same can be applied to beam or shear wall if the cause of collapse was due to their failure, as it is quoted from reference 6.

“NONLINEAR STATIC PROCEDURES, the evaluation of seismic performance requires a structural analysis tool to gauge what happens to a building, in terms of damage, when subjected to earthquake shaking that exceeds the elastic capacity of the structural system. Structural analysis techniques consist fundamentally of a comparison of a demand parameter with a corresponding capacity parameter for a building. Base shear (total horizontal force at the lowest level of the building) has been the traditional parameter that is used for design of buildings. The engineer calculates the

base shear force demand that would be generated by a given earthquake, or intensity of ground motion, and compares this to the base shear force capacity of the building (Figure 3). In conventional design, the earthquake forces are artificially reduced to keep the design process in the elastic range. When working in the inelastic range, the generalization of capacity as a force makes it difficult to characterize the actual damage to specific parts of the”

4.2 The Nonlinear Time History Analysis.

In this chapter seven topic are going to discussed as following:

- 4.2.1 Time History Analysis in Building Code UBC 97
- 4.2.2 THE RESPONSE SPECTRUM- TARGET SPECTRUM
- 4.2.3 Ground Motions Selection Criteria.
- 4.2.4 Selection of Ground Motions from PEER Ground Motion Database
- 4.2.5 Modification of Ground Motions to Match the Target Hazard - Scaling vs. Spectral Matching
- 4.2.6 Time History Analysis of Buildings Using CSI ETABS
- 4.2.7 Time History Analysis of Buildings Result.

4.2.1 Time History Analysis in Building Code UBC 97.

The time history analysis as prescribed in different building codes. There are certain guidelines available for designing of new buildings or reviewing or performance evaluation of existing building using nonlinear time history analysis. In this section reviewing of UBC-97 building code and its requirements for nonlinear time history analysis are going to be discussed. UBC-97 (Uniform Building Code), the most widely used, has guidelines for the selection, modification, application of ground motions for nonlinear time history analysis.

The first guideline is about the number of horizontal ground motions that should be used for a particular analysis. UBC-97 required not less than three recordings.

Second, as it's quoted below (UBC-97: CL. 1631.6), these records shall have magnitudes, fault distances and source mechanisms that are consistent with those control the design-basis earthquake or the maximum capable earthquake at site.

Quotation from uniform building code 1997, Volume 2 chapter 16:

“1631.6 Time-history Analysis.

1631.6.1 Time history. Time-history analysis shall be performed with pairs of appropriate horizontal ground-motion time history components that shall be selected and scaled from not less than three recorded events. Appropriate time histories shall have magnitudes, fault distances and source mechanisms that are consistent with those that control the design-basis earthquake (or maximum capable earthquake). Where three appropriate recorded ground-motion time-history pairs are not available, appropriate simulated ground-motion time-history pairs may be used to make up the total number required. For each pair of horizontal ground motion components, the square root of the sum of the squares (SRSS) of the 5 percent-damped site-specific spectrum of the scaled horizontal component shall be constructed. The motions shall be scaled such that the average value of the SRSS spectra does not fall below 1.4 times the 5 percent-damped spectrum of the design-basis earthquake for periods from 0.2T second to 1.5T seconds. Each pair of time histories shall be applied simultaneously to the model considering torsional effects.

The parameter of interest shall be calculated for each time history analysis. If three time-history analyses are performed, then the maximum response of the parameter of interest shall be used for design. If seven or more time-history analyses are performed, then the average value of the response parameter of interest may be used for design.”

A selection criterion should be developed based on a very comprehensive study of site properties.

First, the design spectrum shall be constructed for site should be the SRSS of the two components, it should have a damping ratio of 5%. Because each

earthquake has two horizontal components, each component will have a separate spectrum. Accordingly, the target spectrum should be SRSS of the two spectrums. This will be the design spectrum from building code. After downloading a particular past ground motion which pass out selection criteria, that ground motions will not have smooth spectrum, and will be very rough and irregular spectrum.

The design spectrum and actual spectrum must match. Design spectrum (representing level of seismic hazard at the site) and the actual spectrum (representing the past recorded ground motion) should be compatible and match. The actual record spectrum should be as close as the design spectrum. If the ground motion has a spectrum resembles very close to the design spectrum, then this ground motions are now representing a future expected or future ground motion as it is represented or characterized by design spectrum. If not, the ground motion shall be scaled (Up or down) by multiplying it with factor such that the average value of the SRSS spectrum does not fall below 1.4 times the 5% damped spectrum of the design spectrum between time period range which is $0.2 T, 1.5 T$. Where T is the time period of the earthquake.

Each pair of time histories shall be applied simultaneously to the model considering torsional effects. That achieved by defining two load cases for both horizontal acceleration at x and y directions, both have effect on the structure simultaneously as following:

Load Case 1: Acceleration at X direction $U1$ + Acceleration at y direction $U2$

Load Case 2: Acceleration at y direction $U2$ + Acceleration at x direction $U1$

It shall be calculated for each time history analysis. If three-time history analysis are performed, then the maximum response of these three should be extracted. But if seven or more ground motions were used, then average of the peak response is carried out.

Time History Analysis: process and advantages, reference No. 49,

” In fact, time history analysis serves as a method used to predict the dynamic response, considering the actual time-varying loads.

The most demanding aspect lies in developing the time history curve. Moreover, several variations in ground acceleration records are necessary. This data can be available for countries with experience in earthquakes, while nations lacking such experience may need to rely on curves developed by other countries.

To conduct time history analysis, engineers follow a process which includes several essential steps:

- 1. Identifying Dynamic Loads.*
- 2. Creating a Mathematical Model.*
- 3. Choosing Time History Records.*
- 4. Simulating Structural Response.*
- 5. Assessing Structural Performance.*
- 6. Design Optimization.*

Time history analysis offers several advantages:

- 1. Realistic Representation.*
- 2. Safety Evaluation:*
- 3. Design Optimization.*
- 4. Compliance with Standards and Design Codes.”*

4.2.2 THE RESPONSE SPECTRUM- TARGET SPECTRUM

Before going to database, establish the seismic hazard at site (the response spectrum) must be done first, that will be used as target hazard level based on which ground motions needs to be modified. It's also called the smooth design spectrum, (spectral acceleration vs time period) as shown in figure 4.33 below.

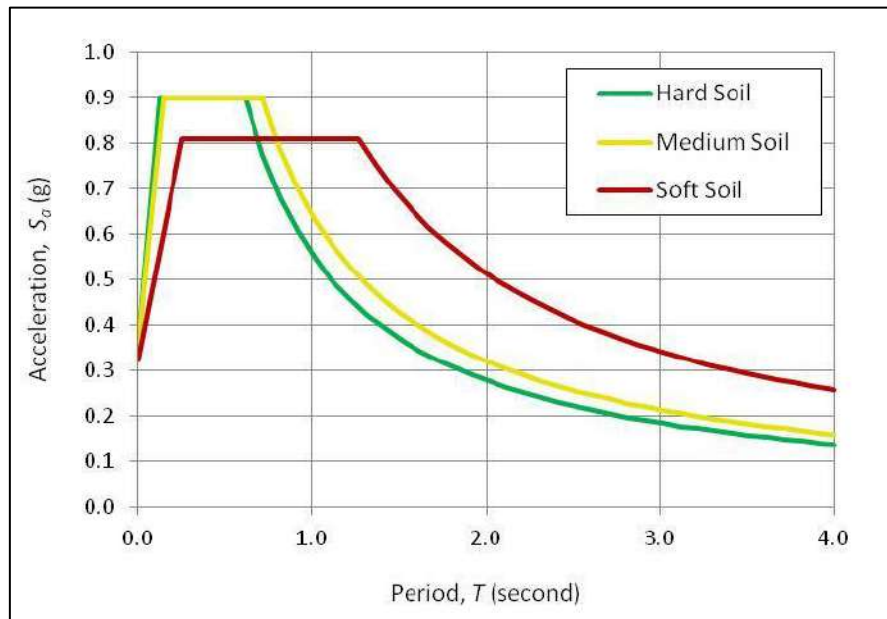


Figure (4.33): Target spectrum based on Site's hazard level.

As mentioned in reference 2 “A. K. Chopra, (1995): Dynamics of Structures-Theory and Applications to Earthquake Engineering Book, Prentice Hall, New Jersey.”

“A procedure is presented for construction the design Spectrum for elastic plastic system for specified activity Factor. This could be achieved by construction the consent ductility response Spectrum. for many plausible Grand motion for the site and based on these data the design Spectrum associated with an exceedance probability could be established.”

The same can be obtained from two sources.

1. One by performing the site-specific hazard assessment and that process will give the response spectrum or uniform hazard spectrum.

Its sometimes called the **uniform hazard spectrum**.

“Performing specific seismic hazard assessment PSHA to obtain the uniform hazard spectrum of the site.”

2. The second option, by using a particular building codes, that provides the smooth design spectrum based on site hazard parameters “the code prescribed spectrum”.

In this research the second option – code prescribed spectrum is going to be used. Assume that a particular building code is used, that building code will provides an equation for that design spectrum, and that equation will use the hazard parameters of the site as an input and construct the spectrum as an output.

The code used in this research is ASCE7-10 onwards (originally IBC 2012 onwards). (Refer to reference No.25). The process of the construction of **response spectrum** for the site using ASCE7-10 code distributed to steps as follows:

Step 1: Select the S_s and S_1 (bedrock level) from the hazard maps.

Step 2: Classify the soil at site, the site classification based on the V_{s-30} value, (the shear wave velocity in first 30 meters), or the SPT-N value (standard penetration test results) or the undrained shear strength S_u . Any of these three parameters can be used to perform the soil classification. Accordingly, the site can be classified as S_A , S_B , S_C .

Step 3: Determining F_a and F_v factors (site correction factors), code provides tables for calculating the same based on soil class. The soil may have the capability to amplify or de-amplify ground motions and that amplification or de amplification will be accounted for using the F_A & F_V parameters. F_a parameter is applied to S_s , and F_v parameter is applied to S_1 .

$$F_a = \frac{(S_s)_{Top}}{(S_s)_{Rock}} \quad (\text{Equation 4.1})$$

$$F_v = \frac{(S_1)_{Top}}{(S_1)_{Rock}} \quad (\text{Equation 4.2})$$

Basically, the bottom soil layer spectrum is the input, and the top surface spectrum is the output. The difference between these two spectra is telling how the soil layers have modified the ground motion. The ratio of the S_s and S_1 values output over input will give F_A and F_V factors.

Step 4: Calculate S_{MS} and S_{M1} (modified parameters to modify the original S_s and S_1), including the soil effect. (Refer to reference No.24).

$$S_{MS} = F_a S_s \quad (\text{Equation 4.3})$$

$$S_{M1} = F_v S_{S1} \quad (\text{Equation 4.4})$$

building codes provide tables corresponding to different soil classifications where values of F_A and F_V factors can be obtained and then multiply it with S_s and S_1 .

Step 5: Calculate S_{DS} and S_{D1} (Design ground motion parameters)

Now since these S_{MS} and S_{M1} are MCE_R level needs to be multiply them with two by three to bring them to the design level to get S_{DS} and S_{D1} .

$$S_{DS} = \frac{2}{3} S_{MS} \quad (\text{Equation 4.5})$$

$$S_{D1} = \frac{2}{3} S_{M1} \quad (\text{Equation 4.6})$$

The factor of 2/3 was originally proposed for California, the engineers decided to design on two by three of the MCE, but later this idea was widely accepted and then use globally and now is included in IBC. The

structures must be designed at a level which is $2/3$ of the MCE_R level as S_{DS} and S_{D1}

Step 6: Determine T_o , T_L and T_s . definitions of T_o , T_L and T_s will be described later in this section. They are function of S_s and S_1 and simply three different time periods at which the spectrum changes its shape.

Step 7: Construct the target spectrum by using the code equations which is a function of S_{DS} and S_{D1} calculated already, it also called design response spectrum of site.

Step 8: Assign an occupancy category or risk category to the structure (I, II, III and IV). Four risk categories in this building code and their descriptions are available, based on structure's type.

Step 9: Classify the seismic design category in IBC, categories are (A, B, C, D, E, F), they are basically classified for different categories. Instead of the concept of seismic zone in UBC-97, IBC uses the concept of seismic design category to classify the structures having different levels of seismic hazard and having different levels of safety provisions.

For example:

Seismic design category A has minimum detailing requirements.

Seismic design category D has substantial detailing requirements.

Based on the seismic hazard level and the risk category assigned, the seismic design category can be classified.

For more information regarding soil dynamic behavior and characteristic, refer to reference 36. Soil Dynamics and Earthquake Engineering, Elsevier, Edited By: Ioannis Anastasopoulos, M. Hesham El Naggar, Dong-Sheng Jeng.

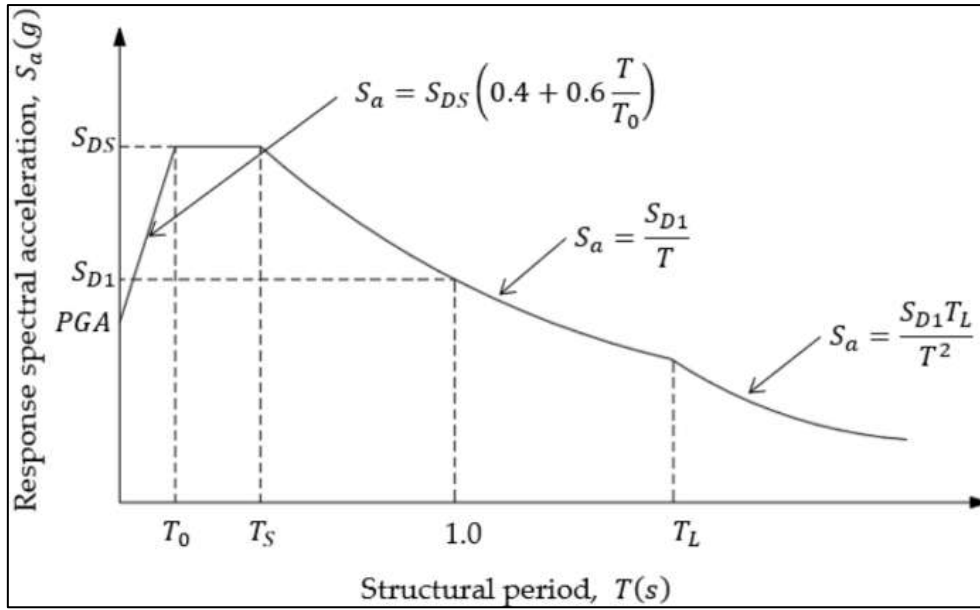


Figure (4.34): the response spectrum as per UBC-97 building code.

Figure 4.34 shows the code equations for S_s and S_1 . It starts with $0.4 S_{DS}$, then goes up to $1 \times S_{DS}$ then it stays constant at S_{DS} level. Then at a particular time stamp it time period T_s changes to a curve $S_A = S_{D1}/T$ and then after another point it again changes the equation to $S_{D1}T_L/T^2$, only S_{DS} and S_{D1} are required. These time periods where it changes its equation T_0 , T_L and T_s is required. The value obviously at one second will be S_{D1} . $T_0 = 0.2 S_{D1}/S_{DS}$ and $T_s = S_{D1}/S_{DS}$.

T_0 is defined as the point at up to which the spectral acceleration varies linearly till the plateau.

T_s is the point from which that plateau ends and then the curve part of the response spectrum starts.

And T_L is called the long period transition period, and it is a point from when at when the equation again changes to $S_{D1}T_L/T^2$. T_L is generally 7 or 8 seconds and in IBC and in the ASCE 7-10 there are maps available for T_L for different sites shown as a map. After that the curve changes its degree and then in the denominator T^2 will replace T , at this certain point. This is the procedure to construct the site-specific response spectrum according to ASCE7-10. Starting with S_1 and site classifications and then

ending up by constructing the design spectrum. This spectrum represents the seismic hazard level at the site. Then the past ground motions spectra should be compatible /match with this spectrum.

To do so, ground motions which have almost consistent magnitude source to side distance and the faulting mechanism match to site must be selected. The same must be considered as a guideline while selecting the ground motions from past records. (Refer to reference no. 21-23 and 26-27).

As it is mentioned in TBI (2010): Guidelines for performance-Based seismic Design of Tall Buildings-PEER. Reference 39:

“Select records for site-response analysis for a site condition that is generally compatible with the geologic conditions at the bottom of the site profile being simulated. If bedrock is reasonably shallow and its depth is known, the profile should extend into rock, and input motions should be defined for the rock condition. If the site consists of deep soils that cannot be reasonably simulated in their entirety, then the soil profile should extend to a firm soil horizon”

4.2.3 Ground Motions Selection Criteria.

As it's described at the beginning of the research, our building is located at Gaziantep city in Turkey, let us study our site location and try to find out what are the properties on the soil, nature of that city, enables us to select similar earthquakes that match our site, enables us predicting accurately and as close as possible to reality the future earthquake.

Some websites provide earthquakes information all around the world such as Interactive Earthquake Browser in reference No. 18.

As it's shown in the figure 4.35, Gaziantep is located in south-central of Turkey and figure 4.36 shows the location of Gaziantep with respect to tectonic plates border.



Figure (4.35): Location of Gaziantep at turkey on the map. Source : <https://en.wikipedia.org/wiki/Gaziantep#/map/0>

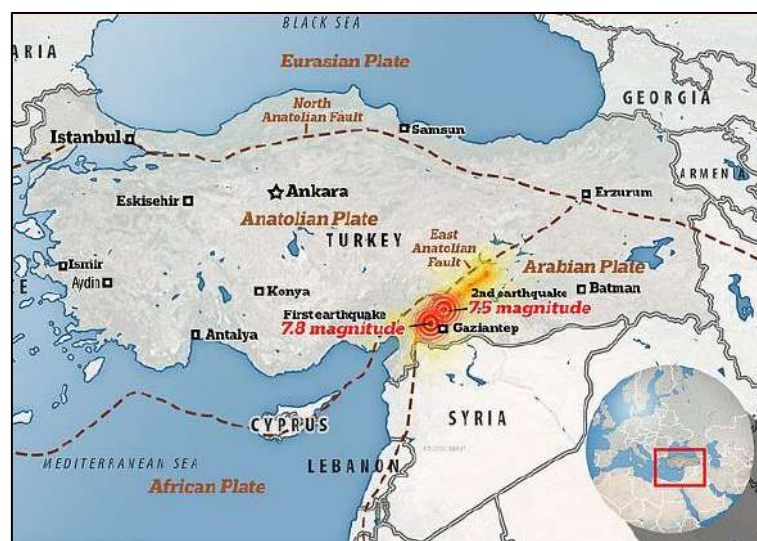


Figure (4.36): Gaziantep with respect to tectonic plates border

Source : <https://en.mogaznews.com/Technology/2110671/Turkey-earthquake-map-Where-in-Syria-and-Turkey-did-the-quake-hit-trends-now.html>

According to geoscience world organization, as its is shown in reference 40

“On 6 February 2023, southeastern Türkiye experienced two 7.7 and 7.6 earthquakes. The earthquake sequence caused widespread damage and tens of thousands of casualties in Türkiye and Syria. We analyze mainshocks and aftershocks, combining complementary source characterization techniques, relying on local, regional, and teleseism data. Back projection analysis and finite source inversion for the mainshocks

resolve seismic slip, rupture length, and propagation mode along the main faults, whereas centroid moment tensor inversion for 221 aftershocks resolves details of the fault network. The first mainshock nucleated on a splay fault and activated the neighboring East Anatolian fault zone (EAFZ). It ruptured bilaterally along ~500 km first toward northeast and later to south-southwest on multiple, previously partly dormant fault segments. The second mainshock ruptured the east–west-oriented Sürgü-Misis fault zone (SMFZ), reaching a slip of 7 m. The analysis of aftershocks with heterogeneous moment tensors retrospectively reconstructs rupture details. Along the main strand of the EAFZ, they map the geometry of different segments in unprecedented detail, whereas along the SMFZ they illuminate the geometry and behavior of large structures for the first time. Our work sheds light on multiple aspects of rupture evolution and provides new insights into the devastating earthquake sequence.”

Reference from other journalist shown also in reference 34.

By using R.T. Ministry of interior- department of earthquake website (AFAD)- <https://tadas.afad.gov.tr/list-waveform> and study of the past recorded earthquakes happened in the same city and at same region during the past 100 years between 1932-2023 that have magnitudes between 6 to 8 Richter scale, to observe the common specifications and characteristics of earthquakes in this region, 246 records have been fetched, six main earthquakes have been recorded as shown in table 4.5 and table 4.6.

Table (4.5): Six main earthquakes records at area near our location

	Event ID	Date
1	551067	20-02-2023 17:04
2	543593	6/2/2023 10:24
3	543431	6/2/2023 1:28
4	457758	24-01-2020 17:55

5	-	27-06-1998 13:55
6	-	9/10/1996 13:10

Table (4.6): The specification of the six main earthquakes records at area near our location

	Event ID	Magnitude	Soil type	Vs30 (m/sn)	Avg Sa(0.3s)	Avg Sa(1s)	Avg Sa(3s)	Avg T90(s)	Avg Rjb
1	551067	6.4	A	758	0.40	0.13	0.015	41	164.26
2	543593	7.6	A	758	0.11	0.1	0.38	45	115.06
3	543431	6.6	A	758	0.9	0.6	0.15	30	46.9
4	457758	6.8	A	758	-	-	-	-	202.95
5	-	6.2	B	421	-	-	-	-	110.89
6	-	6.8	-	-	-	-	-	-	409.02

Table (4.7): Shows the records of earthquakes between 1923-2023.

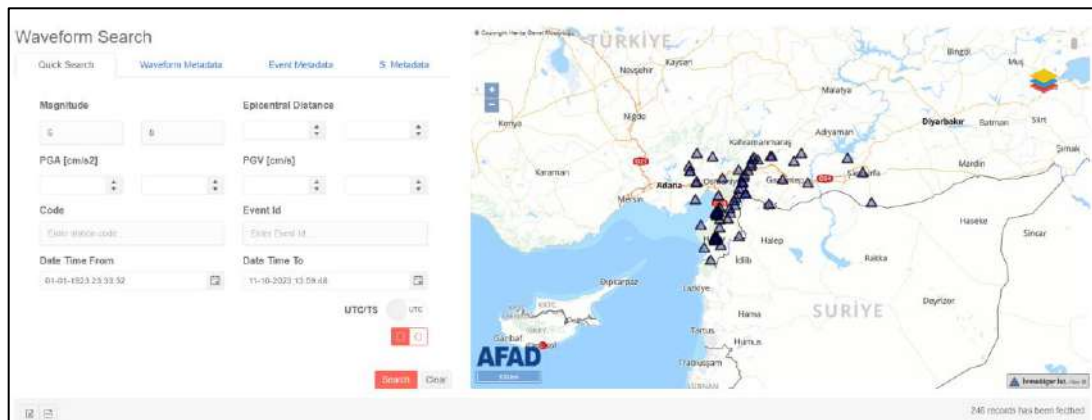


Figure (4.37): View the record of earthquakes occurring near the site of the building to be studied from 1923 to 2023.

Figure 4.38 shows the magnitude of 20th Feb 2023 earthquakes.



Figure (4.38): Earthquakes record No. 1 happened on 20th Feb 2023 with magnitude of 6.4.

Figure 4.39 shows the magnitude of 6th Feb 2023 earthquakes.



Figure (4.39): Earthquakes record No. 2 happened on 6th Feb 2023 with magnitude of 7.6.

Figure 4.40 shows the magnitude of 6th Feb 2023 earthquakes.



Figure (4.40): Earthquakes record No. 3 happened on 6th Feb 2023 with magnitude of 6.6.

Figure 4.41 shows the earthquakes record No. 4 happened on 24th Jan2020.



Figure (4.41): Earthquakes record No. 4 happened on 24th Jan2020 with magnitude of 6.8.

Figure 4.42 shows the earthquakes record No. 5 happened on 27th June 1998.



Figure (4.42): Earthquakes record No. 5 happened on 27th June 1998 with magnitude of 6.2.

Figure 4.43 shows the earthquakes record No. 6 happened on 9th Oct 1996.

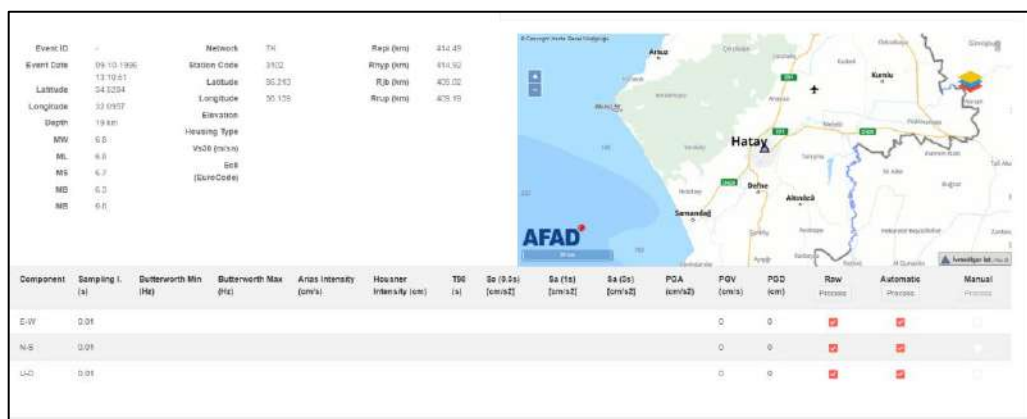


Figure (4.43): Earthquakes record No. 6 happened on 9th Oct 1996 with magnitude of 6.8.

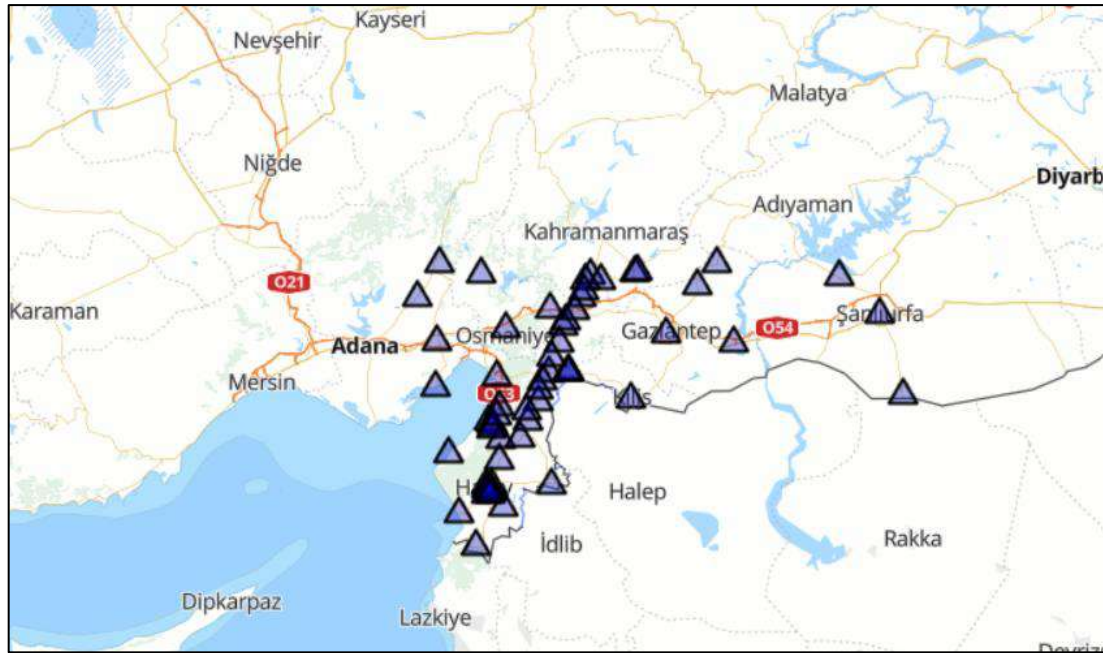


Figure (4.44): Locations of earthquakes that occurred near the area to be studied.

From the previous records above and figure 4.44, it's obvious that most of the earthquakes that occurred near the area where the building is to be erected, have a magnitude on the Richter scale of six to eight degrees. Now, by reviewing research done by Turkish engineers under title of "PRELIMINARY ENGINEERING REPORT ON GROUND MOTION DATA OF THE FEB. 2023 TURKEY SEISMIC SEQUENCE" refer to Appendix (4), it can be noticed that pulse type can be considered as strike slip, and the fault type shown as the finite-fault geometry. As shown in table 4.7. Types of soil faults are represented in figure 4.45.

Table (4.7): Pulse type of the essential data about four largest magnitudes.

Table 1. Essential data about the four largest magnitude events in the sequence (data from EPOS; see Data and resources).						
Date	Time (UTC)	Magnitude	Long. [°]	Lat. [°]	Depth [km]	Mechanism*
06-02-2023	01:17:36	7.8 or 7.7	37.08	37.17	20	Strike-Slip
06-02-2023	01:28:19	6.7 or 6.6	36.81	37.13	40	Strike-Slip
06-02-2023	10:24:49	7.5 or 7.6	37.24	38.11	10	Strike-Slip
20-02-2023	17:04:29	6.3 or 6.4	36.16	36.02	10	-

* For now, based on fault models from literature (Gülerce et al., 2017).

The procedure of determining the selection criteria to download proper and suitable ground motions data for the site. As mentioned above the proposed building is located in Gaziantep in Turkey, from AFAD ground motion records website <https://tadas.afad.gov.tr/list-waveform> the past information in the same region can be obtained, by using this data and then constructing the uniform hazard spectrum MCE level.

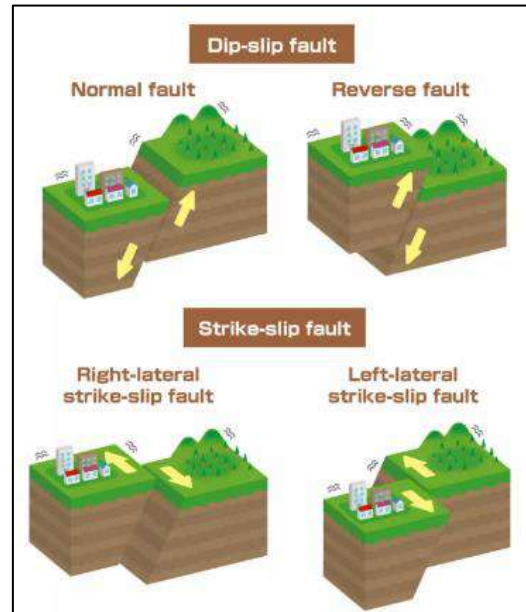


Figure (4.45): Fault types

Finally, by applying building code ASCE 7 -10 using ETABS same as procedure desired above, site target spectrum can be constructed, the following step instruct the procedure. (Refer to reference No.14 to 20).

For more information regarding Seismic Design of Reinforced Concrete and Masonry Buildings, refer to refence 44 Seismic Design of Reinforced Concrete and Masonry Buildings book, John Wiley & Sons, NY. and reference 47 W. F. Chen and C. Scawthorn (2003), Earthquake Engineering Handbook.

First, defining response spectrum, as shown in figure 4.46.

In ETABS go to Define > Functions > Response spectrum.

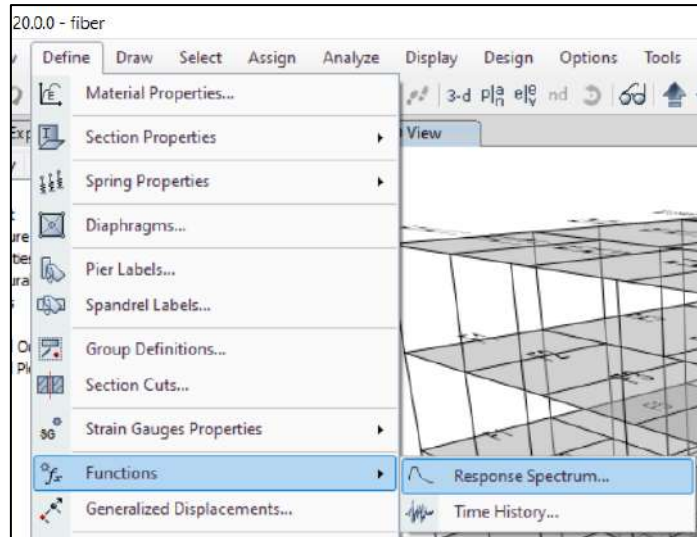


Figure (4.46): Define response spectrum.

As shown in figure 4.47, Select Building code > ASCE 7 -10 (or any codes used)

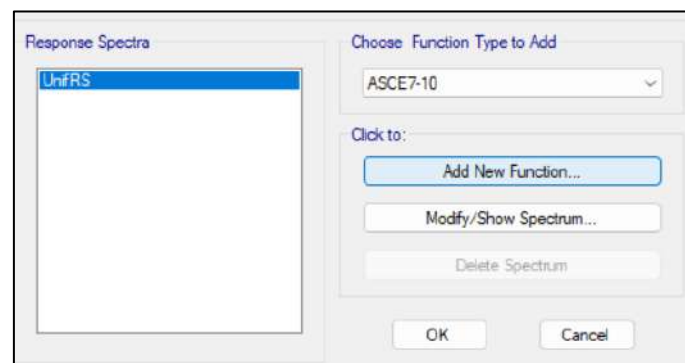


Figure (4.47): Section of response spectrum code

Then, Add New Function> Response Spectrum window will pop up to enter the site information enables the program to draw the target spectrum as shown in figure 4.48.

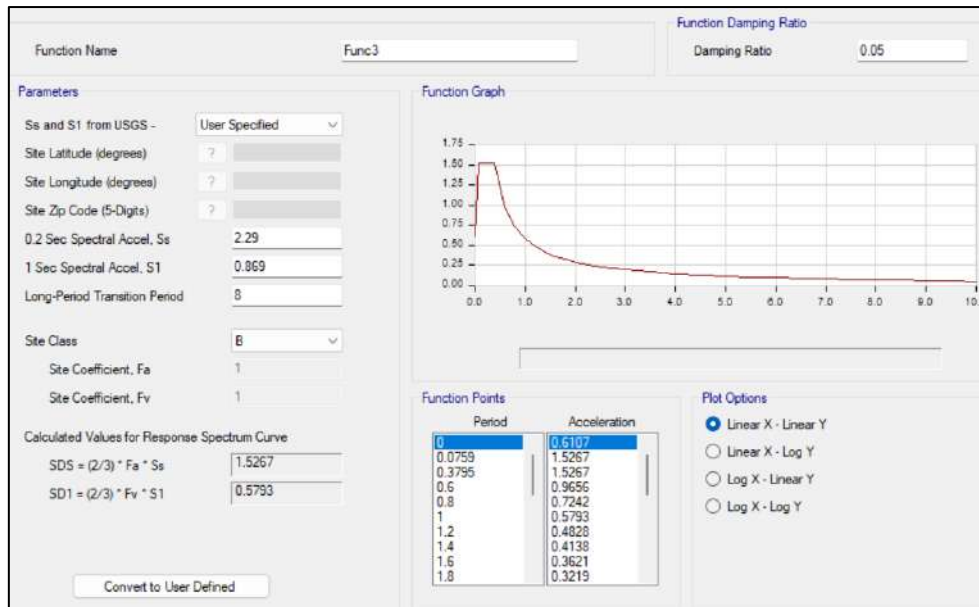


Figure (4.48): function definition of response spectrum.

From the above discussion regarding selection of site criteria, the following information in table 4.8 to be used:

Table (4.8): Site criteria

DATA	INPUT
Function Name	Target Spectrum
S_s & S_1	By user specified
0.2 sec spectral Accel. S_s	0.5
1 sec spectral Accel. S_1	0.3
Long period Transition Period	8
Site Class	A
Damping Ratio	5% (0.05)

After entering all the values, the model will show as figure 4.49and figure 4.50:

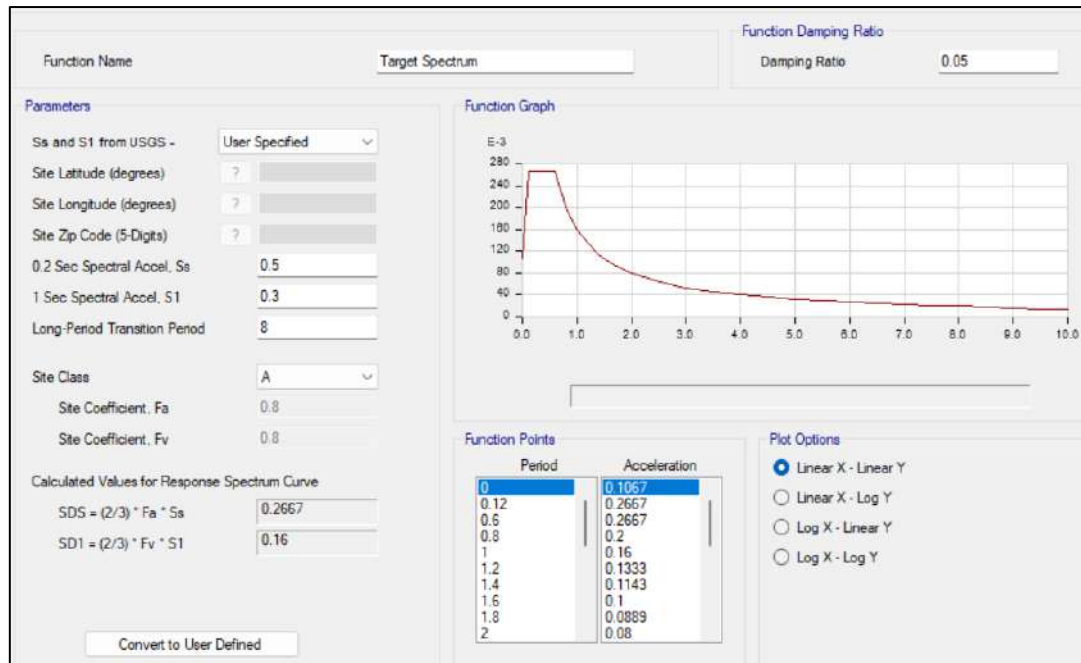


Figure (4.49): Define target spectrum.



Figure (4.50): Site criteria

Ground motion selection criteria for the earthquake happened recently in turkey on 6th Feb 2023 at Gaziantep city are represented in table 4.9.

Table (4.9): Ground motion selection criteria

No.	Selection Criteria	Values
1	Fault Type	Strike-Slip (As shown in engineering report on ground motion data of the February 2023 turkey seismic sequence)

2	Magnitude	6.2 - 8.0 (Based on previous recorded magnitude in the same region)
3	R _{JB} (KM) (Closest horizontal distance from site to the projection of the surface rupture)	40-400 km (Based on previous recorded distance in the same region)
4	R _{rup} (Km) (Closest distance to rupturing fault plane)	40-400 (Based on previous recorded distance in the same region)
5	V _{S30} (m/s)	600-758 m/s (Based on common values recorded in the same region)
6	D5-95 (sec)	30-50 sec (Based on previous recorded time in the same region)
7	Pulse	Any Record (No specific record is mentioned)
8	Max No. Records	20 (reasonable no. since the code specify 7 if calculation of the average value is required).

These are the selection criteria finalized based on project location.

4.2.4 Ground motions database

Nonlinear time history procedure is true dynamic analysis, rigorous dynamic analysis in which the complete equation of motion including the initial damping terms, is solved for each time step and all the responses are calculated for each time step. But to perform this analysis, selecting and then modifying the ground motion records must first be applied, which can be used as an input for the history time analysis. This section will focus on that part and the procedure of selection of ground motions and then modify the downloaded ground motions to start representing the future anticipated ground motions at project site. Not just by selecting any past record and using them for the analysis.

There are several international ground motion databases allow to download the past ground motion records. Some are listed below along with their links:

The Major International Ground Motion Databases:

1. USGS Earthquake Catalog

<https://earthquake.usgs.gov/earthquakes/search/>

(Refer to reference No. 46 USGS Earthquake Catalog Ground Motion Databases).

2. PEER Ground Motion Database

<https://ngawest2.berkeley.edu/site>

<https://peer.berkeley.edu/peer-strong-ground-motion-databases>

(Refer to reference No. 30 PEER Ground Motion Database).

3. British Geological Survey Database

<http://quakes.bgs.ac.uk/>

(Refer to reference No.7, British Geological Survey Database - Ground Motion Databases).

4. COSMOS Ground Motion Data Center

<http://strongmotioncenter.org/vdc/scripts/default.plx>

<http://www.cosmos-eq.org/>

(Refer to reference No.10, COSMOS Ground Motion Data Center).

5. K-NET and KiK-net, the NIED Strong-motion Seismograph Network Database <https://www.kyoshin.bosai.go.jp/>
6. (Refer to reference 27 K-NET and KiK-net, the NIED Strong-motion Seismograph Network Database).

The most common used is the USGS Earthquake Catalog, and then the Pacific Earthquake Engineering Research (PEER), which will be used in this research. Demonstrating of downloading the past ground motion from this database will be shown below. Then the British Geological Survey database, Cosmos Ground Motion Data Center and K-NET and KiK-net, these are Japanese ground motion database. (Refer to reference No.40), Another several international organizations which provide the past recorded data for different earthquakes. (Refer to reference No.29 to 35).

4.2.5 Selection of Ground Motions from PEER Ground Motion Database

The PEER research program (Pacific Earthquake Engineering Research Center) aims to provide data, models, and software tools to support a formalized performance-based earthquake engineering methodology. Within the broad field of earthquake engineering, PEER's research currently is focused on four thrusts, these being Building Systems, Bridge and Transportation Systems, Lifelines Systems, and Information Technologies in support of the methodology implementation. For more information refer to reference No. 20.

The process of selection of ground motions from the Peer Ground Motion database, Pacific Earthquake Engineering Research link:

<https://ngawest2.berkeley.edu/site>

<https://peer.berkeley.edu/peer-strong-ground-motion-databases>

By using the selection criterion as an input, the ground motion files can be downloaded.

Open the link or PEER website> the home page is shown in figure 4.51 below:

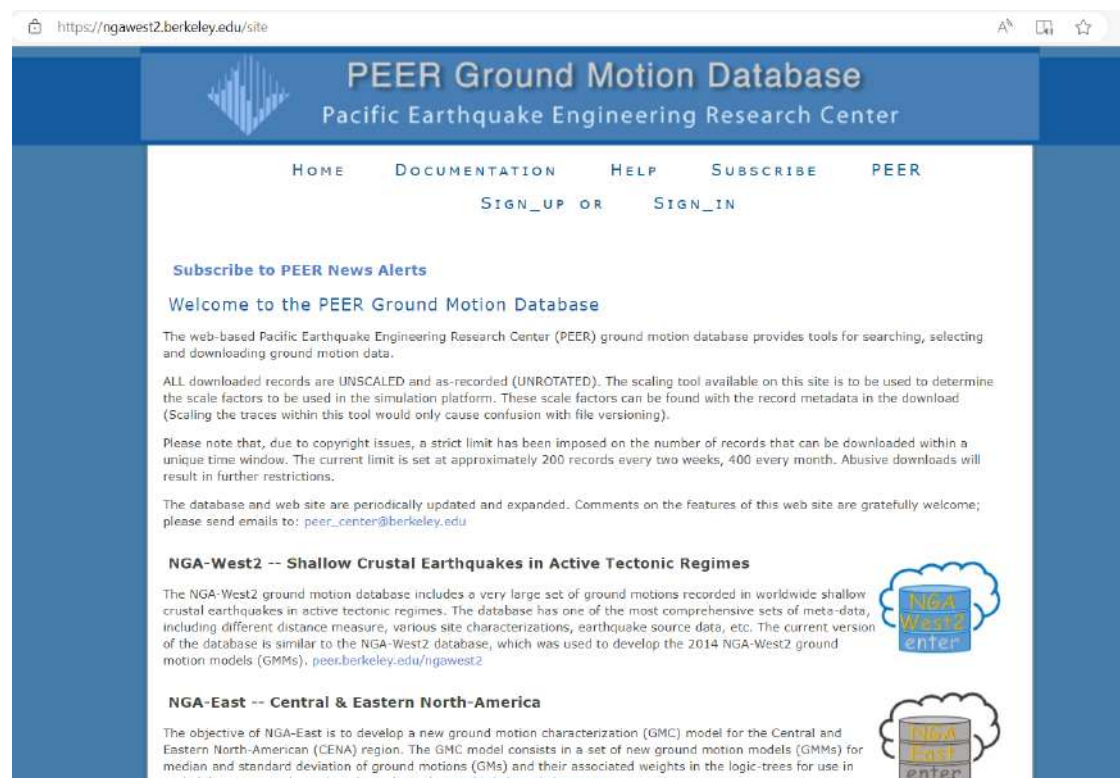


Figure (4.51): PEER ground motion database main page

As it's shown in figure 4.52, Sign in > select West2 >

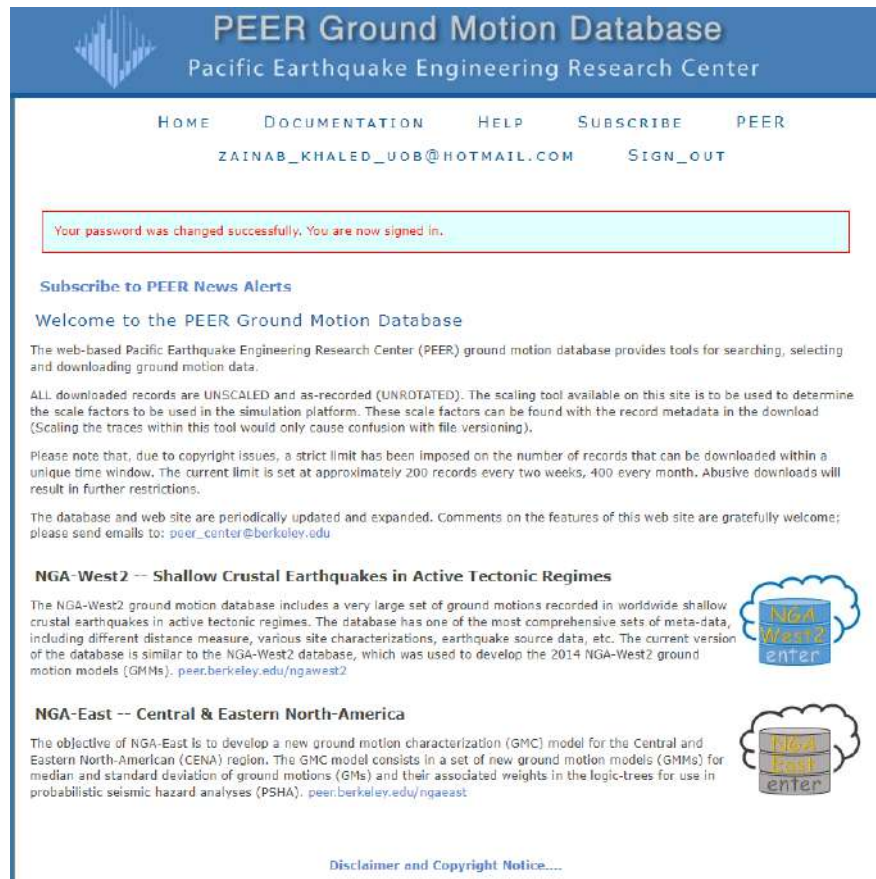


Figure (4.52): PEER ground motion selection of region

In Figure 4.53 > select no scaling (since raw earthquake values without any modification are required, modification will be applied later to match the site properties)> submit

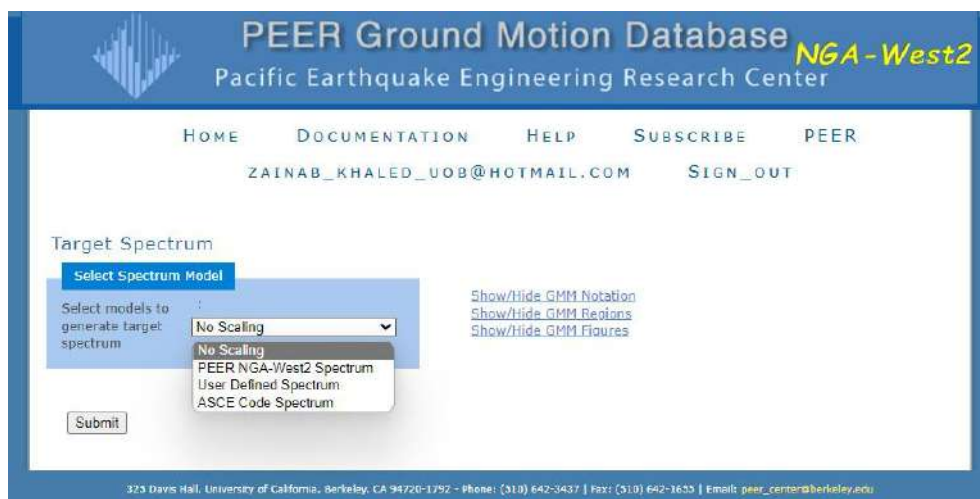


Figure (4.53): Selection of spectrum model.

Table 4.10 shows the main **selection criteria** used as an input, as in figure 4.54 to download the ground motions, then the ground motions database that match our criteria is filtered.

[ZAINAB_KHALED_UOB@HOTMAIL.COM](#) [SIGN_OUT](#)

New Search

Search

These characteristics are defined in the NGA-West2 Flatfile. You need to re-run Search when any of these parameters are updated.

Record Characteristics:

RSN(s) : RSN1...RSNm

Event Name :

Station Name :

Search Parameters:

Fault Type :

Magnitude :

min,max

RJB(km) :

min,max

Rrup(km) :

min,max

Vs30(m/s) :

min,max

D5-95(sec) :

min,max

Pulse :

Additional Characteristics:

Max No. Records :

(<=100)

Suite

Spectral Ordinate :

Damping Ratio :

Suite Average :

Controls

Search Records

Figure (4.54): Search parameters

Then> input the below values as it has been determined before.

Table (4.10): Ground motion selection criteria

No.	Selection Criteria	Values
1	Fault Type	Strike-Slip. (As shown in engineering report on ground motion data of the February 2023 turkey seismic sequence).
2	Magnitude	6.2 - 8.0. (Based on previous recorded magnitude in the same region).
3	R _{JB} (KM) (Closest horizontal distance from site to the projection of the surface rupture)	40-400 km. (Based on previous recorded distance in the same region).
4	R _{rup} (Km) (Closest distance to rupturing fault plane)	40-400. (Based on previous recorded distance in the same region).
5	V _{S30} (m/s)	600-758 m/s. (Based on common values recorded in the same region).
6	D5-95 (sec)	30-50 sec (Based on previous recorded time in the same region).
7	Pulse	Any Record (No specific record is mentioned).
8	Max No. Records	20

		(reasonable no. since the code specify 7 if calculation of the average value is required).
--	--	--

Figure 4.55 display all fault type.

The screenshot shows a 'New Search' window with several sections:

- Search:** Includes fields for RSN(s), Event Name, and Station Name.
- Record Characteristics:** Includes fields for Fault Type (set to 'All Types'), Magnitude (6.5, 7.5), $R_{JB}(km)$ (10, 30), $R_{rup}(km)$ (10, 30), $Vs30(m/s)$ (360, 760), $DS-95(sec)$ (15, 60), and Pulse (Any Record).
- Additional Characteristics:** Includes Max No. Records (30).
- Suite:** Includes Spectral Ordinate (SRSS), Damping Ratio (5%), and Suite Average (Arithmetic).
- Scaling:** Includes Scaling Method (No Scaling).

A dropdown menu for 'Fault Type' is open, showing the following options: All Types, Strike Slip (SS), Normal/Oblique, Reverse/Oblique, SS+Normal, SS+Reverse, and Normal+Reverse.

Figure (4.55): Fault type

The below figure 4.56 define the $R_{rupture}$ and R_{JB} , and figure 4.57 illustrate the difference between $R_{rupture}$ and R_{JB} . (Refer to reference No.47).

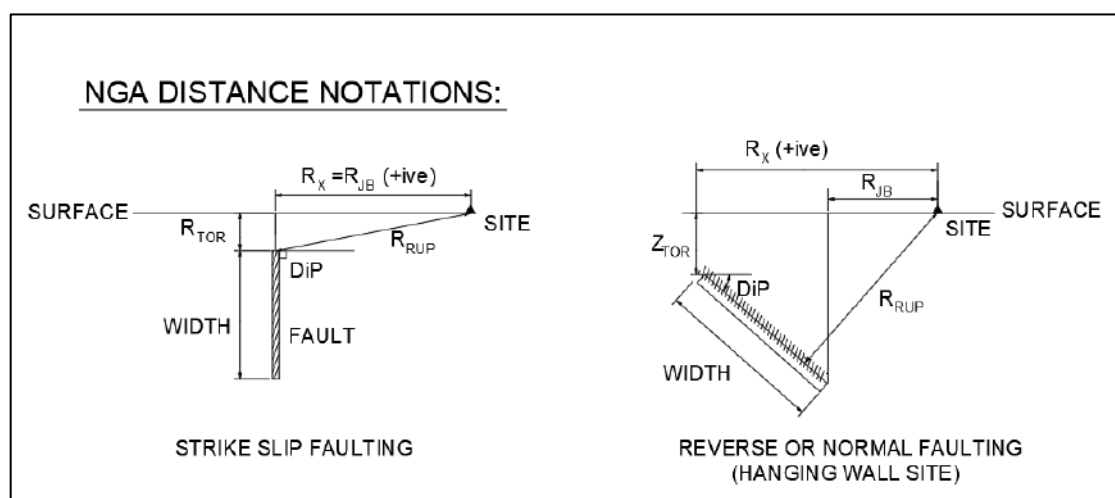


Figure (4.56): Definition of rupture and RJB (Source: On the construction of Joyner-Boore distance (Rjb) for PESMOS and COSMOS databases).

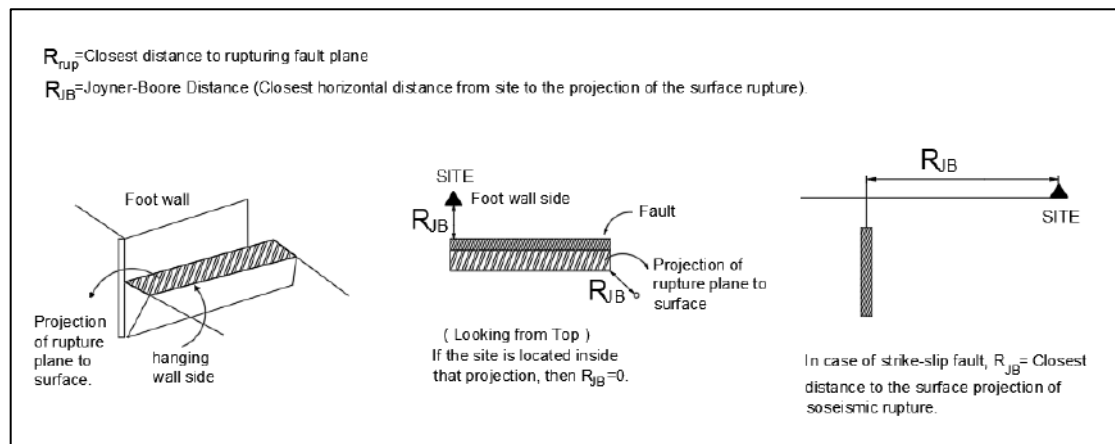


Figure (4.57): The difference between rupture and RJB ((Source: On the construction of Joyner-Boore distance (Rjb) for PSMOS and COSMOS databases)).

By pressing Search Records> the search result will show as shown in figure 4.58.

A number of twenty ground motions will filter out, that passed the previously entries criteria. Most of them have a magnitude between 6.2 and 8.0 since the magnitude have been specified between 6-8.

Results -- Metadata

Click heading of the column to be sorted in ascending order

☐ Rescale Using Checked Records

	Result ID	Spectral Ordinate	Record Seq. #	MSE	Scale Factor	Tp(s)	D5-75(s)	D5-95(s)	Arias Intensity (m/s)	Event	Year	Station	Mag	Mechanism
☐ view	1	SRSS	891	-	1.0	-	21.5	31.7	0.1	Landers	1992	Silent Valley - Poppet Flat	7.28	strike slip
☐ view	2	SRSS	897	-	1.0	-	21.6	30.9	0.1	Landers	1992	Twentynine Palms	7.28	strike slip
☐ view	3	SRSS	1154	-	1.0	-	19.8	34.0	0.1	Kocaeli, Turkey	1999	Bursa Sivil	7.51	strike slip
☐ view	4	SRSS	2817	-	1.0	-	28.9	33.5	0.0	Chi-Chi, Taiwan-04	1999	KAU038	6.2	strike slip
☐ view	5	SRSS	2877	-	1.0	-	19.2	30.3	0.0	Chi-Chi, Taiwan-04	1999	TCU102	6.2	strike slip
☐ view	6	SRSS	5896	-	1.0	-	22.1	36.7	0.0	El Mayor-Cucapah, Mexico	2010	Canyon Lake Vacation Dr&San Joaq	7.2	strike slip
☐ view	7	SRSS	5970	-	1.0	-	16.2	30.8	0.0	El Mayor-Cucapah, Mexico	2010	Borrego Springs	7.2	strike slip
☐										El Mayor-		San Bernardino		

Download Options

Download Search Results (metadata+spectra) Download Time Series Records (metadata+spectra+traces)

Figure (4.58): Result of ground motions search

As it's shown in figure 4.59, the blue rectangle "H1 Acc. File name" means first horizontal component at 0 angle that is for x direction, and the file end with (00. AT2).

The red rectangle "H2 Acc. File name" represent the second horizontal component at 90 angle that is for y direction, and the file end with (90. AT2), means that two horizontal components are always 90 degrees apart and then there is a vertical component.

The green rectangle "Vertical Acc. File name" represent the vertical component at up direction or z direction, and the file end with (up. AT2)

ed in ascending order

H1 Acc. File Name	H2 Acc. File Name	Vertical Acc. File Name
LANDERS_SIL000.AT2	LANDERS_SIL090.AT2	LANDERS_SIL-UP.AT2
LANDERS_29P000.AT2	LANDERS_29P090.AT2	LANDERS_29P-UP.AT2
KOCAELI_BSI090.AT2	KOCAELI_BSI180.AT2	KOCAELI_BSI-UP.AT2
CHICHI.04_KAU038N.AT2	CHICHI.04_KAU038E.AT2	CHICHI.04_KAU038V.AT2
CHICHI.04_TCU102N.AT2	CHICHI.04_TCU102E.AT2	CHICHI.04_TCU102V.AT2
SIERRA.MEX_13096360.AT2	SIERRA.MEX_13096-90.AT2	SIERRA.MEX_13096-UP.AT2
SIERRA.MEX_BOR360.AT2	SIERRA.MEX_BOR-90.AT2	SIERRA.MEX_BOR-UP.AT2

Figure (4.59): Three main components of earthquake record.

After downloading these 21 ground motions, their spectrum shown in figure 4.60 as gray lines represent the SRSS spectrum of the two horizontal components. Solid black line refers to average value. The dotted black lines are one standard deviation plus average and one standard deviation mean - 1 standard deviation based.

It is also showing the variation of selected ground motions in the Spectra.

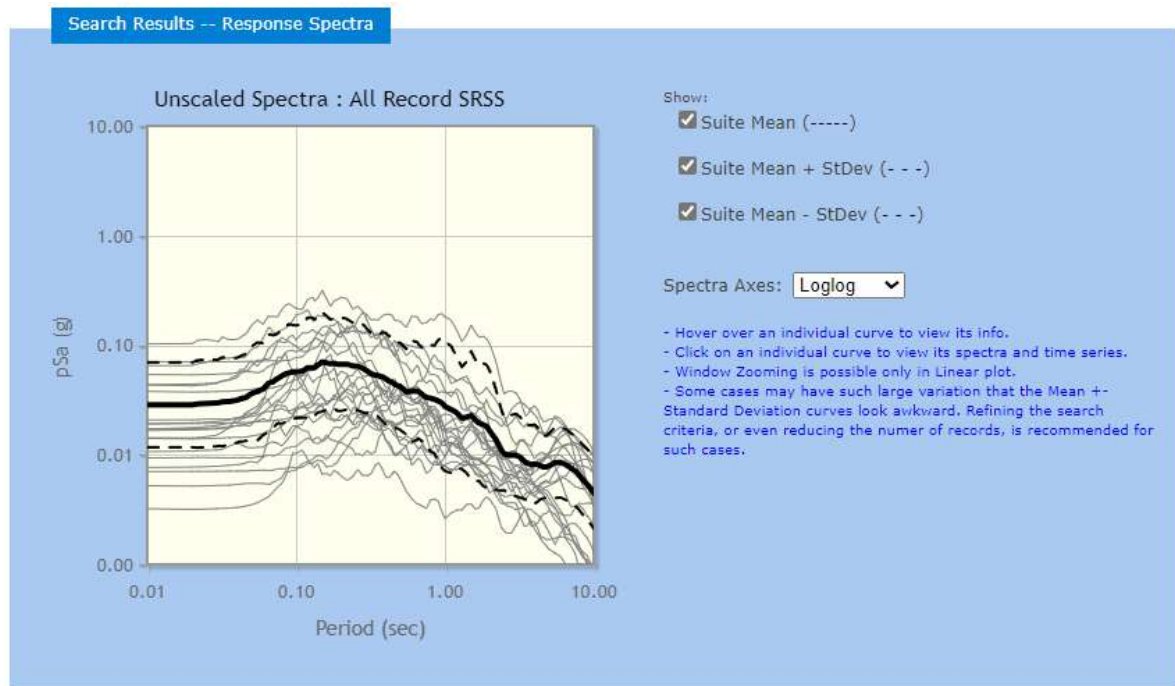


Figure (4.60): Response spectra as loglog of downloaded earthquake record

Figure 4.61 shows linear scale of ground motion spectrums. The solid black line is the average of 21 ground motions while thin gray lines represent the SRSS of the individual ground motions. the mean plus one standard deviation and mean -1 standard deviation in the dashes line is also shown in figure 7.61.

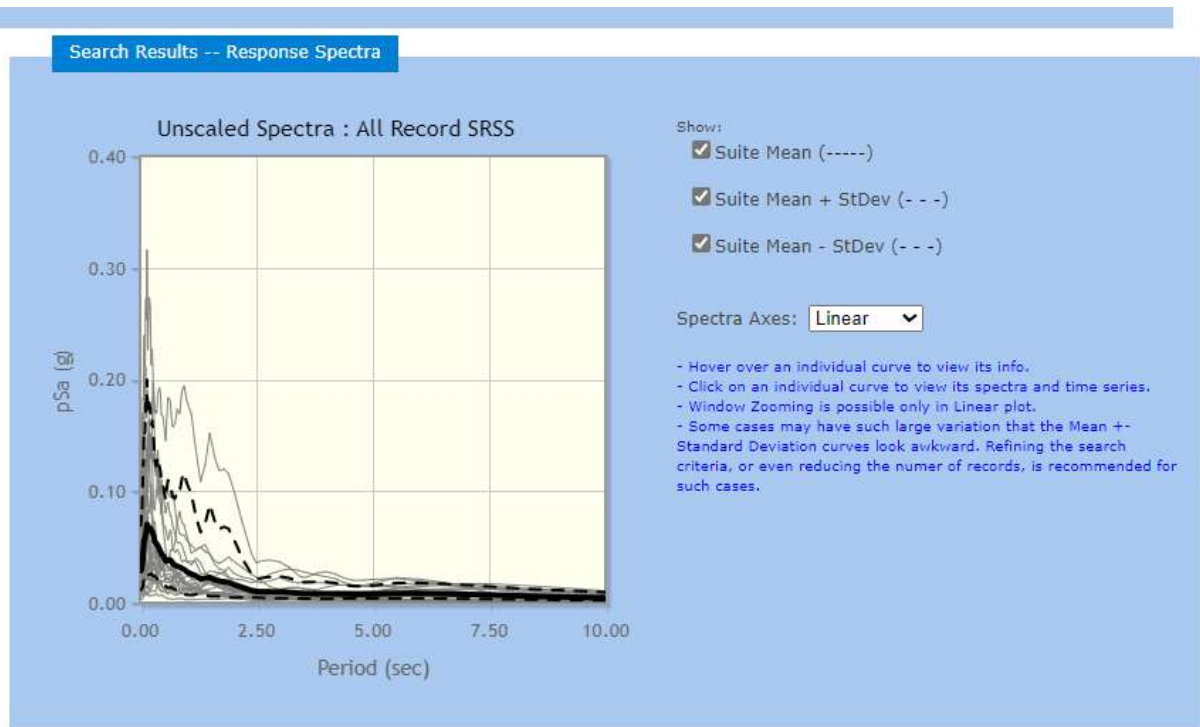


Figure (4.61): Response spectra as linear of downloaded earthquake record

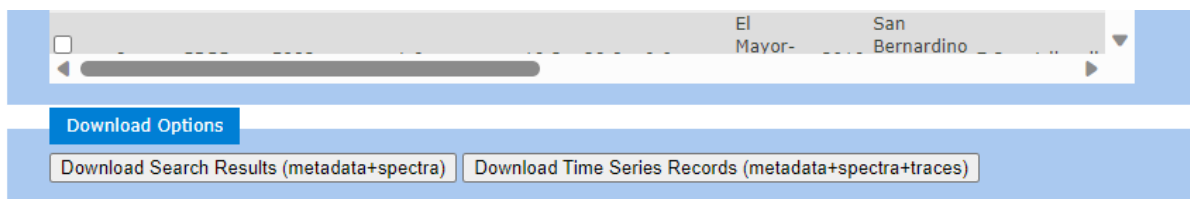


Figure (4.62): Download options

Figure 4.62 shows two options for downloading. One option is downloading the metadata and spectrum only and the second option is downloading spectrum with traces. Traces means that the actual files of ground motion which contain the ground motion data. The second option will be used, download time series records with metadata which means the basic information plus the spectra of these ground motions also plus the acceleration, displacement and velocity time histories. After clicking the second option, these ground motions will be downloaded as a zip file.

Now Download Time Series Records (Metadata + Spectra + traces)

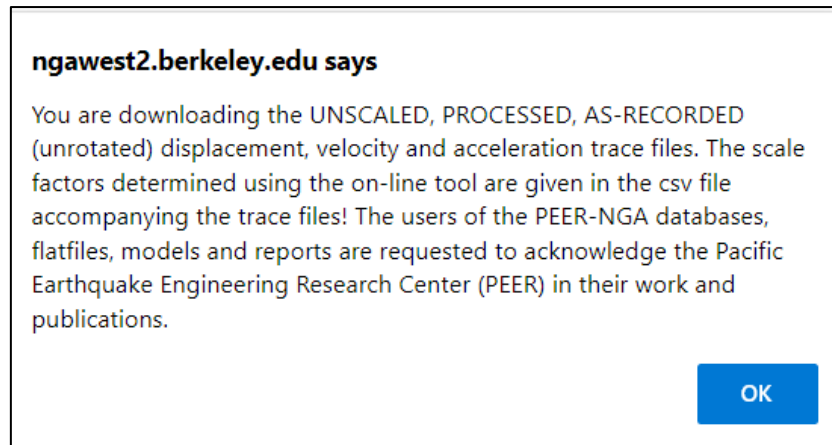


Figure (4.63): Unscaled data option

A message will appear as in figure 4.63 to inform that the downloaded data are unscaled as recorded displacement, velocity and acceleration trace files earthquake records.>press OK.

The data will be downloaded as zip files>

After extracting the file> many folders will be shown as figure 4.64.

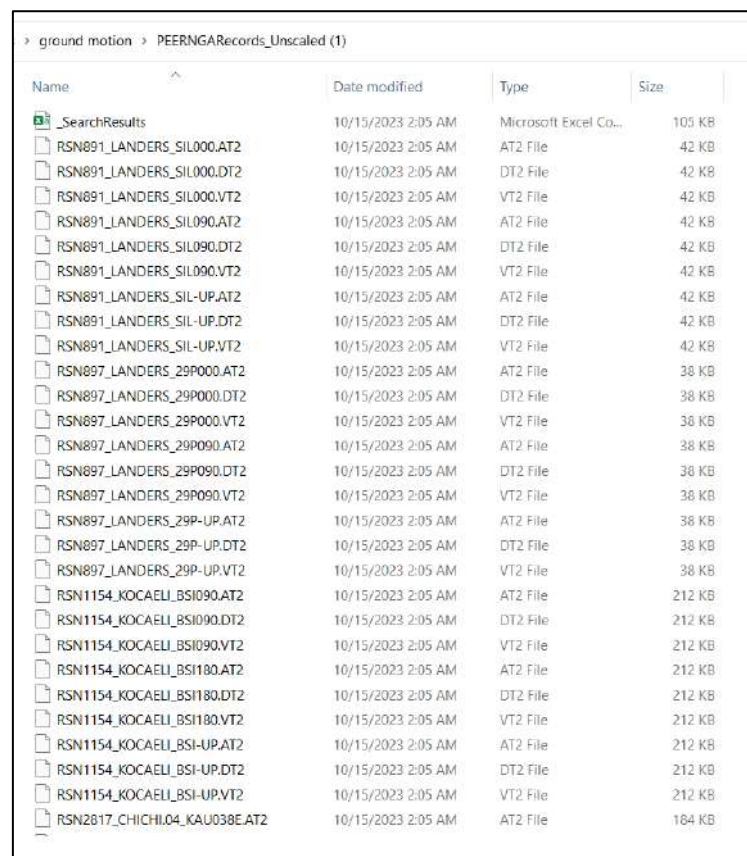


Figure (4.64): Extracted file of downloaded records.

Figure 4.64 shows the types of folders downloaded. The first excel file contains spectrum and all metadata for ground motions (e.g., Station name, event names etc.) as represented in figure 4.65.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
55	21	SR55	6898	-	1	-	27.3	46	0	"Darfield	2010	"DS2"															
56	These records were obtained from the NGA-West2 On-Line Ground-Motion Database Tool																										
57	These rec. AS RECORDED																										
58	Filename Extension:																										
59	AT2 = Acceleration																										
60	VT2 = Velocity																										
61	DT2 = Displacement																										
62	The users' facilities, models and reports are requested to acknowledge the Pacific Earthquake Engineering Research Center (PEER) in their work and publications.																										
63	-- Scaled Spectra used in Search & Scaling --																										
64	Period (s) Arithmetic Arithmetic RSN-891 1 RSN-897 1 RSN-1154 RSN-2817 RSN-2877 RSN-5896 RSN-5970 RSN-5983 RSN-5987 RSN-6002 RSN-6003 RSN-6022 RSN-6031 RSN-6139 RSN-6149 RSN-6157 RSN-6193 RSN-6197 RSN-6256 RSN-6439 RSN-6898 SR55 p5a (g)																										
65	0.01	0.02851	0.06959	0.01168	0.065	0.1026	0.07066	0.00703	0.02078	0.01666	0.04346	0.01917	0.04354	0.05399	0.01067	0.03789	0.01915	0.01427	0.01411	0.00765	0.00321	0.00521	0.01718	0.01716	0.00936		
66	0.02	0.02855	0.06969	0.0117	0.06522	0.10331	0.07046	0.00705	0.02082	0.01683	0.04257	0.01924	0.04411	0.05362	0.01081	0.03737	0.01954	0.01425	0.01396	0.00773	0.00318	0.00518	0.01725	0.01767	0.00941		
67	0.022	0.02912	0.07292	0.01162	0.068	0.11073	0.07049	0.00705	0.02091	0.01693	0.04296	0.01926	0.04436	0.05373	0.01089	0.03744	0.0196	0.01437	0.014	0.00775	0.00318	0.00519	0.0173	0.01781	0.00946		
68	0.025	0.0294	0.07391	0.0117	0.06968	0.11237	0.07052	0.00705	0.02113	0.01698	0.04363	0.0193	0.0447	0.05395	0.01097	0.03755	0.01979	0.01461	0.01405	0.00779	0.0032	0.00521	0.0174	0.01807	0.00944		
69	0.029	0.02966	0.07367	0.01194	0.07397	0.10915	0.0706	0.00706	0.02117	0.01719	0.04495	0.01934	0.04516	0.05431	0.01104	0.03776	0.02009	0.01506	0.01414	0.00785	0.00323	0.00524	0.01759	0.01845	0.00941		
70	0.03	0.02978	0.07366	0.01204	0.07584	0.10775	0.07063	0.00707	0.02119	0.01727	0.04554	0.01936	0.04579	0.0545	0.01106	0.03782	0.02015	0.01556	0.01415	0.00787	0.00323	0.00525	0.01762	0.0186	0.00939		
71	0.032	0.03049	0.07764	0.01198	0.07481	0.11867	0.07066	0.00708	0.02103	0.01742	0.04731	0.0194	0.04688	0.05481	0.01125	0.03787	0.02034	0.01617	0.01422	0.00792	0.00324	0.00527	0.01769	0.01892	0.0094		
72	0.035	0.03056	0.07582	0.01232	0.07612	0.1131	0.07071	0.00709	0.02111	0.01757	0.04798	0.01948	0.04815	0.05487	0.01187	0.03793	0.02076	0.01742	0.01436	0.008	0.00326	0.00527	0.01799	0.01937	0.00937		
73	0.036	0.03067	0.07559	0.01244	0.07651	0.11207	0.07073	0.0071	0.02117	0.01779	0.04963	0.0195	0.04799	0.05476	0.01214	0.03798	0.02087	0.0181	0.01436	0.00802	0.00326	0.00528	0.01808	0.01937	0.00937		
74	0.04	0.03144	0.07652	0.01292	0.07757	0.11275	0.07061	0.00709	0.02186	0.01846	0.0533	0.01959	0.0506	0.0561	0.01267	0.03834	0.02125	0.02144	0.01445	0.00813	0.0033	0.00537	0.01838	0.01966	0.00939		
75	0.042	0.03226	0.07893	0.01319	0.07852	0.11597	0.07072	0.00709	0.02181	0.01859	0.05993	0.01963	0.05423	0.0564	0.0125	0.03856	0.02171	0.02197	0.01443	0.00818	0.00333	0.00539	0.01844	0.02071	0.0094		
76	0.044	0.03282	0.08145	0.01323	0.07725	0.12258	0.07084	0.0071	0.02185	0.01874	0.05977	0.01966	0.05699	0.05783	0.0121	0.0388	0.02237	0.02247	0.01449	0.00825	0.00336	0.00543	0.01857	0.02141	0.0094		
77	0.045	0.03306	0.08201	0.01332	0.07717	0.12381	0.07084	0.0071	0.02195	0.01877	0.0607	0.01967	0.05693	0.05854	0.01193	0.03891	0.02279	0.02371	0.0145	0.00834	0.00337	0.00545	0.01868	0.02116	0.00941		
78	0.046	0.0334	0.08239	0.0134	0.07826	0.1257	0.07083	0.00709	0.02213	0.01858	0.06267	0.01968	0.05694	0.05845	0.0118	0.03903	0.02311	0.02413	0.01448	0.00844	0.0034	0.00546	0.01887	0.02188	0.00941		
79	0.048	0.03468	0.08948	0.01344	0.08495	0.13711	0.0709	0.00713	0.02216	0.01824	0.0681	0.01973	0.05983	0.05704	0.0116	0.03937	0.02368	0.02493	0.01462	0.00862	0.00347	0.00548	0.01939	0.02255	0.00936		
80	0.05	0.03616	0.09698	0.01348	0.09155	0.15056	0.07096	0.00717	0.02237	0.01873	0.07128	0.01977	0.06485	0.05707	0.01153	0.03943	0.02357	0.0257	0.01483	0.00866	0.00349	0.00549	0.0198	0.02321	0.00933		
81	0.055	0.03784	0.10577	0.01353	0.09634	0.16998	0.07084	0.00719	0.02309	0.02179	0.06406	0.01998	0.07303	0.05583	0.0117	0.04017	0.02423	0.02769	0.01514	0.00847	0.00366	0.00549	0.02029	0.026	0.00959		
82	0.06	0.03968	0.10424	0.01311	0.11499	0.15538	0.07185	0.00724	0.02421	0.02429	0.07455	0.02021	0.07246	0.05839	0.01176	0.04002	0.02862	0.0331	0.01564	0.00957	0.00369	0.00547	0.0214	0.03074	0.00958		
83	0.065	0.0446	0.12428	0.01601	0.14331	0.18293	0.07196	0.00722	0.02496	0.02567	0.07486	0.02035	0.05162	0.06378	0.0126	0.04036	0.03131	0.03195	0.01662	0.01431	0.0041	0.00538	0.02032	0.04203	0.00962		
84	0.067	0.04544	0.12535	0.01647	0.14485	0.18324	0.07229	0.00718	0.02468	0.02729	0.07612	0.02044	0.0959	0.06445	0.01292	0.04069	0.03298	0.02888	0.01644	0.0166	0.0043	0.00542	0.02084	0.04488	0.00993		
85	0.07	0.04651	0.12289	0.0176	0.1295	0.18338	0.07222	0.00723	0.0253	0.02898	0.08479	0.02056	0.10147	0.06757	0.01313	0.04093	0.03442	0.02774	0.01606	0.01982	0.00454	0.00562	0.02473	0.05901	0.00976		
86	0.075	0.04954	0.1267	0.01937	0.13031	0.18086	0.07195	0.00743	0.02568	0.03169	0.10612	0.02066	0.11072	0.06762	0.01279	0.04189	0.03842	0.02823	0.01707	0.02108	0.00508	0.00586	0.03018	0.0772	0.01		
87	0.08	0.05209	0.14063	0.0193	0.13806	0.2009	0.07176	0.00746	0.02648	0.03396	0.11764	0.02093	0.10702	0.07419	0.01208	0.04265	0.04001	0.03812	0.01818	0.01709	0.00546	0.00617	0.03341	0.07757	0.01062		
88	0.085	0.05456	0.15015	0.01982	0.1422	0.23169	0.07283	0.00747	0.02528	0.03183	0.11227	0.02122	0.10495	0.08569	0.01311	0.04375	0.04475	0.02773	0.01992	0.01467	0.00634	0.00707	0.03639	0.085	0.01152		
89	0.09	0.05606	0.15525	0.02025	0.15258	0.2392	0.07223	0.00763	0.0251	0.03661	0.13685	0.02164	0.1196	0.08909	0.01445	0.04543	0.05353	0.02416	0.02044	0.01655	0.00795	0.00699	0.03924	0.06639	0.01165		

Figure (4.65): Recorded data of one example of earthquake.

Below the xl file are the trace files in figure 4.64, which are the time history value files. The selected file in figure 4.66 below shows the ground motion files for one particular ground motion.

Name	Date modified	Type	Size
_SearchResults	10/15/2023 2:05 AM	Microsoft Excel Co...	105 KB
RSN891 LANDERS_SIL000.AT2	10/15/2023 2:05 AM	AT2 File	42 KB
RSN891 LANDERS_SIL000.DT2	10/15/2023 2:05 AM	DT2 File	42 KB
RSN891 LANDERS_SIL000.VT2	10/15/2023 2:05 AM	VT2 File	42 KB
RSN891 LANDERS_SIL090.AT2	10/15/2023 2:05 AM	AT2 File	42 KB
RSN891 LANDERS_SIL090.DT2	10/15/2023 2:05 AM	DT2 File	42 KB
RSN891 LANDERS_SIL090.VT2	10/15/2023 2:05 AM	VT2 File	42 KB
RSN891 LANDERS_SIL-UP.AT2	10/15/2023 2:05 AM	AT2 File	42 KB
RSN891 LANDERS_SIL-UP.DT2	10/15/2023 2:05 AM	DT2 File	42 KB
RSN891 LANDERS_SIL-UP.VT2	10/15/2023 2:05 AM	VT2 File	42 KB
RSN897 LANDERS_29P000.AT2	10/15/2023 2:05 AM	AT2 File	38 KB
RSN897 LANDERS_29P000.DT2	10/15/2023 2:05 AM	DT2 File	38 KB
RSN897 LANDERS_29P000.VT2	10/15/2023 2:05 AM	VT2 File	38 KB
RSN897 LANDERS_29P090.AT2	10/15/2023 2:05 AM	AT2 File	38 KB
RSN897 LANDERS_29P090.DT2	10/15/2023 2:05 AM	DT2 File	38 KB
RSN897 LANDERS_29P090.VT2	10/15/2023 2:05 AM	VT2 File	38 KB
RSN897 LANDERS_29P-UP.AT2	10/15/2023 2:05 AM	AT2 File	38 KB
RSN897 LANDERS_29P-UP.DT2	10/15/2023 2:05 AM	DT2 File	38 KB
RSN897 LANDERS_29P-UP.VT2	10/15/2023 2:05 AM	VT2 File	38 KB
RSN1154_KOCAELI_BSI090.AT2	10/15/2023 2:05 AM	AT2 File	212 KB
RSN1154_KOCAELI_BSI090.DT2	10/15/2023 2:05 AM	DT2 File	212 KB
RSN1154_KOCAELI_BSI090.VT2	10/15/2023 2:05 AM	VT2 File	212 KB
RSN1154_KOCAELI_BSI180.AT2	10/15/2023 2:05 AM	AT2 File	212 KB
RSN1154_KOCAELI_BSI180.DT2	10/15/2023 2:05 AM	DT2 File	212 KB
RSN1154_KOCAELI_BSI180.VT2	10/15/2023 2:05 AM	VT2 File	212 KB
RSN1154_KOCAELI_BSI-UP.AT2	10/15/2023 2:05 AM	AT2 File	212 KB
RSN1154_KOCAELI_BSI-UP.DT2	10/15/2023 2:05 AM	DT2 File	212 KB
RSN1154_KOCAELI_BSI-UP.VT2	10/15/2023 2:05 AM	VT2 File	212 KB
RSN2817_CHICHI.04_KAU038E.AT2	10/15/2023 2:05 AM	AT2 File	184 KB

Figure (4.66): The ground motion files for one particular earthquake.

Default format of the name of these peer ground motions start with RSN number (Record sequence number) as shown in figure 4.67. Each ground motion has a different RSN number.

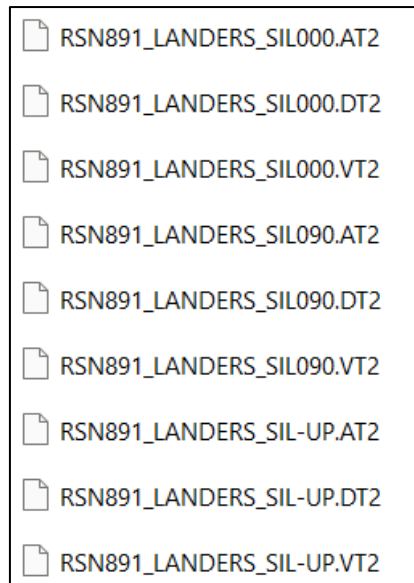


Figure (4.67): RSN number of one earthquake.

Then it is the event name **LANDERS** Earthquake.

Then the Information about station **SILL**.

Then the Information about the component whether it is vertical component (**000**) or horizontal component (**090**) or up component (**UP**).

let's see the first file, which is: RSN891_Landers_SIL_ 000.AT2.

Which means that this is the first horizontal component of its acceleration data.

Then the second File is dot DT2 which means this is displacement data.

And then there is a VT2 which means Velocity data.

The three first files are basically the acceleration, displacement, and velocity of the first horizontal component – x direction.

Then the next three files are the acceleration, displacement, and velocity for the second horizontal component – y direction of this ground motion. Similarly, the next three files are the vertical component, acceleration, displacement, and velocity of z -direction.

Makes each ground motion have a total of nine files. Three acceleration components: 2 horizontal (x and y) and one vertical (z), three displacement components and three velocity components and three accelerations. As shown in figure 4.69.

File Name	Date	File Type	Size
_SearchResults	10/15/2023 2:05 AM	Microsoft Excel Co...	105 KB
RSN891 LANDERS_SIL000.AT2	10/15/2023 2:05 AM	AT2 File	42 KB
RSN891 LANDERS_SIL000.DT2	10/15/2023 2:05 AM	DT2 File	42 KB
RSN891 LANDERS_SIL000.VT2	10/15/2023 2:05 AM	VT2 File	42 KB
RSN891 LANDERS_SIL090.AT2	10/15/2023 2:05 AM	AT2 File	42 KB
RSN891 LANDERS_SIL090.DT2	10/15/2023 2:05 AM	DT2 File	42 KB
RSN891 LANDERS_SIL090.VT2	10/15/2023 2:05 AM	VT2 File	42 KB
RSN891 LANDERS_SIL-UP.AT2	10/15/2023 2:05 AM	AT2 File	42 KB
RSN891 LANDERS_SIL-UP.DT2	10/15/2023 2:05 AM	DT2 File	42 KB
RSN891 LANDERS_SIL-UP.VT2	10/15/2023 2:05 AM	VT2 File	42 KB
RSN897 LANDERS_29P000.AT2	10/15/2023 2:05 AM	AT2 File	38 KB
RSN897 LANDERS_29P000.DT2	10/15/2023 2:05 AM	DT2 File	38 KB
RSN897 LANDERS_29P000.VT2	10/15/2023 2:05 AM	VT2 File	38 KB
RSN897 LANDERS_29P090.AT2	10/15/2023 2:05 AM	AT2 File	38 KB

Figure (4.68): The overall 9 components of one recorded earthquake.

In this research, two horizontal components (x & y) and the acceleration files (which mean the files end up with 00-AT2 and 90-AT2) are going to be used. These two files must be taken out and modified by applying scale factor.

Starting by opening the first file and try to understand its format.

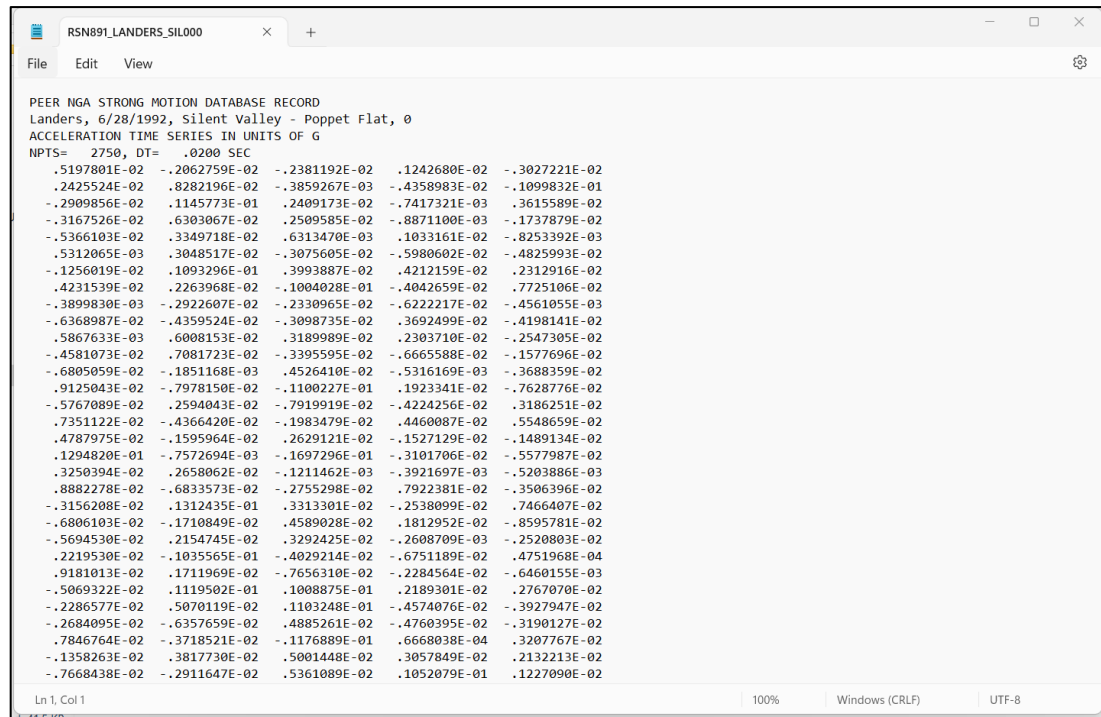


Figure (4.69): Selected file details.

Figure 4.69 shows the ground motion data of the first horizontal component of the first ground motion.

The first four lines gives information about this earthquake data, as shown in figure 4.70.

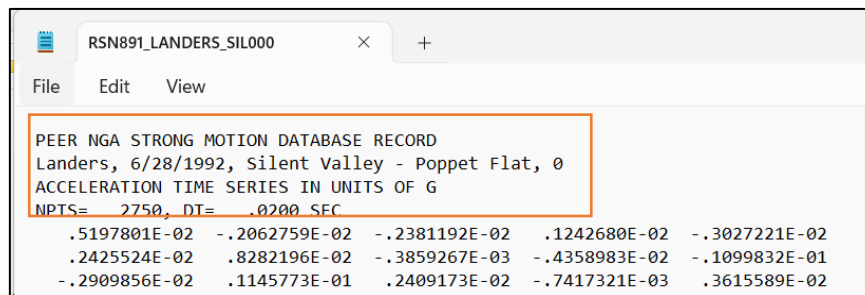


Figure (4.70): General information about particular earthquake data.

It says that it is Peer NGA strong motion database record from Landers earthquake occurred on 28/6/1992 at Silent Valley location. The acceleration time series in units of g (earth gravity 9.81 m/s^2), which required multiplication of units g in working units to convert it into acceleration values. If the program unit is meter and second, then multiply all acceleration values with 9.81.

Number of points are 2750 and delta T is 0.02 seconds, which means all the listed values are directly acceleration values equally spaced at 0.02 seconds, starting from t=0 then 0.02 then 0.04 and so on. By multiply 2750 with 0.02, to get the total duration of ground motion, which is equal to $2750 \times 0.02 = 55$ sec, the earthquake lasted for 55 sec.

Whole data can be imported in any program to apply a scale factor or to perform time history analysis.

As it is shown in figure 4.71, data opened in note file instead of xl sheet.

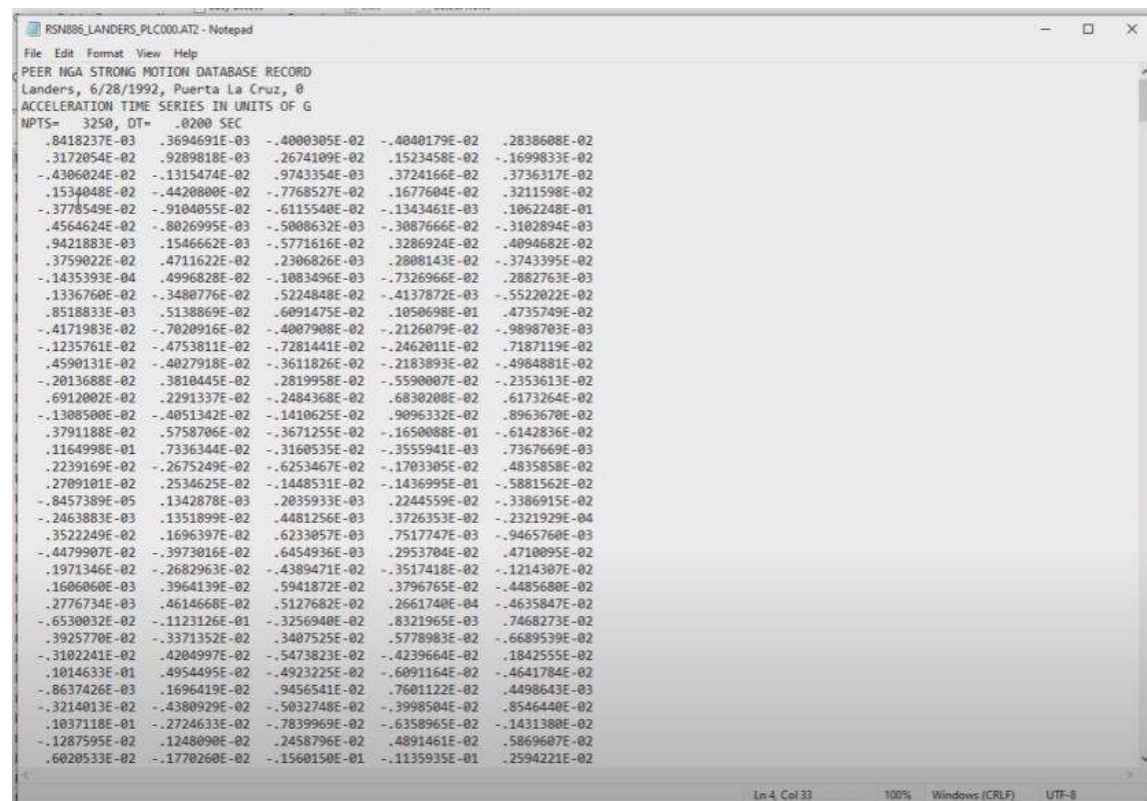


Figure (4.71): Overview of data form.

4.2.5 Modification of ground motions to match the target hazard - scaling vs. spectral matching.

Once the ground motions have been downloaded, there are two options to make them compatible with site seismic hazard, either by scale them or perform spectral matching.

1. The ground motion scaling:

Scaling by applying a constant factor to acceleration-time history and amplifying or de-amplifying it to a level so that it matches the design spectrum of the site. Although it will not exactly match by applying a constant factor, because the design spectrum is smooth spectrum, while the actual spectrum of a ground motion is an irregular spectrum.

If the target spectrum was lower and the recorded ground motion have a higher spectrum, then multiplying ground motions records must be multiplied with scale factor less than one.

The advantage and disadvantage of the ground motion scaling:

- Generally, in the range $0.2 T_n$ to $1.5 T_n$ and it should not be less than 1.3 of the target spectrums. Table 4.11 below illustrate the pros and cons of ground motion scaling.

Table (4.11): The advantage and disadvantage of the ground motion scaling.

Advantages	Disadvantages
• Real Earthquakes (no change in frequency content). • Retains natural variances. • Allows to focus response on the period(s) of interest. • Relatively easy to perform.	• Requires a lot of time histories. • Greater variance (e.g., if the structural model performs inadequately, it cannot be sure whether it is due to poor design of structure or due to some issue with ground motions or their variance).

2. The spectral matching:

In pervious procedure, modifying the frequency content of ground motion using multiplication factor, by modifying amplitude of ground motion only, not by the modifying frequency content. While in spectral matching both amplitude and frequency content are modified by add or subtract different wavelengths or different frequencies from the acceleration time history, such that the resulting in the final time history have a spectrum which exactly matches at all time periods with the target spectrum. Also, the actual shape of the spectrum may look different after modifying the ground motion, such that it matches at all the points and all the time periods with the target spectrum. The ground motion doesn't remain a natural ground motion or past recorded ground motion.

But this procedure cannot be done manually. An algorithm by computer software must be used. That software sequentially adds or subtracts wavelets and checks the change in the spectrum is required. Table 4.12 below illustrate the pros and cons of spectral matching.

Table (4.12): The advantage and disadvantage of spectral matching.

Advantages	Disadvantages
• Reduce variability in response, any flaws in a structure can be clearly understood from the analysis and response.	• Can result in unrealistic earthquake ground motions (because UHS is smooth unrealistic spectrum) • Some important ground motion aspects may be lost, e.g., directivity effect (pulse). It's

	important to check and compare the characteristics of unmatched and matched time histories.
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In this research the **Spectral matching using** ETABS are going to be used, the steps are as follows.

Spectral Matching of Ground Motions using CSI ETABS

As it is shown in figure 4.72, go ETABS> define > functions >time history

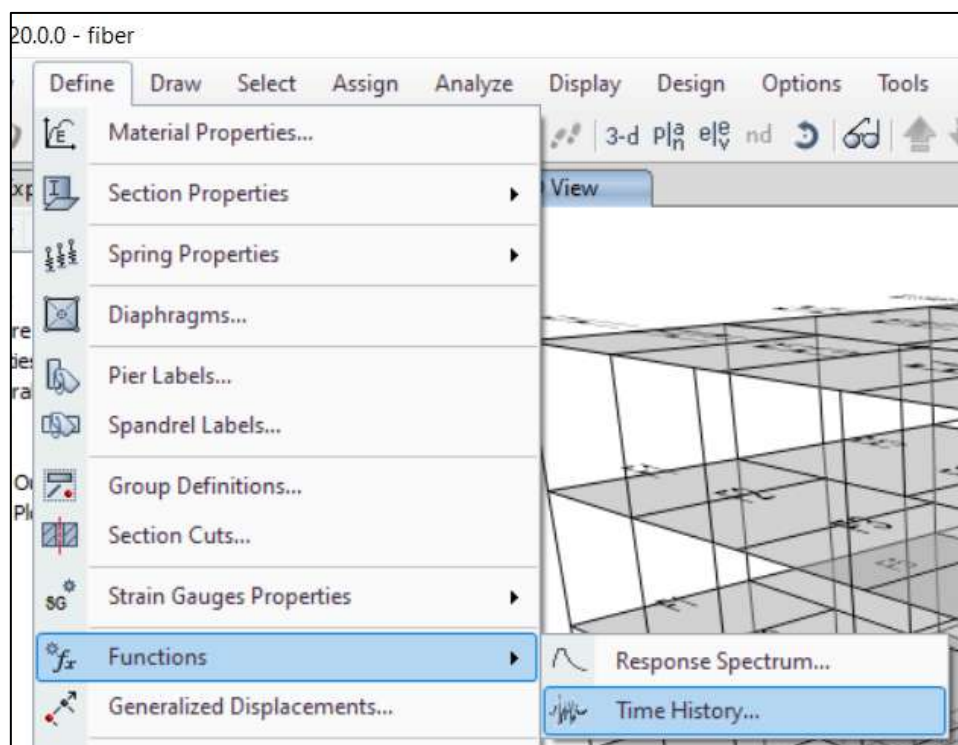


Figure (4.72): Define of time history function.

From choose function type to Add > From File > Add New Function, as shown in figure 4.73.

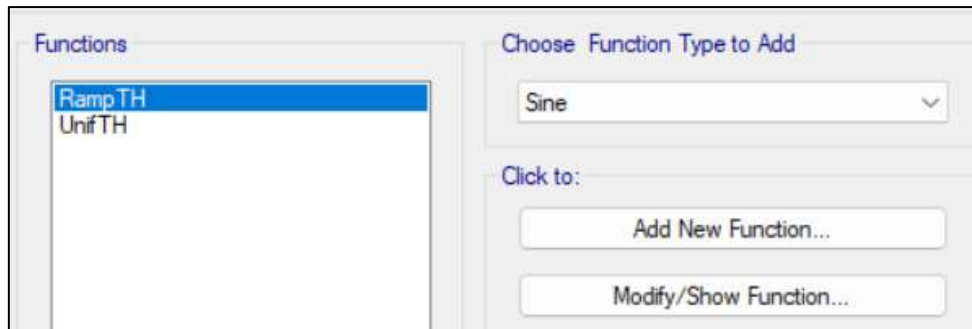


Figure (4.73): Add new function.

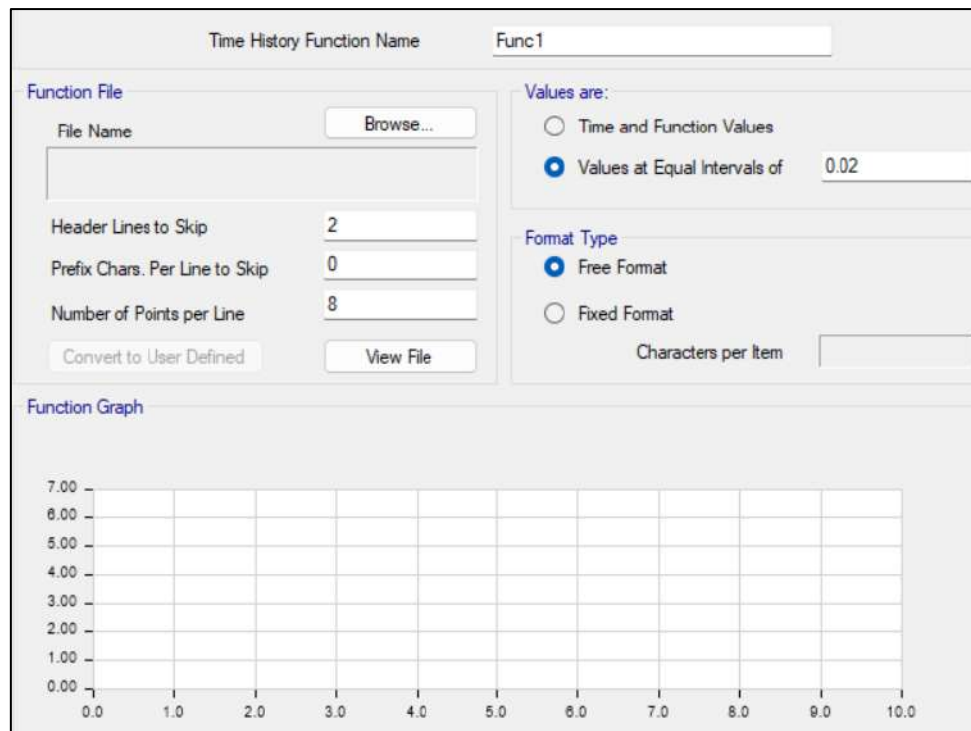


Figure (4.74): Details of time history function.

Change the Time history Function Name to “Ground motion “in figure 4.74.

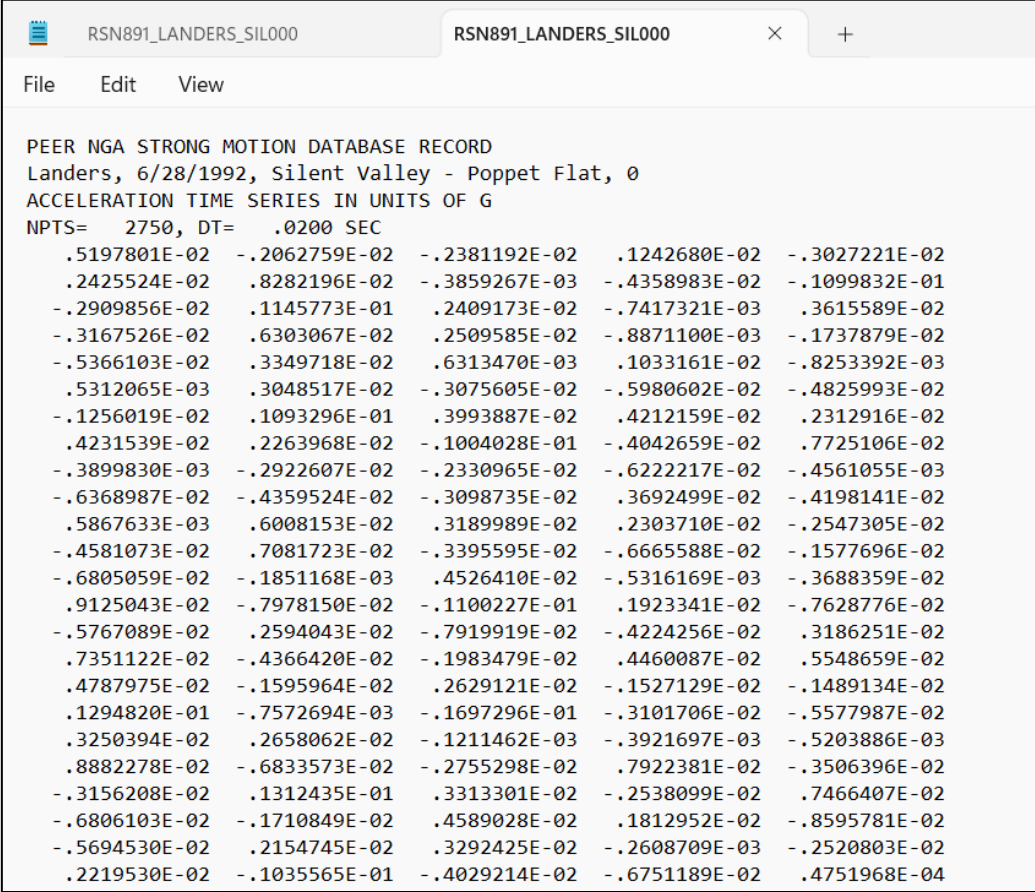
Press browse and select the ground motion file that have been downloaded before.

Headlines to skip = 4 (In this case because the acceleration values start at row no. 5 in the xl sheet in figure 4.71).

Prefix Chars. Per Line to skip = 0 (In this case because the acceleration values start at column no. 1, there is no column in front of the data in the xl sheet in figure 4.71)

Number of points per line= 5 (In this case because the acceleration values are in 5 columns in the xl sheet in figure 4.71)

Values at equal intervals of = 0.02 (In this case the time spacing is 0.02 s as it is shown in the downloaded ground motion file figure 4.75)



RSN891_LANDERS_SIL000

File Edit View

PEER NGA STRONG MOTION DATABASE RECORD
Landers, 6/28/1992, Silent Valley - Poppet Flat, 0
ACCELERATION TIME SERIES IN UNITS OF G
NPTS= 2750, DT= .0200 SEC

.5197801E-02	-.2062759E-02	-.2381192E-02	.1242680E-02	-.3027221E-02
.2425524E-02	.8282196E-02	-.3859267E-03	-.4358983E-02	-.1099832E-01
-.2909856E-02	.1145773E-01	.2409173E-02	-.7417321E-03	.3615589E-02
-.3167526E-02	.6303067E-02	.2509585E-02	-.8871100E-03	-.1737879E-02
-.5366103E-02	.3349718E-02	.6313470E-03	.1033161E-02	-.8253392E-03
.5312065E-03	.3048517E-02	-.3075605E-02	-.5980602E-02	-.4825993E-02
-.1256019E-02	.1093296E-01	.3993887E-02	.4212159E-02	.2312916E-02
.4231539E-02	.2263968E-02	-.1004028E-01	-.4042659E-02	.7725106E-02
-.3899830E-03	-.2922607E-02	-.2330965E-02	-.6222217E-02	-.4561055E-03
-.6368987E-02	-.4359524E-02	-.3098735E-02	.3692499E-02	-.4198141E-02
.5867633E-03	.6008153E-02	.3189989E-02	.2303710E-02	-.2547305E-02
-.4581073E-02	.7081723E-02	-.3395595E-02	-.6665588E-02	-.1577696E-02
-.6805059E-02	-.1851168E-03	.4526410E-02	-.5316169E-03	-.3688359E-02
.9125043E-02	-.7978150E-02	-.1100227E-01	.1923341E-02	-.7628776E-02
-.5767089E-02	.2594043E-02	-.7919919E-02	-.4224256E-02	.3186251E-02
.7351122E-02	-.4366420E-02	-.1983479E-02	.4460087E-02	.5548659E-02
.4787975E-02	-.1595964E-02	.2629121E-02	-.1527129E-02	-.1489134E-02
.1294820E-01	-.7572694E-03	-.1697296E-01	-.3101706E-02	-.5577987E-02
.3250394E-02	.2658062E-02	-.1211462E-03	-.3921697E-03	-.5203886E-03
.8882278E-02	-.6833573E-02	-.2755298E-02	.7922381E-02	-.3506396E-02
-.3156208E-02	.1312435E-01	.3313301E-02	-.2538099E-02	.7466407E-02
-.6806103E-02	-.1710849E-02	.4589028E-02	.1812952E-02	-.8595781E-02
-.5694530E-02	.2154745E-02	.3292425E-02	-.2608709E-03	-.2520803E-02
.2219530E-02	-.1035565E-01	-.4029214E-02	-.6751189E-02	.4751968E-04

Figure (4.75): The ground motion file.

As shown in figure 4.76, the ground motion no.1 will be as below.

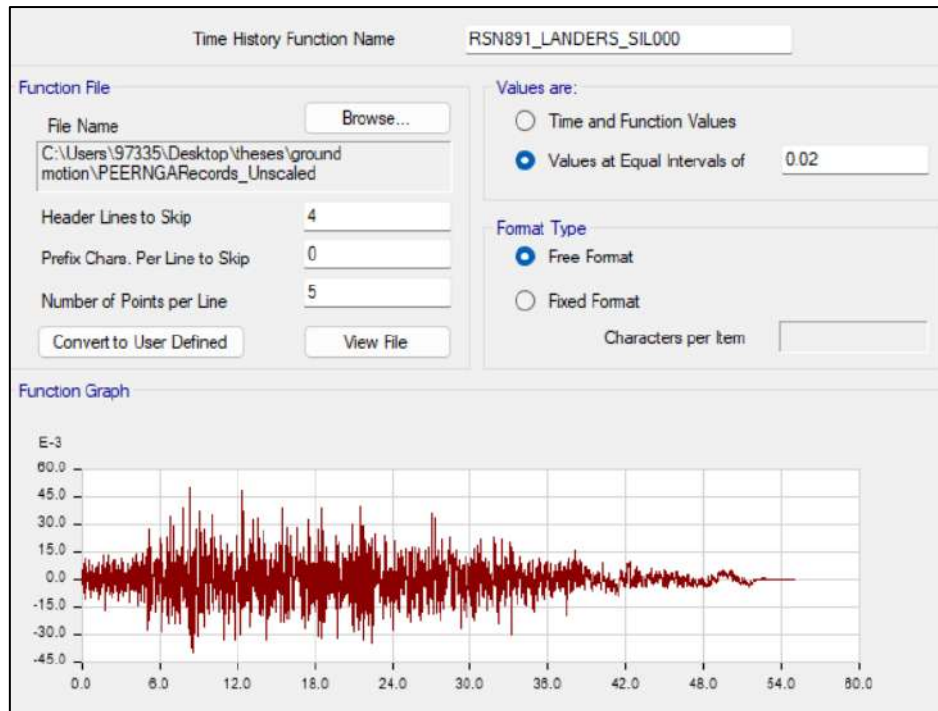


Figure (4.76): The first-time history function.

Then press >ok.

As shown in figure 4.77. Go to View Response spectrum to see the imported ground motion spectrum.

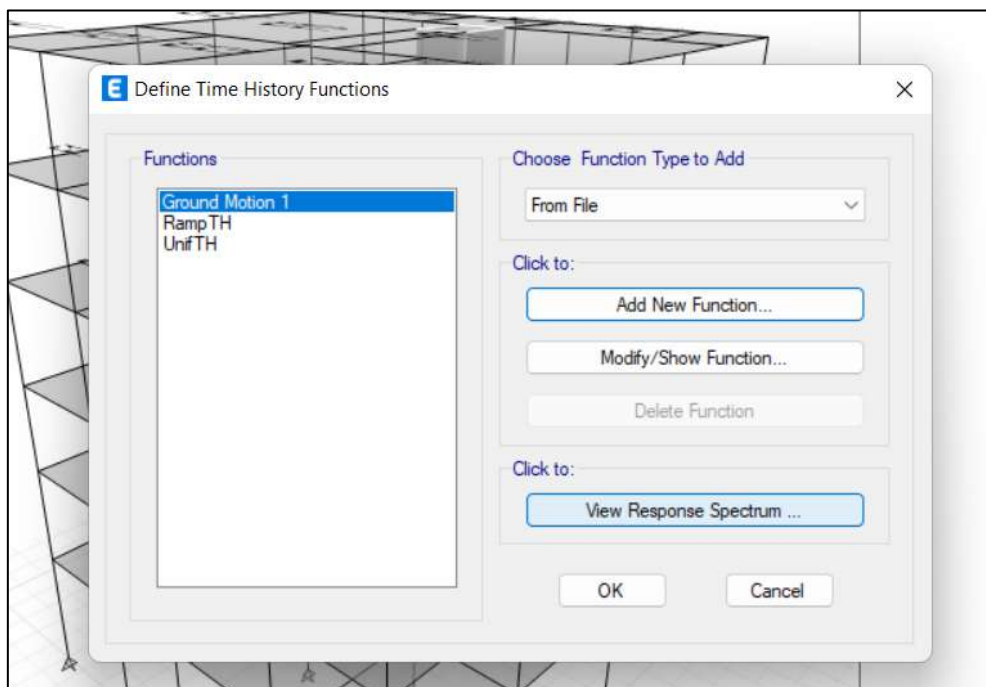


Figure (4.77): Added ground motion number 1.

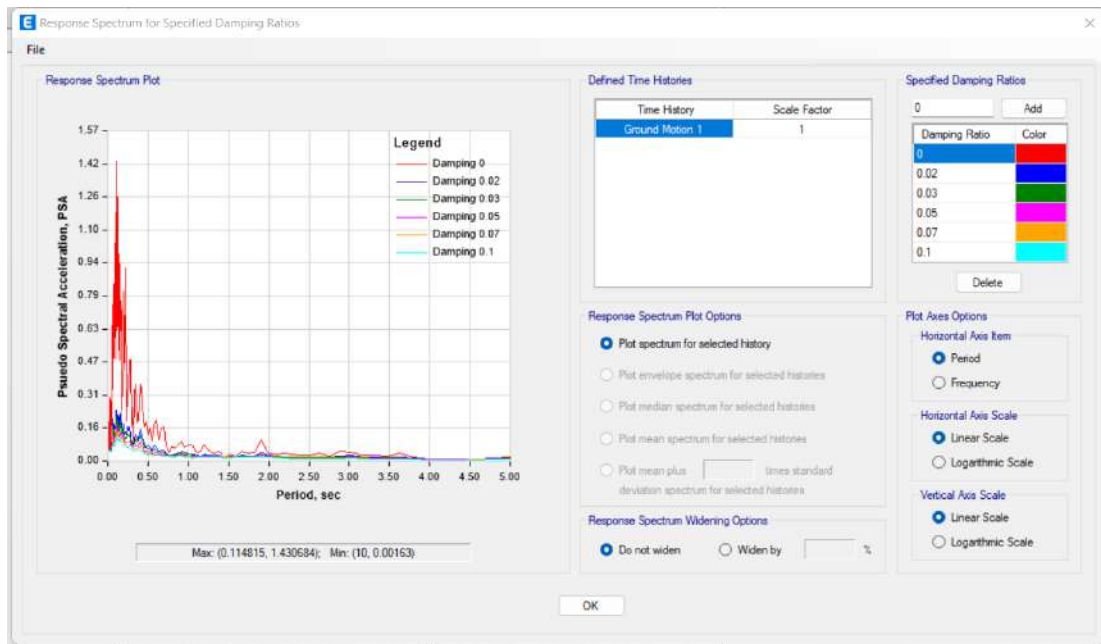


Figure (4.78): Ground motion 1 details.

In figure 4.78, the colored line shows the different damping ratios for this earthquake>ok.

Now, let's spectrally match it with defined target spectrum:

As shown in figure 4.79, choose function type to Add > Match to response spectrum > Add new function

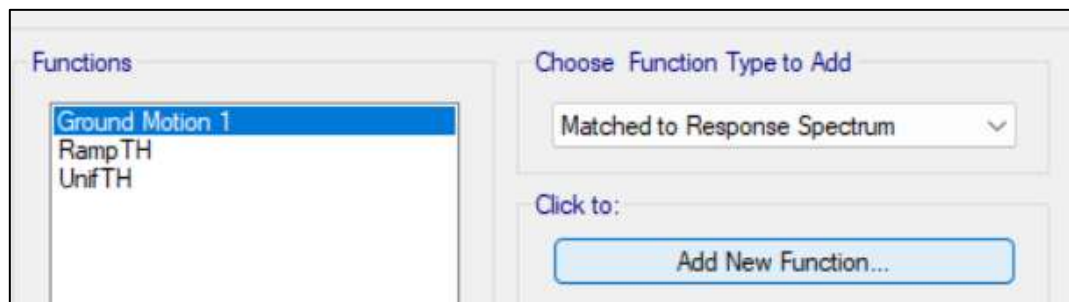


Figure (4.79): Add new function of modified ground motion.

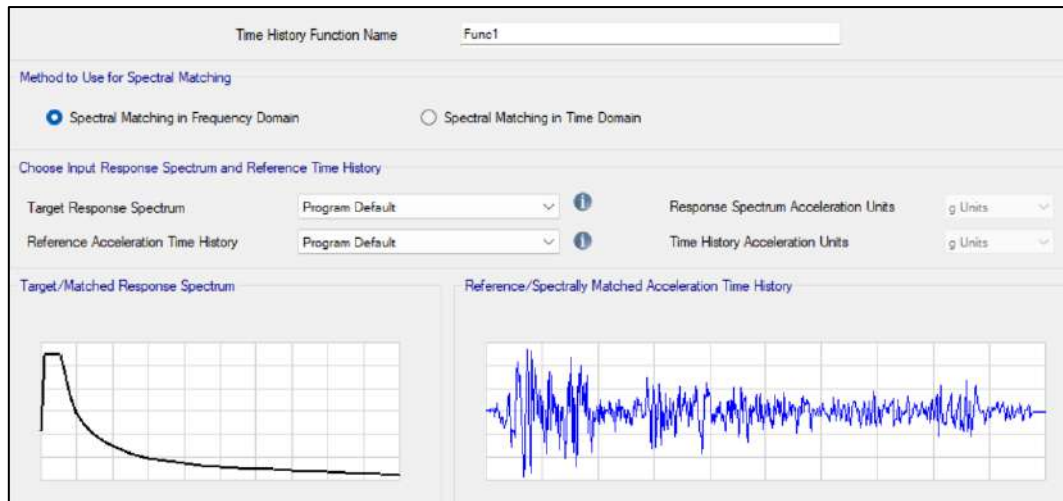


Figure (4.80): Modified ground motion details.

In figure 4.80, change the time history function name to “modified ground motion “

In target response spectrum select “Target Spectrum”

In reference acceleration time history select: “Ground motion” as shown in figure 4.81.

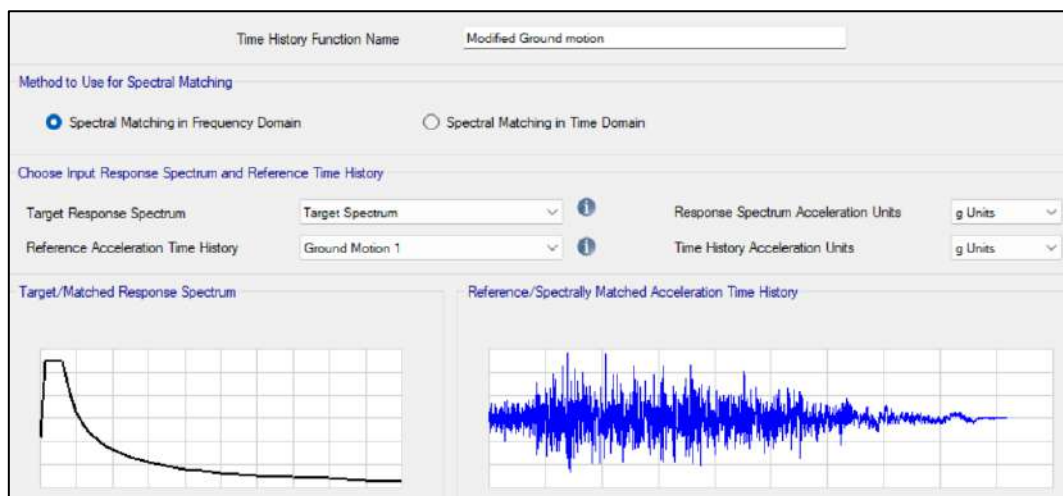


Figure (4.81): Modified ground motion details.

Press > match Time History.

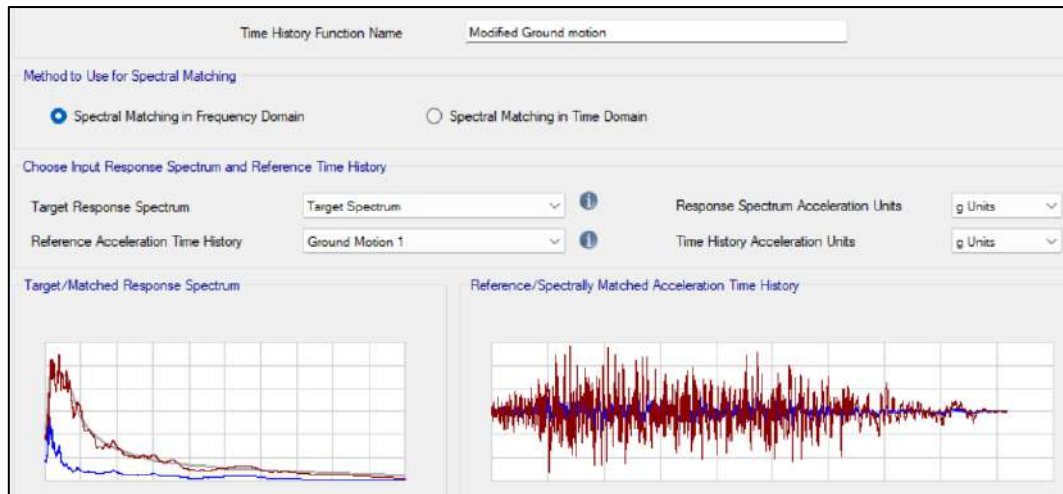


Figure (4.82): The modified ground motion function.

Figure 4.82 shows that the ground motion has been modified. The original ground motion represents in blue spectrum is very low, while the modified ground motion has the red spectrum now matching with the target spectrum.

Similarly on the right-hand side is a comparison of blue and red time histories, blue is very low compared with red line, which is modified ground motion which is after spectral match.

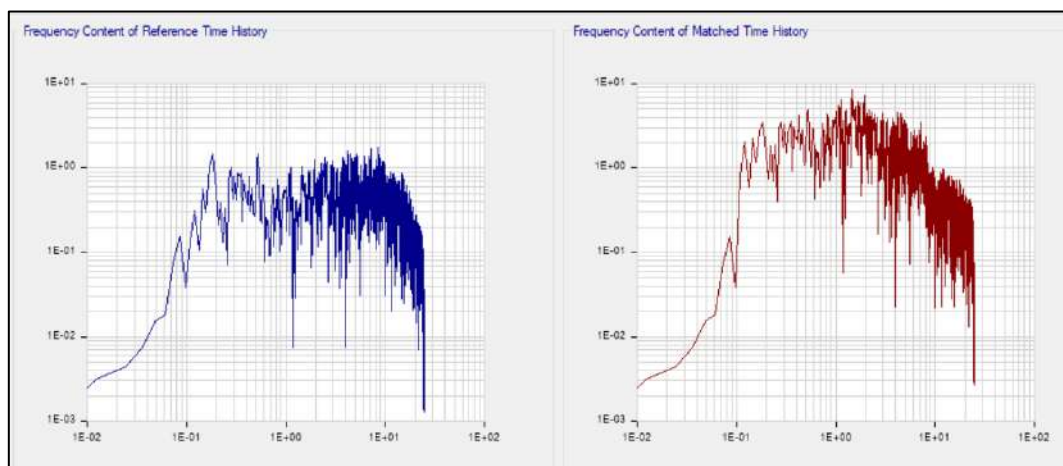


Figure (4.83): The original and modified ground motions frequency content.

Figure 4.83 represent the frequency content, which means the Fourier spectrum. The blue line graph is the Fourier spectrum of the original

ground motion, while red line graph represents frequency content of Fourier spectrum of modified ground motion.

click OK>

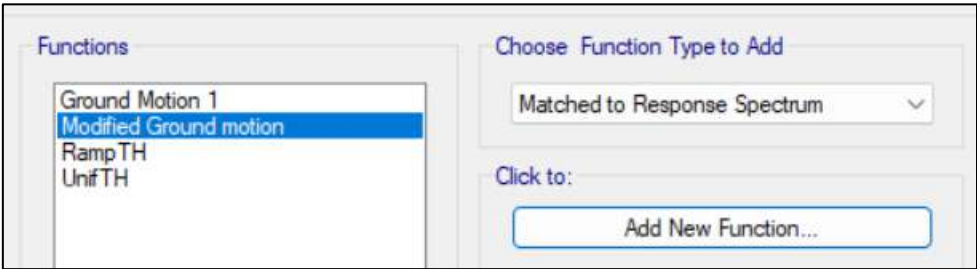


Figure (4.84): Ground motion name after modification.

Now, the modified ground motion can be used in the time history analysis. As it's shown in figure 4.84, go to Define> load cases>Add new load case > Time history load case> add as acceleration type> the function will be” Modified Ground motion” defined above, as shown in figure 4.85 and 4.86.

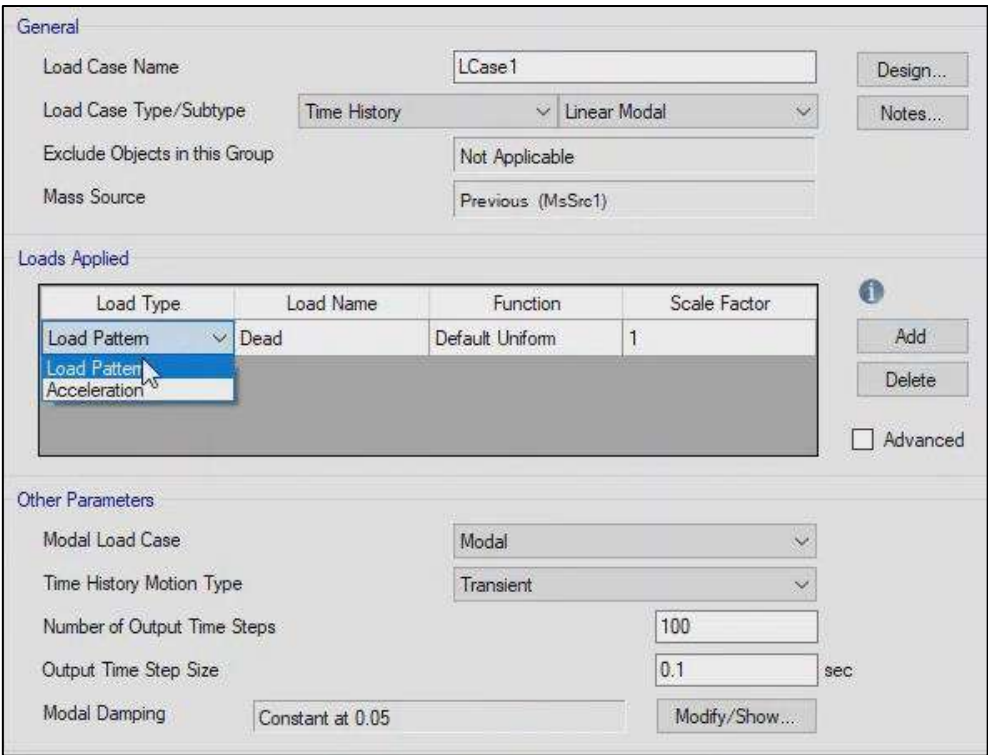


Figure (4.85): Define of load case for time history analysis.

The screenshot displays the 'General' and 'Loads Applied' sections of the ETABS software interface. The 'General' section includes fields for 'Load Case Name' (LCase1), 'Load Case Type/Subtype' (Time History / Linear Modal), 'Exclude Objects in this Group' (Not Applicable), and 'Mass Source' (Previous (MsSrc1)). The 'Loads Applied' section features a table with columns for 'Load Type', 'Load Name', 'Function', and 'Scale Factor'. A dropdown menu is open for the 'Function' column, showing options: 'Default Uniform', 'RampTH', 'UnifTH', 'RSN886 LANDERS P', and 'Modified GM'. The 'Scale Factor' is set to 1. Below the table are 'Add' and 'Delete' buttons, and an 'Advanced' checkbox. The 'Other Parameters' section at the bottom includes 'Modal Load Case' (Modal), 'Time History Motion Type' (Transient), 'Number of Output Time Steps' (100), 'Output Time Step Size' (0.1 sec), and 'Modal Damping' (Constant at 0.05).

Load Type	Load Name	Function	Scale Factor
Acceleration	U1	Default Uniform	1

Figure (4.86): Load case details and inputs.

4.2.7 Time History Analysis of Buildings Using CSI ETABS

In this section application of dynamic time history analysis of project building in ETABS program will be discussed by following these steps:

1. Importing past recorded ground motions Files to ETABS program.
2. Define Mass Source
3. Define P-Delta Options
4. Define Modal Case
5. Define Load Case for Time History Analysis
6. Extracting the Result and responses after the Time history Analysis.

Demonstration dynamic time history analysis start by open the project on ETABS, and directly introduce the options which will be used in the time history analysis. The time history analysis solved the governing equation of motion for multiple degree of freedom systems at each time instant; it's a true rigorous dynamic analysis. Provide the acceleration Time history as

an input and the software performs the dynamic analysis by solving the complete governing equation of motion including the inertial term, the damping term and the elastic restoring term. All the responses are calculated as a function of time in this analysis and all displacement, shears, moments will not be just a single number as a result of this analysis, it will be a complete history of that response, for example, if earthquake of 40 seconds has been applied, all the responses will have a complete history of 40 seconds, the response is fluctuating with time during the actual application of earthquake.

The first step after completing the geometry, it is important to make sure that restraints at the bases joints of each column have already been applied, boundary conditions must be applied before the analysis.

As shown in figure 4.87 and figure 4.88, go to base plan> select the joint>Assign> joint> restraints>Apply.

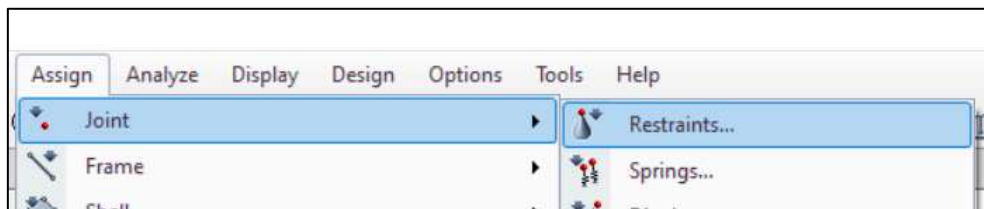


Figure (4.87): Application of restraints for the basis's joints.

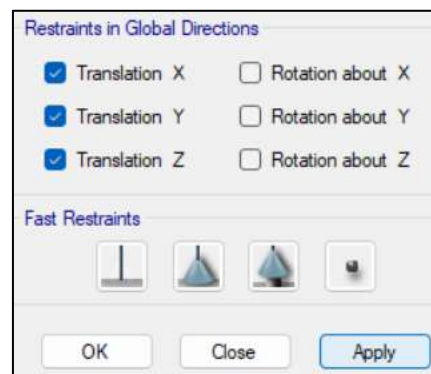


Figure (4.88): Restraints details.

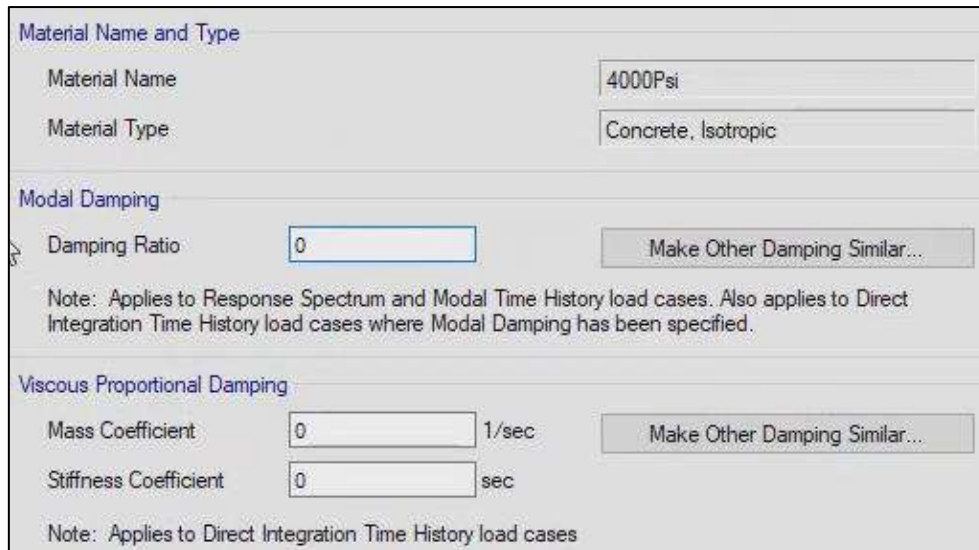
Second is define the damping level, which have been done by either as material level or load case level. In this research the damping is used as, it's the common practice.

As it can see in figure 4.89, material level damping can be performed by going to Define>material properties> select concrete material>material damping properties> enter the damping ration, mass, and stiffness coefficients. As shown in figure 4.90.

The image shows a software dialog box for defining material properties. It is organized into several sections:

- General Data:** Includes fields for Material Name (4000Psi), Material Type (Concrete), Directional Symmetry Type (Isotropic), Material Display Color (with a Change... button), and Material Notes (with a Modify/Show Notes... button).
- Material Weight and Mass:** Features two radio buttons: "Specify Weight Density" (selected) and "Specify Mass Density". Below are input fields for Weight per Unit Volume (150 lb/ft³) and Mass per Unit Volume (4.662 lb-s²/ft⁴).
- Mechanical Property Data:** Contains input fields for Modulus of Elasticity, E (3604996.5 lb/in²), Poisson's Ratio, U (0.2), Coefficient of Thermal Expansion, A (0.0000055 1/F), and Shear Modulus, G (1502081.88 lb/in²).
- Design Property Data:** Includes a single button: "Modify/Show Material Property Design Data...".
- Advanced Material Property Data:** Contains three buttons: "Nonlinear Material Data...", "Material Damping Properties..." (which is highlighted with a blue border), and "Time Dependent Properties...".

Figure (4.89): Adding material damping properties.



Material Name and Type

Material Name: 4000Psi

Material Type: Concrete, Isotropic

Modal Damping

Damping Ratio: 0 Make Other Damping Similar...

Note: Applies to Response Spectrum and Modal Time History load cases. Also applies to Direct Integration Time History load cases where Modal Damping has been specified.

Viscous Proportional Damping

Mass Coefficient: 0 1/sec Make Other Damping Similar...

Stiffness Coefficient: 0 sec

Note: Applies to Direct Integration Time History load cases

Figure (4.90): Material damping properties.

Third, import the ground motions acceleration history for the purpose of time history analysis same as mentioned above.

As in figure 4.91, go to ETABS> define > functions >time history.

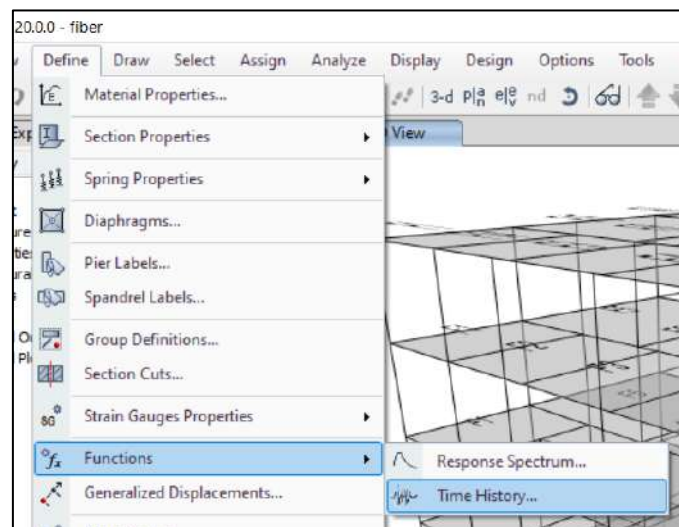
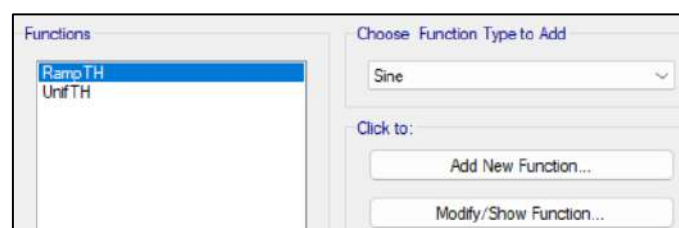


Figure (4.91): Time history function adding.

In figure 4.92, from choose function type to Add > From File > Add New Function



Functions

RampTH
UnifTH

Choose Function Type to Add

Sine

Click to:

Add New Function...

Modify/Show Function...

Figure (4.92): Time history function details.

Time History Function Name: Func1

Function File

File Name: Browse...

Header Lines to Skip:

Prefix Chars. Per Line to Skip:

Number of Points per Line:

Values are:

☐ Time and Function Values

☒ Values at Equal Intervals of

Format Type

☒ Free Format

☐ Fixed Format

Characters per Item:

Function Graph

Graph area showing a grid with x-axis from 0.0 to 10.0 and y-axis from 0.00 to 7.00.

Figure (4.93): Time history function inputs.

Change the Time history Function Name to “Ground motion 2“, as shown in figure 4.93. Press Browse and select the ground motion file that have been downloaded before.

Headlines to skip = 4 (in this case because the acceleration values start at row no. 5 as it shown in figure 4.94)

Prefix Chars. Per Line to skip = 0 (in this case because the acceleration values start at column no. 1, there is no column in front of the data)

Number of points per line= 5 (in this case because the acceleration values are in 5 column)

Values at Equal intervals of = 0.02 (in this case the time spacing is 0.02 s)

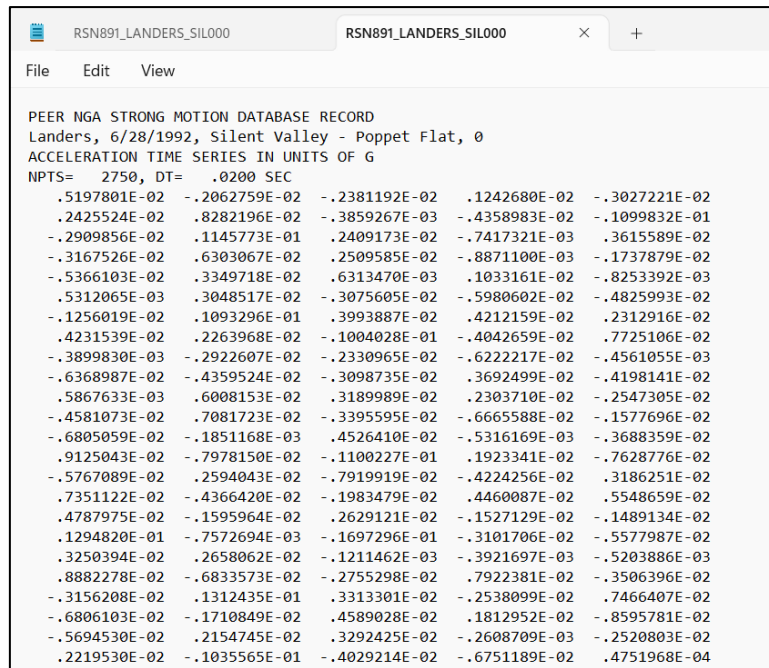


Figure (4.94): Time spacing of earthquake data.

So, the ground motion No.2 will be as shown in figure 4.95 below.

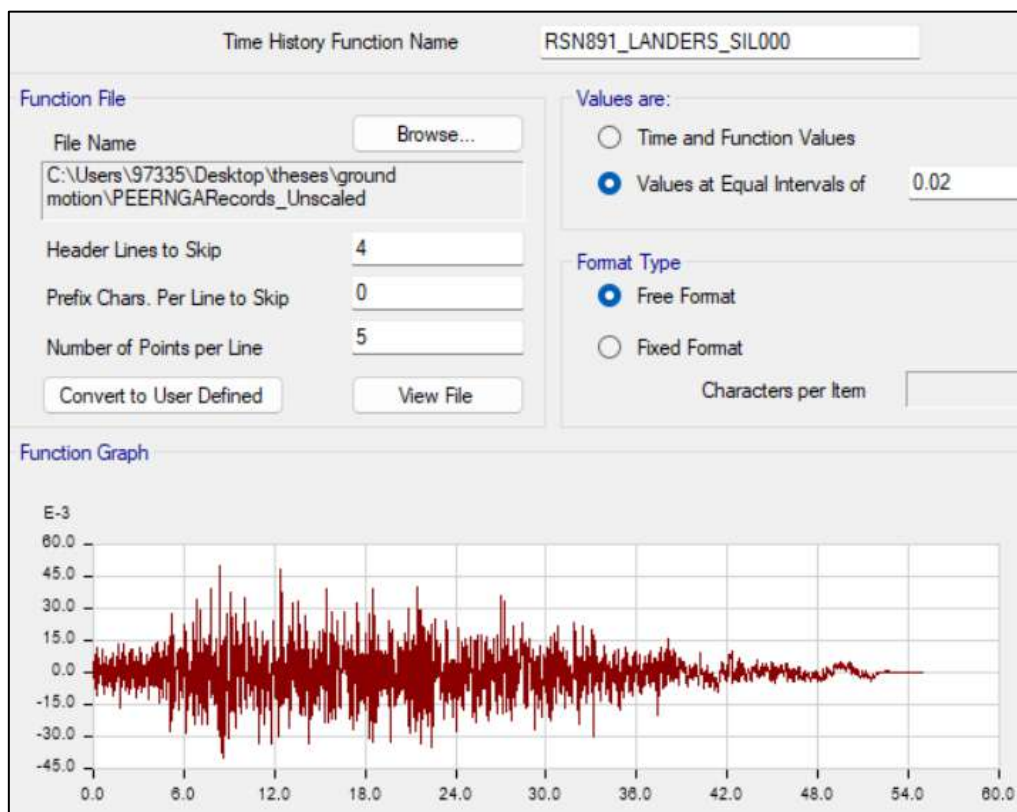


Figure (4.95): The ground motion no.2

Then press >ok.

Repeat the same procedure for all the data downloaded from PEER, in our case it was 21 records. To simplify the step, same procedure to be done for all of them, and their names will be as illustrated in table 4.1.

Table (4.13): Total ground motions

Ground motion 1	Ground motion 2	Ground motion 3	Ground motion 4
Ground motion 5	Ground motion 6	Ground motion 7	Ground motion 8
Ground motion 9	Ground motion 10	Ground motion 11	Ground motion 12
Ground motion 13	Ground motion 14	Ground motion 15	Ground motion 16
Ground motion 17	Ground motion 18	Ground motion 19	Ground motion 20
Ground motion 21			

After adding all the ground motion recodes as shown in figure 4.96, and plotted that's the way of importing the file formats. Different file formats which are downloaded from different ground motion databases, it is required open them first, understand the format of each record and then fill the form so that ETABS can correctly import the data.

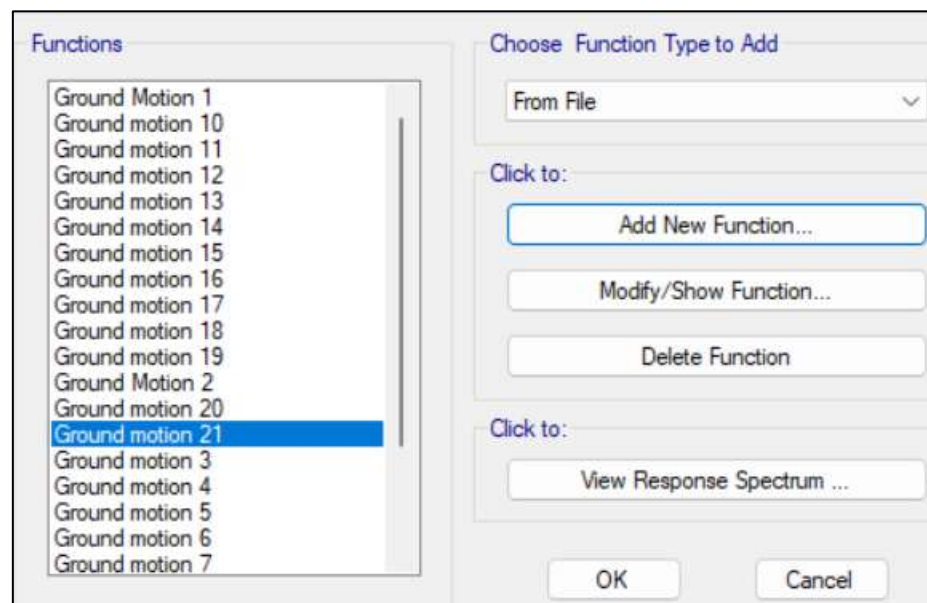


Figure (4.96): Defended all ground motions.

As in figure 4.97, if view response spectrum is selected, and it has been selected any of the ground motion entered before, the response spectrum for different damping ratios can be displaced.

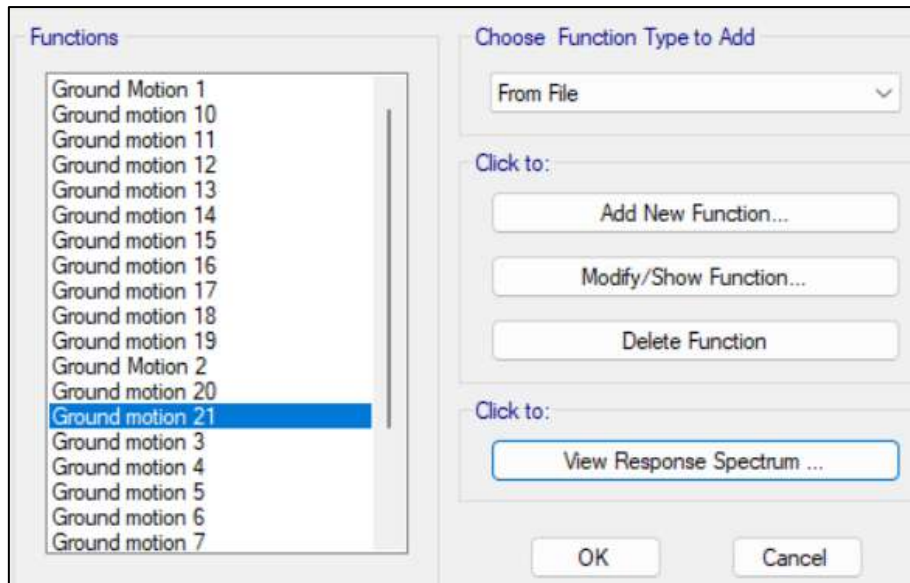


Figure (4.97): View response spectrum of ground motion.

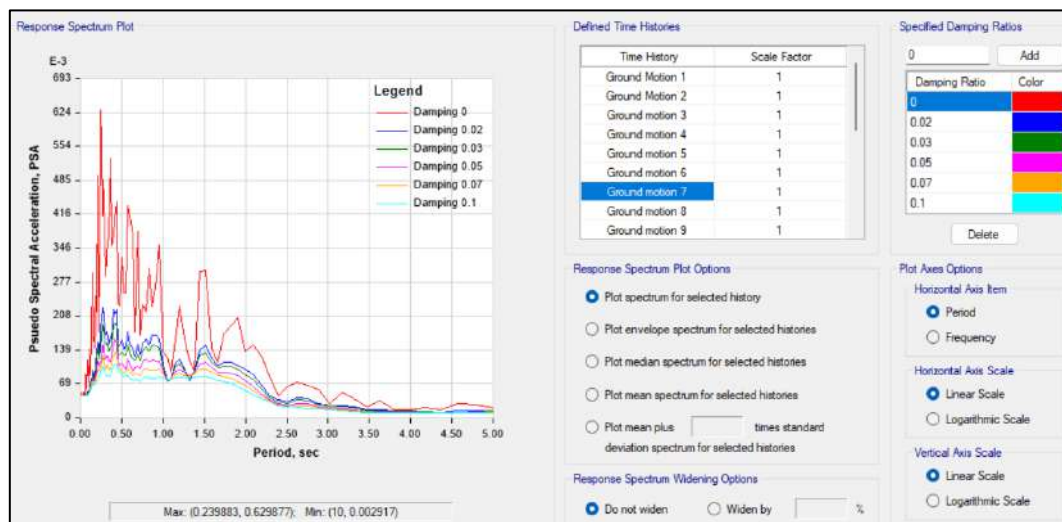


Figure (4.98): Response spectrum details of ground motion.

Now let's matched the recorded spectrum to our previously defined spectrum (Target spectrum), makes sure that the ground motion used is the modified to represent the hazard level at the site. Using spectral matching described above in which it modifies the ground motion, amplifies it or de amplifies some of the frequency contents, such that the response spectrum of the imported ground motion start matching the target response spectrum of the site.

Now let's separately match it with defined target spectrum:

From figure 4.99, choose function type then Add > Match to response spectrum > Add new function.

The same procedure should be repeated 21 times for each record.:

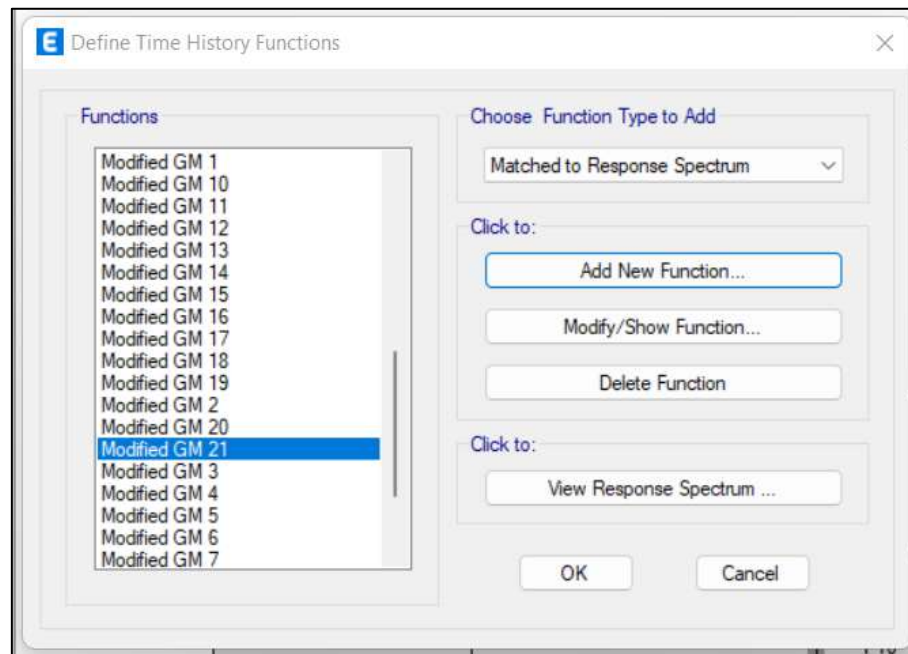


Figure (4.99): Adding of all modified ground motions.

Change the time history function name to “Modified Ground motion from 1 to 21 “

In target response spectrum select “Target Spectrum”

In reference acceleration time history select: “Ground motion”

Press > match time history.

click OK>

Now and only, the modified ground motions can be used in the time history analysis.

Before going to load case definition, define of the three following options are required, as shown in figure 4.100:

1. Mass source
2. P-Delta options
3. and Model cases.

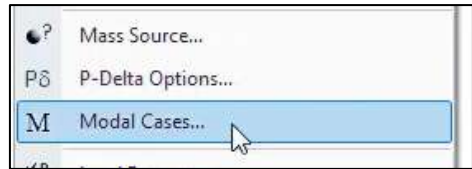


Figure (4.100): Mass source, p-delta & modal cases.

1. Mass source

As in figure 4.101, go to Define> Mass Source >Add New Mass Source

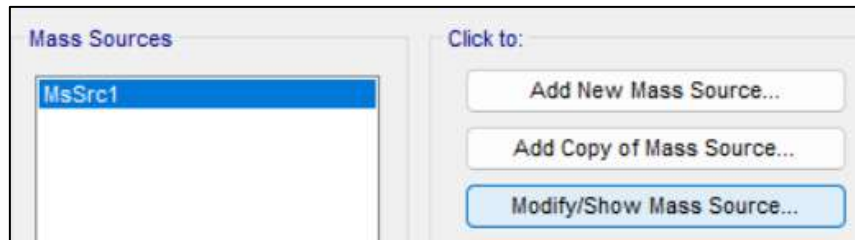


Figure (4.101): Adding of new mass source.

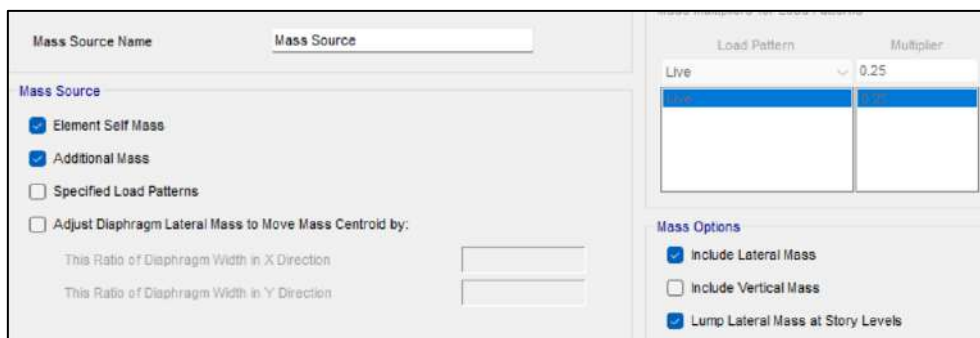


Figure (4.102): Mass source details.

Change the name to “Mass source “and make sure to include element self-mass as well as additional mass. As shown in figure 4.102

2. P-Delta options

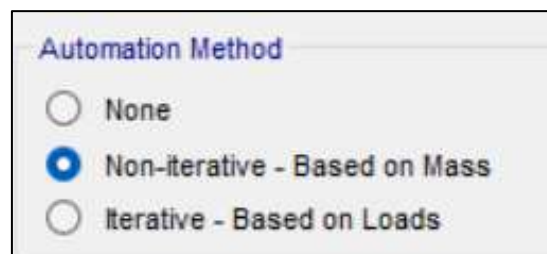


Figure (4.103): Adding p-delta effect.

Another option must be checked before the load case of time history analysis is the P-delta option. As it is shown in figure 4. 103. There are three options available.

- None, which means that no geometric nonlinearity should be accounted in the analysis.
- A non-iterative formulation is based on mass.
- Iterative is the most time consuming in which selection of the load patterns should be included to account for P delta effects. Speed delta should be always included the analysis, because some structures subjected to very high gravity loads, their response may be significantly influenced by P delta effects. To save analysis time then go for non-iterative formulation which is based on simple self-weight or mass. But if it is required to go for the rigorous option, iterative based on loads must be selected, then it is required to select different load cases. All the gravity loads should be included in this load pattern. It either it is dead load or live load or superimposed dead load or any other load which occur in the gravity load category that should be added and then these loads will be used to calculate P-delta.

Quoted from reference No. 2, referring to p delta behavior> A. K. Chopra, (1995): Dynamics of Structures-Theory and Applications to Earthquake Engineering Book , Prentice Hall, New Jersey.

“The accuracy of the natural vibration frequency estimated using above procedure depend entirely on the shape function that is assumed to approximate the exact model shape. And principle any shape maybe selected that satisfied displacement boundary condition at the support”

3. Model cases.

In the time history analysis, there are two solution methods. One is the direct integration. It doesn't involve the use of the mode shapes or modal properties. It is just simple step-by-step numerical integration, and it

solves the coupled equation of motion directory, and it gives the combined dynamic response of the structure.

But there is another option called the modal response history analysis. It is also time history analysis, but it makes this solution method use the mode shapes and other modal properties like time periods, natural frequencies. Figure 4.104 shows the procedure of adding modal cases.

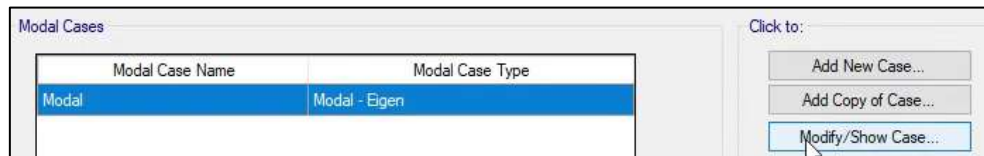


Figure (4.104): Adding modal cases effect.

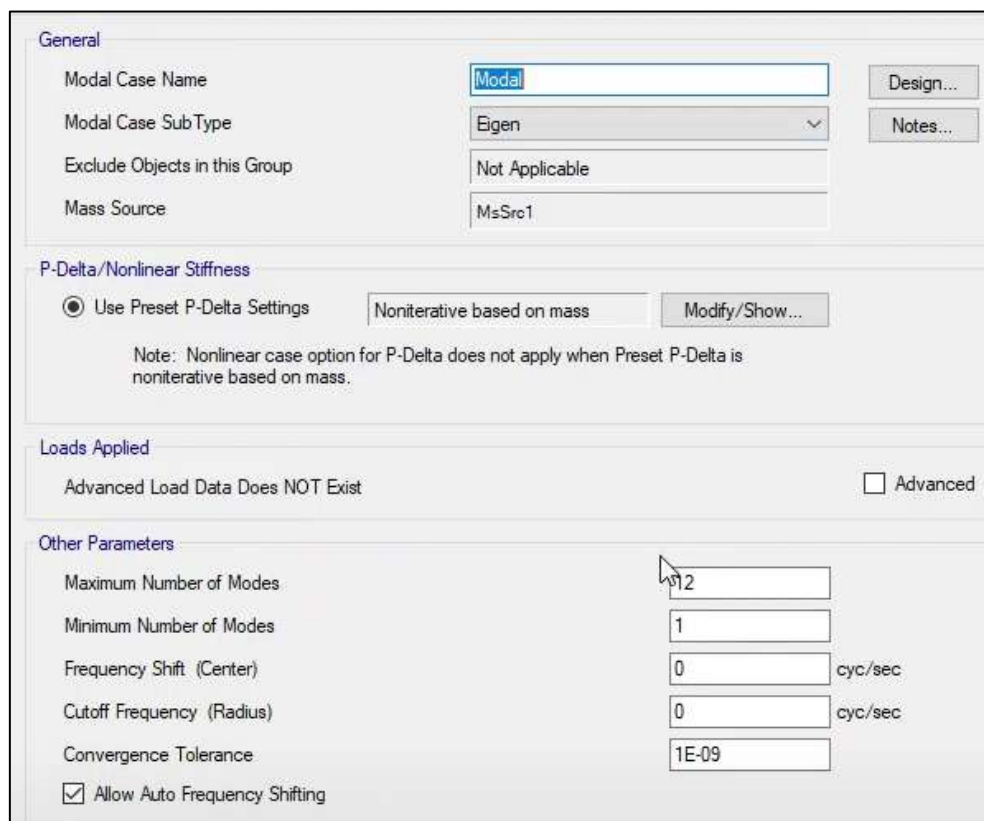


Figure (4.105): Modal cases properties.

Next, as it is shown in figure 4.105, is defining the load cases, the software treats the ground motion as a time history (i.e., a time variation). It will not just apply a ground shaking by defining a time history function. A load case for time history analysis made before, by applying acceleration with variation of time, as it is defined before as “modified GM”. So, application

of ground acceleration while defining the load case for time history must be entered. That's how the ground acceleration is applied. Any other function can also be assigned to an applied load also. For example, as it is shown in figure 4.106 and figure 4.107.

Go to Define>load cases>add new case> Time history > Linear Model

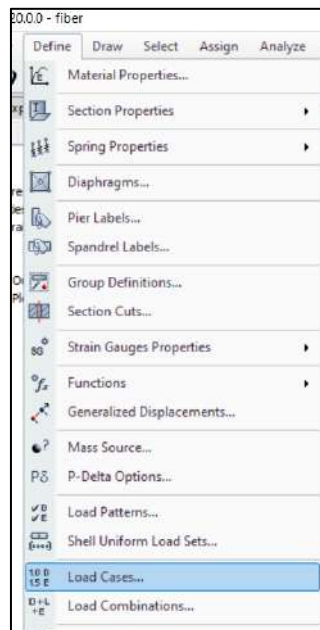


Figure (4.106): Define load cases.

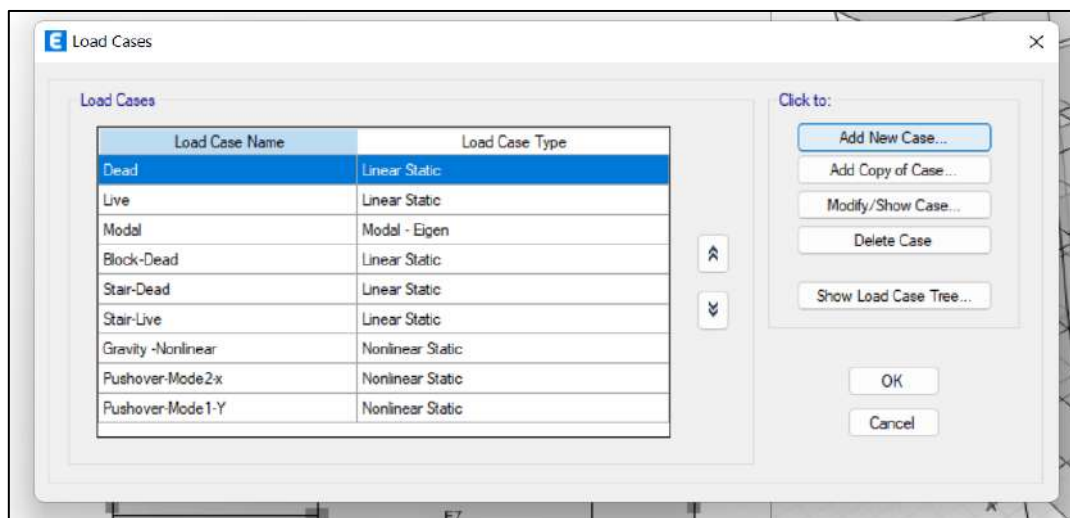


Figure (4.107): List of all load cases.

In the time history motion type select> Transient Number of output time step=2750 (In the case of 1st ground motion, it will vary from one record to another depend on the downloaded data, so take this information from the original earthquake data downloaded before).

Same shall be applicable for output time step size=0.02

In the modal damping, specify it as 0.05 (5%), as it is shown in figure 4.113.

The input to be shown as figure 4.109 making the ground motion horizontal components as x in U1 and y at U2 as Time history 1-1, then switch the values making x in U2 and y at U1 as shown in figure 4.110.

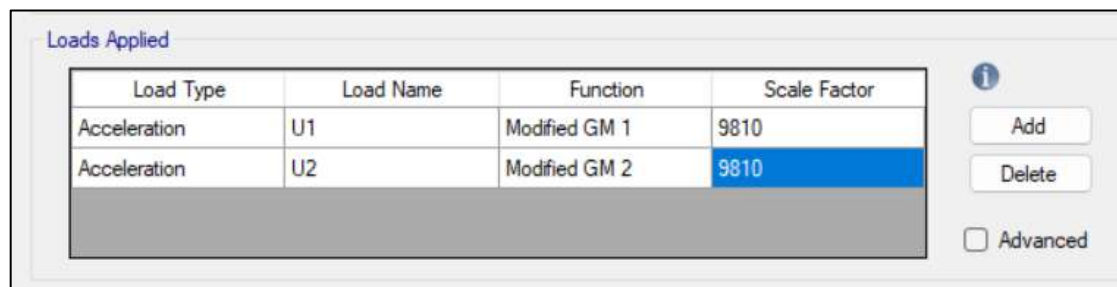


Figure (4.109): Adding time history load case for x direction.



Figure (4.110): Adding time history load case for y direction.

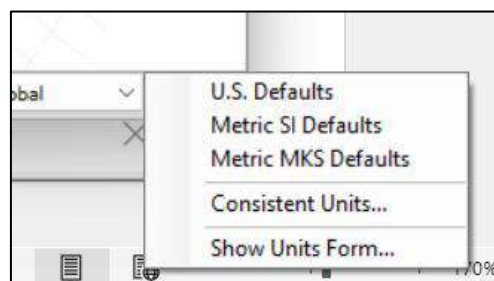


Figure (4.111): Show default units of the program.

E Display Units								
	Item	Length Unit	Force Unit	Temperature Unit	Units Label	Decimal Places	Minimum Significant Figures	Zero Tolerance
Stiffness								
	Translational Stiffness	m	kN		kN/m	3	1	5E-06
	Rotational Stiffness	m	kN		kN-m/rad	4	1	5E-07
	TransRot Coupled Stiff		kN		kN/rad	4	1	5E-07
	Trans Stiffness/Length	m	kN		kN/m/m	3	1	5E-06
	Rot Stiffness/Length		kN		kN/rad	4	1	5E-07
	Trans Stiffness/Area	m	kN		kN/m/m2	3	1	5E-06
Time Related								
	Period				sec	3	1	5E-06
	Frequency				cyc/sec	3	1	5E-06
▶	Acceleration-Trans	mm			mm/sec2	2	1	5E-05
	Acceleration-Rot				rad/sec2	3	1	5E-06
	Velocity-Trans	mm			mm/sec	2	1	5E-05
	Velocity-Rot				rad/sec	3	1	5E-06
	Other Time (Seconds)				sec	4	2	5E-07
Mass and Weight								
	Mass	m	N		kg	2	1	5E-05
	Mass/Length	m	N		kg/m	3	1	5E-06
	Mass/Area	m	N		kg/m2	3	1	5E-06
	Mass/Volume	m	N		kg/m3	3	1	5E-06
	Weight		kN		kN	4	1	5E-07
	Weight/Length	m	N		N/m	2	1	5E-05
	Weight/Area	m	kN		kN/m2	4	1	5E-07
	Weight/Volume	m	kN		kN/m3	4	1	5E-07
	Weight*Length2	m	kN		kN-m2	4	1	5E-07
	Rotational Inertia	m	kN		ton-m2	4	1	5E-07
	Length5	m			m5	6	1	5E-15
☐ Expand Form OK Cancel								

Figure (4.112): Acceleration unit.

E Modal Damping

Modal Damping Type

☒ Constant Damping for all Modes
 ☐ Interpolated Damping by Period or Frequency
 ☐ Mass and Stiffness Proportional Damping by Coefficient

Constant Modal Damping

Constant Damping for all Modes

0.05

Figure (4.113): Modal damping.

After defining all the load cases as shown in figure 4.114 below.

TIME HISTORY 1-1	(Linear Modal History)
TIME HISTORY 1-2	(Linear Modal History)
TIME HISTORY 2-1	(Linear Modal History)
TIME HISTORY 2-2	(Linear Modal History)
TIME HISTORY 3-1	(Linear Modal History)
TIME HISTORY 3-2	(Linear Modal History)
TIME HISTORY 4-1	(Linear Modal History)
TIME HISTORY 4-2	(Linear Modal History)
TIME HISTORY 5-1	(Linear Modal History)
TIME HISTORY 5-2	(Linear Modal History)
TIME HISTORY 6-1	(Linear Modal History)
TIME HISTORY 7-1	(Linear Modal History)
TIME HISTORY 7-2	(Linear Modal History)
TIME HISTORY 8-1	(Linear Modal History)
TIME HISTORY 8-2	(Linear Modal History)
TIME HISTORY 9-1	(Linear Modal History)
TIME HISTORY 9-2	(Linear Modal History)
TIME HISTORY 10-1	(Linear Modal History)
TIME HISTORY 10-2	(Linear Modal History)
TIME HISTORY 6-2	(Linear Modal History)

Figure (4.114): List of all time history load cases defined.

Load Type	Load Name	Function	Scale Factor
Acceleration	U2	Modified GM 3	9810
Acceleration	U1	Modified GM 4	9810

Other Parameters

Modal Load Case: Modal

Time History Motion Type: Transient

Number of Output Time Steps: 2500

Output Time Step Size: 0.02

Modal Damping: Constant at 0.05

Figure (4.115): Acceleration load U1 & U2 represent x, y directions.

Note that only x and y directions for each load case have considered, but there are also another forces that may can used in the analysis, for example as its shown in the figure 4.115 above (U3 – for z direction , R1 – rotation at x direction , R2-y direction , R3- at z direction) but in our case since the seismic load are applied on the structure as a horizontal forces only, taking into the account in this report the U1 & U2 (x, y directions only).

After defining the load cases, the model can be run for analysis.

As shown in figure 4.116, go to Analyze>Set load case to Run>ok

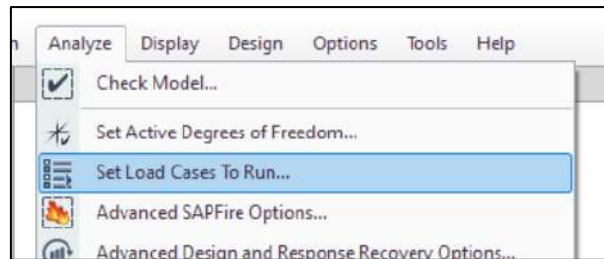


Figure (4.116): Set load case to run.

This load cases are set already to run. by clicking run, as shown in figure 4.117, all those load cases which are listed in figure4.117 will be run one by one. It's also shown the model load case added before as default case. Modal properties are calculated first then the other analysis is performed.

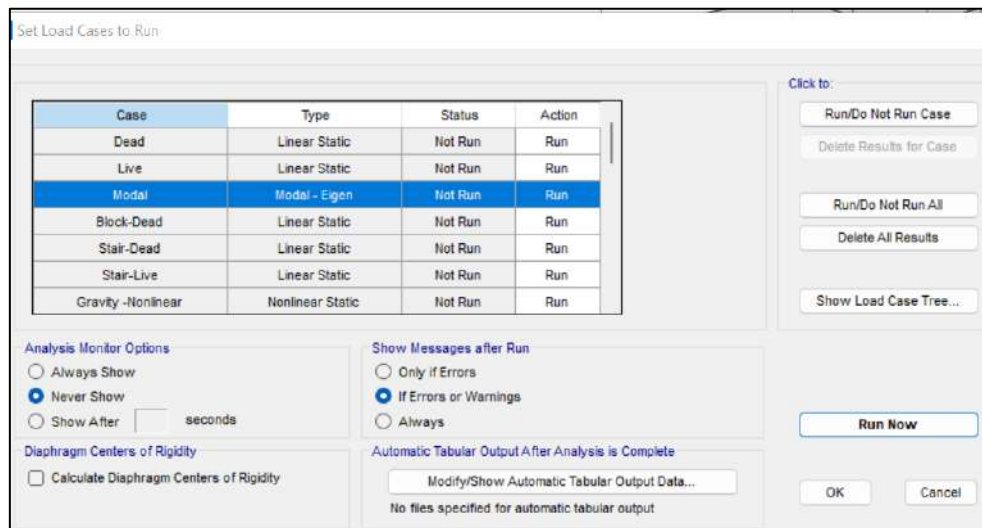


Figure (4.117): Run the load case.

For more information regarding the structural dynamic behavior during earthquakes, refer to reference

4.2.8 The Results of the NLTHA.

At the end, after running the analysis, some of the result shown as below:

- Deformation shape:

To see the effect of time history load cases in the building, as shown in figure 4.118, go to Display>deform shape > Time History 1-1 (select any load cases defined before) >

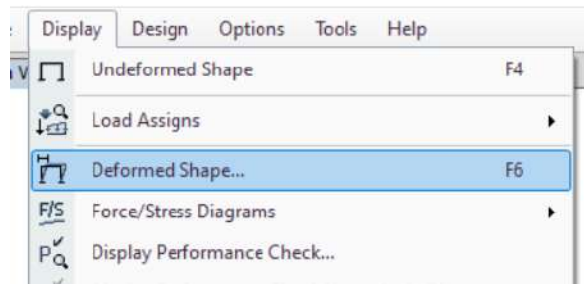


Figure (4.118): Display result - Deformation shape

Then, several options are available to display the deformation, shown in table 4.14.

Table (4.14): Display options for time

Time	Specify certain time to display the displacement during the earthquake. For example: display the displacement of the building at sec no. 13 during an earthquake that last for 55 sec.
Absolute Max	Show the maximum displacement that occur in this particular time history load cases.
Min	Show the minimum displacement that occur in this particular time history load cases.
Multi Step	Show the displacement in regular time interval, in this case the start, end, and time increment must be specified.

As shown in figure 4.119, many time options for display the result are available. Multi step as it is shown in figure 4.120, absolute max as in figure 4.121 and max at is shown in figure 4.122 below.

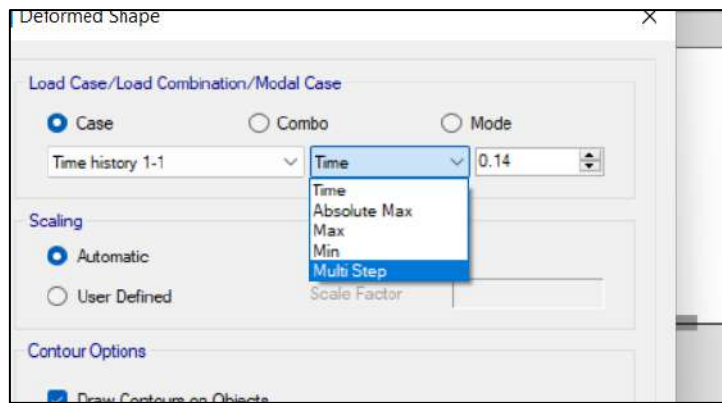


Figure (4.119): Time options.

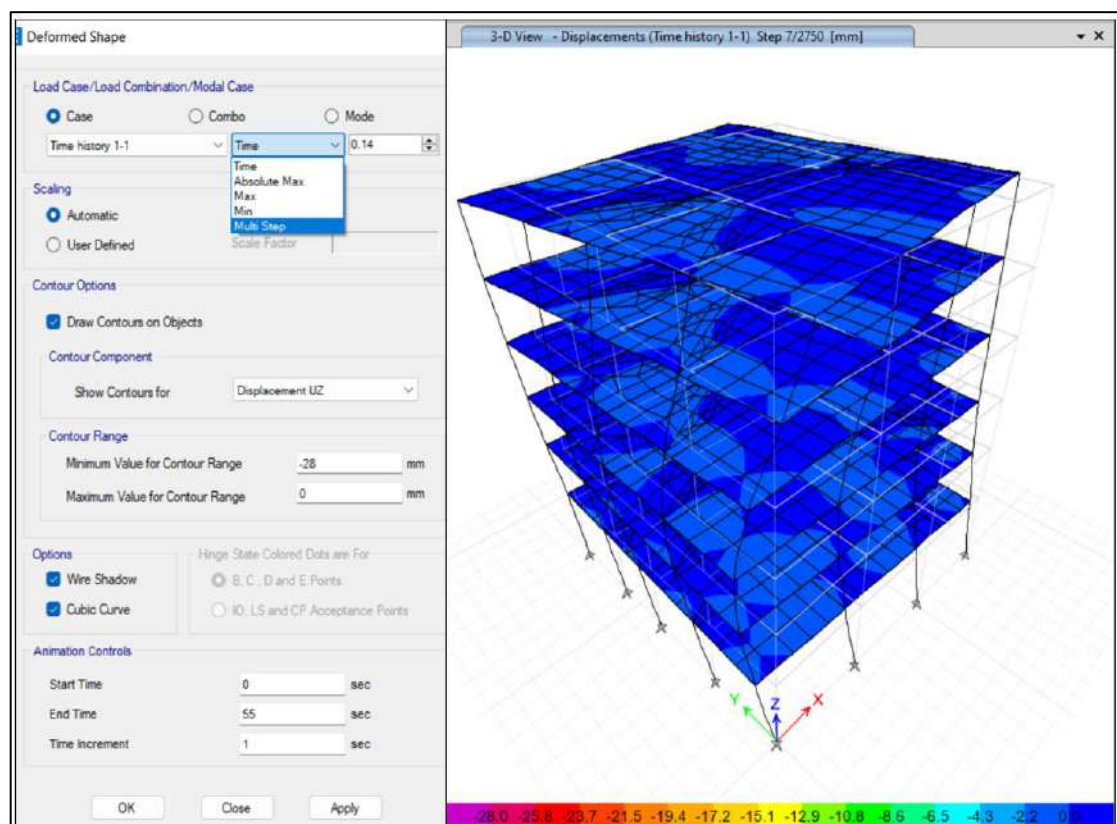


Figure (4.120): Display result - Deformation shape at t=0.14s.

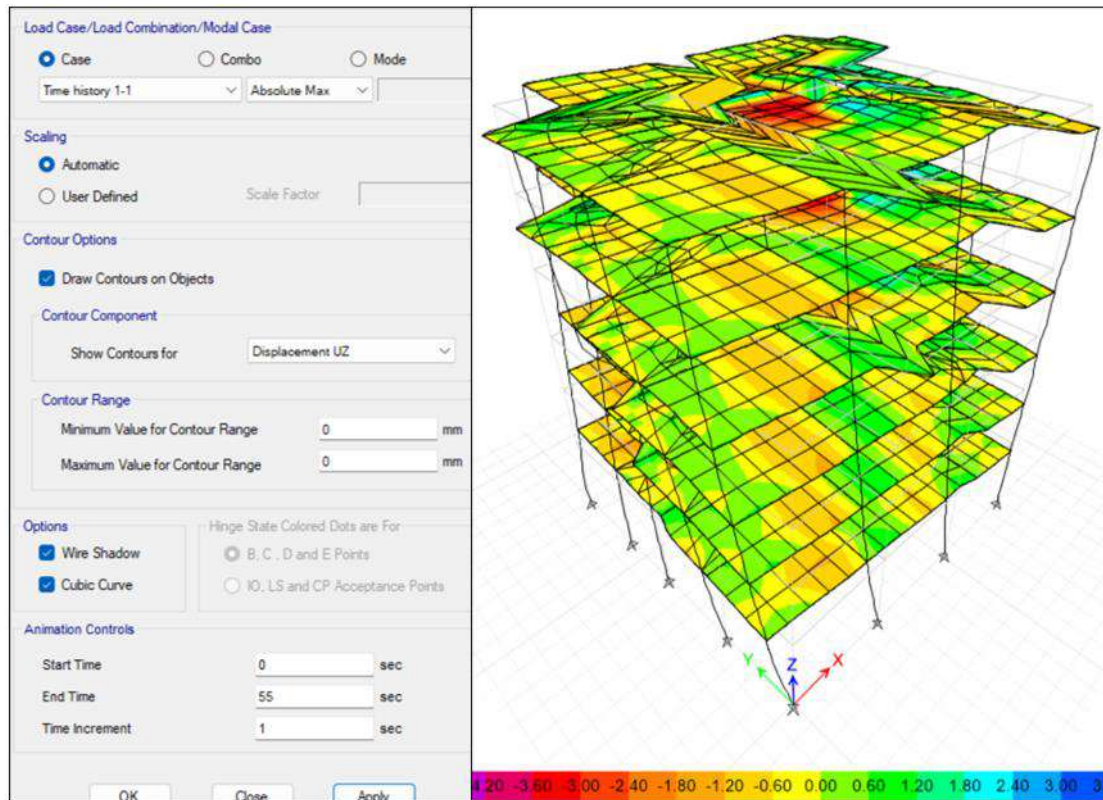


Figure (4.121): Display result - Deformation shape at absolute max.

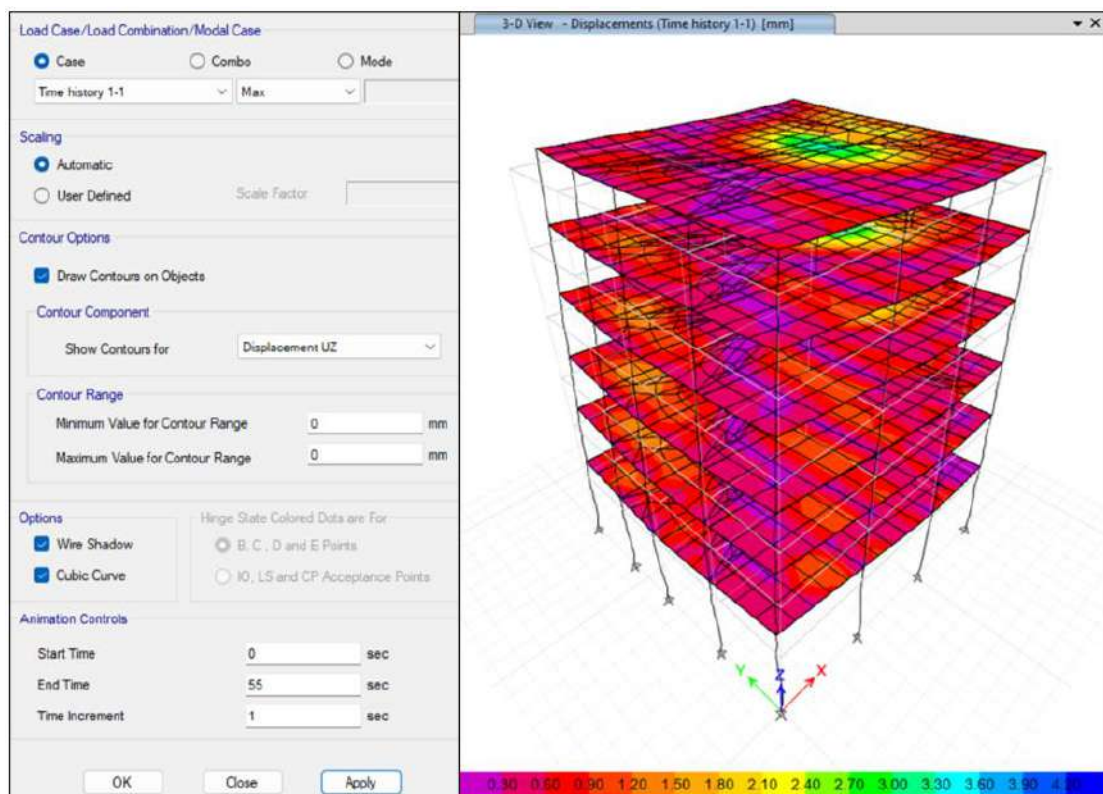


Figure (4.122): Display result - Deformation shape at time=max.

To display the deformation at a particular element such as beam, columns or shear wall, select that element and right click, a window will display same as figure 4.123, the displacement in x, y & z direction will appear, along with the rotation values.

Object ID			
Tower and Stroy	Label	Unique Name	
Story6	26	152	

Point Displacement and Drift			
	X	Y	Z
Translation, mm	52.074	48.021	0.734
Rotation, rad	0.000303	0.001128	0.003516
Drift	0.001921	0.000888	

Figure (4.123): The deformation at a particular element.

Similarly, by repeating the same procedure for the all-load cases defined before.

An animation of the deformed shape during the whole earthquake duration can be displayed, for example at 1st earthquake at our case was 55 seconds of this ground motion.

As it is shown in figure 4.124, go to file> create a video> Multi-step Animation.

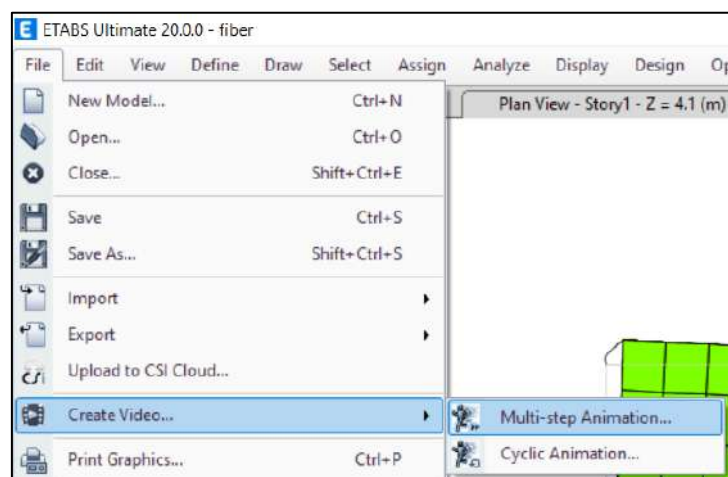


Figure (4.124): Create multi step animation.

Select location to save the project> enter the data tabulated in table 4.15.

Table (4.15): Multi step animation details.

Load case	Time history 1-1
Start time	0
End Time	55s (in the case of time history of 1 st load cases, it depends on the TH data uploaded and its differ from TH to another)
Frame per second	10

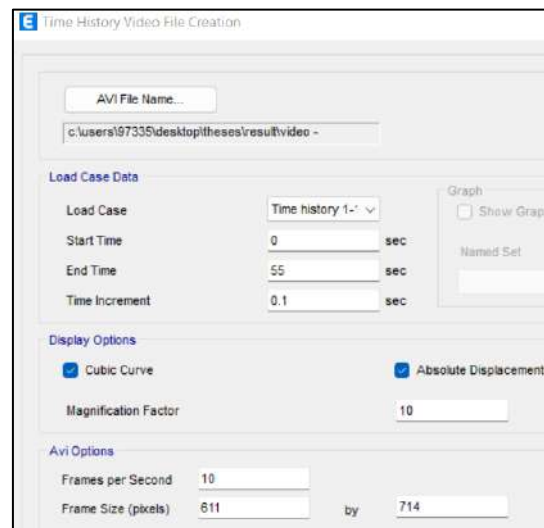


Figure (4.125): Multi step animation properties.

Then>ok> as it is shown in figure 4.125 and wait till its proceed as in figure 4.126 and saved.

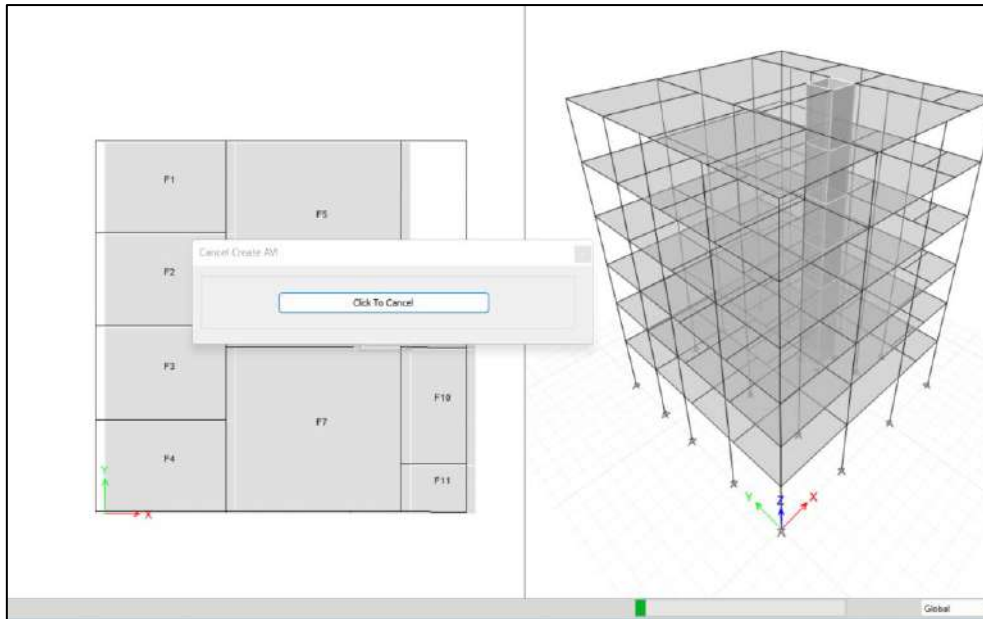


Figure (4.126): Multi step animation under processes.

The structure as it's shown in the video in figure 4.127, vibrated or Shaked in 2 direction X and Y. since it have already considered the two horizontal component of each earthquake U1 and U2. This is the deformation of the structure for the whole duration of earthquake 55 seconds for Time History load case No. 1.

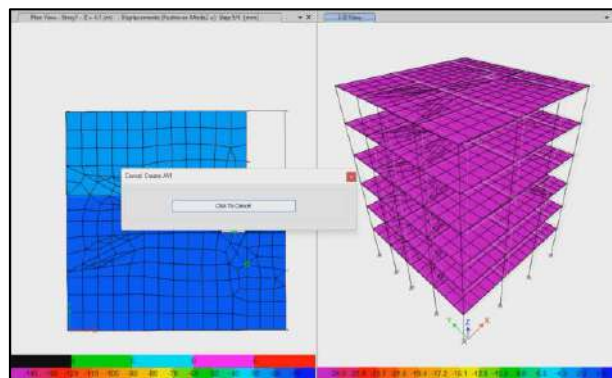


Figure (4.127): Video created for the run time history analysis.

It is possible also to see the effect of the applied earthquake on the forces and moment on members as (local level) or as a whole structure (global level) and create an animation for any response. For example, the shear in beams, bending moment in column. Video file in that response will be converted into a video for the whole duration of ground motion.

Let us make, for example, Force on the reactions (Support).

As it is shown in figure 4.128, go to display> force/Stress Diagrams
>Support/Spring Reactions

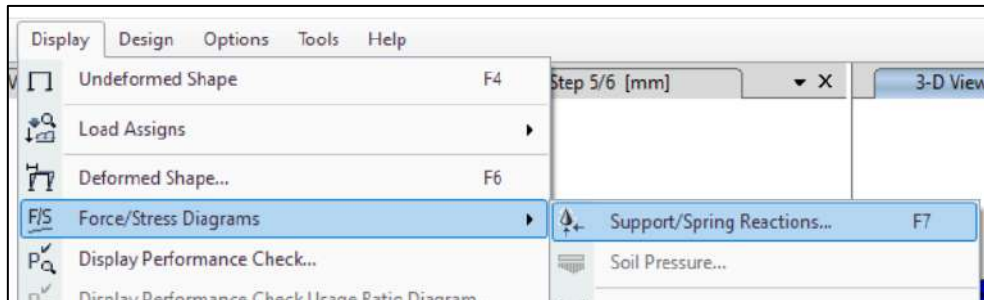


Figure (4.128): Time history result – Support reactions.

Then, select the time history load case want to be studied, let us say 1-1, as shown in figure 4.129, select the type of reaction want to be displayed, which is Fz in this case (The vertical force applied to the building Supports)

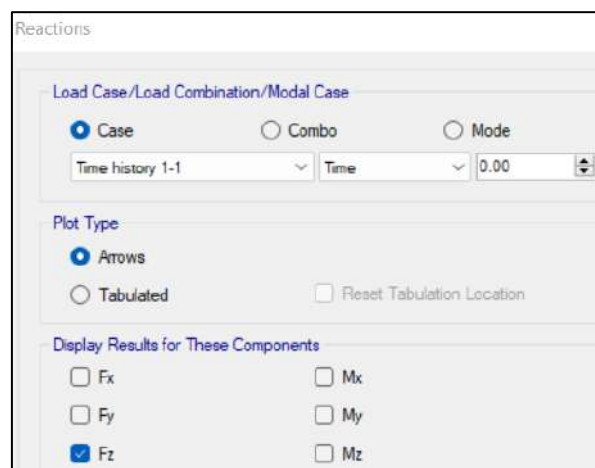


Figure (4.129): Time history result – vertical support reactions.

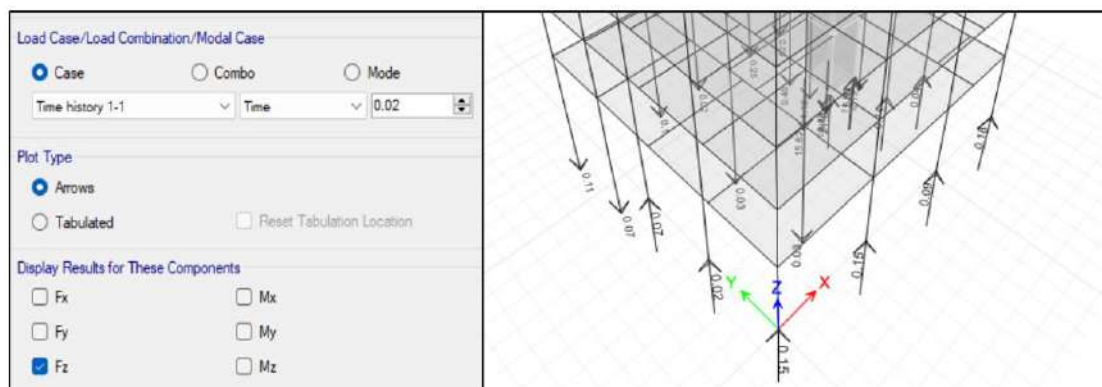


Figure (4.130): Vertical support reaction at time = 0.02s.

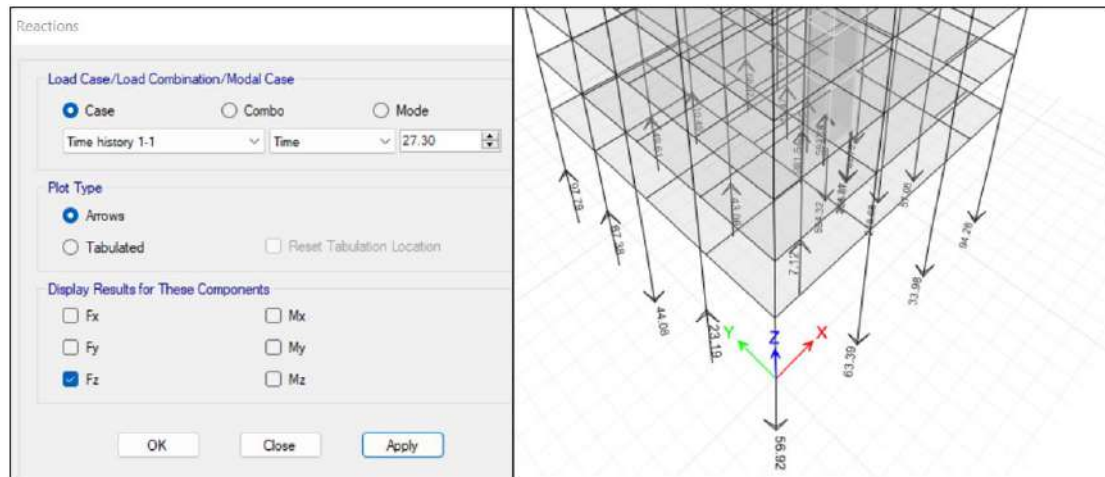


Figure (4.131): Vertical support reaction at time = 27:30s.

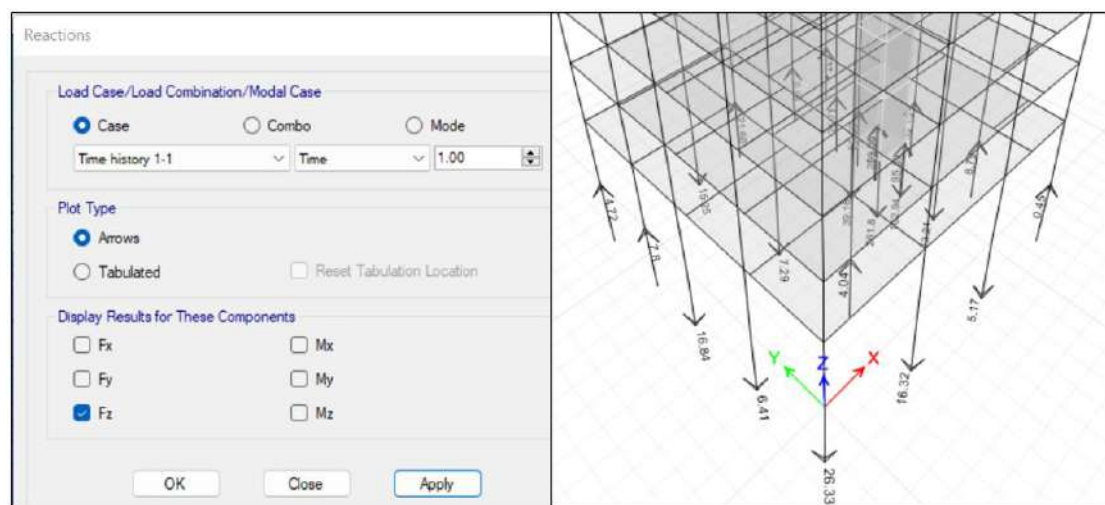


Figure (4.132): Vertical support reaction at time = 1.00 s.

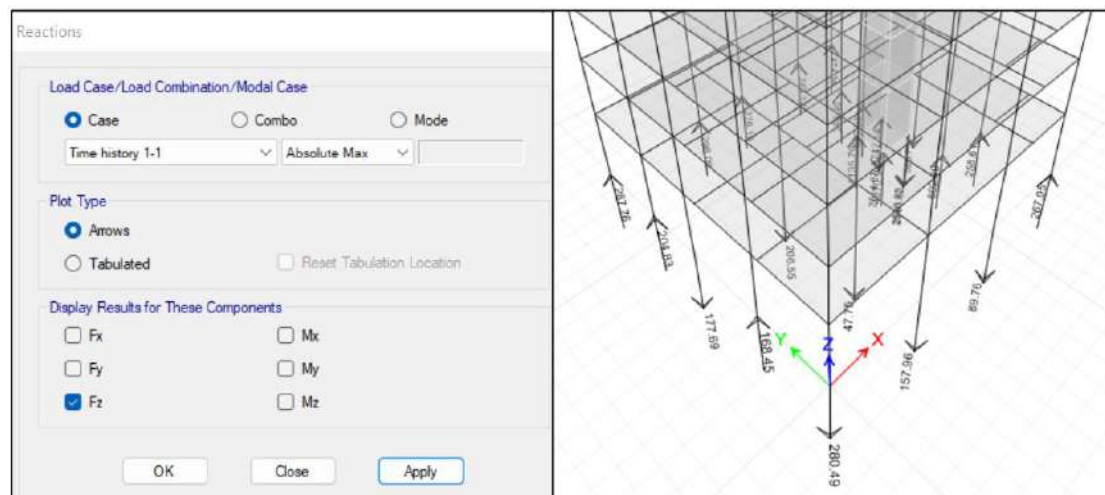


Figure (4.133): Vertical support reaction at absolute max time.

Amount of shear force can be displayed in different time intervals, as it is shown in figure 4.131. As it's shown in figure 4.130 at $t=0.02$ s, figure 4.131 at $t=27.30$ s, figure 4.132 at $t=1$ s and figure 4.133 at $t=\text{maximum time}$.

Vertical forces on the support have changed as shown in table 4.16 as follows:

Table (4.16): Vertical support reaction at different time intervals.

$t=0.02$ s	$F_v = 0.15$ kN
$t= 1$ s	$F_v = 26.33$ kN
$t=27.30$ s middle duration of earthquake	$F_v = 56.92$ kN
$T=$ maximum value of shear calculated	$F_v = 280.49$ kN

Values of F_v at each time interval can be checked by clicking next to go to the next value of F_v . Similarly, A video of the changes of F_v values can be created, by going to file> create a video> Multi-step Animation.

Same animation for any response or result can be displayed, for example shear in beams.

Go to display> force/Stress Diagrams >Support/Spring Reactions. As shown in figure 4.134 and 4.135.

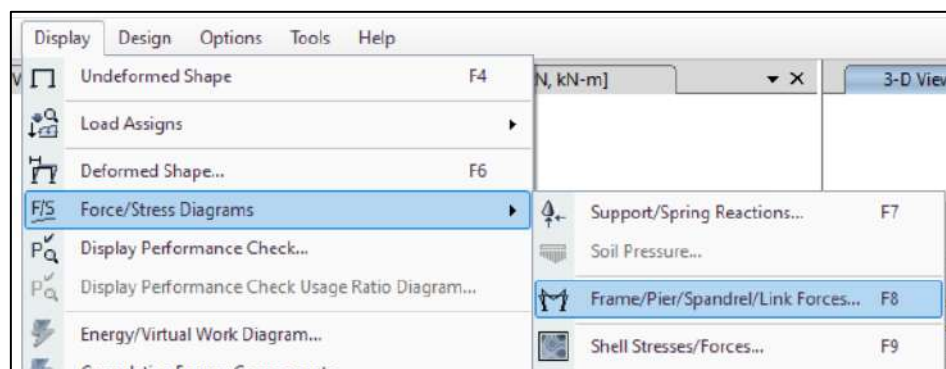


Figure (4.134): Time history analysis result – Forces/moments.

As shown in figure 4.135, at time $t=0.34$ s, this will be the shear forces at beams.

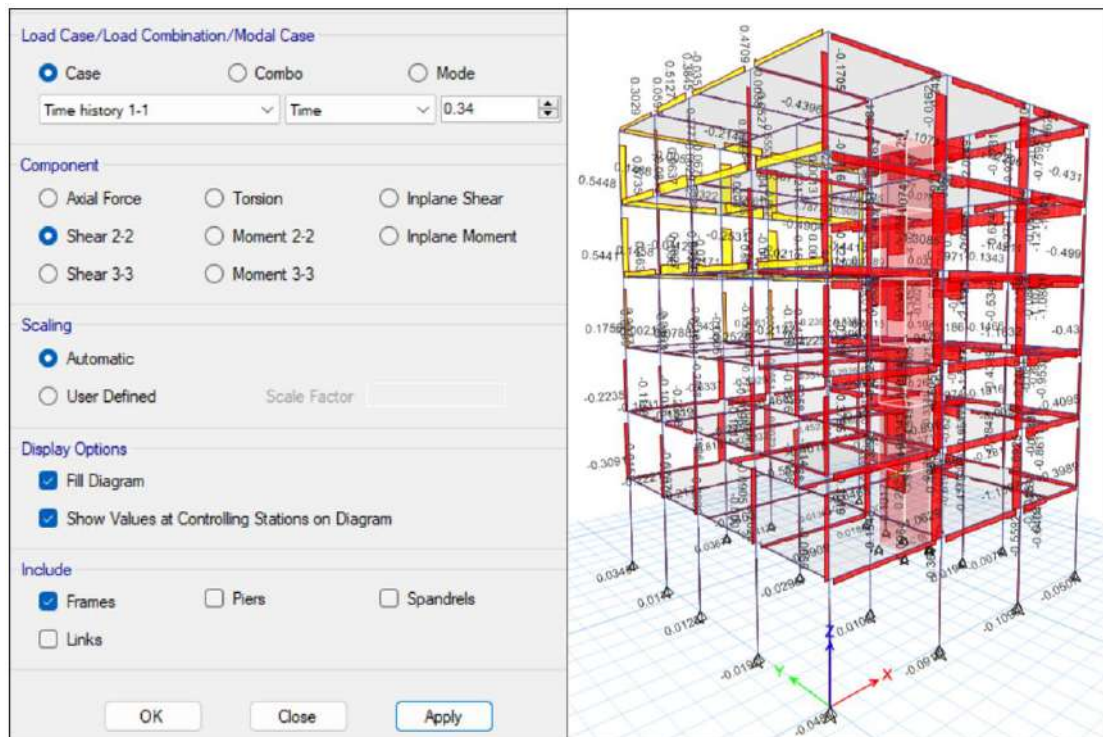


Figure (4.135): Time history analysis result – Shear forces variations for time history analysis 1-1 at $t=0.34s$.

A video of the changes of shear moment on the beam can be created by going to file> create a video> Multi-step Animation. As shown in figure 4.136.

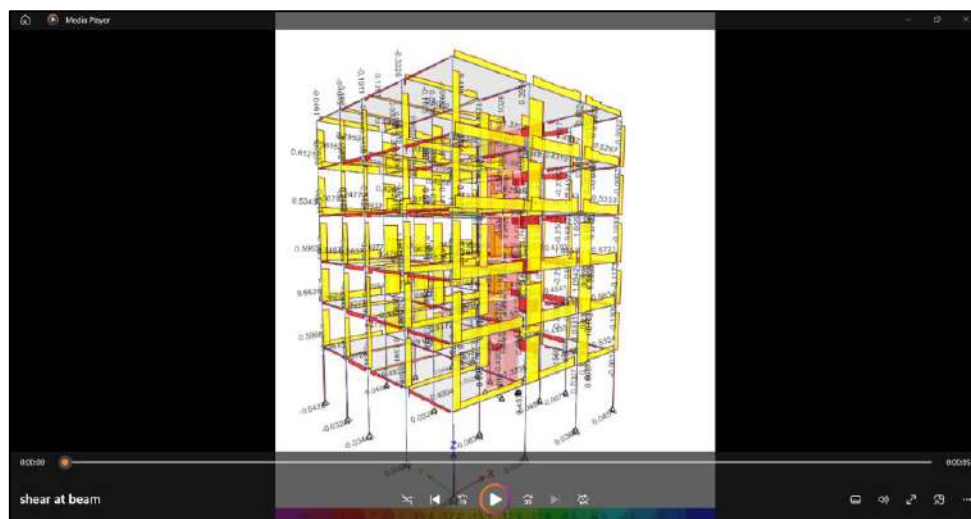


Figure (4.136): Animation of time history analysis result – Shear forces variations for time history analysis 1-1.

Shear force and bending moments of individual elements can be displayed at any specific time during the earthquake period, as it's shown in the figure

4.137 and figure 4.138 below. By right click the member need to be studied.

For beam:

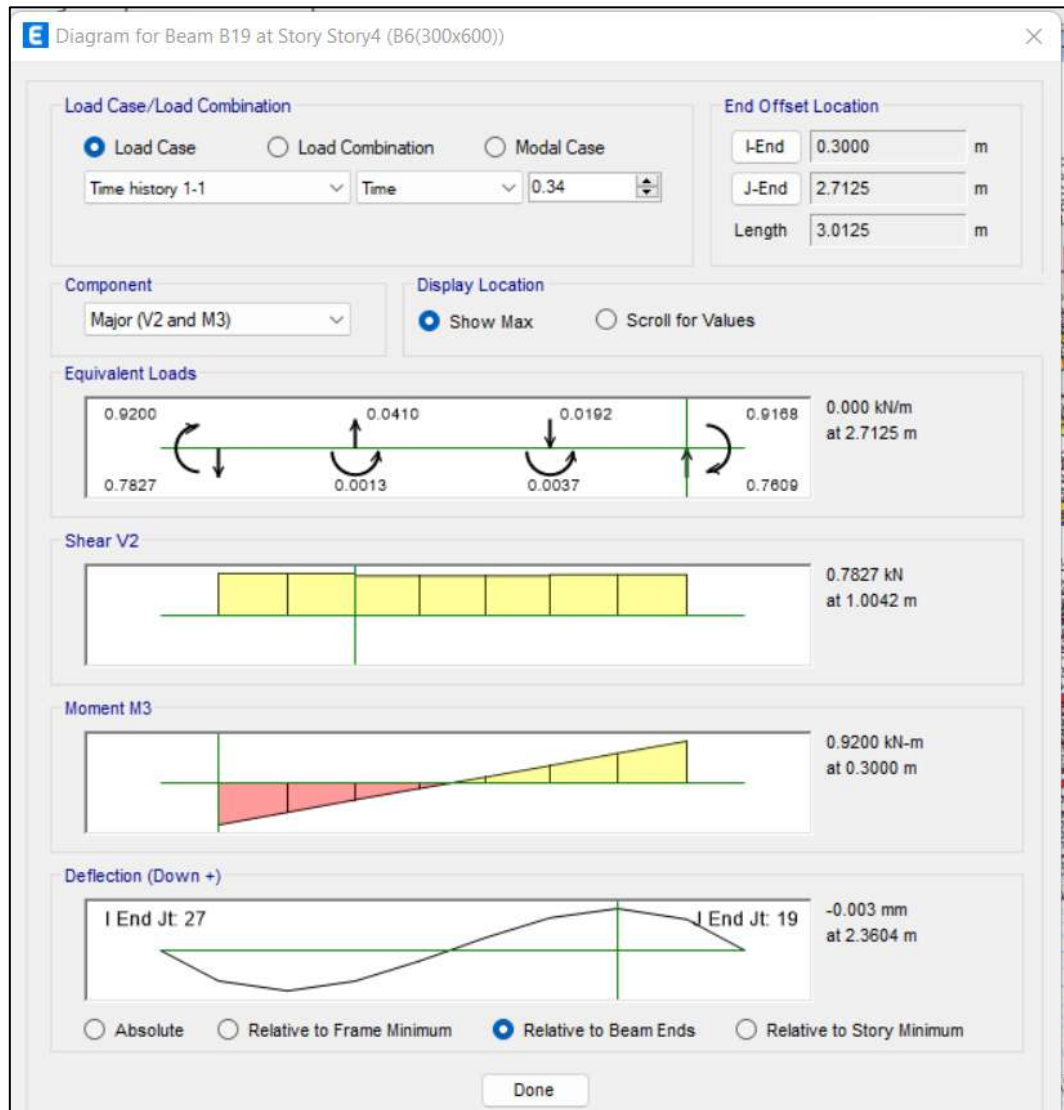


Figure (4.137): Time history analysis result of beam 19 – Forces, moment, deflection variations for time history analysis 1-1

And column

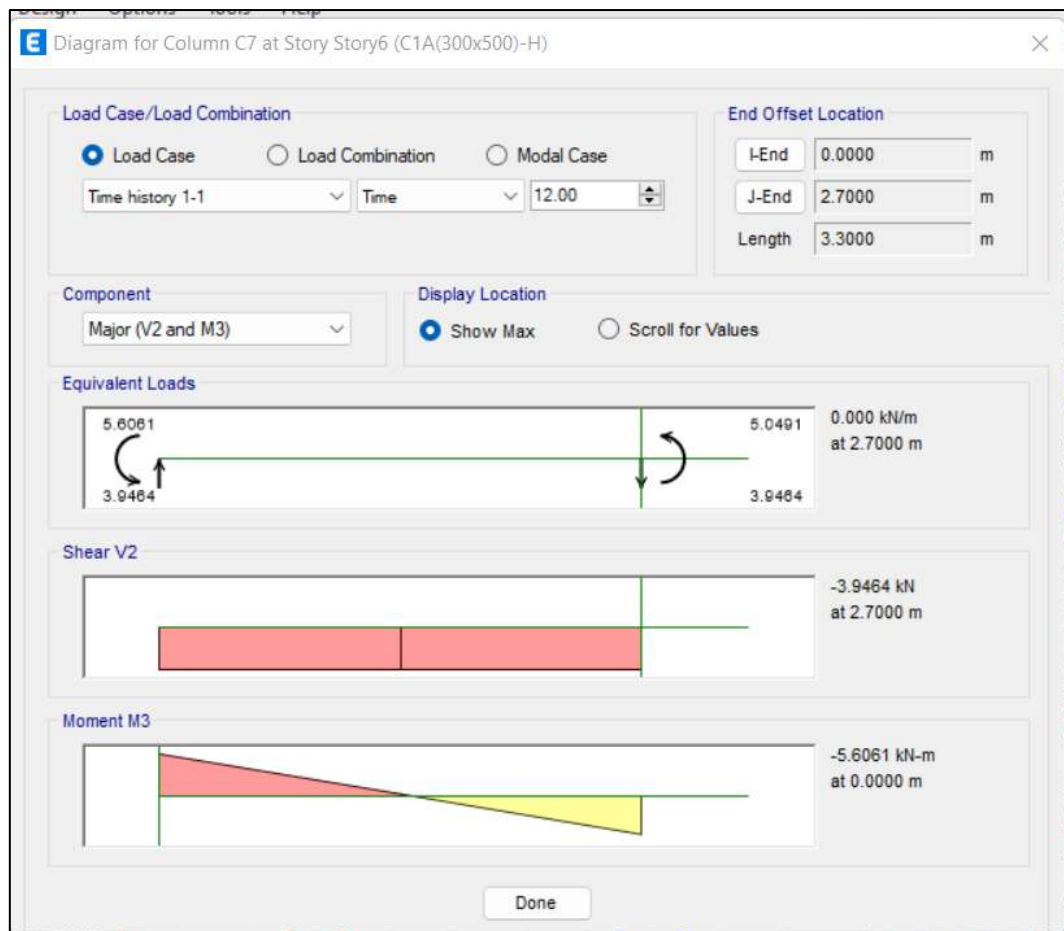


Figure (4.138): Time history analysis result of column7 at story 6 – Forces, moment, deflection variations for time history analysis 1-1

Similarly, same can be applied for moment at columns and beams as figure 4.139.

Moment diagram M33 at 0.34secods of the earthquake

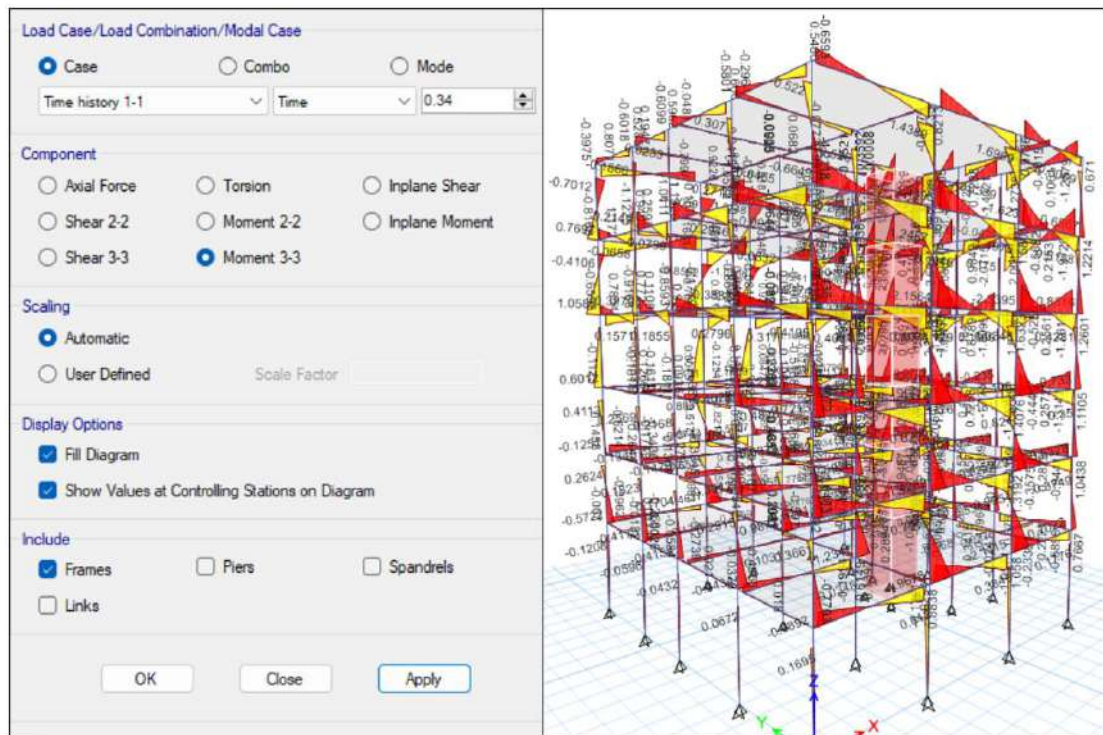


Figure (4.139): Time history analysis result of structure – Moment 3-3 at t=0.34s.

And then creating video records of the changes of moments with time, as shown in figure 4.140.

In the 3D view as well as in the elevation in figure 4.140.

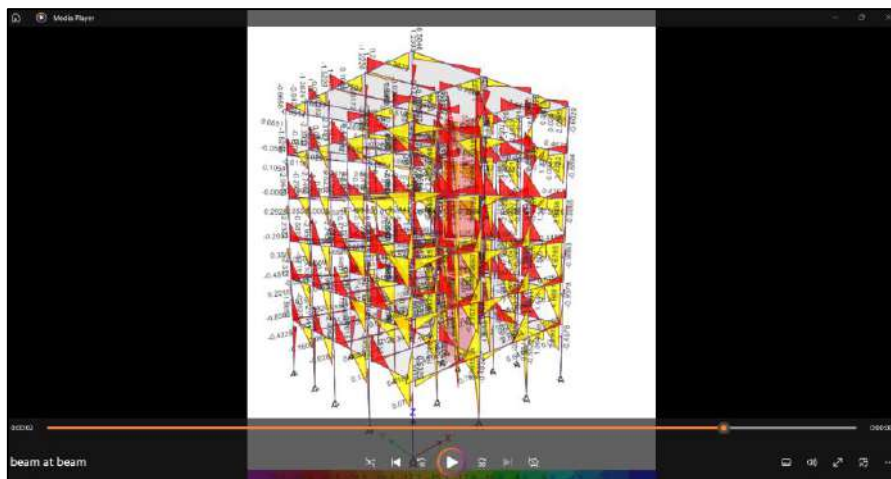


Figure (4.140): Animation of time history analysis result – Moments 33 variations for time history analysis 1-1.

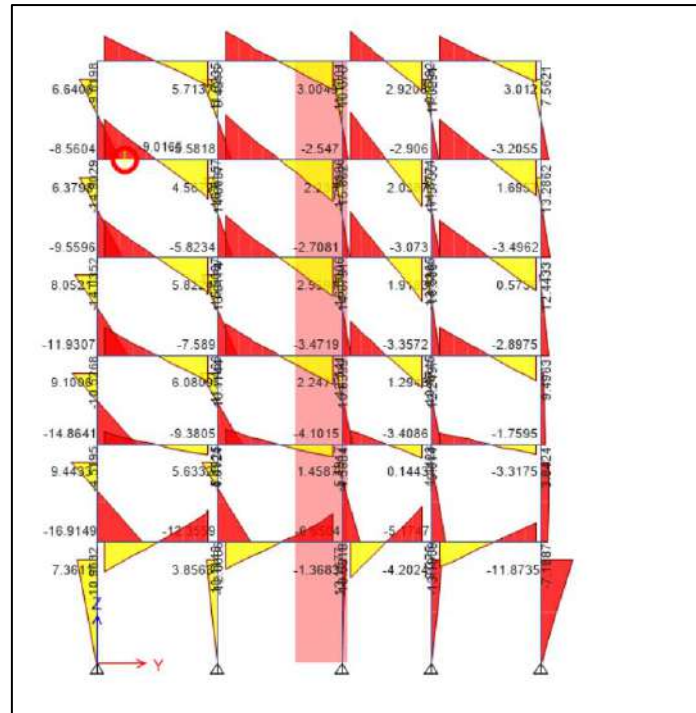


Figure (4.141): Elevation view of time history analysis result – Moment 33 variations for time history analysis 1-1.

Now let us see the result of shear wall:

After selecting the shear wall and make them visible only.

Go to Display>Force/stress Diagrams>shell stresses/forces. As shown in figure 4.142.

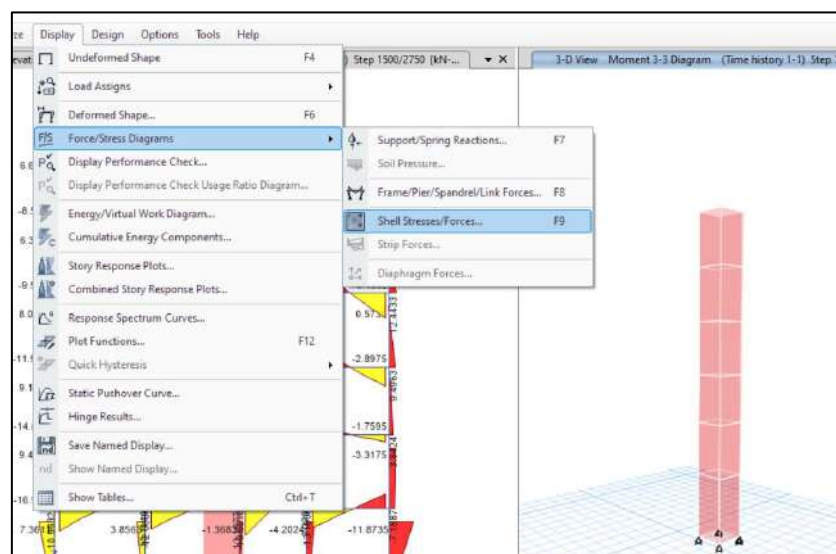


Figure (4.142): Display wall force/stress for shear walls.

Select the time history load case (here is 1-1) and select the type of force (here F11 is selected with mean in plane force). Refer to figure 4.143.

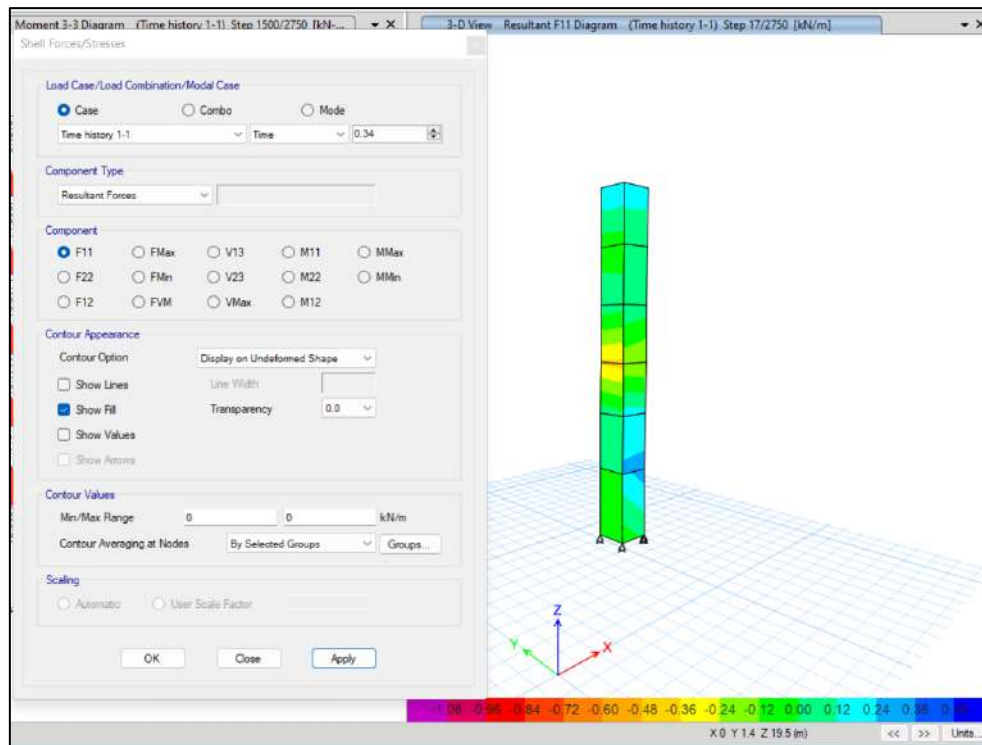


Figure (4.143): Shear force of time history analysis 1-1 at $t=0.34s$ for shear walls.

And then motion video of the same can be created, as shown in figure

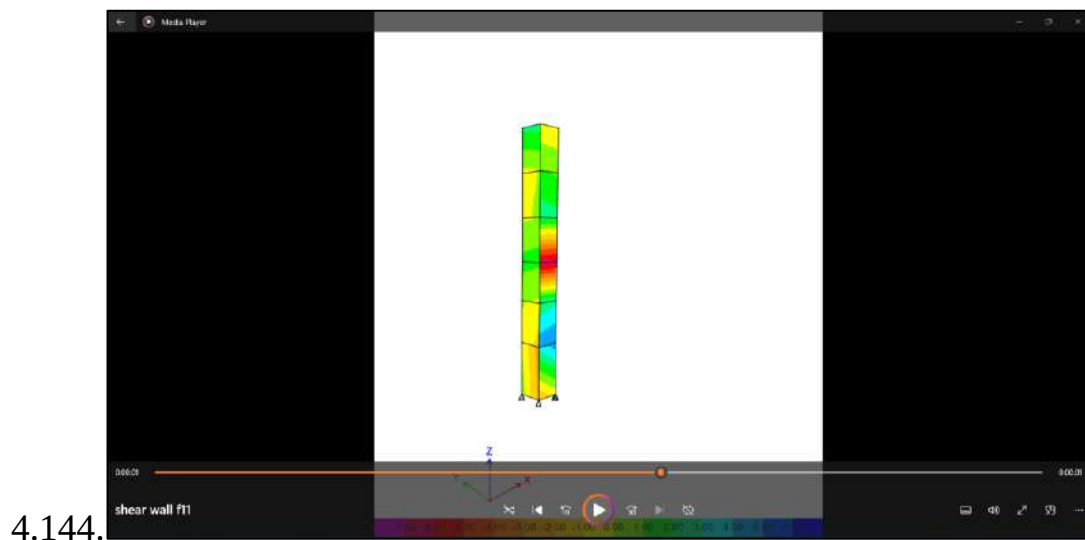


Figure (4.144): Animation of time history analysis result – Shear forces variations for time history analysis 1-1.

Other response is the story response plots which is an important option. As it is shown in figure 4.145. Here it is shown the story level responses, the global responses.

Display>Story Response Plots

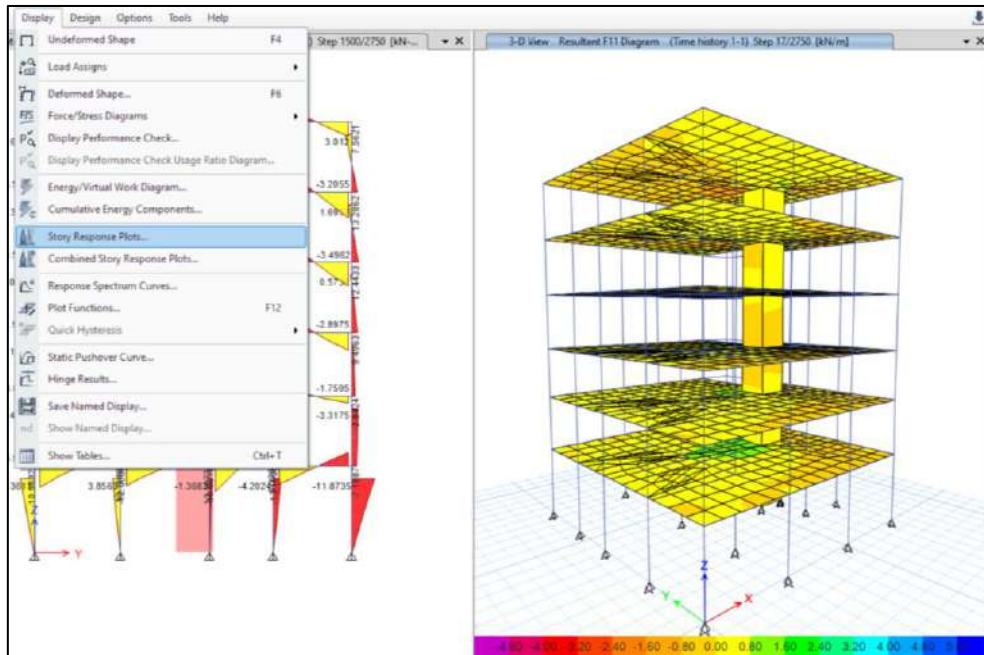


Figure (4.145): Display story response plot.

In the story response, many options are available to display the result which are represented in figure 4.146.

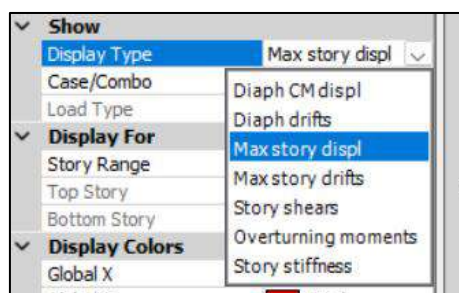


Figure (4.146): Display types for story response plot.

There can be an option for maximum story displacement diaphragm, center of mass displacement, diaphragm, drifts, maximum story drifts, story shears, overturning moment, and story stiffness. All these are considered as a global response. But now it can be seen as time history case. As shown in figure 4.147.

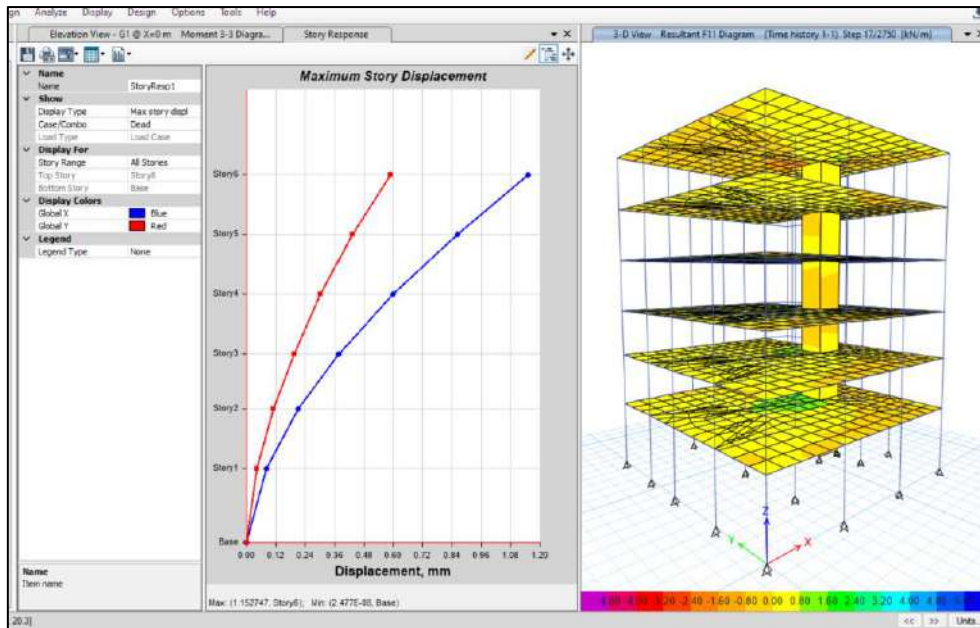


Figure (4.147): Maximum story displacements.

If, for example the story shear needs to be studied, select the time history load case, and specie a particular time step at which it is needs to see the story share profile, due to change of base shear at every time interval. As shown in figures 4.148 and figure 4.149 below, the story shear response at $t=5s$ and $10s$, in X direction represented in blue color and Y direction in red color.

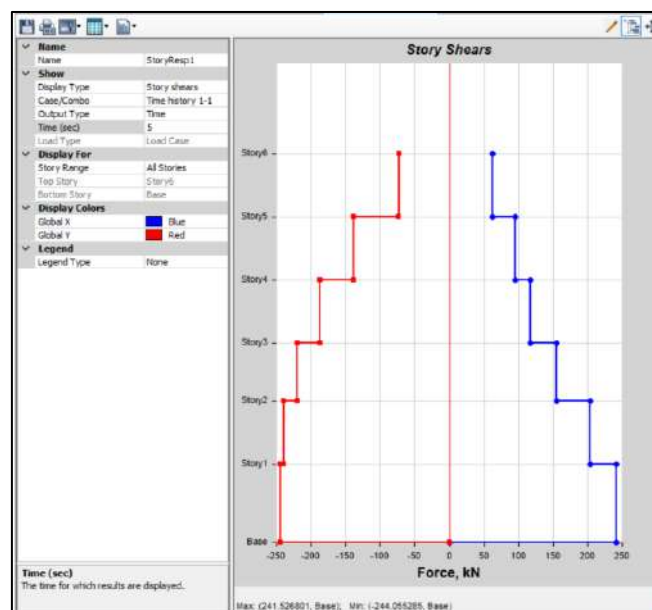


Figure (4.148): Story shear for time history analysis 1-1 at time=5s.

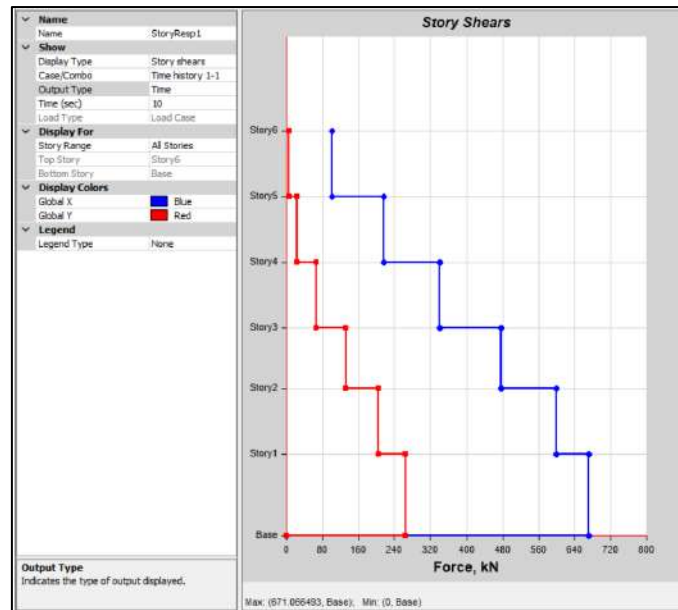


Figure (4.149): Story shear for time history analysis 1-1 at time=10s.

Similarly, the same for all other story response can be applied.

Another very useful animation which software automatically creates is for global responses is combines story response plots. As shown in figure 4.150 below.

Go to Display>Combined Story Response plots.

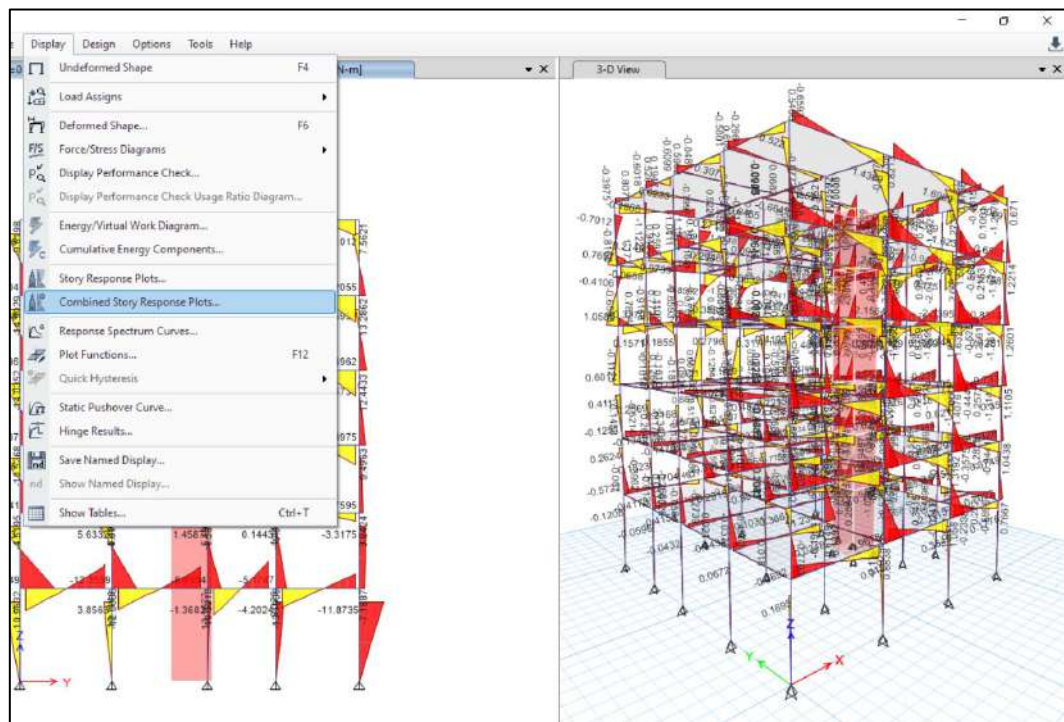


Figure (4.150): Display combined story response plots.

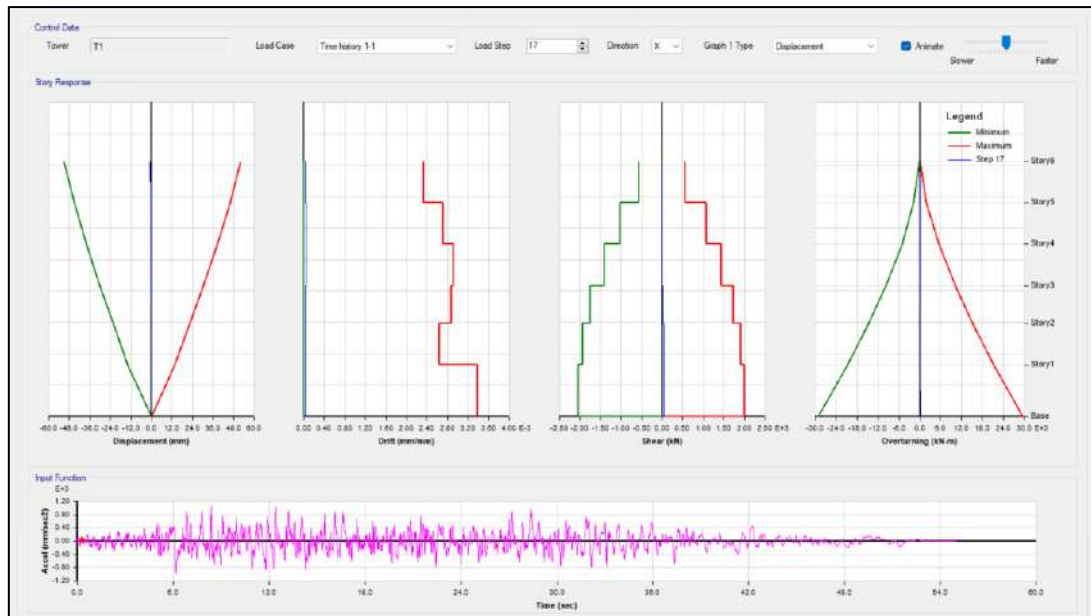


Figure (4.151): Combined story response plots for time history analysis 1-1.

It will display like it is shown in figure 4.151, this kind of an animation. Where at the bottom will show the earthquake, the original input function, and at the story responses, which is the story displacement, story drift, storage shear and story moment fluctuating. The blue line is the figures represent values of the global responses, and the red and green lines represent the maximum values which are achieved during the whole earthquake duration, which is 55 seconds in this case. It can be noticed that all the responses start from zero and as the earthquake start going close to the peak values, that when there is a peak shear, there may not be peak in story moment. The time corresponding to peak story moment can be different than peak shear and their algebraic science can also be seen because the actual values are fluctuating between positive and negative. Sometimes one response is in positive direction, the other response is in negative direction. Other options are available in this animation can be used to serve the field of research depend on the performance objective, such as change its speed, Select other load cases etc.

The response spectrum curve can be obtained. it extracts the acceleration response, acceleration at a particular joint or node and then creates the

response spectrum for that acceleration. the response can be seen of a particular acceleration signal or acceleration values, at a particular joint or at a particular node, as a result of the earthquake. plot can be drawn between peak spectral acceleration or any other response spectrum quantity and other damping ratio. This is very useful output, sometimes used in the seismic loss estimation.

As it is shown in figure 4.152, go to display>Response spectrum curves, and it will draw same as shown in figure 4.153

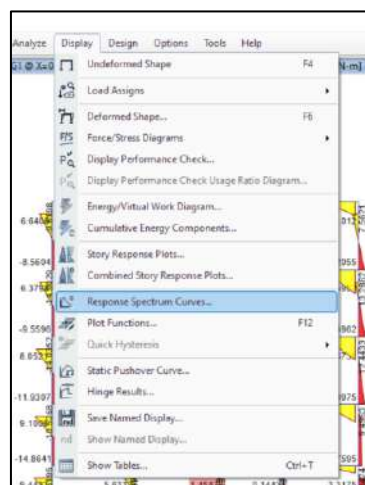


Figure (4.152): Display response spectrum curves.

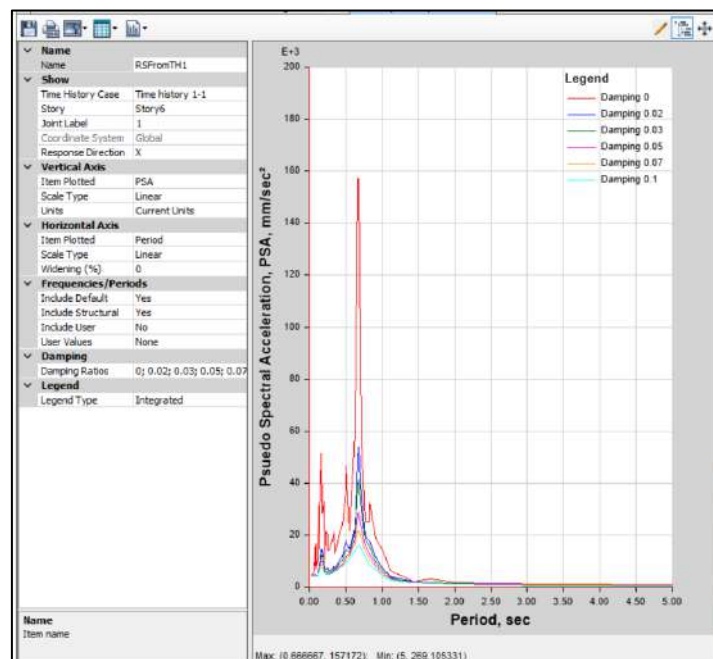


Figure (4.153): Response spectrum curves of story 6 for joint label 1.

There are many options for plotting functions. Plot any result as a function of time for any other quantity. A graphical variation of a particular response as a function of time can be seen and studied in detail. For example, the roof drift value, roof displacement value or base shear value as a function of time, it can be plotted it directly, as shown in figure 4.154. Although it can also extract the values and plot it manually using other programs, but it can be plotted it directly in ETABS.

Go to display>response spectrum curves

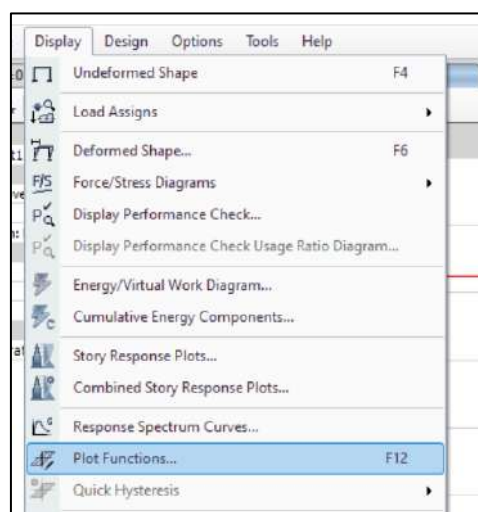


Figure (4.154): Display plot functions.

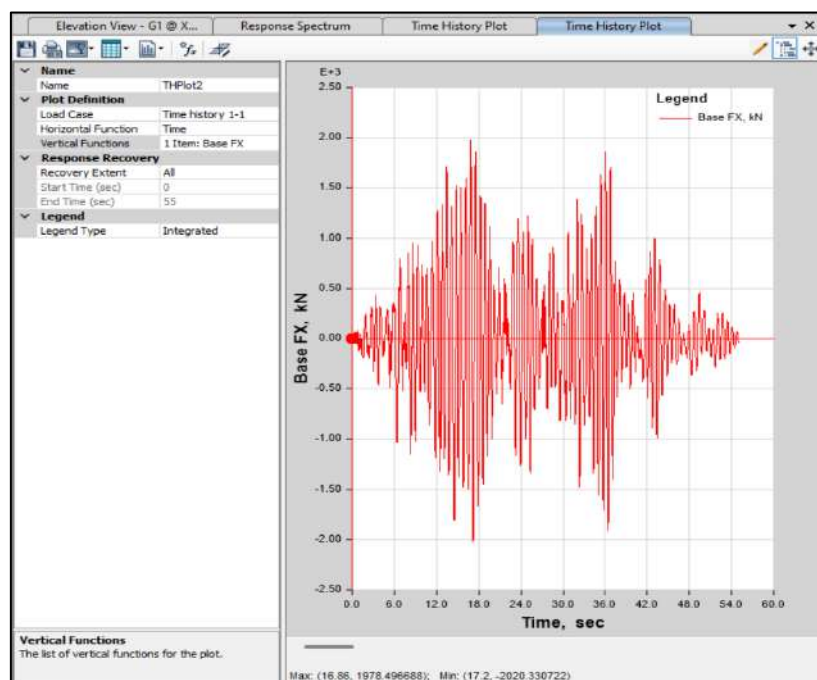


Figure (4.155): Plot functions- Base shear as a function of time.

Let us consider for example, the base shear value in y direction, is plotted as a function of time in x direction, under Time History load case 1-1, as it is shown in figure 4.155. It can be plotted any vertical or horizontal function.

Go to horizontal Function > press the function icon shown in the left-hand side.

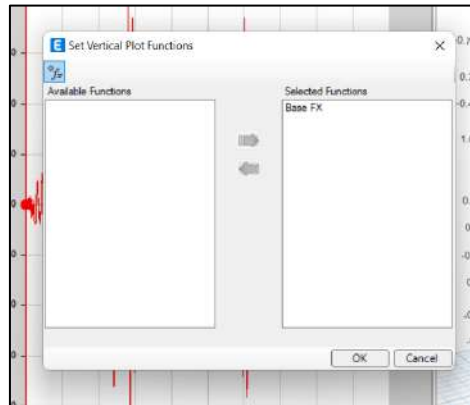


Figure (4.156): Add a horizontal Function.

Here any function needs to be studied, can be plotted a function between each other, as shown in figure 4.156.

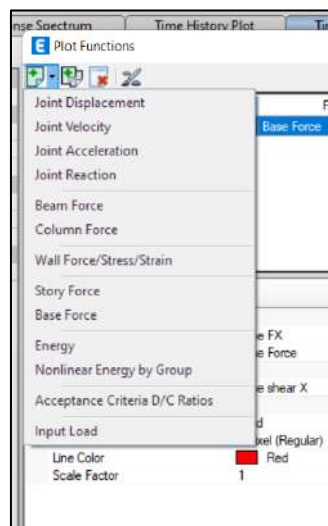


Figure (4.157): Options to add any horizontal parameter as a function of time.

For example, Joint displacement, select the same icon shown in figure 4.157, then select the story Number= story6. Select the joint number that needs to be examen or analysis:1. Select direction: Ux mean at x direction. As shown in figure 4.158.

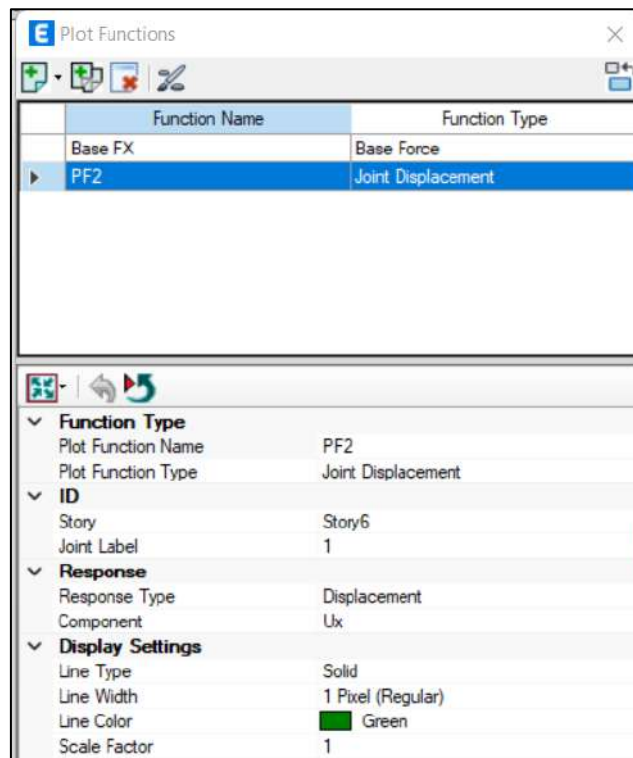


Figure (4.158): Details options for horizontal parameter.

Then add it to the selected function and remove the Base F_x , as shown in figure 4.159.

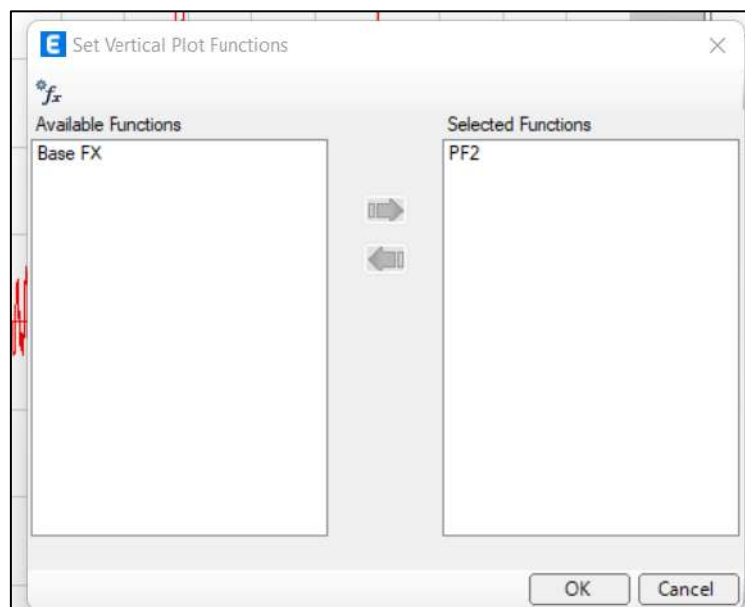


Figure (4.159): Adding and removing of horizontal axis parameter.

Now the joint displacement of joint No.1 at 6 story level is plotted as a function of time.

Finally, numerical values of all the responses can be tabulated in one table or one report, as it is shown in figure 4.160.

Top show table, got to display>Show table



Figure (4.160): Display the result as a tabulated form.

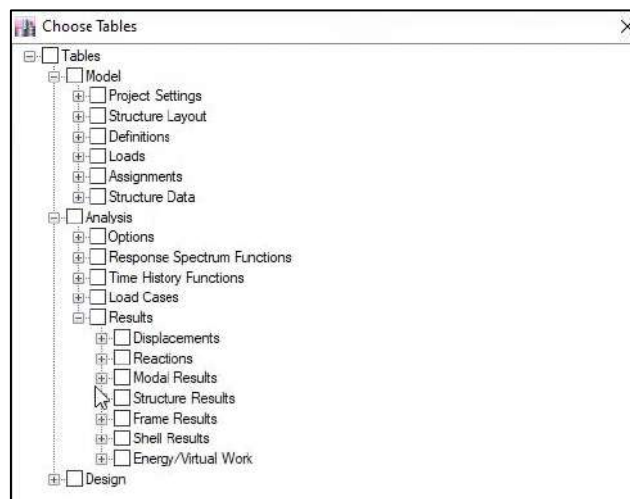


Figure (4.161): Selection of result to be shown as a table.

As it is shown in figure 4.161, three options can be displayed. First is the modal which will show the basic inputs, the information and definitions about the model itself. Second is the analysis option that will display all the analysis results of load cases that have been defined (load patterns, time history functions, the results displacements, reactions, model results, structure results mean the global level results, story level results, Frame results, shell results etc.). Finally, the third option is design, the tabular

form of the data will be available, data for different load cases for different directions can be sorted out and finally copied to Excel and plotted.

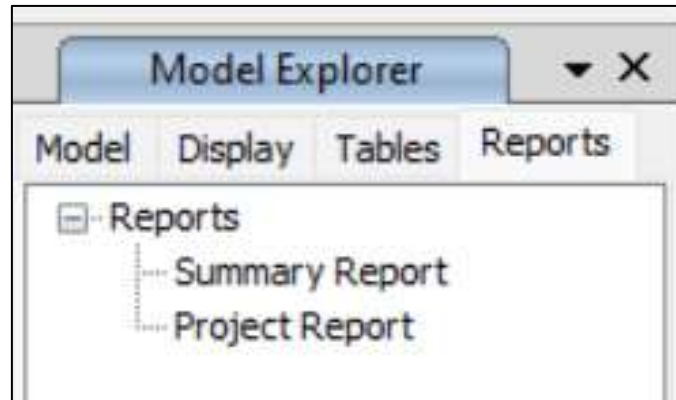


Figure (4.162): Download the summary and project reports option.

As Shown in figure 4.162, the design reports are as follows:

1. Summary Report – shown in figure 4.163

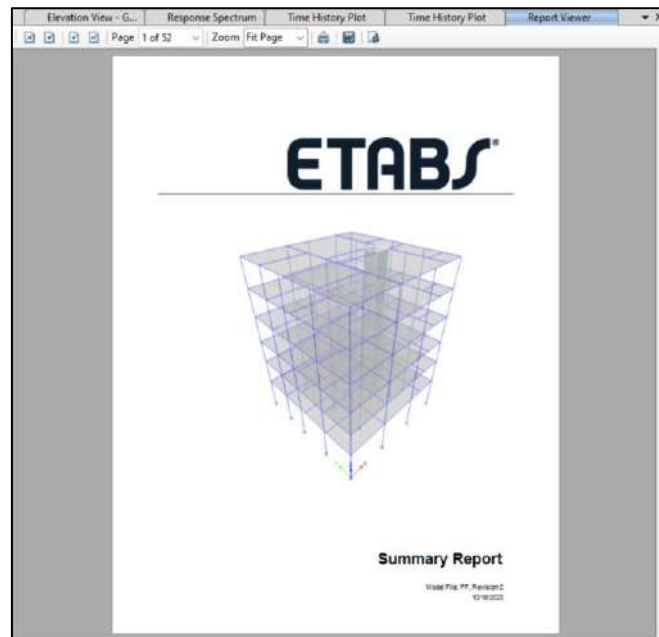


Figure (4.163): Summary report.

2. Project report - Shown to figure 4.163.

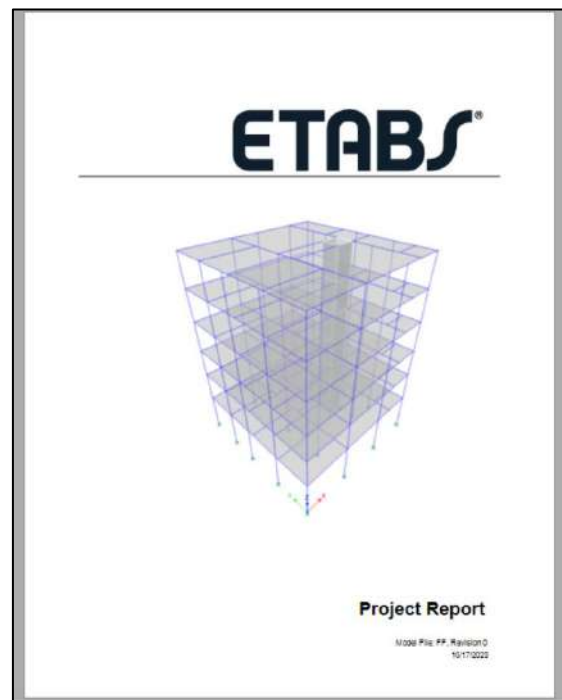


Figure (4.164): Project report.

Project report has presented in detail in appendix (2).

As a summary of Nonlinear Time History Analysis results, the first elements that has been collapsed or failed was the beam at ground floor, as it is shown in the figure (4.165) below, at step no. 4 , since we have defined the step that its represent 10sec, that mean after 40 seconds of earthquake the beam failure has happened, as it is shown in figure (4.166)

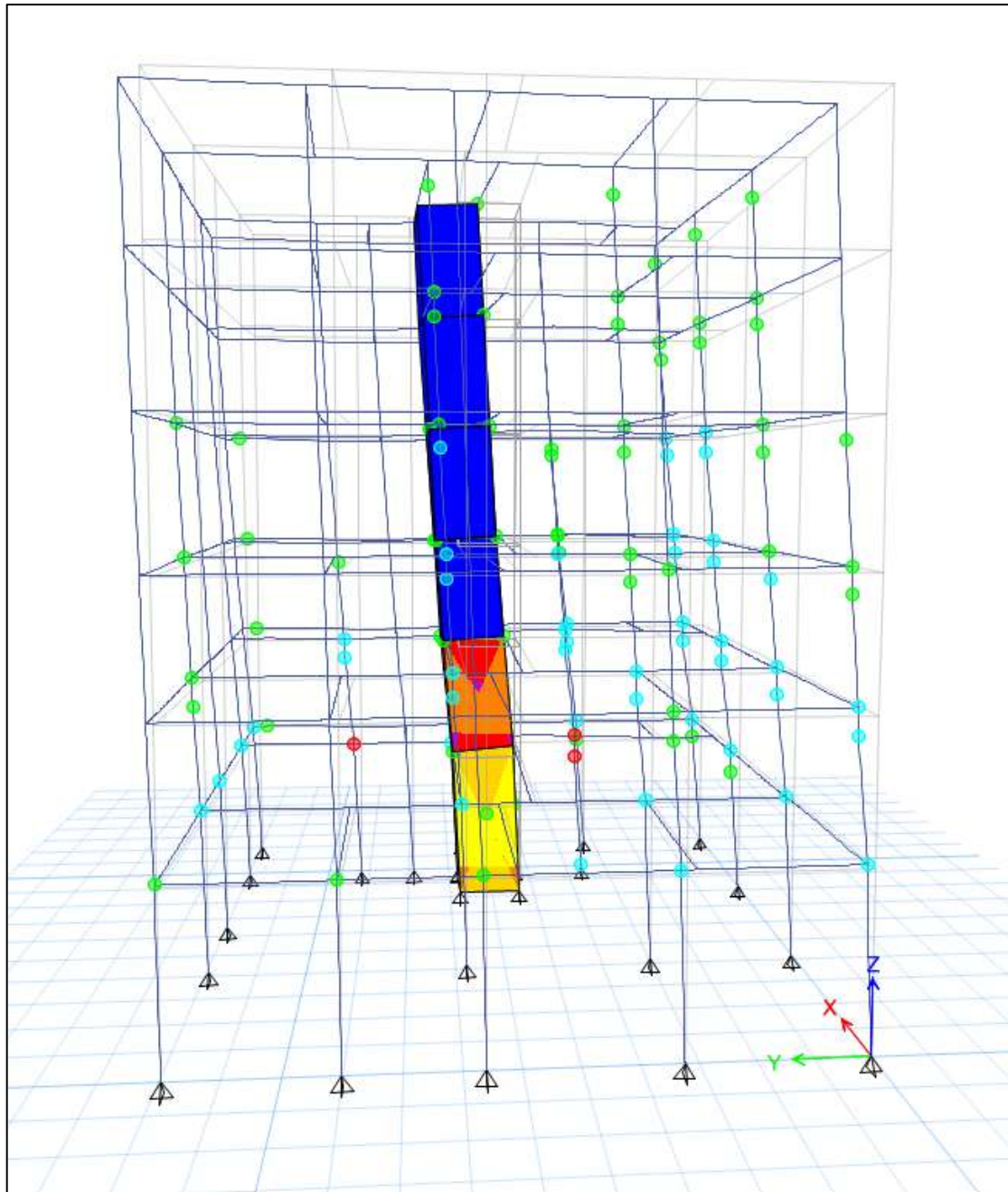


Figure (4.165): beam failure – NLTHA.

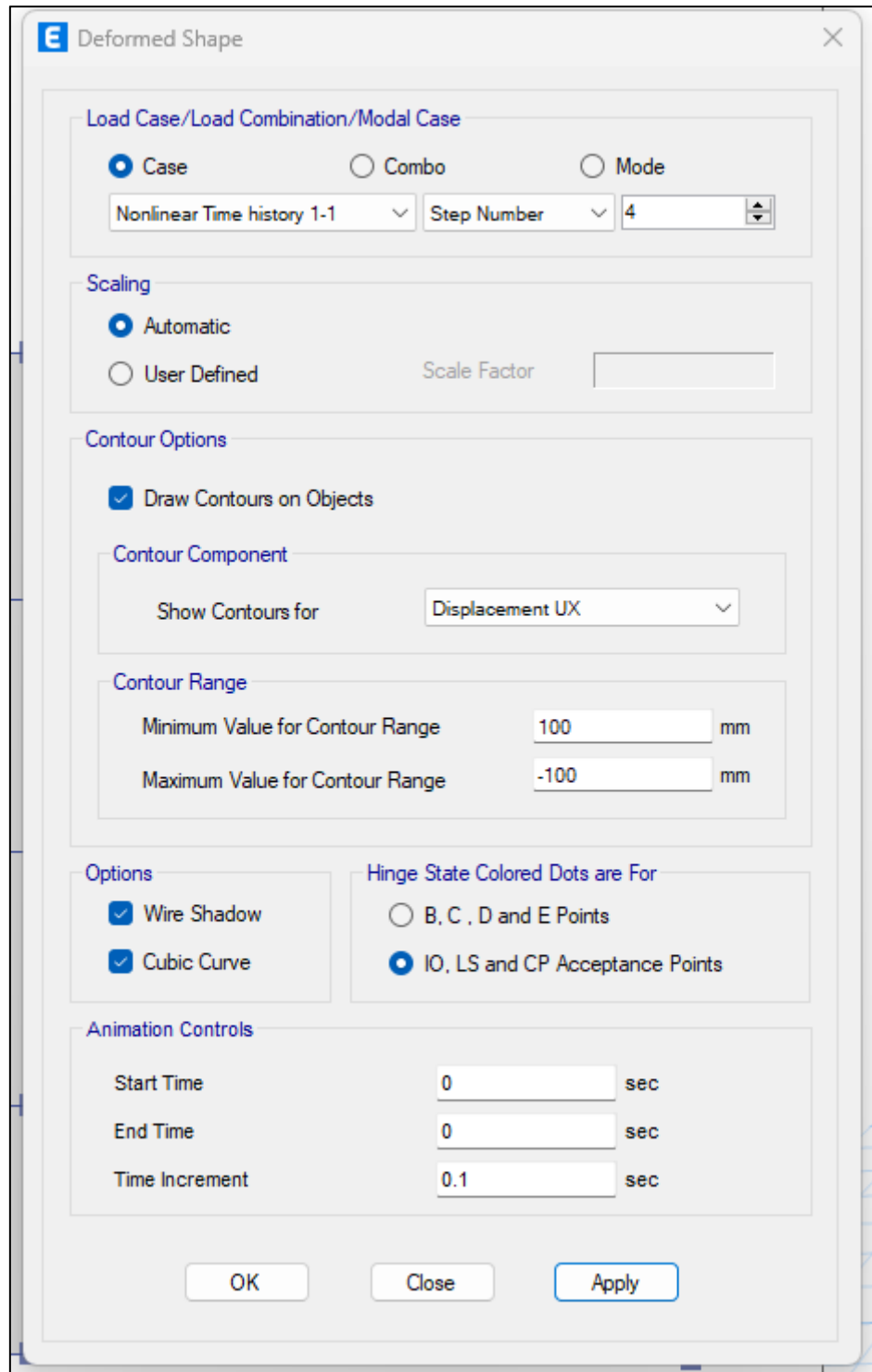


Figure (4.166): Display the result of Nonlinear Time History Analysis as Deformed Shape.

The applied load at 40s of earthquake in the failed beam was 1.7426kN, as shown in figure 4.167, the maximum shear force was -8.5kN, and maximum moment was -5. 4655kN.m, as shown in figures 4.168 and 4.168 respectively.

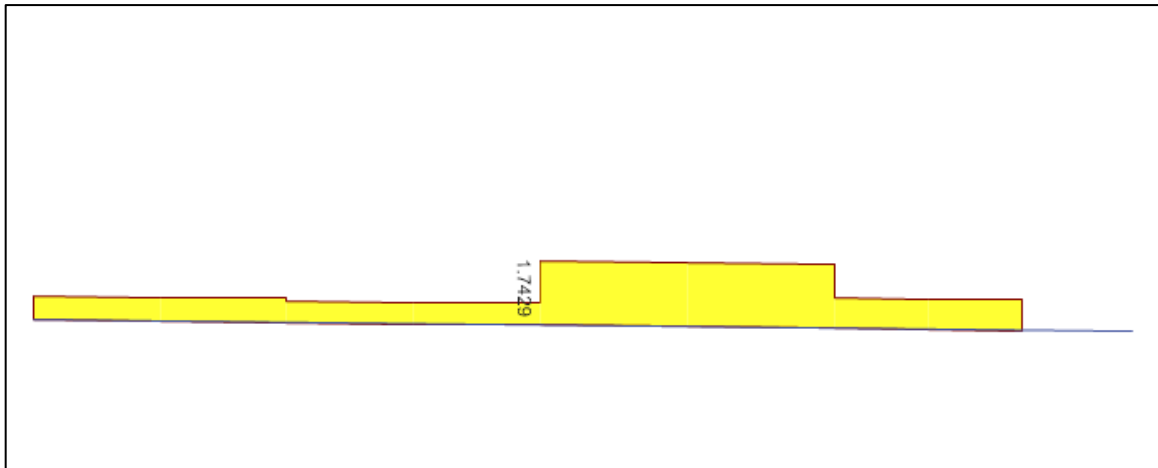


Figure (4.167): Applied axial force on failed beam.

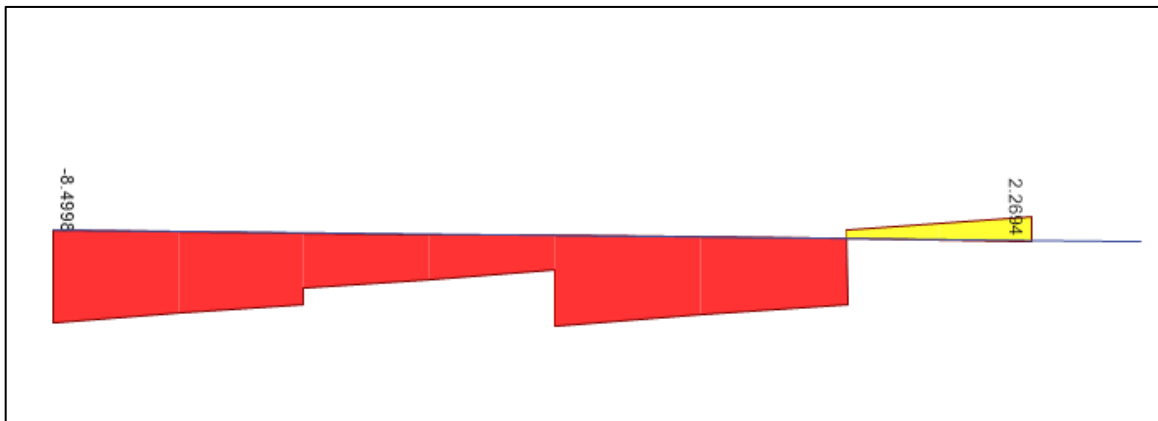


Figure (4.168): Shear force diagram of failed beam.

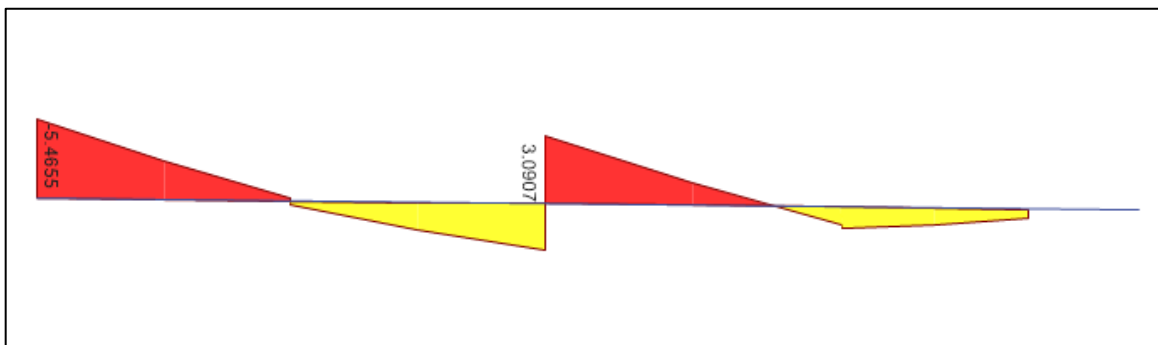


Figure (4.169): Bending moment diagram of failed beam.

A redesign of this particular beam needs to be redesigned to withstand these loads and moments.

Chapter Five

Conclusion and Recommendations

5.1 CONCLUSION AND RECOMMENDATIONS

At the conclusion of this research, one can see that it is possible to predict, or rather anticipate and monitor, the movement, and dynamics of the building at any specific time during the earthquake. This means that the loads or moment applied to any element in the building can be studied and thus designed so that it can resist falling or failing for a certain period. Or to a certain degree of collapse or even by a percentage determined by the owner or the decision maker. Then linking it to any other factors such as the repair cost of the building after the earthquake, the financial losses resulting from its occurrence, and so on.

By comparing the results obtained from the two analyses, it became apparent that the causes of the collapse differed, as the cause of the collapse in the Push-Over analysis was due to a column at first floor, while in the Time History analysis it was due to the beam at ground floor. However, through the analysis, we find that both results are logical and close, as both results are located in almost the same area, meaning that the elements at that area must be strengthened or redesigned. The results differ between the two analyses happened because in the Push-Over analysis, the building is subjected to gradual forces until the building collapses, without taking into account the effect of changing forces intensity as in the Time History analysis.

Given that it is not possible to predict the occurrence of earthquakes with 100 percent accuracy, and it is not possible to apply a real horizontal movement to test the result on the building. in terms of applying the same earthquake force to study it, but observing and studying previous records

of earthquakes, their characteristics, their aftermath, and their effects, made ones understand more the nature of earthquakes and the buildings' response to them, including, for example, what was applied in this research, the safety of site on which the building will be built must be studied first in terms of the safety of the soil and its distance from the limit of the tectonic plate, and then recordings of more than seven (7) earthquake records that correspond to the characteristics of the site to be stabilized are taken, and the movement of the ground is adjusted to match the expected movement of the site's land. All of them helped bring the accuracy of analysis and design closer to reality.

Based on this study, we recommend the following:

Establish a special building code regarding the design of buildings during earthquakes, and not just rely on guidelines and instructions, so that it become mandatory to apply, especially on countries that are frequently exposed to catastrophic earthquakes, and those near the boundaries of tectonic plates.

We also recommend developing the current building codes, considering non-linear analysis, by applying a safety ratio that is calculated in a specific way depending on the degree of danger of the expected earthquakes, or the calculation of check is increased to cover the safety during earthquake.

Therefore, it certainly helps the structural engineer to design the building in a way that preserves the safety of lives first and foremost, and then the public and private property.

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Appendix (1)

Appendix 1 Title: Structural design calculations details.

Appendix 1 Content:

1.1 Basic data

1.2 Load summary

1.2.1 Dead loads

1.2.2 Live load (LL)

1.2.3 Super imposed dead load (SIDL)

i. Wall load

ii. Stair load

1.3 Basic load cases

1.4 Load combinations

Appendix (2)

Appendix 2 Title: Structural design report

Appendix 2 Content:

2.1 Structure Data

2.2 Loads

2.3 Analysis Results

Appendix (3)

Appendix 3 Title: Structural drawings

Appendix 3 Content:

- 2.4 List of structural drawings
- 2.5 General construction notes
- 2.6 Foundation plan
- 2.7 Column setting out plan
- 2.8 Ground floor plan
- 2.9 Typical floor framing plan
- 2.10 Schedule of beams, slab reinforcement schedule, schedule of footings
- 2.11 Schedule of columns

جامعة البحرين

قسم الهندسة المدنية



كلية الهندسة

أطروحة مقدمة كجزء من متطلبات الحصول على درجة الماجستير في الهندسة المدنية

عنوان الأطروحة

تقييم الاستجابة الزلزالية للمباني الخرسانية المسلحة ثلاثية الأبعاد باستخدام تحليل العناصر
المحدودة غير الخطية

إعداد

زينب خالد حسين علي

الرقم الجامعي: ٢٠١٢٢٣٧١

إشراف

د. محمد شاة علم

أستاذ

جامعة البحرين

مملكة البحرين

سبتمبر ٢٠٢٤

ملخص

يهدف هذا البحث إلى دراسة تأثيرات الزلازل على المباني الإنشائية، مع التركيز على فهم أسباب انهيار المباني. كما تسعى الدراسة إلى تحديد المواقع والأسباب المحددة للانهيار الأولي لعناصر المبنى، الذي يؤدي لاحقاً إلى انهيار الهيكل بأكمله. والهدف هو التخفيف من أو منع انهيار المباني أثناء حدوث الزلازل ، وبالتالي تقليل الخسائر في الأرواح والأضرار التي تلحق بالممتلكات العامة أو الخاصة.

تسلط الأحداث الأخيرة الضوء على فجوة كبيرة في تطبيق وفهم أساليب مقاومة الزلازل في تصميم المباني ومراقبتها والتحقق من سلامتها. وقد أدى هذا النقص إلى خسائر في الأرواح والأضرار التي تلحق بالممتلكات، مما يضع عبئاً على الدولة لإجراء الإصلاحات وجهود الاستجابة للطوارئ. لذا فإنه من المهم معالجة هذه العيوب لضمان قدرة أفضل على الصمود في مواجهة الزلازل والمخاطر المرتبطة بها.

يوضح هذا التقرير عملية تصميم مبنى وفقاً لمعيار BS8110 (النظام البريطاني) ، متبوعاً بتطبيق طريقة تحليل قائمة على الأداء. سيتم استخدام نوعين من التحليلات: نمذجة الألياف ونهج المفصلة البلاستيكية. أولاً، سيتم استخدام طريقة نمذجة الألياف للأعمدة المقواة والجدران. يتضمن ذلك تصنيف المواد (الخرسانة أو الحديد) إلى ثلاثة مستويات: الإشغال الفوري (IO) ، وسلامة الحياة (LS) ، ومنع الانهيار (CP). سيتم تقسيم أقسام الأعمدة والجدران إلى أجزاء أصغر لدراسة تأثيرات الحركة عليها.

ثانياً، سيتم استخدام نهج المفصلة البلاستيكية لمقاطع العوارض المقواة. سيتم تقسيم العوارض إلى أجزاء أصغر بناءً على هندستها، وفقاً لإرشادات ASCE41-17 ، وتحليلها وفقاً لذلك.

بعد ذلك، سيخضع المبنى بالكامل لتحليل غير خطي باستخدام طريقتين: تحليل ديناميكي غير خطي للدفع وتحليل التاريخ الزمني غير الخطي. يتضمن تحليل ديناميكي الدفع تطبيق الإزاحة الأفقية تدريجياً حتى يتم الوصول إلى انهيار المبنى. في حين يتضمن تحليل التاريخ الزمني غير الخطي إخضاع المبنى لأحداث زلزالية محاكاة. أخيراً، سيتم تقديم مراجعة شاملة للنتائج التي تم الحصول عليها من هاتين العمليتين التحليليتين.

من خلال تحليل النتائج التي تم الحصول عليها، سيتم توقع أسباب انهيار المباني أثناء الزلازل، وفي هذا البحث سيتم عرض نتيجتين تم الحصول عليهما من تحليلين مختلفين ومقارنتهما ودراستهما كما هو موضح في الفصل الرابع. عند معرفة سبب الانهيار الأولي، والعناصر التي تم تسببها في هذا الانهيار ، سيتم معرفة الحمل المطبق عليها من خلال تحليل النتائج وعليه يلزم إعادة تصميم المبنى لتحمل هذه الأحمال. بعد ذلك سيكتسب المبنى القدرة على تحمل الزلازل لفترة محددة، والتي يمكن تقديرها. علاوة على ذلك، يدرس هذا التقرير عوامل مختلفة بمرور الوقت، مثل الإزاحة الأفقية للأرضيات. توفر هذه التحليلات رؤى حول السلوك الديناميكي للهيكل أثناء الأحداث الزلزالية، مما يساعد في تطوير استراتيجيات فعالة لمقاومة الزلازل.

Appendix (1)

1. Structural design calculations details.

1.1 Basic data

Unit weight of materials	
Unit weight of Brick wall	= 18 kN/m ³
Unit weight of concrete	= 25 kN/m ³

1.2 Load summary.

The following loads have been used to design the sub-structure.

- Dead Loads (DL)
- Live Loads (LL)
- Super Imposed Dead Load (SIDL)

1.2.1 Dead loads

The dead load comprises of self-weight of the structure and loading due to finishes and floorings etc, which are permanent in nature. The self-weight of the slabs, beams and columns are calculated automatically as per assigned properties in ETABS design program, while the superimposed dead load of partitions, ceiling, and floor finishes are applied as floor loads (Area load) to the respective floor slab as SIDL load case. The facade and other solid wall loads are applied as member loads to the respective members.

The following factors will be used for D.L. (γ)

$$\gamma(\text{Concrete}) = 1.5$$

$$\gamma(\text{Steel}) = 1.05$$

Where,

γ (Concrete) is the strength reduction factor for shear in structures that rely on special moment resisting frames or special reinforced concrete structural walls to resist earthquake effects. Gamma (Steel) is the strength reduction factor for shear and torsion.

The following parameters are considered:

Density of Reinforced Concrete = 25 kN/m³

Self-weight of slabs/beams as per actual sizing shall be considered.

Slab Dead Load: As per thickness = 25 x D (D = Thickness of slab in meter)

E.g. for 200mm thick slab, Self-weight=5.0kN/m²

Slab Dead Load

a) Solid Slab 3 -140mm Thick

Self-weight of Solid Slab = $0.14 \times 25 = 3.5 \text{ kN/m}^2$

b) Solid Slab 2-160mm Thick

Self-weight of Solid Slab = $0.16 \times 25 = 4 \text{ kN/m}^2$

c) Solid Slab 3-200mm Thick

Self-weight of Solid Slab = $0.20 \times 25 = 5 \text{ kN/m}^2$

1.2.2 Live load (LL)

British code BS 6399: Part 1 is used for live load calculations and the live load considered are as

$$2 \text{ kN/m}^2$$

1.2.3 Super imposed dead load (SIDL)

The superimposed dead load of partitions, ceiling, and floor finishes are applied as floor loads.

(Area load) to the respective floor slab.

Slab Super Imposed Load (SIDL)

With considering walls = 6 kN/m^2

Without walls = 2 kN/m^2

In ETABS, since we are assigning slab as normal concrete two-way slab of 140, 160mm & 200mm thick, the total dead load will be different from the above value. The factored loading wouldn't show any difference in values because the factor of safety for both dead and SIDL case is 1.4. Slab load calculation as per ETABS is given below.

i. Wall load

Total dead load = $0.14 \times 25 = 3.5 \text{ kN/m}^2$

Live load = 2 kN/m^2 Total Load = 3.5 kN/m^2

Wall density is taken as 18 kN/m^3

For 200mm thick walls, wall load is calculated as follows.

Wall height = Floor height- Beam Depth= $3.3-0.6=2.7\text{m}$

Total wall load in $\text{kN/m} = 18 \times 0.2 \times 2.7 = 9.72 \text{ kN/m}$ approximately 10 kN/m

Similarly,

Table (3.3): Block wall load calculations

	Block load (kN/m^3)	wall thickness (m)	wall height (m)	Wall load (kN/m)	Roundoff to integer Number
Internal Wall	18	0.2	2.7	9.72	10
external Wall	18	0.3	2.7	14.58	15
Roof Parapet	18	0.3	0.5	2.7	3

ii. Stair load:

For staircase,

Dead Load = 5 kN/m^2 (for 200mm thick stair)

Live load = 2 kN/m^2 Floor finish

(SIDL) = 2 kN/m^2

Total load = 9 kN/m^2

Stair load is given on the supporting beams as uniformly distributed load. Span between support is 4.250m.

UDL on supporting beam = $9 \times 4.250 / 2 = 19.125 \text{ kN/m}$

1.3 Basic load cases

Dead Load (DEAD)

Live Load (LIVE)
Superimposed Dead load (SIDL)

1.4 Load combinations

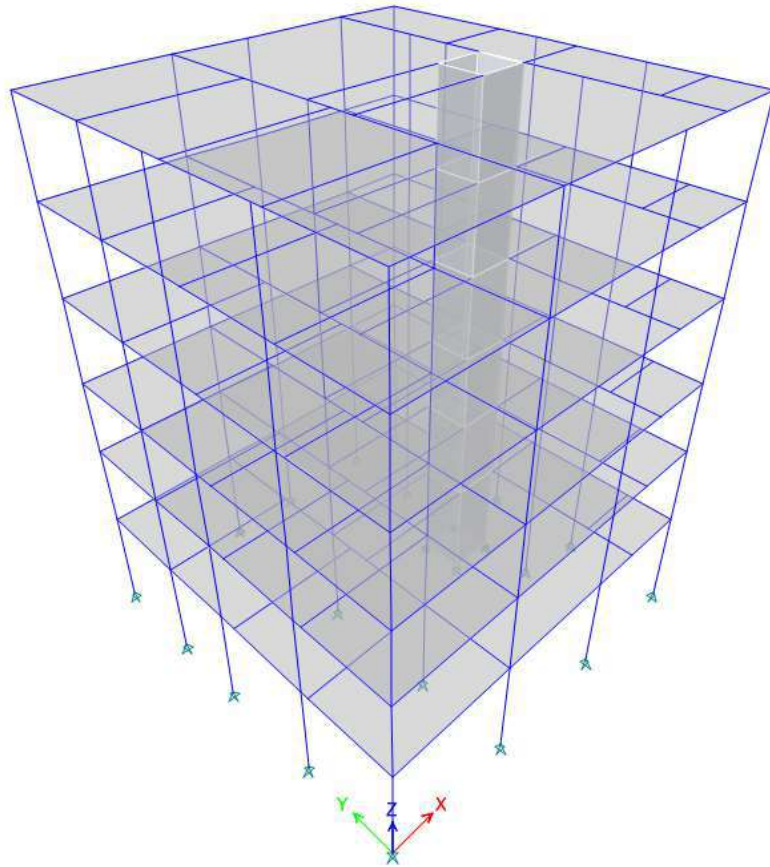
SERVICEABILITY LIMIT STATE LOAD COMBINATIONS

1.0 (DL + Wall + Stair) + 1.0 LIVE - (UNFACT)

ULTIMATE LIMIT STATE LOAD COMBINATIONS

1.4 (DL+ Wall + Stair) - (DCON1)

1.4 (DL+ Wall + Stair) +1.6LIVE - (DCON2)



Summary Report

Model File: FF, Revision 0
10/16/2023

1 Structure Data

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

1.1 Story Data

Table 1.1 - Story Definitions

Tower	Name	Height m	Master Story	Similar To	Splice Story	Color
T1	Story6	3.3	No	None	No	Cyan
T1	Story5	3.3	No	None	No	Cyan
T1	Story4	3.3	No	None	No	Cyan
T1	Story3	3	No	None	No	Red
T1	Story2	3.3	No	None	No	Magenta
T1	Story1	4.1	Yes	None	No	Yellow

2 Loads

This chapter provides loading information as applied to the model.

2.1 Load Patterns

Table 2.1 - Load Pattern Definitions

Name	Is Auto Load	Type	Self Weight Multiplier
~LLRF	Yes	Other	0
Block-Dead	No	Super Dead	0
Dead	No	Dead	1
Live	No	Live	0
Stair-Dead	No	Super Dead	0
Stair-Live	No	Live	0

2.2 Functions

2.2.1 Response Spectrum Functions

Table 2.2 - Functions - Response Spectrum - ASCE7-10

Name	Period sec	Value	Ss And S1 From	Ss	S1	TL sec	Site Class	Fa	Fv	SDS	SD1	Damping Ratio
Target Spectrum	0	0.106667	User Defined	0.5	0.3	8	A	0.8	0.8	0.266667	0.16	0.05
Target Spectrum	0.12	0.266667										
Target Spectrum	0.6	0.266667										
Target Spectrum	0.8	0.2										
Target Spectrum	1	0.16										
Target Spectrum	1.2	0.133333										
Target Spectrum	1.4	0.114286										
Target Spectrum	1.6	0.1										
Target Spectrum	1.8	0.088889										
Target Spectrum	2	0.08										
Target Spectrum	2.5	0.064										
Target Spectrum	3	0.053333										
Target Spectrum	3.5	0.045714										
Target Spectrum	4	0.04										

Table 2.2 - Functions - Response Spectrum - ASCE7-10 (continued)

Name	Period sec	Value	Ss And S1 From	Ss	S1	TL sec	Site Class	Fa	Fv	SDS	SD1	Damping Ratio
Target Spectrum	4.5	0.035556										
Target Spectrum	5	0.032										
Target Spectrum	5.5	0.029091										
Target Spectrum	6	0.026667										
Target Spectrum	6.5	0.024615										
Target Spectrum	7	0.022857										
Target Spectrum	7.5	0.021333										
Target Spectrum	8	0.02										
Target Spectrum	8.5	0.017716										
Target Spectrum	9	0.015802										
Target Spectrum	9.5	0.014183										
Target Spectrum	10	0.0128										

Table 2.3 - Functions - Response Spectrum - User Defined

Name	Period sec	Value	Damping Ratio
UnifRS	0	1	0.05
UnifRS	1	1	

2.3 Load Cases

Table 2.4 - Load Case Definitions - Summary

Name	Type
Dead	Linear Static
Live	Linear Static
Modal	Modal - Eigen
Block-Dead	Linear Static
Stair-Dead	Linear Static
Stair-Live	Linear Static
Gravity -Nonlinear	Nonlinear Static
Pushover-Mode2-x	Nonlinear Static
Pushover-Mode1-Y	Nonlinear Static
Time history 1-1	Linear Modal History
Time history 1-2	Linear Modal History
Time history 2-1	Linear Modal History

Table 2.4 - Load Case Definitions - Summary (continued)

Name	Type
Time history 2-2	Linear Modal History
Time history 3-1	Linear Modal History
Time history 3-2	Linear Modal History
Time history 4-1	Linear Modal History
Time history 4-2	Linear Modal History
Time history 5-1	Linear Modal History
Time history 5-2	Linear Modal History
Time history 6-1	Linear Modal History
Time history 7-1	Linear Modal History
Time history 7-2	Linear Modal History
Time history 8-1	Linear Modal History
Time history 8-2	Linear Modal History
Time history 9-1	Linear Modal History
Time history 9-2	Linear Modal History
Time history 10-1	Linear Modal History
Time history 10-2	Linear Modal History
Time history 6-2	Linear Modal History

3 Analysis Results

This chapter provides analysis results.

3.1 Structure Results

Table 3.1 - Base Reactions (Part 1 of 2)

Output Case	Case Type	Step Type	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	LinStatic		0	0	9964.3009	74401.4019	-76898.2436	0
Live	LinStatic		0	0	2506.8328	18068.6978	-17756.2066	0
Block-Dead	LinStatic		0	0	7771.15	57597.1623	-58416.3603	0
Stair-Dead	LinStatic		0	0	0	0	0	0
Stair-Live	LinStatic		0	0	0	0	0	0
Gravity -Nonlinear	NonStatic	Max	0	0	10591.0091	78918.5763	-81337.2953	0
Gravity -Nonlinear	NonStatic	Min	0	0	10591.0091	78918.5763	-81337.2953	0
Pushover-Mode2-x	NonStatic	Max	5020.6303	438.3706	10591.0091	78918.5763	-5644.9086	0
Pushover-Mode2-x	NonStatic	Min	0	0	10591.0091	73017.1366	-81337.2953	-37259.3688
Pushover-Mode1-Y	NonStatic	Max	3143.7158	272.4083	10591.0091	78918.5763	-34000.5935	0
Pushover-Mode1-Y	NonStatic	Min	0	0	10591.0091	75262.7093	-81337.2953	-23353.8596
Time history 1-1	LinModHist	Max	1978.4967	1113.7423	2.36E-06	19864.5491	29248.8463	17443.9271
Time history 1-1	LinModHist	Min	-2020.3307	-1361.4225	-2.358E-06	-17943.6557	-28869.8927	-21734.0732
Time history 1-2	LinModHist	Max	2061.9449	1225.8815	2.507E-06	18449.0866	31061.9271	25512.674
Time history 1-2	LinModHist	Min	-2104.2182	-1328.5099	-2.474E-06	-18194.2067	-29426.5758	-24675.6733
Time history 2-1	LinModHist	Max	1844.8987	1647.97	2.314E-06	20995.2603	25615.6127	26092.4623
Time history 2-1	LinModHist	Min	-1907.252	-1443.6829	-2.531E-06	-23342.222	-25998.4921	-21417.3004
Time history 2-2	LinModHist	Max	1827.6568	1227.0308	2.344E-06	24152.3976	26085.5857	19295.578
Time history 2-2	LinModHist	Min	-2127.1826	-1640.7824	-2.457E-06	-17940.8738	-30954.0475	-22985.3179
Time history 3-1	LinModHist	Max	1587.9074	1429.4851	2.19E-06	18340.5971	25134.8148	19184.3506
Time history 3-1	LinModHist	Min	-1704.1518	-1325.4555	-2.237E-06	-20531.96	-25639.8589	-18289.5611
Time history 3-2	LinModHist	Max	1533.8437	1422.501	1.99E-06	18524.5212	24103.1316	20069.7268
Time history 3-2	LinModHist	Min	-1725.8352	-1454.0495	-2.309E-06	-20515.5019	-25459.5892	-19109.6453
Time history 4-1	LinModHist	Max	1509.5345	1269.1911	1.823E-06	18188.8964	22317.0925	15501.5073
Time history 4-1	LinModHist	Min	-1283.6001	-1157.0667	-1.862E-06	-19019.5146	-21590.2827	-17462.0059
Time history 4-2	LinModHist	Max	1733.1924	1347.8264	1.956E-06	20661.7229	24819.5809	22667.6144
Time history 4-2	LinModHist	Min	-1536.3454	-1441.4994	-2.138E-06	-19948.9706	-23756.5881	-21348.3076
Time history 5-1	LinModHist	Max	2039.1544	1142.593	2.214E-06	16752.4816	27960.8342	15343.0547
Time history 5-1	LinModHist	Min	-1740.967	-1182.6637	-1.792E-06	-16707.1595	-25336.9078	-16105.5735
Time history 5-2	LinModHist	Max	1821.7019	988.1941	2.203E-06	15257.6836	27361.0846	18290.6758
Time history 5-2	LinModHist	Min	-1603.5335	-1051.1947	-1.967E-06	-14576.3263	-24163.5879	-16634.3587
Time history 6-1	LinModHist	Max	1859.1729	1130.6187	2.454E-06	17573.7113	26354.5827	17714.8473
Time history 6-1	LinModHist	Min	-1802.4153	-1246.8314	-2.192E-06	-17523.7447	-26459.7012	-17614.1729
Time history 7-1	LinModHist	Max	1643.4214	1046.045	1.987E-06	18491.0616	24312.498	16181.3132
Time history 7-1	LinModHist	Min	-1738.5609	-1417.7752	-2.149E-06	-16023.5603	-25722.8393	-15250.6463
Time history 7-2	LinModHist	Max	1481.2278	1152.4313	1.554E-06	19864.324	21729.6204	17138.1269
Time history 7-2	LinModHist	Min	-1329.6171	-1290.8372	-1.386E-06	-18073.8073	-18971.689	-17702.3753
Time history 8-1	LinModHist	Max	1419.2727	1255.431	1.595E-06	20175.7524	19009.8256	20322.7748
Time history 8-1	LinModHist	Min	-1604.5479	-1469.5549	-1.774E-06	-17496.4131	-21061.6386	-19440.4611
Time history 8-2	LinModHist	Max	1261.1964	1308.3368	1.594E-06	20333.27	19587.1951	15529.9773
Time history 8-2	LinModHist	Min	-1182.2425	-1479.5705	-1.49E-06	-18017.8367	-18311.6969	-14334.3929

Table 3.1 - Base Reactions (Part 1 of 2, continued)

Output Case	Case Type	Step Type	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Time history 9-1	LinModHist	Max	2064.5497	1158.3544	2.725E-06	14984.0891	32035.8913	32471.7256
Time history 9-1	LinModHist	Min	-2250.2471	-1102.7866	-3.067E-06	-17648.8771	-34148.0236	-27685.2545
Time history 9-2	LinModHist	Max	2127.2557	1374.8216	2.614E-06	16168.9253	30750.9655	21415.1203
Time history 9-2	LinModHist	Min	-2222.3872	-1090.5018	-2.903E-06	-19134.1784	-32436.3588	-17968.8835
Time history 10-1	LinModHist	Max	1862.3594	1240.1829	2.391E-06	21079.7738	27985.7662	16911.6638
Time history 10-1	LinModHist	Min	-1592.1761	-1551.8208	-2.152E-06	-18962.6806	-24147.0522	-19001.2083
Time history 10-2	LinModHist	Max	1862.3594	1240.1829	2.391E-06	21079.7738	27985.7662	16911.6638
Time history 10-2	LinModHist	Min	-1592.1761	-1551.8208	-2.152E-06	-18962.6806	-24147.0522	-19001.2083
Time history 6-2	LinModHist	Max	1745.905	1090.9443	1.947E-06	17193.4515	26271.7766	19340.2004
Time history 6-2	LinModHist	Min	-1643.9137	-1160.3401	-2.141E-06	-16750.1381	-24152.9906	-16005.0416
DConS1	Combination		0	0	24829.6313	184797.9897	-189440.4456	0
DConS2	Combination		0	0	28840.5637	213707.9063	-217850.3761	0
Working Compo	Combination		0	0	20242.2837	150067.2619	-153070.8106	0

Table 3.1 - Base Reactions (Part 2 of 2)

[illegible]

Table 3.1 - Base Reactions (Part 2 of 2, continued)

[illegible]

3.2 Story Results

Table 3.2 - Story Drifts

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story6	Dead	LinStatic		X	8.9E-05	31	14.95	0	20.3
Story6	Dead	LinStatic		Y	5.1E-05	35	14.95	14.95	20.3
Story6	Live	LinStatic		X	3.5E-05	31	14.95	0	20.3
Story6	Live	LinStatic		Y	2E-05	35	14.95	14.95	20.3
Story6	Block-Dead	LinStatic		X	2.6E-05	35	14.95	14.95	20.3
Story6	Block-Dead	LinStatic		Y	3E-05	31	14.95	0	20.3
Story6	Gravity -Nonlinear	NonStatic	Max	X	9.7E-05	31	14.95	0	20.3
Story6	Gravity -Nonlinear	NonStatic	Max	Y	5.6E-05	35	14.95	14.95	20.3
Story6	Gravity -Nonlinear	NonStatic	Min	X	9.7E-05	31	14.95	0	20.3
Story6	Gravity -Nonlinear	NonStatic	Min	Y	5.6E-05	35	14.95	14.95	20.3
Story6	Pushover-Mode2-x	NonStatic	Max	X	9.7E-05	31	14.95	0	20.3
Story6	Pushover-Mode2-x	NonStatic	Max	Y	0.000289	31	14.95	0	20.3
Story6	Pushover-Mode2-x	NonStatic	Min	X	0.007861	4	12.3	8.45	20.3
Story6	Pushover-Mode1-Y	NonStatic	Max	X	9.7E-05	31	14.95	0	20.3

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story6	Pushover-Mode1-Y	NonStatic	Min	X	0.003824	38	12.3	6.65	20.3
Story6	Time history 1-1	LinModHist	Max	X	0.00217	23	5.25	0	20.3
Story6	Time history 1-1	LinModHist	Max	Y	0.001188	33	14.95	8.25	20.3
Story6	Time history 1-1	LinModHist	Min	X	0.00234	29	0	0	20.3
Story6	Time history 1-1	LinModHist	Min	Y	0.001118	33	14.95	8.25	20.3
Story6	Time history 1-2	LinModHist	Max	X	0.002178	29	0	0	20.3
Story6	Time history 1-2	LinModHist	Max	Y	0.00093	32	14.95	4.05	20.3
Story6	Time history 1-2	LinModHist	Min	X	0.00228	29	0	0	20.3
Story6	Time history 1-2	LinModHist	Min	Y	0.001044	33	14.95	8.25	20.3
Story6	Time history 2-1	LinModHist	Max	X	0.001926	26	0	14.95	20.3
Story6	Time history 2-1	LinModHist	Max	Y	0.000971	33	14.95	8.25	20.3
Story6	Time history 2-1	LinModHist	Min	X	0.001965	26	0	14.95	20.3
Story6	Time history 2-1	LinModHist	Min	Y	0.001043	33	14.95	8.25	20.3
Story6	Time history 2-2	LinModHist	Max	X	0.002395	23	5.25	0	20.3
Story6	Time history 2-2	LinModHist	Max	Y	0.001133	29	0	0	20.3
Story6	Time history 2-2	LinModHist	Min	X	0.002011	29	0	0	20.3
Story6	Time history 2-2	LinModHist	Min	Y	0.000913	33	14.95	8.25	20.3
Story6	Time history 3-1	LinModHist	Max	X	0.001915	26	0	14.95	20.3
Story6	Time history 3-1	LinModHist	Max	Y	0.000968	32	14.95	4.05	20.3
Story6	Time history 3-1	LinModHist	Min	X	0.001962	23	5.25	0	20.3
Story6	Time history 3-1	LinModHist	Min	Y	0.000941	32	14.95	4.05	20.3
Story6	Time history 3-2	LinModHist	Max	X	0.00185	31	14.95	0	20.3
Story6	Time history 3-2	LinModHist	Max	Y	0.001014	33	14.95	8.25	20.3
Story6	Time history 3-2	LinModHist	Min	X	0.001963	23	5.25	0	20.3
Story6	Time history 3-2	LinModHist	Min	Y	0.000972	32	14.95	4.05	20.3
Story6	Time history 4-1	LinModHist	Max	X	0.001859	26	0	14.95	20.3
Story6	Time history 4-1	LinModHist	Max	Y	0.000885	26	0	14.95	20.3
Story6	Time history 4-1	LinModHist	Min	X	0.001743	23	5.25	0	20.3
Story6	Time history 4-1	LinModHist	Min	Y	0.001002	33	14.95	8.25	20.3
Story6	Time history 4-2	LinModHist	Max	X	0.00175	4	12.3	8.45	20.3
Story6	Time history 4-2	LinModHist	Max	Y	0.000936	26	0	14.95	20.3
Story6	Time history 4-2	LinModHist	Min	X	0.00182	23	5.25	0	20.3
Story6	Time history 4-2	LinModHist	Min	Y	0.000956	35	14.95	14.95	20.3
Story6	Time history 5-1	LinModHist	Max	X	0.001898	29	0	0	20.3
Story6	Time history 5-1	LinModHist	Max	Y	0.000728	35	14.95	14.95	20.3
Story6	Time history 5-1	LinModHist	Min	X	0.001886	29	0	0	20.3
Story6	Time history 5-1	LinModHist	Min	Y	0.000853	33	14.95	8.25	20.3
Story6	Time history 5-2	LinModHist	Max	X	0.00178	23	5.25	0	20.3
Story6	Time history 5-2	LinModHist	Max	Y	0.000771	29	0	0	20.3
Story6	Time history 5-2	LinModHist	Min	X	0.002027	23	5.25	0	20.3
Story6	Time history 5-2	LinModHist	Min	Y	0.000827	33	14.95	8.25	20.3
Story6	Time history 6-1	LinModHist	Max	X	0.001953	23	5.25	0	20.3
Story6	Time history 6-1	LinModHist	Max	Y	0.000888	32	14.95	4.05	20.3
Story6	Time history 6-1	LinModHist	Min	X	0.00207	25	5.25	14.95	20.3
Story6	Time history 6-1	LinModHist	Min	Y	0.000964	32	14.95	4.05	20.3

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story6	Time history 7-1	LinModHist	Max	X	0.001898	23	5.25	0	20.3
Story6	Time history 7-1	LinModHist	Max	Y	0.000846	29	0	0	20.3
Story6	Time history 7-1	LinModHist	Min	X	0.001795	23	5.25	0	20.3
Story6	Time history 7-1	LinModHist	Min	Y	0.000807	33	14.95	8.25	20.3
Story6	Time history 7-2	LinModHist	Max	X	0.001477	29	0	0	20.3
Story6	Time history 7-2	LinModHist	Max	Y	0.001028	33	14.95	8.25	20.3
Story6	Time history 7-2	LinModHist	Min	X	0.001624	29	0	0	20.3
Story6	Time history 7-2	LinModHist	Min	Y	0.000966	32	14.95	4.05	20.3
Story6	Time history 8-1	LinModHist	Max	X	0.001457	4	12.3	8.45	20.3
Story6	Time history 8-1	LinModHist	Max	Y	0.001042	33	14.95	8.25	20.3
Story6	Time history 8-1	LinModHist	Min	X	0.001431	38	12.3	6.65	20.3
Story6	Time history 8-1	LinModHist	Min	Y	0.000907	35	14.95	14.95	20.3
Story6	Time history 8-2	LinModHist	Max	X	0.001446	29	0	0	20.3
Story6	Time history 8-2	LinModHist	Max	Y	0.001033	33	14.95	8.25	20.3
Story6	Time history 8-2	LinModHist	Min	X	0.001567	23	5.25	0	20.3
Story6	Time history 8-2	LinModHist	Min	Y	0.00091	35	14.95	14.95	20.3
Story6	Time history 9-1	LinModHist	Max	X	0.002661	26	0	14.95	20.3
Story6	Time history 9-1	LinModHist	Max	Y	0.000797	31	14.95	0	20.3
Story6	Time history 9-1	LinModHist	Min	X	0.002701	26	0	14.95	20.3
Story6	Time history 9-1	LinModHist	Min	Y	0.000954	35	14.95	14.95	20.3
Story6	Time history 9-2	LinModHist	Max	X	0.002395	31	14.95	0	20.3
Story6	Time history 9-2	LinModHist	Max	Y	0.000982	35	14.95	14.95	20.3
Story6	Time history 9-2	LinModHist	Min	X	0.002436	23	5.25	0	20.3
Story6	Time history 9-2	LinModHist	Min	Y	0.000997	35	14.95	14.95	20.3
Story6	Time history 10-1	LinModHist	Max	X	0.001933	23	5.25	0	20.3
Story6	Time history 10-1	LinModHist	Max	Y	0.000996	33	14.95	8.25	20.3
Story6	Time history 10-1	LinModHist	Min	X	0.002374	23	5.25	0	20.3
Story6	Time history 10-1	LinModHist	Min	Y	0.00106	33	14.95	8.25	20.3
Story6	Time history 10-2	LinModHist	Max	X	0.001933	23	5.25	0	20.3
Story6	Time history 10-2	LinModHist	Max	Y	0.000996	33	14.95	8.25	20.3
Story6	Time history 10-2	LinModHist	Min	X	0.002374	23	5.25	0	20.3
Story6	Time history 10-2	LinModHist	Min	Y	0.00106	33	14.95	8.25	20.3
Story6	Time history 6-2	LinModHist	Max	X	0.001786	26	0	14.95	20.3
Story6	Time history 6-2	LinModHist	Max	Y	0.000986	33	14.95	8.25	20.3
Story6	Time history 6-2	LinModHist	Min	X	0.001996	29	0	0	20.3
Story6	Time history 6-2	LinModHist	Min	Y	0.00098	33	14.95	8.25	20.3
Story6	DConS1	Combination		X	0.000102	31	14.95	0	20.3
Story6	DConS1	Combination		Y	0.000111	35	14.95	14.95	20.3
Story6	DConS2	Combination		X	0.000158	31	14.95	0	20.3
Story6	DConS2	Combination		Y	0.000142	35	14.95	14.95	20.3
Story6	Working Compo	Combination		X	0.000108	31	14.95	0	20.3
Story6	Working Compo	Combination		Y	9.9E-05	35	14.95	14.95	20.3
Story5	Dead	LinStatic		X	8E-05	29	0	0	17
Story5	Dead	LinStatic		Y	3.9E-05	31	14.95	0	17
Story5	Live	LinStatic		X	3.1E-05	29	0	0	17

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story5	Live	LinStatic		Y	1.5E-05	31	14.95	0	17
Story5	Block-Dead	LinStatic		X	3.2E-05	26	0	14.95	17
Story5	Block-Dead	LinStatic		Y	3.7E-05	35	14.95	14.95	17
Story5	Gravity -Nonlinear	NonStatic	Max	X	8.9E-05	29	0	0	17
Story5	Gravity -Nonlinear	NonStatic	Max	Y	4.3E-05	31	14.95	0	17
Story5	Gravity -Nonlinear	NonStatic	Min	X	8.9E-05	29	0	0	17
Story5	Gravity -Nonlinear	NonStatic	Min	Y	4.3E-05	31	14.95	0	17
Story5	Pushover-Mode2-x	NonStatic	Max	X	8.9E-05	29	0	0	17
Story5	Pushover-Mode2-x	NonStatic	Max	Y	0.000304	35	14.95	14.95	17
Story5	Pushover-Mode2-x	NonStatic	Min	X	0.0089	35	14.95	14.95	17
Story5	Pushover-Mode1-Y	NonStatic	Max	X	8.9E-05	29	0	0	17
Story5	Pushover-Mode1-Y	NonStatic	Max	Y	4.3E-05	31	14.95	0	17
Story5	Pushover-Mode1-Y	NonStatic	Min	X	0.004328	31	14.95	0	17
Story5	Time history 1-1	LinModHist	Max	X	0.002517	31	14.95	0	17
Story5	Time history 1-1	LinModHist	Max	Y	0.00144	31	14.95	0	17
Story5	Time history 1-1	LinModHist	Min	X	0.002716	31	14.95	0	17
Story5	Time history 1-1	LinModHist	Min	Y	0.001422	26	0	14.95	17
Story5	Time history 1-2	LinModHist	Max	X	0.002483	31	14.95	0	17
Story5	Time history 1-2	LinModHist	Max	Y	0.001122	31	14.95	0	17
Story5	Time history 1-2	LinModHist	Min	X	0.002581	35	14.95	14.95	17
Story5	Time history 1-2	LinModHist	Min	Y	0.00124	31	14.95	0	17
Story5	Time history 2-1	LinModHist	Max	X	0.002234	31	14.95	0	17
Story5	Time history 2-1	LinModHist	Max	Y	0.00137	29	0	0	17
Story5	Time history 2-1	LinModHist	Min	X	0.002246	35	14.95	14.95	17
Story5	Time history 2-1	LinModHist	Min	Y	0.001458	29	0	0	17
Story5	Time history 2-2	LinModHist	Max	X	0.002805	31	14.95	0	17
Story5	Time history 2-2	LinModHist	Max	Y	0.001615	26	0	14.95	17
Story5	Time history 2-2	LinModHist	Min	X	0.002403	31	14.95	0	17
Story5	Time history 2-2	LinModHist	Min	Y	0.001192	26	0	14.95	17
Story5	Time history 3-1	LinModHist	Max	X	0.002217	35	14.95	14.95	17
Story5	Time history 3-1	LinModHist	Max	Y	0.001223	29	0	0	17
Story5	Time history 3-1	LinModHist	Min	X	0.002247	31	14.95	0	17
Story5	Time history 3-1	LinModHist	Min	Y	0.001137	29	0	0	17
Story5	Time history 3-2	LinModHist	Max	X	0.002143	30	10.28	0	17
Story5	Time history 3-2	LinModHist	Max	Y	0.001186	35	14.95	14.95	17
Story5	Time history 3-2	LinModHist	Min	X	0.0023	31	14.95	0	17
Story5	Time history 3-2	LinModHist	Min	Y	0.001127	26	0	14.95	17
Story5	Time history 4-1	LinModHist	Max	X	0.00222	35	14.95	14.95	17
Story5	Time history 4-1	LinModHist	Max	Y	0.00124	29	0	0	17
Story5	Time history 4-1	LinModHist	Min	X	0.002181	31	14.95	0	17
Story5	Time history 4-1	LinModHist	Min	Y	0.001179	35	14.95	14.95	17
Story5	Time history 4-2	LinModHist	Max	X	0.002047	35	14.95	14.95	17
Story5	Time history 4-2	LinModHist	Max	Y	0.001363	29	0	0	17
Story5	Time history 4-2	LinModHist	Min	X	0.002105	31	14.95	0	17
Story5	Time history 4-2	LinModHist	Min	Y	0.001336	29	0	0	17

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story5	Time history 5-1	LinModHist	Max	X	0.002163	31	14.95	0	17
Story5	Time history 5-1	LinModHist	Max	Y	0.001125	29	0	0	17
Story5	Time history 5-1	LinModHist	Min	X	0.002154	31	14.95	0	17
Story5	Time history 5-1	LinModHist	Min	Y	0.001015	29	0	0	17
Story5	Time history 5-2	LinModHist	Max	X	0.00202	31	14.95	0	17
Story5	Time history 5-2	LinModHist	Max	Y	0.001167	26	0	14.95	17
Story5	Time history 5-2	LinModHist	Min	X	0.002311	31	14.95	0	17
Story5	Time history 5-2	LinModHist	Min	Y	0.001044	26	0	14.95	17
Story5	Time history 6-1	LinModHist	Max	X	0.002259	31	14.95	0	17
Story5	Time history 6-1	LinModHist	Max	Y	0.001078	26	0	14.95	17
Story5	Time history 6-1	LinModHist	Min	X	0.002577	35	14.95	14.95	17
Story5	Time history 6-1	LinModHist	Min	Y	0.001092	35	14.95	14.95	17
Story5	Time history 7-1	LinModHist	Max	X	0.002178	31	14.95	0	17
Story5	Time history 7-1	LinModHist	Max	Y	0.001231	29	0	0	17
Story5	Time history 7-1	LinModHist	Min	X	0.002051	31	14.95	0	17
Story5	Time history 7-1	LinModHist	Min	Y	0.001134	26	0	14.95	17
Story5	Time history 7-2	LinModHist	Max	X	0.001698	31	14.95	0	17
Story5	Time history 7-2	LinModHist	Max	Y	0.001185	31	14.95	0	17
Story5	Time history 7-2	LinModHist	Min	X	0.001867	31	14.95	0	17
Story5	Time history 7-2	LinModHist	Min	Y	0.001133	35	14.95	14.95	17
Story5	Time history 8-1	LinModHist	Max	X	0.001641	35	14.95	14.95	17
Story5	Time history 8-1	LinModHist	Max	Y	0.001235	31	14.95	0	17
Story5	Time history 8-1	LinModHist	Min	X	0.001676	35	14.95	14.95	17
Story5	Time history 8-1	LinModHist	Min	Y	0.001158	29	0	0	17
Story5	Time history 8-2	LinModHist	Max	X	0.001672	31	14.95	0	17
Story5	Time history 8-2	LinModHist	Max	Y	0.001227	31	14.95	0	17
Story5	Time history 8-2	LinModHist	Min	X	0.001814	31	14.95	0	17
Story5	Time history 8-2	LinModHist	Min	Y	0.001194	29	0	0	17
Story5	Time history 9-1	LinModHist	Max	X	0.003182	35	14.95	14.95	17
Story5	Time history 9-1	LinModHist	Max	Y	0.000991	29	0	0	17
Story5	Time history 9-1	LinModHist	Min	X	0.003255	35	14.95	14.95	17
Story5	Time history 9-1	LinModHist	Min	Y	0.00109	31	14.95	0	17
Story5	Time history 9-2	LinModHist	Max	X	0.002769	30	10.28	0	17
Story5	Time history 9-2	LinModHist	Max	Y	0.0012	31	14.95	0	17
Story5	Time history 9-2	LinModHist	Min	X	0.002797	31	14.95	0	17
Story5	Time history 9-2	LinModHist	Min	Y	0.00118	31	14.95	0	17
Story5	Time history 10-1	LinModHist	Max	X	0.002343	30	10.28	0	17
Story5	Time history 10-1	LinModHist	Max	Y	0.001208	26	0	14.95	17
Story5	Time history 10-1	LinModHist	Min	X	0.002862	31	14.95	0	17
Story5	Time history 10-1	LinModHist	Min	Y	0.001239	31	14.95	0	17
Story5	Time history 10-2	LinModHist	Max	X	0.002343	30	10.28	0	17
Story5	Time history 10-2	LinModHist	Max	Y	0.001208	26	0	14.95	17
Story5	Time history 10-2	LinModHist	Min	X	0.002862	31	14.95	0	17
Story5	Time history 10-2	LinModHist	Min	Y	0.001239	31	14.95	0	17
Story5	Time history 6-2	LinModHist	Max	X	0.002084	35	14.95	14.95	17

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story5	Time history 6-2	LinModHist	Max	Y	0.001176	31	14.95	0	17
Story5	Time history 6-2	LinModHist	Min	X	0.002247	31	14.95	0	17
Story5	Time history 6-2	LinModHist	Min	Y	0.00118	31	14.95	0	17
Story5	DConS1	Combination		X	9.1E-05	23	5.25	0	17
Story5	DConS1	Combination		Y	0.000102	35	14.95	14.95	17
Story5	DConS2	Combination		X	0.000142	23	5.25	0	17
Story5	DConS2	Combination		Y	0.000126	33	14.95	8.25	17
Story5	Working Compo	Combination		X	9.7E-05	23	5.25	0	17
Story5	Working Compo	Combination		Y	8.8E-05	33	14.95	8.25	17
Story4	Dead	LinStatic		X	6.7E-05	29	0	0	13.7
Story4	Dead	LinStatic		Y	3.3E-05	32	14.95	4.05	13.7
Story4	Live	LinStatic		X	2.6E-05	29	0	0	13.7
Story4	Live	LinStatic		Y	1.2E-05	35	14.95	14.95	13.7
Story4	Block-Dead	LinStatic		X	2.9E-05	35	14.95	14.95	13.7
Story4	Block-Dead	LinStatic		Y	3.4E-05	31	14.95	0	13.7
Story4	Gravity -Nonlinear	NonStatic	Max	X	7.4E-05	29	0	0	13.7
Story4	Gravity -Nonlinear	NonStatic	Max	Y	3.6E-05	32	14.95	4.05	13.7
Story4	Gravity -Nonlinear	NonStatic	Min	X	7.4E-05	29	0	0	13.7
Story4	Gravity -Nonlinear	NonStatic	Min	Y	3.6E-05	32	14.95	4.05	13.7
Story4	Pushover-Mode2-x	NonStatic	Max	X	7.4E-05	29	0	0	13.7
Story4	Pushover-Mode2-x	NonStatic	Max	Y	0.000379	33	14.95	8.25	13.7
Story4	Pushover-Mode2-x	NonStatic	Min	X	0.009961	35	14.95	14.95	13.7
Story4	Pushover-Mode1-Y	NonStatic	Max	X	7.4E-05	29	0	0	13.7
Story4	Pushover-Mode1-Y	NonStatic	Max	Y	3.6E-05	32	14.95	4.05	13.7
Story4	Pushover-Mode1-Y	NonStatic	Min	X	0.004738	35	14.95	14.95	13.7
Story4	Time history 1-1	LinModHist	Max	X	0.002728	31	14.95	0	13.7
Story4	Time history 1-1	LinModHist	Max	Y	0.001791	26	0	14.95	13.7
Story4	Time history 1-1	LinModHist	Min	X	0.002921	31	14.95	0	13.7
Story4	Time history 1-1	LinModHist	Min	Y	0.0018	26	0	14.95	13.7
Story4	Time history 1-2	LinModHist	Max	X	0.002695	31	14.95	0	13.7
Story4	Time history 1-2	LinModHist	Max	Y	0.00142	26	0	14.95	13.7
Story4	Time history 1-2	LinModHist	Min	X	0.002847	35	14.95	14.95	13.7
Story4	Time history 1-2	LinModHist	Min	Y	0.001381	35	14.95	14.95	13.7
Story4	Time history 2-1	LinModHist	Max	X	0.002534	29	0	0	13.7
Story4	Time history 2-1	LinModHist	Max	Y	0.001822	29	0	0	13.7
Story4	Time history 2-1	LinModHist	Min	X	0.002379	35	14.95	14.95	13.7
Story4	Time history 2-1	LinModHist	Min	Y	0.00189	29	0	0	13.7
Story4	Time history 2-2	LinModHist	Max	X	0.003081	31	14.95	0	13.7
Story4	Time history 2-2	LinModHist	Max	Y	0.001913	26	0	14.95	13.7
Story4	Time history 2-2	LinModHist	Min	X	0.00278	29	0	0	13.7
Story4	Time history 2-2	LinModHist	Min	Y	0.001585	26	0	14.95	13.7
Story4	Time history 3-1	LinModHist	Max	X	0.002392	35	14.95	14.95	13.7
Story4	Time history 3-1	LinModHist	Max	Y	0.001381	29	0	0	13.7
Story4	Time history 3-1	LinModHist	Min	X	0.002386	31	14.95	0	13.7
Story4	Time history 3-1	LinModHist	Min	Y	0.001383	26	0	14.95	13.7

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story4	Time history 3-2	LinModHist	Max	X	0.002302	31	14.95	0	13.7
Story4	Time history 3-2	LinModHist	Max	Y	0.001355	29	0	0	13.7
Story4	Time history 3-2	LinModHist	Min	X	0.002491	31	14.95	0	13.7
Story4	Time history 3-2	LinModHist	Min	Y	0.001406	26	0	14.95	13.7
Story4	Time history 4-1	LinModHist	Max	X	0.002443	35	14.95	14.95	13.7
Story4	Time history 4-1	LinModHist	Max	Y	0.001479	29	0	0	13.7
Story4	Time history 4-1	LinModHist	Min	X	0.002542	29	0	0	13.7
Story4	Time history 4-1	LinModHist	Min	Y	0.001447	26	0	14.95	13.7
Story4	Time history 4-2	LinModHist	Max	X	0.002233	29	0	0	13.7
Story4	Time history 4-2	LinModHist	Max	Y	0.001778	29	0	0	13.7
Story4	Time history 4-2	LinModHist	Min	X	0.002295	35	14.95	14.95	13.7
Story4	Time history 4-2	LinModHist	Min	Y	0.001667	29	0	0	13.7
Story4	Time history 5-1	LinModHist	Max	X	0.002338	31	14.95	0	13.7
Story4	Time history 5-1	LinModHist	Max	Y	0.001543	29	0	0	13.7
Story4	Time history 5-1	LinModHist	Min	X	0.00233	31	14.95	0	13.7
Story4	Time history 5-1	LinModHist	Min	Y	0.001341	29	0	0	13.7
Story4	Time history 5-2	LinModHist	Max	X	0.00214	31	14.95	0	13.7
Story4	Time history 5-2	LinModHist	Max	Y	0.001464	26	0	14.95	13.7
Story4	Time history 5-2	LinModHist	Min	X	0.002457	31	14.95	0	13.7
Story4	Time history 5-2	LinModHist	Min	Y	0.001366	26	0	14.95	13.7
Story4	Time history 6-1	LinModHist	Max	X	0.002481	35	14.95	14.95	13.7
Story4	Time history 6-1	LinModHist	Max	Y	0.001459	26	0	14.95	13.7
Story4	Time history 6-1	LinModHist	Min	X	0.002958	35	14.95	14.95	13.7
Story4	Time history 6-1	LinModHist	Min	Y	0.001366	29	0	0	13.7
Story4	Time history 7-1	LinModHist	Max	X	0.002311	31	14.95	0	13.7
Story4	Time history 7-1	LinModHist	Max	Y	0.001608	29	0	0	13.7
Story4	Time history 7-1	LinModHist	Min	X	0.002185	31	14.95	0	13.7
Story4	Time history 7-1	LinModHist	Min	Y	0.001577	26	0	14.95	13.7
Story4	Time history 7-2	LinModHist	Max	X	0.001812	31	14.95	0	13.7
Story4	Time history 7-2	LinModHist	Max	Y	0.001273	35	14.95	14.95	13.7
Story4	Time history 7-2	LinModHist	Min	X	0.002	31	14.95	0	13.7
Story4	Time history 7-2	LinModHist	Min	Y	0.001276	35	14.95	14.95	13.7
Story4	Time history 8-1	LinModHist	Max	X	0.001895	35	14.95	14.95	13.7
Story4	Time history 8-1	LinModHist	Max	Y	0.001406	26	0	14.95	13.7
Story4	Time history 8-1	LinModHist	Min	X	0.002038	35	14.95	14.95	13.7
Story4	Time history 8-1	LinModHist	Min	Y	0.001417	26	0	14.95	13.7
Story4	Time history 8-2	LinModHist	Max	X	0.001796	31	14.95	0	13.7
Story4	Time history 8-2	LinModHist	Max	Y	0.001419	26	0	14.95	13.7
Story4	Time history 8-2	LinModHist	Min	X	0.001933	31	14.95	0	13.7
Story4	Time history 8-2	LinModHist	Min	Y	0.001471	26	0	14.95	13.7
Story4	Time history 9-1	LinModHist	Max	X	0.003517	35	14.95	14.95	13.7
Story4	Time history 9-1	LinModHist	Max	Y	0.001282	29	0	0	13.7
Story4	Time history 9-1	LinModHist	Min	X	0.003555	35	14.95	14.95	13.7
Story4	Time history 9-1	LinModHist	Min	Y	0.001249	29	0	0	13.7
Story4	Time history 9-2	LinModHist	Max	X	0.002971	29	0	0	13.7

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story4	Time history 9-2	LinModHist	Max	Y	0.00138	31	14.95	0	13.7
Story4	Time history 9-2	LinModHist	Min	X	0.002974	31	14.95	0	13.7
Story4	Time history 9-2	LinModHist	Min	Y	0.001348	26	0	14.95	13.7
Story4	Time history 10-1	LinModHist	Max	X	0.002617	31	14.95	0	13.7
Story4	Time history 10-1	LinModHist	Max	Y	0.001487	26	0	14.95	13.7
Story4	Time history 10-1	LinModHist	Min	X	0.003171	29	0	0	13.7
Story4	Time history 10-1	LinModHist	Min	Y	0.001537	29	0	0	13.7
Story4	Time history 10-2	LinModHist	Max	X	0.002617	31	14.95	0	13.7
Story4	Time history 10-2	LinModHist	Max	Y	0.001487	26	0	14.95	13.7
Story4	Time history 10-2	LinModHist	Min	X	0.003171	29	0	0	13.7
Story4	Time history 10-2	LinModHist	Min	Y	0.001537	29	0	0	13.7
Story4	Time history 6-2	LinModHist	Max	X	0.002276	35	14.95	14.95	13.7
Story4	Time history 6-2	LinModHist	Max	Y	0.00132	35	14.95	14.95	13.7
Story4	Time history 6-2	LinModHist	Min	X	0.002388	31	14.95	0	13.7
Story4	Time history 6-2	LinModHist	Min	Y	0.001343	35	14.95	14.95	13.7
Story4	DConS1	Combination		X	7.7E-05	29	0	0	13.7
Story4	DConS1	Combination		Y	9.4E-05	31	14.95	0	13.7
Story4	DConS2	Combination		X	0.000118	29	0	0	13.7
Story4	DConS2	Combination		Y	0.000113	31	14.95	0	13.7
Story4	Working Compo	Combination		X	8.1E-05	29	0	0	13.7
Story4	Working Compo	Combination		Y	7.9E-05	31	14.95	0	13.7
Story3	Dead	LinStatic		X	5.5E-05	31	14.95	0	10.4
Story3	Dead	LinStatic		Y	2.8E-05	35	14.95	14.95	10.4
Story3	Live	LinStatic		X	2.1E-05	31	14.95	0	10.4
Story3	Live	LinStatic		Y	1E-05	35	14.95	14.95	10.4
Story3	Block-Dead	LinStatic		X	2.7E-05	26	0	14.95	10.4
Story3	Block-Dead	LinStatic		Y	3.2E-05	35	14.95	14.95	10.4
Story3	Gravity -Nonlinear	NonStatic	Max	X	6E-05	31	14.95	0	10.4
Story3	Gravity -Nonlinear	NonStatic	Max	Y	3E-05	35	14.95	14.95	10.4
Story3	Gravity -Nonlinear	NonStatic	Min	X	6E-05	31	14.95	0	10.4
Story3	Gravity -Nonlinear	NonStatic	Min	Y	3E-05	35	14.95	14.95	10.4
Story3	Pushover-Mode2-x	NonStatic	Max	X	6E-05	31	14.95	0	10.4
Story3	Pushover-Mode2-x	NonStatic	Max	Y	0.000464	35	14.95	14.95	10.4
Story3	Pushover-Mode2-x	NonStatic	Min	X	0.010553	26	0	14.95	10.4
Story3	Pushover-Mode1-Y	NonStatic	Max	X	6E-05	31	14.95	0	10.4
Story3	Pushover-Mode1-Y	NonStatic	Max	Y	3E-05	35	14.95	14.95	10.4
Story3	Pushover-Mode1-Y	NonStatic	Min	X	0.004946	26	0	14.95	10.4
Story3	Time history 1-1	LinModHist	Max	X	0.002714	23	5.25	0	10.4
Story3	Time history 1-1	LinModHist	Max	Y	0.002094	26	0	14.95	10.4
Story3	Time history 1-1	LinModHist	Min	X	0.002882	23	5.25	0	10.4
Story3	Time history 1-1	LinModHist	Min	Y	0.00203	27	0	8.25	10.4
Story3	Time history 1-2	LinModHist	Max	X	0.002708	29	0	0	10.4
Story3	Time history 1-2	LinModHist	Max	Y	0.001628	29	0	0	10.4
Story3	Time history 1-2	LinModHist	Min	X	0.002867	26	0	14.95	10.4
Story3	Time history 1-2	LinModHist	Min	Y	0.001436	26	0	14.95	10.4

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story3	Time history 2-1	LinModHist	Max	X	0.002639	31	14.95	0	10.4
Story3	Time history 2-1	LinModHist	Max	Y	0.002139	26	0	14.95	10.4
Story3	Time history 2-1	LinModHist	Min	X	0.002393	26	0	14.95	10.4
Story3	Time history 2-1	LinModHist	Min	Y	0.00212	26	0	14.95	10.4
Story3	Time history 2-2	LinModHist	Max	X	0.003098	23	5.25	0	10.4
Story3	Time history 2-2	LinModHist	Max	Y	0.001966	29	0	0	10.4
Story3	Time history 2-2	LinModHist	Min	X	0.002926	31	14.95	0	10.4
Story3	Time history 2-2	LinModHist	Min	Y	0.001809	27	0	8.25	10.4
Story3	Time history 3-1	LinModHist	Max	X	0.002373	26	0	14.95	10.4
Story3	Time history 3-1	LinModHist	Max	Y	0.001605	26	0	14.95	10.4
Story3	Time history 3-1	LinModHist	Min	X	0.002289	23	5.25	0	10.4
Story3	Time history 3-1	LinModHist	Min	Y	0.001611	26	0	14.95	10.4
Story3	Time history 3-2	LinModHist	Max	X	0.002311	23	5.25	0	10.4
Story3	Time history 3-2	LinModHist	Max	Y	0.001527	29	0	0	10.4
Story3	Time history 3-2	LinModHist	Min	X	0.002462	23	5.25	0	10.4
Story3	Time history 3-2	LinModHist	Min	Y	0.001565	29	0	0	10.4
Story3	Time history 4-1	LinModHist	Max	X	0.002501	31	14.95	0	10.4
Story3	Time history 4-1	LinModHist	Max	Y	0.001725	26	0	14.95	10.4
Story3	Time history 4-1	LinModHist	Min	X	0.002697	31	14.95	0	10.4
Story3	Time history 4-1	LinModHist	Min	Y	0.001659	29	0	0	10.4
Story3	Time history 4-2	LinModHist	Max	X	0.002284	31	14.95	0	10.4
Story3	Time history 4-2	LinModHist	Max	Y	0.002071	26	0	14.95	10.4
Story3	Time history 4-2	LinModHist	Min	X	0.002394	26	0	14.95	10.4
Story3	Time history 4-2	LinModHist	Min	Y	0.001865	26	0	14.95	10.4
Story3	Time history 5-1	LinModHist	Max	X	0.002351	23	5.25	0	10.4
Story3	Time history 5-1	LinModHist	Max	Y	0.00183	26	0	14.95	10.4
Story3	Time history 5-1	LinModHist	Min	X	0.002341	23	5.25	0	10.4
Story3	Time history 5-1	LinModHist	Min	Y	0.001609	26	0	14.95	10.4
Story3	Time history 5-2	LinModHist	Max	X	0.002078	23	5.25	0	10.4
Story3	Time history 5-2	LinModHist	Max	Y	0.001611	29	0	0	10.4
Story3	Time history 5-2	LinModHist	Min	X	0.002394	23	5.25	0	10.4
Story3	Time history 5-2	LinModHist	Min	Y	0.001539	29	0	0	10.4
Story3	Time history 6-1	LinModHist	Max	X	0.002582	26	0	14.95	10.4
Story3	Time history 6-1	LinModHist	Max	Y	0.001697	29	0	0	10.4
Story3	Time history 6-1	LinModHist	Min	X	0.003077	26	0	14.95	10.4
Story3	Time history 6-1	LinModHist	Min	Y	0.001557	29	0	0	10.4
Story3	Time history 7-1	LinModHist	Max	X	0.002247	23	5.25	0	10.4
Story3	Time history 7-1	LinModHist	Max	Y	0.001865	26	0	14.95	10.4
Story3	Time history 7-1	LinModHist	Min	X	0.002127	23	5.25	0	10.4
Story3	Time history 7-1	LinModHist	Min	Y	0.001874	27	0	8.25	10.4
Story3	Time history 7-2	LinModHist	Max	X	0.001817	23	5.25	0	10.4
Story3	Time history 7-2	LinModHist	Max	Y	0.00131	27	0	8.25	10.4
Story3	Time history 7-2	LinModHist	Min	X	0.001944	29	0	0	10.4
Story3	Time history 7-2	LinModHist	Min	Y	0.001327	35	14.95	14.95	10.4
Story3	Time history 8-1	LinModHist	Max	X	0.002064	26	0	14.95	10.4

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story3	Time history 8-1	LinModHist	Max	Y	0.001569	29	0	0	10.4
Story3	Time history 8-1	LinModHist	Min	X	0.002244	26	0	14.95	10.4
Story3	Time history 8-1	LinModHist	Min	Y	0.001461	29	0	0	10.4
Story3	Time history 8-2	LinModHist	Max	X	0.001759	23	5.25	0	10.4
Story3	Time history 8-2	LinModHist	Max	Y	0.001535	26	0	14.95	10.4
Story3	Time history 8-2	LinModHist	Min	X	0.001872	23	5.25	0	10.4
Story3	Time history 8-2	LinModHist	Min	Y	0.001524	29	0	0	10.4
Story3	Time history 9-1	LinModHist	Max	X	0.003561	26	0	14.95	10.4
Story3	Time history 9-1	LinModHist	Max	Y	0.001435	26	0	14.95	10.4
Story3	Time history 9-1	LinModHist	Min	X	0.003478	26	0	14.95	10.4
Story3	Time history 9-1	LinModHist	Min	Y	0.001326	26	0	14.95	10.4
Story3	Time history 9-2	LinModHist	Max	X	0.002963	30	10.28	0	10.4
Story3	Time history 9-2	LinModHist	Max	Y	0.001469	33	14.95	8.25	10.4
Story3	Time history 9-2	LinModHist	Min	X	0.003024	23	5.25	0	10.4
Story3	Time history 9-2	LinModHist	Min	Y	0.001459	29	0	0	10.4
Story3	Time history 10-1	LinModHist	Max	X	0.002631	23	5.25	0	10.4
Story3	Time history 10-1	LinModHist	Max	Y	0.001607	27	0	8.25	10.4
Story3	Time history 10-1	LinModHist	Min	X	0.003271	31	14.95	0	10.4
Story3	Time history 10-1	LinModHist	Min	Y	0.00179	26	0	14.95	10.4
Story3	Time history 10-2	LinModHist	Max	X	0.002631	23	5.25	0	10.4
Story3	Time history 10-2	LinModHist	Max	Y	0.001607	27	0	8.25	10.4
Story3	Time history 10-2	LinModHist	Min	X	0.003271	31	14.95	0	10.4
Story3	Time history 10-2	LinModHist	Min	Y	0.00179	26	0	14.95	10.4
Story3	Time history 6-2	LinModHist	Max	X	0.002276	26	0	14.95	10.4
Story3	Time history 6-2	LinModHist	Max	Y	0.001366	33	14.95	8.25	10.4
Story3	Time history 6-2	LinModHist	Min	X	0.002356	23	5.25	0	10.4
Story3	Time history 6-2	LinModHist	Min	Y	0.001404	33	14.95	8.25	10.4
Story3	DConS1	Combination		X	6.2E-05	31	14.95	0	10.4
Story3	DConS1	Combination		Y	8.4E-05	35	14.95	14.95	10.4
Story3	DConS2	Combination		X	9.6E-05	31	14.95	0	10.4
Story3	DConS2	Combination		Y	0.0001	35	14.95	14.95	10.4
Story3	Working Compo	Combination		X	6.6E-05	31	14.95	0	10.4
Story3	Working Compo	Combination		Y	7E-05	35	14.95	14.95	10.4
Story2	Dead	LinStatic		X	4.1E-05	31	14.95	0	7.4
Story2	Dead	LinStatic		Y	2.3E-05	35	14.95	14.95	7.4
Story2	Live	LinStatic		X	1.6E-05	31	14.95	0	7.4
Story2	Live	LinStatic		Y	8E-06	33	14.95	8.25	7.4
Story2	Block-Dead	LinStatic		X	2.5E-05	26	0	14.95	7.4
Story2	Block-Dead	LinStatic		Y	3.1E-05	35	14.95	14.95	7.4
Story2	Gravity -Nonlinear	NonStatic	Max	X	4.5E-05	31	14.95	0	7.4
Story2	Gravity -Nonlinear	NonStatic	Max	Y	2.5E-05	35	14.95	14.95	7.4
Story2	Gravity -Nonlinear	NonStatic	Min	X	4.5E-05	31	14.95	0	7.4
Story2	Gravity -Nonlinear	NonStatic	Min	Y	2.5E-05	35	14.95	14.95	7.4
Story2	Pushover-Mode2-x	NonStatic	Max	X	4.5E-05	31	14.95	0	7.4
Story2	Pushover-Mode2-x	NonStatic	Max	Y	0.000618	31	14.95	0	7.4

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story2	Pushover-Mode2-x	NonStatic	Min	X	0.010868	34	8.145	14.95	7.4
Story2	Pushover-Mode1-Y	NonStatic	Max	X	4.5E-05	31	14.95	0	7.4
Story2	Pushover-Mode1-Y	NonStatic	Max	Y	4.6E-05	31	14.95	0	7.4
Story2	Pushover-Mode1-Y	NonStatic	Min	X	0.004903	25	5.25	14.95	7.4
Story2	Time history 1-1	LinModHist	Max	X	0.002645	34	8.145	14.95	7.4
Story2	Time history 1-1	LinModHist	Max	Y	0.002632	28	0	4.05	7.4
Story2	Time history 1-1	LinModHist	Min	X	0.002609	31	14.95	0	7.4
Story2	Time history 1-1	LinModHist	Min	Y	0.002465	28	0	4.05	7.4
Story2	Time history 1-2	LinModHist	Max	X	0.00253	26	0	14.95	7.4
Story2	Time history 1-2	LinModHist	Max	Y	0.002018	28	0	4.05	7.4
Story2	Time history 1-2	LinModHist	Min	X	0.002731	26	0	14.95	7.4
Story2	Time history 1-2	LinModHist	Min	Y	0.001774	19	0	11.2625	7.4
Story2	Time history 2-1	LinModHist	Max	X	0.00275	30	10.28	0	7.4
Story2	Time history 2-1	LinModHist	Max	Y	0.002706	28	0	4.05	7.4
Story2	Time history 2-1	LinModHist	Min	X	0.002533	30	10.28	0	7.4
Story2	Time history 2-1	LinModHist	Min	Y	0.002525	28	0	4.05	7.4
Story2	Time history 2-2	LinModHist	Max	X	0.002805	29	0	0	7.4
Story2	Time history 2-2	LinModHist	Max	Y	0.002168	28	0	4.05	7.4
Story2	Time history 2-2	LinModHist	Min	X	0.002926	30	10.28	0	7.4
Story2	Time history 2-2	LinModHist	Min	Y	0.002228	28	0	4.05	7.4
Story2	Time history 3-1	LinModHist	Max	X	0.002179	26	0	14.95	7.4
Story2	Time history 3-1	LinModHist	Max	Y	0.002106	28	0	4.05	7.4
Story2	Time history 3-1	LinModHist	Min	X	0.002023	26	0	14.95	7.4
Story2	Time history 3-1	LinModHist	Min	Y	0.002164	28	0	4.05	7.4
Story2	Time history 3-2	LinModHist	Max	X	0.0023	30	10.28	0	7.4
Story2	Time history 3-2	LinModHist	Max	Y	0.00189	28	0	4.05	7.4
Story2	Time history 3-2	LinModHist	Min	X	0.002201	23	5.25	0	7.4
Story2	Time history 3-2	LinModHist	Min	Y	0.001944	28	0	4.05	7.4
Story2	Time history 4-1	LinModHist	Max	X	0.002593	30	10.28	0	7.4
Story2	Time history 4-1	LinModHist	Max	Y	0.002284	27	0	8.25	7.4
Story2	Time history 4-1	LinModHist	Min	X	0.002816	30	10.28	0	7.4
Story2	Time history 4-1	LinModHist	Min	Y	0.002032	28	0	4.05	7.4
Story2	Time history 4-2	LinModHist	Max	X	0.002272	26	0	14.95	7.4
Story2	Time history 4-2	LinModHist	Max	Y	0.002593	28	0	4.05	7.4
Story2	Time history 4-2	LinModHist	Min	X	0.002533	25	5.25	14.95	7.4
Story2	Time history 4-2	LinModHist	Min	Y	0.002408	28	0	4.05	7.4
Story2	Time history 5-1	LinModHist	Max	X	0.002075	29	0	0	7.4
Story2	Time history 5-1	LinModHist	Max	Y	0.002391	28	0	4.05	7.4
Story2	Time history 5-1	LinModHist	Min	X	0.002048	4	12.3	8.45	7.4
Story2	Time history 5-1	LinModHist	Min	Y	0.0022	28	0	4.05	7.4
Story2	Time history 5-2	LinModHist	Max	X	0.001747	38	12.3	6.65	7.4
Story2	Time history 5-2	LinModHist	Max	Y	0.001949	28	0	4.05	7.4
Story2	Time history 5-2	LinModHist	Min	X	0.00202	29	0	0	7.4
Story2	Time history 5-2	LinModHist	Min	Y	0.00179	28	0	4.05	7.4
Story2	Time history 6-1	LinModHist	Max	X	0.002647	25	5.25	14.95	7.4

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story2	Time history 6-1	LinModHist	Max	Y	0.002168	29	0	0	7.4
Story2	Time history 6-1	LinModHist	Min	X	0.003158	25	5.25	14.95	7.4
Story2	Time history 6-1	LinModHist	Min	Y	0.002205	29	0	0	7.4
Story2	Time history 7-1	LinModHist	Max	X	0.002193	31	14.95	0	7.4
Story2	Time history 7-1	LinModHist	Max	Y	0.002192	28	0	4.05	7.4
Story2	Time history 7-1	LinModHist	Min	X	0.002007	30	10.28	0	7.4
Story2	Time history 7-1	LinModHist	Min	Y	0.00243	28	0	4.05	7.4
Story2	Time history 7-2	LinModHist	Max	X	0.001785	23	5.25	0	7.4
Story2	Time history 7-2	LinModHist	Max	Y	0.001591	28	0	4.05	7.4
Story2	Time history 7-2	LinModHist	Min	X	0.001762	34	8.145	14.95	7.4
Story2	Time history 7-2	LinModHist	Min	Y	0.001721	28	0	4.05	7.4
Story2	Time history 8-1	LinModHist	Max	X	0.002155	26	0	14.95	7.4
Story2	Time history 8-1	LinModHist	Max	Y	0.002012	28	0	4.05	7.4
Story2	Time history 8-1	LinModHist	Min	X	0.002466	26	0	14.95	7.4
Story2	Time history 8-1	LinModHist	Min	Y	0.001977	28	0	4.05	7.4
Story2	Time history 8-2	LinModHist	Max	X	0.001639	30	10.28	0	7.4
Story2	Time history 8-2	LinModHist	Max	Y	0.001918	28	0	4.05	7.4
Story2	Time history 8-2	LinModHist	Min	X	0.00162	29	0	0	7.4
Story2	Time history 8-2	LinModHist	Min	Y	0.001847	28	0	4.05	7.4
Story2	Time history 9-1	LinModHist	Max	X	0.003419	26	0	14.95	7.4
Story2	Time history 9-1	LinModHist	Max	Y	0.001576	27	0	8.25	7.4
Story2	Time history 9-1	LinModHist	Min	X	0.003231	26	0	14.95	7.4
Story2	Time history 9-1	LinModHist	Min	Y	0.001698	28	0	4.05	7.4
Story2	Time history 9-2	LinModHist	Max	X	0.002689	31	14.95	0	7.4
Story2	Time history 9-2	LinModHist	Max	Y	0.001474	33	14.95	8.25	7.4
Story2	Time history 9-2	LinModHist	Min	X	0.002958	23	5.25	0	7.4
Story2	Time history 9-2	LinModHist	Min	Y	0.001725	28	0	4.05	7.4
Story2	Time history 10-1	LinModHist	Max	X	0.002496	31	14.95	0	7.4
Story2	Time history 10-1	LinModHist	Max	Y	0.001976	28	0	4.05	7.4
Story2	Time history 10-1	LinModHist	Min	X	0.003193	30	10.28	0	7.4
Story2	Time history 10-1	LinModHist	Min	Y	0.00211	19	0	11.2625	7.4
Story2	Time history 10-2	LinModHist	Max	X	0.002496	31	14.95	0	7.4
Story2	Time history 10-2	LinModHist	Max	Y	0.001976	28	0	4.05	7.4
Story2	Time history 10-2	LinModHist	Min	X	0.003193	30	10.28	0	7.4
Story2	Time history 10-2	LinModHist	Min	Y	0.00211	19	0	11.2625	7.4
Story2	Time history 6-2	LinModHist	Max	X	0.002098	30	10.28	0	7.4
Story2	Time history 6-2	LinModHist	Max	Y	0.001633	19	0	11.2625	7.4
Story2	Time history 6-2	LinModHist	Min	X	0.002081	34	8.145	14.95	7.4
Story2	Time history 6-2	LinModHist	Min	Y	0.001702	29	0	0	7.4
Story2	DConS1	Combination		X	4.8E-05	31	14.95	0	7.4
Story2	DConS1	Combination		Y	7.5E-05	35	14.95	14.95	7.4
Story2	DConS2	Combination		X	7.3E-05	31	14.95	0	7.4
Story2	DConS2	Combination		Y	8.8E-05	35	14.95	14.95	7.4
Story2	Working Compo	Combination		X	5E-05	31	14.95	0	7.4
Story2	Working Compo	Combination		Y	6.2E-05	35	14.95	14.95	7.4

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story1	Dead	LinStatic		X	2E-05	29	0	0	4.1
Story1	Dead	LinStatic		Y	1E-05	31	14.95	0	4.1
Story1	Live	LinStatic		X	8E-06	29	0	0	4.1
Story1	Live	LinStatic		Y	4E-06	31	14.95	0	4.1
Story1	Block-Dead	LinStatic		X	1.2E-05	35	14.95	14.95	4.1
Story1	Block-Dead	LinStatic		Y	1.2E-05	31	14.95	0	4.1
Story1	Gravity -Nonlinear	NonStatic	Max	X	2.2E-05	29	0	0	4.1
Story1	Gravity -Nonlinear	NonStatic	Max	Y	1.1E-05	31	14.95	0	4.1
Story1	Gravity -Nonlinear	NonStatic	Min	X	2.2E-05	29	0	0	4.1
Story1	Gravity -Nonlinear	NonStatic	Min	Y	1.1E-05	31	14.95	0	4.1
Story1	Pushover-Mode2-x	NonStatic	Max	Y	0.000713	35	14.95	14.95	4.1
Story1	Pushover-Mode2-x	NonStatic	Min	X	0.007052	35	14.95	14.95	4.1
Story1	Pushover-Mode2-x	NonStatic	Min	Y	0.001881	26	0	14.95	4.1
Story1	Pushover-Mode1-Y	NonStatic	Max	X	2.2E-05	29	0	0	4.1
Story1	Pushover-Mode1-Y	NonStatic	Max	Y	0.000263	33	14.95	8.25	4.1
Story1	Pushover-Mode1-Y	NonStatic	Min	X	0.003474	35	14.95	14.95	4.1
Story1	Pushover-Mode1-Y	NonStatic	Min	Y	0.001212	26	0	14.95	4.1
Story1	Time history 1-1	LinModHist	Max	X	0.003327	29	0	0	4.1
Story1	Time history 1-1	LinModHist	Max	Y	0.004941	26	0	14.95	4.1
Story1	Time history 1-1	LinModHist	Min	X	0.003387	29	0	0	4.1
Story1	Time history 1-1	LinModHist	Min	Y	0.00472	26	0	14.95	4.1
Story1	Time history 1-2	LinModHist	Max	X	0.00275	29	0	0	4.1
Story1	Time history 1-2	LinModHist	Max	Y	0.00378	26	0	14.95	4.1
Story1	Time history 1-2	LinModHist	Min	X	0.002809	35	14.95	14.95	4.1
Story1	Time history 1-2	LinModHist	Min	Y	0.003531	26	0	14.95	4.1
Story1	Time history 2-1	LinModHist	Max	X	0.003591	29	0	0	4.1
Story1	Time history 2-1	LinModHist	Max	Y	0.005312	29	0	0	4.1
Story1	Time history 2-1	LinModHist	Min	X	0.003931	29	0	0	4.1
Story1	Time history 2-1	LinModHist	Min	Y	0.004404	26	0	14.95	4.1
Story1	Time history 2-2	LinModHist	Max	X	0.003507	29	0	0	4.1
Story1	Time history 2-2	LinModHist	Max	Y	0.004178	29	0	0	4.1
Story1	Time history 2-2	LinModHist	Min	X	0.003503	29	0	0	4.1
Story1	Time history 2-2	LinModHist	Min	Y	0.004597	26	0	14.95	4.1
Story1	Time history 3-1	LinModHist	Max	X	0.002987	29	0	0	4.1
Story1	Time history 3-1	LinModHist	Max	Y	0.004238	26	0	14.95	4.1
Story1	Time history 3-1	LinModHist	Min	X	0.00301	29	0	0	4.1
Story1	Time history 3-1	LinModHist	Min	Y	0.004352	26	0	14.95	4.1
Story1	Time history 3-2	LinModHist	Max	X	0.00303	29	0	0	4.1
Story1	Time history 3-2	LinModHist	Max	Y	0.003887	26	0	14.95	4.1
Story1	Time history 3-2	LinModHist	Min	X	0.002772	35	14.95	14.95	4.1
Story1	Time history 3-2	LinModHist	Min	Y	0.004069	26	0	14.95	4.1
Story1	Time history 4-1	LinModHist	Max	X	0.003277	29	0	0	4.1
Story1	Time history 4-1	LinModHist	Max	Y	0.004638	29	0	0	4.1
Story1	Time history 4-1	LinModHist	Min	X	0.003705	29	0	0	4.1
Story1	Time history 4-1	LinModHist	Min	Y	0.003842	26	0	14.95	4.1

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story1	Time history 4-2	LinModHist	Max	X	0.003649	29	0	0	4.1
Story1	Time history 4-2	LinModHist	Max	Y	0.004966	26	0	14.95	4.1
Story1	Time history 4-2	LinModHist	Min	X	0.003883	35	14.95	14.95	4.1
Story1	Time history 4-2	LinModHist	Min	Y	0.005334	26	0	14.95	4.1
Story1	Time history 5-1	LinModHist	Max	X	0.003387	29	0	0	4.1
Story1	Time history 5-1	LinModHist	Max	Y	0.004795	26	0	14.95	4.1
Story1	Time history 5-1	LinModHist	Min	X	0.003296	29	0	0	4.1
Story1	Time history 5-1	LinModHist	Min	Y	0.004692	26	0	14.95	4.1
Story1	Time history 5-2	LinModHist	Max	X	0.002533	35	14.95	14.95	4.1
Story1	Time history 5-2	LinModHist	Max	Y	0.003601	26	0	14.95	4.1
Story1	Time history 5-2	LinModHist	Min	X	0.002718	35	14.95	14.95	4.1
Story1	Time history 5-2	LinModHist	Min	Y	0.003772	26	0	14.95	4.1
Story1	Time history 6-1	LinModHist	Max	X	0.003388	35	14.95	14.95	4.1
Story1	Time history 6-1	LinModHist	Max	Y	0.004246	26	0	14.95	4.1
Story1	Time history 6-1	LinModHist	Min	X	0.004024	35	14.95	14.95	4.1
Story1	Time history 6-1	LinModHist	Min	Y	0.004759	26	0	14.95	4.1
Story1	Time history 7-1	LinModHist	Max	X	0.003054	29	0	0	4.1
Story1	Time history 7-1	LinModHist	Max	Y	0.004027	26	0	14.95	4.1
Story1	Time history 7-1	LinModHist	Min	X	0.00318	35	14.95	14.95	4.1
Story1	Time history 7-1	LinModHist	Min	Y	0.004791	26	0	14.95	4.1
Story1	Time history 7-2	LinModHist	Max	X	0.002276	29	0	0	4.1
Story1	Time history 7-2	LinModHist	Max	Y	0.002975	26	0	14.95	4.1
Story1	Time history 7-2	LinModHist	Min	X	0.002343	35	14.95	14.95	4.1
Story1	Time history 7-2	LinModHist	Min	Y	0.003471	26	0	14.95	4.1
Story1	Time history 8-1	LinModHist	Max	X	0.00306	35	14.95	14.95	4.1
Story1	Time history 8-1	LinModHist	Max	Y	0.004193	26	0	14.95	4.1
Story1	Time history 8-1	LinModHist	Min	X	0.003578	35	14.95	14.95	4.1
Story1	Time history 8-1	LinModHist	Min	Y	0.004525	26	0	14.95	4.1
Story1	Time history 8-2	LinModHist	Max	X	0.002972	29	0	0	4.1
Story1	Time history 8-2	LinModHist	Max	Y	0.003905	26	0	14.95	4.1
Story1	Time history 8-2	LinModHist	Min	X	0.00283	35	14.95	14.95	4.1
Story1	Time history 8-2	LinModHist	Min	Y	0.00419	26	0	14.95	4.1
Story1	Time history 9-1	LinModHist	Max	X	0.003416	35	14.95	14.95	4.1
Story1	Time history 9-1	LinModHist	Max	Y	0.002872	26	0	14.95	4.1
Story1	Time history 9-1	LinModHist	Min	X	0.003348	35	14.95	14.95	4.1
Story1	Time history 9-1	LinModHist	Min	Y	0.003312	26	0	14.95	4.1
Story1	Time history 9-2	LinModHist	Max	X	0.002879	31	14.95	0	4.1
Story1	Time history 9-2	LinModHist	Max	Y	0.003522	29	0	0	4.1
Story1	Time history 9-2	LinModHist	Min	X	0.003182	31	14.95	0	4.1
Story1	Time history 9-2	LinModHist	Min	Y	0.003371	29	0	0	4.1
Story1	Time history 10-1	LinModHist	Max	X	0.002892	35	14.95	14.95	4.1
Story1	Time history 10-1	LinModHist	Max	Y	0.003835	26	0	14.95	4.1
Story1	Time history 10-1	LinModHist	Min	X	0.003358	29	0	0	4.1
Story1	Time history 10-1	LinModHist	Min	Y	0.00386	26	0	14.95	4.1
Story1	Time history 10-2	LinModHist	Max	X	0.002892	35	14.95	14.95	4.1

Table 3.2 - Story Drifts (continued)

Story	Output Case	Case Type	Step Type	Direction	Drift	Label	X m	Y m	Z m
Story1	Time history 10-2	LinModHist	Max	Y	0.003835	26	0	14.95	4.1
Story1	Time history 10-2	LinModHist	Min	X	0.003358	29	0	0	4.1
Story1	Time history 10-2	LinModHist	Min	Y	0.00386	26	0	14.95	4.1
Story1	Time history 6-2	LinModHist	Max	X	0.002388	29	0	0	4.1
Story1	Time history 6-2	LinModHist	Max	Y	0.003169	29	0	0	4.1
Story1	Time history 6-2	LinModHist	Min	X	0.002761	35	14.95	14.95	4.1
Story1	Time history 6-2	LinModHist	Min	Y	0.003424	26	0	14.95	4.1
Story1	DConS1	Combination		X	2.9E-05	29	0	0	4.1
Story1	DConS1	Combination		Y	3.1E-05	31	14.95	0	4.1
Story1	DConS2	Combination		X	4.2E-05	29	0	0	4.1
Story1	DConS2	Combination		Y	3.8E-05	31	14.95	0	4.1
Story1	Working Compo	Combination		X	2.9E-05	29	0	0	4.1
Story1	Working Compo	Combination		Y	2.6E-05	31	14.95	0	4.1

Table 3.3 - Story Forces (Part 1 of 2)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story6	Top	Dead	LinStatic		1270.3809	0.0705	0.0294	-0.2261	9449.8737
Story6	Bottom	Dead	LinStatic		1686.5405	0.0705	0.0294	-0.2261	12766.5184
Story6	Top	Live	LinStatic		440.4132	0.0271	0.0107	-0.0892	3291.3103
Story6	Bottom	Live	LinStatic		440.4132	0.0271	0.0107	-0.0892	3291.2752
Story6	Top	Block-Dead	LinStatic		179.4	-0.0252	0.0293	0.4775	1341.015
Story6	Bottom	Block-Dead	LinStatic		179.4	-0.0252	0.0293	0.4775	1340.9182
Story6	Top	Stair-Dead	LinStatic		0	0	0	0	0
Story6	Bottom	Stair-Dead	LinStatic		0	0	0	0	0
Story6	Top	Stair-Live	LinStatic		0	0	0	0	0
Story6	Bottom	Stair-Live	LinStatic		0	0	0	0	0
Story6	Top	Gravity -Nonlinear	NonStatic	Max	1380.4842	0.0774	0.0322	-0.2487	10272.7013
Story6	Bottom	Gravity -Nonlinear	NonStatic	Max	1796.6438	0.0774	0.0322	-0.2487	13589.3367
Story6	Top	Gravity -Nonlinear	NonStatic	Min	1380.4842	0.0774	0.0322	-0.2487	10272.7013
Story6	Bottom	Gravity -Nonlinear	NonStatic	Min	1796.6438	0.0774	0.0322	-0.2487	13589.3367
Story6	Top	Pushover-Mode2-x	NonStatic	Max	1380.4842	1419.6798	85.8685	-0.2487	10273.1536
Story6	Bottom	Pushover-Mode2-x	NonStatic	Max	1796.6438	1420.0246	85.8943	-0.2487	13589.3367
Story6	Top	Pushover-Mode2-x	NonStatic	Min	1380.4842	0.0774	0.0322	-10501.7177	10272.7013
Story6	Bottom	Pushover-Mode2-x	NonStatic	Min	1796.6438	0.0774	0.0322	-10504.1588	13306.0514
Story6	Top	Pushover-Mode1-Y	NonStatic	Max	1380.4842	885.6356	53.9453	-0.2487	10272.9769
Story6	Bottom	Pushover-Mode1-Y	NonStatic	Max	1796.6438	885.9287	53.9609	-0.2487	13589.3367
Story6	Top	Pushover-Mode1-Y	NonStatic	Min	1380.4841	0.0774	0.0322	-6546.6852	10272.7013
Story6	Bottom	Pushover-Mode1-Y	NonStatic	Min	1796.6438	0.0774	0.0322	-6549.0727	13411.7416
Story6	Top	Time history 1-1	LinModHist	Max	0	572.6554	383.5117	6232.6195	1.443E-06
Story6	Bottom	Time history 1-1	LinModHist	Max	0	572.797	383.6087	6234.2889	1215.7162
Story6	Top	Time history 1-1	LinModHist	Min	0	-563.1331	-368.3253	-5958.5329	-1.55E-06
Story6	Bottom	Time history 1-1	LinModHist	Min	0	-563.2692	-368.4193	-5960.1648	-1265.8411
Story6	Top	Time history 1-2	LinModHist	Max	0	600.4078	364.6507	7047.1901	1.824E-06
Story6	Bottom	Time history 1-2	LinModHist	Max	0	600.5581	364.7425	7049.1059	1178.176

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story6	Top	Time history 1-2	LinModHist	Min	0	-618.4913	-356.9539	-7063.1546	-1.841E-06
Story6	Bottom	Time history 1-2	LinModHist	Min	0	-618.6464	-357.0415	-7065.0673	-1203.5853
Story6	Top	Time history 2-1	LinModHist	Max	0	544.0352	386.4186	6650.4636	1.655E-06
Story6	Bottom	Time history 2-1	LinModHist	Max	0	544.1726	386.5176	6652.2752	1313.715
Story6	Top	Time history 2-1	LinModHist	Min	0	-598.6166	-398.0166	-6137.9908	-1.411E-06
Story6	Bottom	Time history 2-1	LinModHist	Min	0	-598.7631	-398.1166	-6139.6536	-1275.4386
Story6	Top	Time history 2-2	LinModHist	Max	0	581.5286	346.8105	6503.4398	1.178E-06
Story6	Bottom	Time history 2-2	LinModHist	Max	0	581.6703	346.8944	6505.1233	1619.0059
Story6	Top	Time history 2-2	LinModHist	Min	0	-609.4679	-490.5112	-6220.9018	-1.47E-06
Story6	Bottom	Time history 2-2	LinModHist	Min	0	-609.6191	-490.6332	-6222.7081	-1144.694
Story6	Top	Time history 3-1	LinModHist	Max	0	510.2824	383.5556	6143.7864	1.365E-06
Story6	Bottom	Time history 3-1	LinModHist	Max	0	510.4088	383.6513	6145.4759	1237.0358
Story6	Top	Time history 3-1	LinModHist	Min	0	-502.7437	-374.786	-5937.127	-1.362E-06
Story6	Bottom	Time history 3-1	LinModHist	Min	0	-502.8645	-374.8788	-5938.77	-1265.9822
Story6	Top	Time history 3-2	LinModHist	Max	0	482.4051	352.8122	5317.6743	1.111E-06
Story6	Bottom	Time history 3-2	LinModHist	Max	0	482.5255	352.9025	5319.1634	1239.5623
Story6	Top	Time history 3-2	LinModHist	Min	0	-469.5351	-375.5501	-5681.1582	-1.29E-06
Story6	Bottom	Time history 3-2	LinModHist	Min	0	-469.6541	-375.6453	-5682.6749	-1164.5148
Story6	Top	Time history 4-1	LinModHist	Max	0	437.9867	347.2148	5427.9208	1.042E-06
Story6	Bottom	Time history 4-1	LinModHist	Max	0	438.0963	347.3035	5429.4393	1193.717
Story6	Top	Time history 4-1	LinModHist	Min	0	-528.0253	-361.6603	-4807.0856	-1.085E-06
Story6	Bottom	Time history 4-1	LinModHist	Min	0	-528.1583	-361.7516	-4808.3853	-1146.0388
Story6	Top	Time history 4-2	LinModHist	Max	0	451.3193	384.8469	5414.479	1.195E-06
Story6	Bottom	Time history 4-2	LinModHist	Max	0	451.4328	384.9434	5416.0584	1213.9352
Story6	Top	Time history 4-2	LinModHist	Min	0	-479.3134	-367.7858	-5039.5584	-1.459E-06
Story6	Bottom	Time history 4-2	LinModHist	Min	0	-479.4347	-367.8787	-5041.0711	-1270.2465
Story6	Top	Time history 5-1	LinModHist	Max	0	474.5106	302.5334	5338.0348	1.154E-06
Story6	Bottom	Time history 5-1	LinModHist	Max	0	474.6301	302.6103	5339.4839	944.9035
Story6	Top	Time history 5-1	LinModHist	Min	0	-507.3176	-286.277	-5000.9348	-1.352E-06
Story6	Bottom	Time history 5-1	LinModHist	Min	0	-507.4428	-286.3497	-5002.3022	-998.56
Story6	Top	Time history 5-2	LinModHist	Max	0	515.5671	312.3409	5315.0626	1.021E-06
Story6	Bottom	Time history 5-2	LinModHist	Max	0	515.697	312.4191	5316.5683	1030.5407
Story6	Top	Time history 5-2	LinModHist	Min	0	-456.3985	-312.2244	-4742.2073	-1.184E-06
Story6	Bottom	Time history 5-2	LinModHist	Min	0	-456.5136	-312.3013	-4743.4673	-1030.928
Story6	Top	Time history 6-1	LinModHist	Max	0	557.8768	398.688	4978.1595	1.213E-06
Story6	Bottom	Time history 6-1	LinModHist	Max	0	558.0158	398.788	4979.5822	1099.1102
Story6	Top	Time history 6-1	LinModHist	Min	0	-489.658	-332.9972	-5990.555	-1.121E-06
Story6	Bottom	Time history 6-1	LinModHist	Min	0	-489.7809	-333.0817	-5992.1039	-1315.9304
Story6	Top	Time history 7-1	LinModHist	Max	0	443.8818	309.0802	3991.843	1.091E-06
Story6	Bottom	Time history 7-1	LinModHist	Max	0	443.9934	309.1582	3992.8822	1029.0364
Story6	Top	Time history 7-1	LinModHist	Min	0	-470.1774	-311.7677	-4174.053	-9.882E-07
Story6	Bottom	Time history 7-1	LinModHist	Min	0	-470.2956	-311.8453	-4175.1704	-1020.1679
Story6	Top	Time history 7-2	LinModHist	Max	0	399.7899	363.6429	4730.894	1.172E-06
Story6	Bottom	Time history 7-2	LinModHist	Max	0	399.8911	363.735	4732.198	1311.763
Story6	Top	Time history 7-2	LinModHist	Min	0	-374.0207	-397.4249	-5746.0291	-1.549E-06

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story6	Bottom	Time history 7-2	LinModHist	Min	0	-374.1118	-397.5253	-5747.6826	-1200.2608
Story6	Top	Time history 8-1	LinModHist	Max	0	406.78	351.7871	6406.5209	9.76E-07
Story6	Bottom	Time history 8-1	LinModHist	Max	0	406.8814	351.8734	6408.3355	1312.9961
Story6	Top	Time history 8-1	LinModHist	Min	0	-411.9155	-397.7998	-5468.9295	-1.114E-06
Story6	Bottom	Time history 8-1	LinModHist	Min	0	-412.0178	-397.8983	-5470.4431	-1161.1221
Story6	Top	Time history 8-2	LinModHist	Max	0	398.1432	352.6509	4437.3843	7.99E-07
Story6	Bottom	Time history 8-2	LinModHist	Max	0	398.2427	352.7373	4438.6899	1304.1695
Story6	Top	Time history 8-2	LinModHist	Min	0	-354.5346	-395.1256	-4784.3369	-9.726E-07
Story6	Bottom	Time history 8-2	LinModHist	Min	0	-354.6236	-395.2234	-4785.7389	-1163.9731
Story6	Top	Time history 9-1	LinModHist	Max	0	731.5824	363.6152	7902.4375	1.632E-06
Story6	Bottom	Time history 9-1	LinModHist	Max	0	731.7674	363.7065	7904.7441	1090.4375
Story6	Top	Time history 9-1	LinModHist	Min	0	-707.4889	-330.3712	-8340.4443	-1.434E-06
Story6	Bottom	Time history 9-1	LinModHist	Min	0	-707.6666	-330.4526	-8342.8172	-1200.1674
Story6	Top	Time history 9-2	LinModHist	Max	0	691.0639	387.1023	6596.0084	1.404E-06
Story6	Bottom	Time history 9-2	LinModHist	Max	0	691.234	387.1977	6597.7383	1057.1233
Story6	Top	Time history 9-2	LinModHist	Min	0	-645.408	-320.2762	-5540.9718	-1.549E-06
Story6	Bottom	Time history 9-2	LinModHist	Min	0	-645.5695	-320.3576	-5542.4991	-1277.6861
Story6	Top	Time history 10-1	LinModHist	Max	0	580.918	398.8835	5347.6299	1.419E-06
Story6	Bottom	Time history 10-1	LinModHist	Max	0	581.0616	398.9835	5349.1797	1442.9785
Story6	Top	Time history 10-1	LinModHist	Min	0	-484.6582	-437.1802	-4957.1413	-1.434E-06
Story6	Bottom	Time history 10-1	LinModHist	Min	0	-484.7725	-437.2891	-4958.583	-1316.5758
Story6	Top	Time history 10-2	LinModHist	Max	0	580.918	398.8835	5347.6299	1.419E-06
Story6	Bottom	Time history 10-2	LinModHist	Max	0	581.0616	398.9835	5349.1797	1442.9785
Story6	Top	Time history 10-2	LinModHist	Min	0	-484.6582	-437.1802	-4957.1413	-1.434E-06
Story6	Bottom	Time history 10-2	LinModHist	Min	0	-484.7725	-437.2891	-4958.583	-1316.5758
Story6	Top	Time history 6-2	LinModHist	Max	0	492.8457	312.6899	5476.1841	1.502E-06
Story6	Bottom	Time history 6-2	LinModHist	Max	0	492.9692	312.7705	5477.6981	1057.4144
Story6	Top	Time history 6-2	LinModHist	Min	0	-443.6118	-320.3646	-4367.795	-1.189E-06
Story6	Bottom	Time history 6-2	LinModHist	Min	0	-443.7254	-320.4463	-4368.924	-1032.085
Story6	Top	DConS1	Combination		2029.6932	0.0634	0.0822	0.352	15107.2441
Story6	Bottom	DConS1	Combination		2612.3168	0.0634	0.0822	0.352	19750.4113
Story6	Top	DConS2	Combination		2734.3543	0.1067	0.0992	0.2092	20373.3407
Story6	Bottom	DConS2	Combination		3316.9779	0.1067	0.0992	0.2092	25016.4516
Story6	Top	Working Compo	Combination		1890.1941	0.0724	0.0694	0.1622	14082.199
Story6	Bottom	Working Compo	Combination		2306.3537	0.0724	0.0694	0.1622	17398.7118
Story5	Top	Dead	LinStatic		2913.4031	0.1412	0.0587	-0.4535	21676.7651
Story5	Bottom	Dead	LinStatic		3329.5628	0.1412	0.0587	-0.4535	24993.313
Story5	Top	Live	LinStatic		853.7964	0.0543	0.0212	-0.18	6247.4135
Story5	Bottom	Live	LinStatic		853.7964	0.0543	0.0212	-0.18	6247.3435
Story5	Top	Block-Dead	LinStatic		1697.75	-0.0518	0.0605	0.9897	12592.1477
Story5	Bottom	Block-Dead	LinStatic		1697.75	-0.0518	0.0605	0.9897	12591.948
Story5	Top	Stair-Dead	LinStatic		0	0	0	0	0
Story5	Bottom	Stair-Dead	LinStatic		0	0	0	0	0
Story5	Top	Stair-Live	LinStatic		0	0	0	0	0
Story5	Bottom	Stair-Live	LinStatic		0	0	0	0	0

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story5	Top	Gravity -Nonlinear	NonStatic	Max	3126.8522	0.1552	0.0643	-0.4992	23238.6181
Story5	Bottom	Gravity -Nonlinear	NonStatic	Max	3543.0119	0.1552	0.0643	-0.4992	26555.1475
Story5	Top	Gravity -Nonlinear	NonStatic	Min	3126.8522	0.1552	0.0643	-0.4992	23238.6181
Story5	Bottom	Gravity -Nonlinear	NonStatic	Min	3543.0119	0.1552	0.0643	-0.4992	26555.1475
Story5	Top	Pushover-Mode2-x	NonStatic	Max	3126.8522	2739.123	177.0953	-0.4992	23238.6181
Story5	Bottom	Pushover-Mode2-x	NonStatic	Max	3543.0119	2739.5135	177.1177	-0.4992	26555.1475
Story5	Top	Pushover-Mode2-x	NonStatic	Min	3126.8522	0.1552	0.0643	-20192.0203	22955.1732
Story5	Bottom	Pushover-Mode2-x	NonStatic	Min	3543.0119	0.1552	0.0643	-20194.2188	25686.7494
Story5	Top	Pushover-Mode1-Y	NonStatic	Max	3126.8523	1708.4612	111.2657	-0.4992	23238.6181
Story5	Bottom	Pushover-Mode1-Y	NonStatic	Max	3543.0119	1708.6997	111.2702	-0.4992	26555.1475
Story5	Top	Pushover-Mode1-Y	NonStatic	Min	3126.8522	0.1552	0.0643	-12588.8207	23061.0497
Story5	Bottom	Pushover-Mode1-Y	NonStatic	Min	3543.0119	0.1552	0.0643	-12590.8084	26010.7152
Story5	Top	Time history 1-1	LinModHist	Max	9.463E-07	1072.3133	726.8422	11243.8727	1215.7164
Story5	Bottom	Time history 1-1	LinModHist	Max	9.452E-07	1072.4218	726.9183	11245.0551	3512.776
Story5	Top	Time history 1-1	LinModHist	Min	-9.073E-07	-1024.8159	-696.0207	-10943.9099	-1265.8413
Story5	Bottom	Time history 1-1	LinModHist	Min	-9.049E-07	-1024.9246	-696.0948	-10945.1128	-3664.6186
Story5	Top	Time history 1-2	LinModHist	Max	9.954E-07	1105.7399	667.7547	13055.4723	1178.1763
Story5	Bottom	Time history 1-2	LinModHist	Max	9.943E-07	1105.8633	667.8228	13056.9402	3192.6326
Story5	Top	Time history 1-2	LinModHist	Min	-9.375E-07	-1123.2049	-625.7449	-13364.4102	-1203.5856
Story5	Bottom	Time history 1-2	LinModHist	Min	-9.382E-07	-1123.3158	-625.8121	-13366.0177	-3399.1861
Story5	Top	Time history 2-1	LinModHist	Max	8.177E-07	1008.2336	771.3615	12837.2816	1313.7152
Story5	Bottom	Time history 2-1	LinModHist	Max	8.166E-07	1008.3366	771.4493	12838.8449	3759.0066
Story5	Top	Time history 2-1	LinModHist	Min	-8.379E-07	-1025.837	-743.3688	-11585.02	-1275.4387
Story5	Bottom	Time history 2-1	LinModHist	Min	-8.369E-07	-1025.9302	-743.4497	-11586.374	-3821.16
Story5	Top	Time history 2-2	LinModHist	Max	8.353E-07	986.2947	623.152	10929.7147	1619.0062
Story5	Bottom	Time history 2-2	LinModHist	Max	8.321E-07	986.3968	623.2208	10930.7028	4684.7528
Story5	Top	Time history 2-2	LinModHist	Min	-9.805E-07	-1123.6562	-930.4692	-11865.6021	-1144.6944
Story5	Bottom	Time history 2-2	LinModHist	Min	-9.781E-07	-1123.7682	-930.5667	-11867.0459	-3112.2921
Story5	Top	Time history 3-1	LinModHist	Max	8.16E-07	953.8132	690.0983	11403.8288	1237.036
Story5	Bottom	Time history 3-1	LinModHist	Max	8.131E-07	953.9176	690.1752	11405.1163	3430.7995
Story5	Top	Time history 3-1	LinModHist	Min	-7.968E-07	-941.1519	-664.7278	-10980.3142	-1265.9824
Story5	Bottom	Time history 3-1	LinModHist	Min	-7.931E-07	-941.2527	-664.7897	-10981.5542	-3542.959
Story5	Top	Time history 3-2	LinModHist	Max	7.979E-07	918.8202	696.2792	10275.5546	1239.5625
Story5	Bottom	Time history 3-2	LinModHist	Max	7.963E-07	918.916	696.3574	10276.7634	3581.0619
Story5	Top	Time history 3-2	LinModHist	Min	-7.885E-07	-908.9531	-709.4867	-10844.6	-1164.5149
Story5	Bottom	Time history 3-2	LinModHist	Min	-7.847E-07	-909.0519	-709.5612	-10845.8317	-3462.4394
Story5	Top	Time history 4-1	LinModHist	Max	7.216E-07	832.4128	675.4972	10002.683	1193.7171
Story5	Bottom	Time history 4-1	LinModHist	Max	7.198E-07	832.4997	675.5716	10003.8273	3477.9499
Story5	Top	Time history 4-1	LinModHist	Min	-7.537E-07	-951.6439	-692.1337	-9100.0792	-1146.0389
Story5	Bottom	Time history 4-1	LinModHist	Min	-7.513E-07	-951.7372	-692.2071	-9101.1084	-3375.3727
Story5	Top	Time history 4-2	LinModHist	Max	7.737E-07	862.153	724.2305	10629.1813	1213.9353
Story5	Bottom	Time history 4-2	LinModHist	Max	7.717E-07	862.2447	724.3053	10630.5623	3550.7568
Story5	Top	Time history 4-2	LinModHist	Min	-7.959E-07	-911.8704	-708.3596	-9465.3577	-1270.2467
Story5	Bottom	Time history 4-2	LinModHist	Min	-7.96E-07	-911.9666	-708.4368	-9466.5784	-3660.4029
Story5	Top	Time history 5-1	LinModHist	Max	8.208E-07	896.0963	584.172	9557.2907	944.9036

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story5	Bottom	Time history 5-1	LinModHist	Max	8.18E-07	896.1922	584.2356	9558.3056	2798.686
Story5	Top	Time history 5-1	LinModHist	Min	-8.075E-07	-876.0973	-561.9365	-9061.6865	-998.5601
Story5	Bottom	Time history 5-1	LinModHist	Min	-8.07E-07	-876.1764	-561.9989	-9062.6739	-2926.4928
Story5	Top	Time history 5-2	LinModHist	Max	8.709E-07	988.9047	567.681	10088.6091	1030.541
Story5	Bottom	Time history 5-2	LinModHist	Max	8.685E-07	989.0103	567.7368	10089.8124	2779.4308
Story5	Top	Time history 5-2	LinModHist	Min	-7.672E-07	-879.6371	-541.3757	-8784.5169	-1030.9281
Story5	Bottom	Time history 5-2	LinModHist	Min	-7.654E-07	-879.7314	-541.4339	-8785.461	-2904.4206
Story5	Top	Time history 6-1	LinModHist	Max	8.452E-07	1027.4191	735.8975	9526.0988	1099.1104
Story5	Bottom	Time history 6-1	LinModHist	Max	8.409E-07	1027.5215	735.9717	9527.2719	3177.9815
Story5	Top	Time history 6-1	LinModHist	Min	-8.276E-07	-933.1786	-630.6867	-11127.6444	-1315.9307
Story5	Bottom	Time history 6-1	LinModHist	Min	-8.249E-07	-933.2776	-630.7535	-11128.8124	-3740.7039
Story5	Top	Time history 7-1	LinModHist	Max	7.645E-07	854.9692	593.0888	7512.1481	1029.0365
Story5	Bottom	Time history 7-1	LinModHist	Max	7.629E-07	855.0617	593.1534	7512.9849	2968.7407
Story5	Top	Time history 7-1	LinModHist	Min	-8.018E-07	-905.4683	-591.6609	-7775.0876	-1020.1681
Story5	Bottom	Time history 7-1	LinModHist	Min	-7.988E-07	-905.5663	-591.7254	-7775.9368	-2969.3867
Story5	Top	Time history 7-2	LinModHist	Max	6.905E-07	765.9266	696.2076	9135.5316	1311.7632
Story5	Bottom	Time history 7-2	LinModHist	Max	6.901E-07	766.0114	696.2828	9136.634	3787.7201
Story5	Top	Time history 7-2	LinModHist	Min	-6.078E-07	-675.4521	-750.2282	-10865.3872	-1200.2609
Story5	Bottom	Time history 7-2	LinModHist	Min	-6.073E-07	-675.5185	-750.3065	-10866.6893	-3485.7748
Story5	Top	Time history 8-1	LinModHist	Max	6.219E-07	744.2123	620.6623	11270.1188	1312.9964
Story5	Bottom	Time history 8-1	LinModHist	Max	6.199E-07	744.2866	620.7292	11271.3135	3658.6289
Story5	Top	Time history 8-1	LinModHist	Min	-6.292E-07	-745.5554	-713.7234	-10049.4397	-1161.1224
Story5	Bottom	Time history 8-1	LinModHist	Min	-6.268E-07	-745.6286	-713.7916	-10050.5657	-3136.902
Story5	Top	Time history 8-2	LinModHist	Max	6.485E-07	755.5433	632.3852	7885.7983	1304.1698
Story5	Bottom	Time history 8-2	LinModHist	Max	6.47E-07	755.6216	632.4531	7886.6799	3626.4193
Story5	Top	Time history 8-2	LinModHist	Min	-6.015E-07	-685.6344	-706.4486	-8633.9043	-1163.9734
Story5	Bottom	Time history 8-2	LinModHist	Min	-6.005E-07	-685.7075	-706.5159	-8634.8932	-3168.2624
Story5	Top	Time history 9-1	LinModHist	Max	1.082E-06	1325.0246	676.2101	15304.3297	1090.4377
Story5	Bottom	Time history 9-1	LinModHist	Max	1.079E-06	1325.1568	676.2789	15306.2482	3006.6738
Story5	Top	Time history 9-1	LinModHist	Min	-1.089E-06	-1305.2505	-581.3394	-15165.8422	-1200.1676
Story5	Bottom	Time history 9-1	LinModHist	Min	-1.084E-06	-1305.3845	-581.3931	-15167.5671	-3431.8403
Story5	Top	Time history 9-2	LinModHist	Max	1.014E-06	1235.333	670.3336	12204.534	1057.1234
Story5	Bottom	Time history 9-2	LinModHist	Max	1.012E-06	1235.4531	670.3929	12205.8622	3120.3754
Story5	Top	Time history 9-2	LinModHist	Min	-1.017E-06	-1196.7528	-625.1741	-9694.7501	-1277.6864
Story5	Bottom	Time history 9-2	LinModHist	Min	-1.013E-06	-1196.8749	-625.2421	-9695.7168	-3489.9423
Story5	Top	Time history 10-1	LinModHist	Max	9.222E-07	1076.0539	732.0152	9993.811	1442.9788
Story5	Bottom	Time history 10-1	LinModHist	Max	9.197E-07	1076.1602	732.0886	9994.9997	4070.0318
Story5	Top	Time history 10-1	LinModHist	Min	-7.701E-07	-889.9425	-796.0148	-8796.5358	-1316.576
Story5	Bottom	Time history 10-1	LinModHist	Min	-7.67E-07	-890.031	-796.0931	-8797.5606	-3732.4168
Story5	Top	Time history 10-2	LinModHist	Max	9.222E-07	1076.0539	732.0152	9993.811	1442.9788
Story5	Bottom	Time history 10-2	LinModHist	Max	9.197E-07	1076.1602	732.0886	9994.9997	4070.0318
Story5	Top	Time history 10-2	LinModHist	Min	-7.701E-07	-889.9425	-796.0148	-8796.5358	-1316.576
Story5	Bottom	Time history 10-2	LinModHist	Min	-7.67E-07	-890.031	-796.0931	-8797.5606	-3732.4168
Story5	Top	Time history 6-2	LinModHist	Max	8.6E-07	947.7112	613.2946	10438.7904	1057.4146
Story5	Bottom	Time history 6-2	LinModHist	Max	8.598E-07	947.812	613.3634	10440.0217	3070.8435

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story5	Top	Time history 6-2	LinModHist	Min	-7.356E-07	-855.4197	-610.2761	-8341.3301	-1032.0851
Story5	Bottom	Time history 6-2	LinModHist	Min	-7.318E-07	-855.5141	-610.342	-8342.355	-3054.6123
Story5	Top	DConS1	Combination		6455.6143	0.1251	0.167	0.7507	47976.4779
Story5	Bottom	DConS1	Combination		7038.2379	0.1251	0.167	0.7507	52619.3653
Story5	Top	DConS2	Combination		7821.6886	0.212	0.2009	0.4627	57972.3396
Story5	Bottom	DConS2	Combination		8404.3122	0.212	0.2009	0.4627	62615.1149
Story5	Top	Working Compo	Combination		5464.9495	0.1437	0.1405	0.3562	40516.3263
Story5	Bottom	Working Compo	Combination		5881.1092	0.1437	0.1405	0.3562	43832.6045
Story4	Top	Dead	LinStatic		4556.4253	0.2017	0.0841	-0.6431	33903.5597
Story4	Bottom	Dead	LinStatic		4972.585	0.2017	0.0841	-0.6431	37220.0238
Story4	Top	Live	LinStatic		1267.1796	0.0775	0.0303	-0.2563	9203.4818
Story4	Bottom	Live	LinStatic		1267.1796	0.0775	0.0303	-0.2563	9203.382
Story4	Top	Block-Dead	LinStatic		3216.1	-0.0758	0.0887	1.4584	23843.1774
Story4	Bottom	Block-Dead	LinStatic		3216.1	-0.0758	0.0887	1.4584	23842.8846
Story4	Top	Stair-Dead	LinStatic		0	0	0	0	0
Story4	Bottom	Stair-Dead	LinStatic		0	0	0	0	0
Story4	Top	Stair-Live	LinStatic		0	0	0	0	0
Story4	Bottom	Stair-Live	LinStatic		0	0	0	0	0
Story4	Top	Gravity -Nonlinear	NonStatic	Max	4873.2202	0.2217	0.0921	-0.7081	36204.4288
Story4	Bottom	Gravity -Nonlinear	NonStatic	Max	5289.3799	0.2217	0.0921	-0.7081	39520.8667
Story4	Top	Gravity -Nonlinear	NonStatic	Min	4873.2202	0.2217	0.0921	-0.7081	36204.4288
Story4	Bottom	Gravity -Nonlinear	NonStatic	Min	5289.3799	0.2217	0.0921	-0.7081	39520.8667
Story4	Top	Pushover-Mode2-x	NonStatic	Max	4873.2203	3767.2788	261.1244	-0.7081	36204.4288
Story4	Bottom	Pushover-Mode2-x	NonStatic	Max	5289.38	3767.5456	261.1373	-0.7081	39520.8667
Story4	Top	Pushover-Mode2-x	NonStatic	Min	4873.2202	0.2217	0.0921	-27785.1066	35335.5706
Story4	Bottom	Pushover-Mode2-x	NonStatic	Min	5289.3799	0.2217	0.0921	-27786.7385	37788.0432
Story4	Top	Pushover-Mode1-Y	NonStatic	Max	4873.2204	2348.9906	164.0724	-0.7081	36204.4288
Story4	Bottom	Pushover-Mode1-Y	NonStatic	Max	5289.3801	2349.3338	164.0451	-0.7081	39520.8667
Story4	Top	Pushover-Mode1-Y	NonStatic	Min	4873.2202	0.2217	0.0921	-17317.5304	35659.9798
Story4	Bottom	Pushover-Mode1-Y	NonStatic	Min	5289.3799	0.2217	0.0921	-17321.0079	38435.2375
Story4	Top	Time history 1-1	LinModHist	Max	7.168E-07	1441.3442	959.5047	14752.0355	3512.7762
Story4	Bottom	Time history 1-1	LinModHist	Max	7.073E-07	1441.4311	959.554	14752.8535	6651.9297
Story4	Top	Time history 1-1	LinModHist	Min	-7.773E-07	-1409.5337	-951.2137	-14365.2618	-3664.6189
Story4	Bottom	Time history 1-1	LinModHist	Min	-7.715E-07	-1409.6384	-951.2711	-14366.0284	-6831.1129
Story4	Top	Time history 1-2	LinModHist	Max	9.307E-07	1543.2734	890.7789	17566.5971	3192.6328
Story4	Bottom	Time history 1-2	LinModHist	Max	9.204E-07	1543.3694	890.8282	17567.8365	5961.6211
Story4	Top	Time history 1-2	LinModHist	Min	-8.79E-07	-1439.0234	-867.9729	-18746.6993	-3399.1863
Story4	Bottom	Time history 1-2	LinModHist	Min	-8.688E-07	-1439.1106	-868.032	-18748.0451	-6322.6859
Story4	Top	Time history 2-1	LinModHist	Max	8.149E-07	1308.6801	1103.3208	18128.703	3759.0068
Story4	Bottom	Time history 2-1	LinModHist	Max	8.066E-07	1308.744	1103.3955	18130.0033	7098.0139
Story4	Top	Time history 2-1	LinModHist	Min	-9.096E-07	-1267.0155	-1023.4545	-15772.9891	-3821.1601
Story4	Bottom	Time history 2-1	LinModHist	Min	-9.004E-07	-1267.0673	-1023.5165	-15774.136	-7462.3134
Story4	Top	Time history 2-2	LinModHist	Max	7.582E-07	1316.2371	868.3768	14171.9772	4684.7531
Story4	Bottom	Time history 2-2	LinModHist	Max	7.496E-07	1316.3073	868.432	14172.9062	8768.7129
Story4	Top	Time history 2-2	LinModHist	Min	-7.452E-07	-1500.2276	-1237.512	-15841.3898	-3112.2922

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story4	Bottom	Time history 2-2	LinModHist	Min	-7.373E-07	-1500.3176	-1237.5769	-15842.3612	-5978.0788
Story4	Top	Time history 3-1	LinModHist	Max	7.198E-07	1305.9119	981.3885	15067.7021	3430.7997
Story4	Bottom	Time history 3-1	LinModHist	Max	7.144E-07	1305.9876	981.454	15068.5888	6146.5016
Story4	Top	Time history 3-1	LinModHist	Min	-7.395E-07	-1272.3576	-890.2792	-14367.5442	-3542.9592
Story4	Bottom	Time history 3-1	LinModHist	Min	-7.303E-07	-1272.4308	-890.3356	-14368.3574	-6658.8566
Story4	Top	Time history 3-2	LinModHist	Max	7.984E-07	1235.5766	983.6991	14329.2989	3581.0621
Story4	Bottom	Time history 3-2	LinModHist	Max	7.923E-07	1235.6435	983.7637	14330.2542	6704.354
Story4	Top	Time history 3-2	LinModHist	Min	-7.646E-07	-1255.2769	-946.4116	-14732.5805	-3462.4395
Story4	Bottom	Time history 3-2	LinModHist	Min	-7.562E-07	-1255.3535	-946.463	-14733.497	-6708.8146
Story4	Top	Time history 4-1	LinModHist	Max	6.54E-07	1120.8897	936.9605	12981.5305	3477.9501
Story4	Bottom	Time history 4-1	LinModHist	Max	6.477E-07	1120.9515	937.019	12982.2712	6550.2766
Story4	Top	Time history 4-1	LinModHist	Min	-6.02E-07	-1194.353	-930.9674	-12440.6449	-3375.3728
Story4	Bottom	Time history 4-1	LinModHist	Min	-5.93E-07	-1194.4037	-931.0187	-12441.4431	-6465.6057
Story4	Top	Time history 4-2	LinModHist	Max	7.251E-07	1189.2347	977.1932	15061.1008	3550.757
Story4	Bottom	Time history 4-2	LinModHist	Max	7.203E-07	1189.3071	977.2483	15062.2835	6796.0439
Story4	Top	Time history 4-2	LinModHist	Min	-7.292E-07	-1221.6398	-985.824	-13663.8857	-3660.403
Story4	Bottom	Time history 4-2	LinModHist	Min	-7.224E-07	-1221.7061	-985.8857	-13664.9244	-6870.5048
Story4	Top	Time history 5-1	LinModHist	Max	6.052E-07	1287.39	808.135	12194.3528	2798.686
Story4	Bottom	Time history 5-1	LinModHist	Max	5.969E-07	1287.485	808.1851	12194.9821	5415.6937
Story4	Top	Time history 5-1	LinModHist	Min	-6.048E-07	-1222.0052	-793.4203	-11541.794	-2926.4929
Story4	Bottom	Time history 5-1	LinModHist	Min	-5.972E-07	-1222.0814	-793.4721	-11542.398	-5593.4686
Story4	Top	Time history 5-2	LinModHist	Max	5.88E-07	1352.5475	738.2563	13615.8556	2779.4311
Story4	Bottom	Time history 5-2	LinModHist	Max	5.825E-07	1352.6272	738.2929	13616.6939	5172.1623
Story4	Top	Time history 5-2	LinModHist	Min	-6.419E-07	-1198.0788	-749.3254	-11421.4243	-2904.4208
Story4	Bottom	Time history 5-2	LinModHist	Min	-6.348E-07	-1198.1483	-749.3711	-11422.0231	-5326.0541
Story4	Top	Time history 6-1	LinModHist	Max	8.582E-07	1338.0853	952.7087	13027.1366	3177.9817
Story4	Bottom	Time history 6-1	LinModHist	Max	8.499E-07	1338.1505	952.7545	13028.0397	5965.5998
Story4	Top	Time history 6-1	LinModHist	Min	-7.168E-07	-1283.8968	-845.815	-14641.3203	-3740.7041
Story4	Bottom	Time history 6-1	LinModHist	Min	-7.11E-07	-1283.9745	-845.8624	-14642.0882	-6877.5335
Story4	Top	Time history 7-1	LinModHist	Max	5.921E-07	1190.957	816.8699	10381.5284	2968.7408
Story4	Bottom	Time history 7-1	LinModHist	Max	5.849E-07	1191.0328	816.9198	10382.2385	5668.408
Story4	Top	Time history 7-1	LinModHist	Min	-5.909E-07	-1257.1694	-848.2153	-10516.4942	-2969.3868
Story4	Bottom	Time history 7-1	LinModHist	Min	-5.825E-07	-1257.248	-848.2779	-10517.1847	-5638.1079
Story4	Top	Time history 7-2	LinModHist	Max	6.057E-07	1071.08	944.2741	12639.8145	3787.7203
Story4	Bottom	Time history 7-2	LinModHist	Max	6.004E-07	1071.1494	944.3285	12640.7265	7100.2688
Story4	Top	Time history 7-2	LinModHist	Min	-5.937E-07	-913.7304	-1003.8177	-14415.2567	-3485.775
Story4	Bottom	Time history 7-2	LinModHist	Min	-5.903E-07	-913.7879	-1003.8732	-14416.123	-6582.4045
Story4	Top	Time history 8-1	LinModHist	Max	6.436E-07	972.2242	858.5176	13947.8247	3658.6292
Story4	Bottom	Time history 8-1	LinModHist	Max	6.396E-07	972.2748	858.5744	13948.4522	6600.2946
Story4	Top	Time history 8-1	LinModHist	Min	-5.976E-07	-982.155	-936.1391	-13195.5672	-3136.9022
Story4	Bottom	Time history 8-1	LinModHist	Min	-5.909E-07	-982.2091	-936.1984	-13196.3391	-5875.4559
Story4	Top	Time history 8-2	LinModHist	Max	0	1009.8509	871.5061	10444.4714	3626.4195
Story4	Bottom	Time history 8-2	LinModHist	Max	0	1009.9049	871.5613	10445.2879	6626.7335
Story4	Top	Time history 8-2	LinModHist	Min	0	-933.7077	-951.7119	-11000.2019	-3168.2626
Story4	Bottom	Time history 8-2	LinModHist	Min	0	-933.7608	-951.7709	-11000.7976	-5981.8139

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story4	Top	Time history 9-1	LinModHist	Max	9.576E-07	1698.697	895.7779	21313.4527	3006.674
Story4	Bottom	Time history 9-1	LinModHist	Max	9.456E-07	1698.7781	895.8246	21314.9729	5392.9778
Story4	Top	Time history 9-1	LinModHist	Min	-9.585E-07	-1719.8549	-751.8673	-20201.8358	-3431.8404
Story4	Bottom	Time history 9-1	LinModHist	Min	-9.452E-07	-1719.9506	-751.9134	-20203.307	-6388.0301
Story4	Top	Time history 9-2	LinModHist	Max	7.372E-07	1608.9401	915.3596	16438.9448	3120.3756
Story4	Bottom	Time history 9-2	LinModHist	Max	7.285E-07	1609.0244	915.4179	16439.9514	5936.7326
Story4	Top	Time history 9-2	LinModHist	Min	-9.202E-07	-1596.9834	-855.311	-12445.8922	-3489.9426
Story4	Bottom	Time history 9-2	LinModHist	Min	-9.096E-07	-1597.0733	-855.3609	-12446.6316	-6278.0622
Story4	Top	Time history 10-1	LinModHist	Max	6.667E-07	1414.6175	950.9635	13214.077	4070.0321
Story4	Bottom	Time history 10-1	LinModHist	Max	6.593E-07	1414.6872	951.011	13214.9232	7470.2424
Story4	Top	Time history 10-1	LinModHist	Min	-7.019E-07	-1210.3911	-1039.1678	-11657.717	-3732.417
Story4	Bottom	Time history 10-1	LinModHist	Min	-6.952E-07	-1210.4687	-1039.2199	-11658.5198	-6870.7198
Story4	Top	Time history 10-2	LinModHist	Max	6.667E-07	1414.6175	950.9635	13214.077	4070.0321
Story4	Bottom	Time history 10-2	LinModHist	Max	6.593E-07	1414.6872	951.011	13214.9232	7470.2424
Story4	Top	Time history 10-2	LinModHist	Min	-7.019E-07	-1210.3911	-1039.1678	-11657.717	-3732.417
Story4	Bottom	Time history 10-2	LinModHist	Min	-6.952E-07	-1210.4687	-1039.2199	-11658.5198	-6870.7198
Story4	Top	Time history 6-2	LinModHist	Max	5.534E-07	1300.2527	848.9528	14245.765	3070.8436
Story4	Bottom	Time history 6-2	LinModHist	Max	5.461E-07	1300.3293	849.0055	14246.7046	5834.0582
Story4	Top	Time history 6-2	LinModHist	Min	-7.017E-07	-1183.6092	-839.3627	-11584.5235	-3054.6125
Story4	Bottom	Time history 6-2	LinModHist	Min	-6.928E-07	-1183.6833	-839.4147	-11585.3374	-5854.7555
Story4	Top	DConS1	Combination		10881.5355	0.1762	0.242	1.1415	80845.432
Story4	Bottom	DConS1	Combination		11464.159	0.1762	0.242	1.1415	85488.0717
Story4	Top	DConS2	Combination		12909.0229	0.3003	0.2904	0.7314	95571.003
Story4	Bottom	DConS2	Combination		13491.6465	0.3003	0.2904	0.7314	100213.4829
Story4	Top	Working Compo	Combination		9039.705	0.2034	0.2031	0.559	66950.219
Story4	Bottom	Working Compo	Combination		9455.8647	0.2034	0.2031	0.559	70266.2904
Story3	Top	Dead	LinStatic		6199.0422	0.2507	0.1051	-0.7902	46127.5781
Story3	Bottom	Dead	LinStatic		6577.3692	0.2507	0.1051	-0.7902	49142.4827
Story3	Top	Live	LinStatic		1680.0664	0.0963	0.0377	-0.316	12156.2162
Story3	Bottom	Live	LinStatic		1680.0664	0.0963	0.0377	-0.316	12156.1032
Story3	Top	Block-Dead	LinStatic		4734.45	-0.0962	0.1122	1.8604	35094.1141
Story3	Bottom	Block-Dead	LinStatic		4734.45	-0.0962	0.1122	1.8604	35093.7776
Story3	Top	Stair-Dead	LinStatic		0	0	0	0	0
Story3	Bottom	Stair-Dead	LinStatic		0	0	0	0	0
Story3	Top	Stair-Live	LinStatic		0	0	0	0	0
Story3	Bottom	Stair-Live	LinStatic		0	0	0	0	0
Story3	Top	Gravity -Nonlinear	NonStatic	Max	6619.0588	0.2755	0.1149	-0.8705	49166.6296
Story3	Bottom	Gravity -Nonlinear	NonStatic	Max	6997.3858	0.2755	0.1149	-0.8705	52181.5045
Story3	Top	Gravity -Nonlinear	NonStatic	Min	6619.0588	0.2755	0.1149	-0.8705	49166.6296
Story3	Bottom	Gravity -Nonlinear	NonStatic	Min	6997.3858	0.2755	0.1149	-0.8705	52181.5045
Story3	Top	Pushover-Mode2-x	NonStatic	Max	6619.0588	4476.2043	334.0854	-0.8705	49166.6296
Story3	Bottom	Pushover-Mode2-x	NonStatic	Max	6997.3858	4476.5126	334.076	-0.8705	52181.5045
Story3	Top	Pushover-Mode2-x	NonStatic	Min	6619.0588	0.2755	0.1149	-33067.2104	47433.2023
Story3	Bottom	Pushover-Mode2-x	NonStatic	Min	6997.3858	0.2755	0.1149	-33069.4757	49440.9972
Story3	Top	Pushover-Mode1-Y	NonStatic	Max	6619.059	2790.0724	209.9156	-0.8705	49166.6296

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story3	Bottom	Pushover-Mode1-Y	NonStatic	Max	6997.386	2790.5235	209.8511	-0.8705	52181.5045
Story3	Top	Pushover-Mode1-Y	NonStatic	Min	6619.0588	0.2755	0.1149	-20601.816	48081.0029
Story3	Bottom	Pushover-Mode1-Y	NonStatic	Min	6997.3858	0.2755	0.1149	-20606.8454	50466.0485
Story3	Top	Time history 1-1	LinModHist	Max	1.24E-06	1724.9729	1068.3231	16470.7402	6651.9298
Story3	Bottom	Time history 1-1	LinModHist	Max	1.234E-06	1725.0368	1068.3441	16471.1418	10087.1467
Story3	Top	Time history 1-1	LinModHist	Min	-1.207E-06	-1744.3893	-1145.039	-16643.4114	-6831.1131
Story3	Bottom	Time history 1-1	LinModHist	Min	-1.202E-06	-1744.4612	-1145.0822	-16644.4167	-10036.1311
Story3	Top	Time history 1-2	LinModHist	Max	1.307E-06	1845.23	1040.0301	21381.7097	5961.6212
Story3	Bottom	Time history 1-2	LinModHist	Max	1.301E-06	1845.2942	1040.0627	21382.7824	9048.8987
Story3	Top	Time history 1-2	LinModHist	Min	-1.212E-06	-1733.1992	-1083.1958	-22298.2113	-6322.686
Story3	Bottom	Time history 1-2	LinModHist	Min	-1.207E-06	-1733.2701	-1083.2463	-22299.098	-9442.8517
Story3	Top	Time history 2-1	LinModHist	Max	1.096E-06	1507.6441	1366.4544	22113.1265	7098.0141
Story3	Bottom	Time history 2-1	LinModHist	Max	1.091E-06	1507.7101	1366.5126	22114.0513	10769.1443
Story3	Top	Time history 2-1	LinModHist	Min	-1.073E-06	-1503.2903	-1223.6762	-18996.54	-7462.3135
Story3	Bottom	Time history 2-1	LinModHist	Min	-1.068E-06	-1503.3643	-1223.7199	-18997.3311	-11561.812
Story3	Top	Time history 2-2	LinModHist	Max	1.127E-06	1534.9539	1051.9006	16619.3013	8768.7131
Story3	Bottom	Time history 2-2	LinModHist	Max	1.122E-06	1535.0049	1051.9411	16619.9813	12961.4235
Story3	Top	Time history 2-2	LinModHist	Min	-1.306E-06	-1821.4201	-1429.9126	-18918.9158	-5978.0789
Story3	Bottom	Time history 2-2	LinModHist	Min	-1.3E-06	-1821.4946	-1429.9594	-18919.9315	-9133.8745
Story3	Top	Time history 3-1	LinModHist	Max	1.099E-06	1508.3375	1205.5624	17289.2818	6146.5017
Story3	Bottom	Time history 3-1	LinModHist	Max	1.094E-06	1508.3817	1205.6118	17289.8257	9297.9057
Story3	Top	Time history 3-1	LinModHist	Min	-1.083E-06	-1506.0086	-1102.2673	-16203.7396	-6658.8567
Story3	Bottom	Time history 3-1	LinModHist	Min	-1.078E-06	-1506.0618	-1102.3162	-16204.1718	-10275.6586
Story3	Top	Time history 3-2	LinModHist	Max	1.053E-06	1418.692	1203.2925	17221.0278	6704.3542
Story3	Bottom	Time history 3-2	LinModHist	Max	1.048E-06	1418.7285	1203.3409	17221.7012	9965.8958
Story3	Top	Time history 3-2	LinModHist	Min	-1.083E-06	-1497.8736	-1087.1578	-17254.9913	-6708.8147
Story3	Bottom	Time history 3-2	LinModHist	Min	-1.078E-06	-1497.926	-1087.1872	-17255.574	-10318.8046
Story3	Top	Time history 4-1	LinModHist	Max	9.623E-07	1309.02	1120.9054	14419.2707	6550.2768
Story3	Bottom	Time history 4-1	LinModHist	Max	9.578E-07	1309.0598	1120.9452	14419.6434	9757.9948
Story3	Top	Time history 4-1	LinModHist	Min	-9.908E-07	-1276.2957	-1074.583	-14874.6202	-6465.6059
Story3	Bottom	Time history 4-1	LinModHist	Min	-9.872E-07	-1276.3111	-1074.6128	-14875.2189	-9823.5527
Story3	Top	Time history 4-2	LinModHist	Max	1.035E-06	1444.7699	1160.5594	18618.9712	6796.044
Story3	Bottom	Time history 4-2	LinModHist	Max	1.03E-06	1444.8271	1160.5997	18619.9225	10386.4278
Story3	Top	Time history 4-2	LinModHist	Min	-1.024E-06	-1403.8781	-1206.8582	-17236.8432	-6870.505
Story3	Bottom	Time history 4-2	LinModHist	Min	-1.02E-06	-1403.9164	-1206.907	-17237.721	-10323.8061
Story3	Top	Time history 5-1	LinModHist	Max	1.12E-06	1644.5691	974.2154	13721.0046	5415.6937
Story3	Bottom	Time history 5-1	LinModHist	Max	1.114E-06	1644.6492	974.2521	13721.4281	8339.1258
Story3	Top	Time history 5-1	LinModHist	Min	-1.055E-06	-1484.6237	-974.6537	-13553.6959	-5593.4687
Story3	Bottom	Time history 5-1	LinModHist	Min	-1.05E-06	-1484.6802	-974.6941	-13554.2395	-8516.1999
Story3	Top	Time history 5-2	LinModHist	Max	1.16E-06	1606.6571	836.4902	15975.2852	5172.1624
Story3	Bottom	Time history 5-2	LinModHist	Max	1.154E-06	1606.7119	836.5102	15975.8249	7859.6686
Story3	Top	Time history 5-2	LinModHist	Min	-1.025E-06	-1422.4193	-898.0418	-13638.1681	-5326.0541
Story3	Bottom	Time history 5-2	LinModHist	Min	-1.02E-06	-1422.4679	-898.0744	-13638.9123	-7830.4094
Story3	Top	Time history 6-1	LinModHist	Max	1.148E-06	1540.8027	1050.0349	15458.508	5965.6
Story3	Bottom	Time history 6-1	LinModHist	Max	1.142E-06	1540.8683	1050.056	15459.1495	8896.7199

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story3	Top	Time history 6-1	LinModHist	Min	-1.113E-06	-1546.635	-1022.6978	-16595.9491	-6877.5337
Story3	Bottom	Time history 6-1	LinModHist	Min	-1.107E-06	-1546.6924	-1022.741	-16596.357	-9981.9393
Story3	Top	Time history 7-1	LinModHist	Max	1.026E-06	1437.3015	961.7825	12621.7342	5668.4082
Story3	Bottom	Time history 7-1	LinModHist	Max	1.021E-06	1437.3551	961.813	12622.272	8769.9504
Story3	Top	Time history 7-1	LinModHist	Min	-1.082E-06	-1511.7133	-1096.9965	-12817.681	-5638.108
Story3	Bottom	Time history 7-1	LinModHist	Min	-1.077E-06	-1511.7689	-1097.0546	-12818.2703	-8494.5299
Story3	Top	Time history 7-2	LinModHist	Max	9.084E-07	1291.3623	1087.5455	15130.6605	7100.269
Story3	Bottom	Time history 7-2	LinModHist	Max	9.043E-07	1291.4109	1087.5766	15131.3096	10580.7994
Story3	Top	Time history 7-2	LinModHist	Min	-7.81E-07	-1119.1407	-1164.6488	-16275.1059	-6582.4047
Story3	Bottom	Time history 7-2	LinModHist	Min	-7.775E-07	-1119.1879	-1164.6837	-16275.5788	-9798.1226
Story3	Top	Time history 8-1	LinModHist	Max	8.264E-07	1125.3965	1044.4828	16813.4907	6600.2949
Story3	Bottom	Time history 8-1	LinModHist	Max	8.229E-07	1125.4569	1044.5265	16814.3909	9916.3625
Story3	Top	Time history 8-1	LinModHist	Min	-8.511E-07	-1228.9555	-1168.0457	-15939.1411	-5875.4561
Story3	Bottom	Time history 8-1	LinModHist	Min	-8.471E-07	-1229.024	-1168.101	-15940.0908	-8850.092
Story3	Top	Time history 8-2	LinModHist	Max	8.576E-07	1157.8565	1068.8731	12681.8804	6626.7336
Story3	Bottom	Time history 8-2	LinModHist	Max	8.538E-07	1157.8876	1068.9194	12682.5148	10076.5478
Story3	Top	Time history 8-2	LinModHist	Min	-7.929E-07	-1085.4721	-1175.2698	-12231.7693	-5981.8141
Story3	Bottom	Time history 8-2	LinModHist	Min	-7.893E-07	-1085.5034	-1175.3252	-12232.1323	-9007.952
Story3	Top	Time history 9-1	LinModHist	Max	1.413E-06	1885.229	1028.0048	26207.8821	5392.9779
Story3	Bottom	Time history 9-1	LinModHist	Max	1.408E-06	1885.2695	1028.0321	26209.1735	7773.9646
Story3	Top	Time history 9-1	LinModHist	Min	-1.437E-06	-2019.6747	-934.053	-24234.0362	-6388.0302
Story3	Bottom	Time history 9-1	LinModHist	Min	-1.432E-06	-2019.7463	-934.0986	-24235.0879	-9466.664
Story3	Top	Time history 9-2	LinModHist	Max	1.334E-06	1837.2147	1113.8663	19315.4632	5936.7328
Story3	Bottom	Time history 9-2	LinModHist	Max	1.328E-06	1837.2897	1113.9101	19316.1216	8859.8792
Story3	Top	Time history 9-2	LinModHist	Min	-1.386E-06	-1892.8333	-983.4067	-15179.6402	-6278.0623
Story3	Bottom	Time history 9-2	LinModHist	Min	-1.379E-06	-1892.9029	-983.4323	-15180.2879	-9608.494
Story3	Top	Time history 10-1	LinModHist	Max	1.229E-06	1645.9993	1085.0499	15108.0604	7470.2426
Story3	Bottom	Time history 10-1	LinModHist	Max	1.223E-06	1646.0561	1085.079	15108.5938	10992.8179
Story3	Top	Time history 10-1	LinModHist	Min	-1.038E-06	-1440.7724	-1183.5615	-14738.2087	-6870.7199
Story3	Bottom	Time history 10-1	LinModHist	Min	-1.033E-06	-1440.8191	-1183.6208	-14739.2609	-10125.9369
Story3	Top	Time history 10-2	LinModHist	Max	1.229E-06	1645.9993	1085.0499	15108.0604	7470.2426
Story3	Bottom	Time history 10-2	LinModHist	Max	1.223E-06	1646.0561	1085.079	15108.5938	10992.8179
Story3	Top	Time history 10-2	LinModHist	Min	-1.038E-06	-1440.7724	-1183.5615	-14738.2087	-6870.7199
Story3	Bottom	Time history 10-2	LinModHist	Min	-1.033E-06	-1440.8191	-1183.6208	-14739.2609	-10125.9369
Story3	Top	Time history 6-2	LinModHist	Max	1.107E-06	1542.4994	1000.7435	16903.0878	5834.0583
Story3	Bottom	Time history 6-2	LinModHist	Max	1.102E-06	1542.5507	1000.7758	16903.7495	8844.1135
Story3	Top	Time history 6-2	LinModHist	Min	-1.015E-06	-1420.4398	-1008.1569	-13899.9226	-5854.7556
Story3	Bottom	Time history 6-2	LinModHist	Min	-1.01E-06	-1420.4923	-1008.1947	-13900.5066	-8851.301
Story3	Top	DConS1	Combination		15306.8891	0.2162	0.3041	1.4983	113710.3691
Story3	Bottom	DConS1	Combination		15836.5469	0.2162	0.3041	1.4983	117930.7643
Story3	Top	DConS2	Combination		17994.9953	0.3704	0.3644	0.9927	133160.315
Story3	Bottom	DConS2	Combination		18524.6531	0.3704	0.3644	0.9927	137380.5294
Story3	Top	Working Compo	Combination		12613.5586	0.2508	0.2549	0.7542	93377.9084
Story3	Bottom	Working Compo	Combination		12991.8856	0.2508	0.2549	0.7542	96392.3634
Story2	Top	Dead	LinStatic		7804.2317	0.289	0.1217	-0.8987	58052.7294

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story2	Bottom	Dead	LinStatic		8220.3914	0.289	0.1217	-0.8987	61369.0695
Story2	Top	Live	LinStatic		2093.4496	0.1111	0.0436	-0.3602	15112.2415
Story2	Bottom	Live	LinStatic		2093.4496	0.1111	0.0436	-0.3602	15112.0977
Story2	Top	Block-Dead	LinStatic		6252.8	-0.1124	0.1299	2.1839	46345.007
Story2	Bottom	Block-Dead	LinStatic		6252.8	-0.1124	0.1299	2.1839	46344.5782
Story2	Top	Stair-Dead	LinStatic		0	0	0	0	0
Story2	Bottom	Stair-Dead	LinStatic		0	0	0	0	0
Story2	Top	Stair-Live	LinStatic		0	0	0	0	0
Story2	Bottom	Stair-Live	LinStatic		0	0	0	0	0
Story2	Top	Gravity -Nonlinear	NonStatic	Max	8327.5941	0.3176	0.1331	-0.9903	61830.7858
Story2	Bottom	Gravity -Nonlinear	NonStatic	Max	8743.7538	0.3176	0.1331	-0.9903	65147.0882
Story2	Top	Gravity -Nonlinear	NonStatic	Min	8327.5941	0.3176	0.1331	-0.9903	61830.7858
Story2	Bottom	Gravity -Nonlinear	NonStatic	Min	8743.7538	0.3176	0.1331	-0.9903	65147.0882
Story2	Top	Pushover-Mode2-x	NonStatic	Max	8327.5942	4911.8147	395.393	-0.9903	61830.7858
Story2	Bottom	Pushover-Mode2-x	NonStatic	Max	8743.7539	4912.3083	395.3341	-0.9903	65147.0882
Story2	Top	Pushover-Mode2-x	NonStatic	Min	8327.5941	0.3176	0.1331	-36375.7379	59088.6812
Story2	Bottom	Pushover-Mode2-x	NonStatic	Min	8743.7538	0.3176	0.1331	-36379.3041	61087.5226
Story2	Top	Pushover-Mode1-Y	NonStatic	Max	8327.5943	3060.5019	248.3397	-0.9903	61830.7858
Story2	Bottom	Pushover-Mode1-Y	NonStatic	Max	8743.754	3061.1361	248.0916	-0.9903	65147.0882
Story2	Top	Pushover-Mode1-Y	NonStatic	Min	8327.5941	0.3176	0.1331	-22654.3663	60115.0405
Story2	Bottom	Pushover-Mode1-Y	NonStatic	Min	8743.7538	0.3176	0.1331	-22663.1356	62609.9027
Story2	Top	Time history 1-1	LinModHist	Max	1.523E-06	1916.0356	1127.5493	17144.0645	10087.1469
Story2	Bottom	Time history 1-1	LinModHist	Max	1.519E-06	1916.0743	1127.5606	17144.3254	14336.78
Story2	Top	Time history 1-1	LinModHist	Min	-1.443E-06	-1933.6671	-1287.7432	-19863.0156	-10036.1313
Story2	Bottom	Time history 1-1	LinModHist	Min	-1.441E-06	-1933.7051	-1287.774	-19863.8056	-13626.8718
Story2	Top	Time history 1-2	LinModHist	Max	1.626E-06	2019.4819	1156.5147	24271.7471	9048.8988
Story2	Bottom	Time history 1-2	LinModHist	Max	1.622E-06	2019.5168	1156.5402	24272.4651	13093.2411
Story2	Top	Time history 1-2	LinModHist	Min	-1.565E-06	-1971.0258	-1247.6841	-24214.7455	-9442.8518
Story2	Bottom	Time history 1-2	LinModHist	Min	-1.56E-06	-1971.083	-1247.7193	-24215.2469	-13251.4503
Story2	Top	Time history 2-1	LinModHist	Max	1.284E-06	1737.7129	1556.0041	24838.2315	10769.1444
Story2	Bottom	Time history 2-1	LinModHist	Max	1.282E-06	1737.7642	1556.0443	24838.8511	15257.4062
Story2	Top	Time history 2-1	LinModHist	Min	-1.283E-06	-1765.1132	-1360.0565	-20861.1691	-11561.8122
Story2	Bottom	Time history 2-1	LinModHist	Min	-1.282E-06	-1765.1702	-1360.0853	-20861.6297	-16696.7314
Story2	Top	Time history 2-2	LinModHist	Max	1.31E-06	1722.0039	1172.9086	18386.5922	12961.4236
Story2	Bottom	Time history 2-2	LinModHist	Max	1.309E-06	1722.0518	1172.934	18387.0802	17786.4903
Story2	Top	Time history 2-2	LinModHist	Min	-1.582E-06	-2046.1278	-1576.7408	-21605.457	-9133.8746
Story2	Bottom	Time history 2-2	LinModHist	Min	-1.579E-06	-2046.1739	-1576.7781	-21606.1439	-13004.5391
Story2	Top	Time history 3-1	LinModHist	Max	1.289E-06	1599.732	1361.4721	18537.5266	9297.9059
Story2	Bottom	Time history 3-1	LinModHist	Max	1.288E-06	1599.7491	1361.505	18537.8394	13180.9598
Story2	Top	Time history 3-1	LinModHist	Min	-1.252E-06	-1656.4992	-1243.7647	-17522.2592	-10275.6588
Story2	Bottom	Time history 3-1	LinModHist	Min	-1.251E-06	-1656.5315	-1243.8019	-17522.6253	-14768.6029
Story2	Top	Time history 3-2	LinModHist	Max	1.267E-06	1518.3738	1354.0643	19221.7972	9965.896
Story2	Bottom	Time history 3-2	LinModHist	Max	1.264E-06	1518.3931	1354.0962	19222.2632	13788.8395
Story2	Top	Time history 3-2	LinModHist	Min	-1.251E-06	-1658.3762	-1234.1412	-18695.4299	-10318.8047
Story2	Bottom	Time history 3-2	LinModHist	Min	-1.25E-06	-1658.413	-1234.2133	-18695.7442	-14787.3002

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story2	Top	Time history 4-1	LinModHist	Max	1.149E-06	1441.9606	1232.5058	14929.7276	9757.995
Story2	Bottom	Time history 4-1	LinModHist	Max	1.147E-06	1441.9907	1232.5286	14929.9037	13535.0004
Story2	Top	Time history 4-1	LinModHist	Min	-1.144E-06	-1282.6386	-1146.1907	-16589.8444	-9823.5529
Story2	Bottom	Time history 4-1	LinModHist	Min	-1.144E-06	-1282.6439	-1146.2043	-16590.2828	-13888.635
Story2	Top	Time history 4-2	LinModHist	Max	1.25E-06	1638.8725	1292.6794	21270.9461	10386.428
Story2	Bottom	Time history 4-2	LinModHist	Max	1.247E-06	1638.9144	1292.7072	21271.6416	14861.2915
Story2	Top	Time history 4-2	LinModHist	Min	-1.282E-06	-1505.1974	-1366.1205	-19935.5897	-10323.8062
Story2	Bottom	Time history 4-2	LinModHist	Min	-1.279E-06	-1505.2184	-1366.1545	-19936.2384	-14520.8653
Story2	Top	Time history 5-1	LinModHist	Max	1.36E-06	1911.8337	1088.5742	14821.091	8339.126
Story2	Bottom	Time history 5-1	LinModHist	Max	1.357E-06	1911.8906	1088.5984	14821.4558	12001.2065
Story2	Top	Time history 5-1	LinModHist	Min	-1.326E-06	-1664.5557	-1110.2095	-15230.2246	-8516.2
Story2	Bottom	Time history 5-1	LinModHist	Min	-1.322E-06	-1664.5925	-1110.2385	-15230.6196	-12108.558
Story2	Top	Time history 5-2	LinModHist	Max	1.39E-06	1765.1047	914.3302	17598.0612	7859.6687
Story2	Bottom	Time history 5-2	LinModHist	Max	1.388E-06	1765.1374	914.3512	17598.4622	11126.744
Story2	Top	Time history 5-2	LinModHist	Min	-1.223E-06	-1560.2851	-994.2593	-15705.6396	-7830.4094
Story2	Bottom	Time history 5-2	LinModHist	Min	-1.222E-06	-1560.3135	-994.279	-15706.1521	-10789.6792
Story2	Top	Time history 6-1	LinModHist	Max	1.331E-06	1757.4237	1091.4841	17048.4079	8896.72
Story2	Bottom	Time history 6-1	LinModHist	Max	1.329E-06	1757.4694	1091.5053	17048.8332	12580.6401
Story2	Top	Time history 6-1	LinModHist	Min	-1.322E-06	-1726.3613	-1167.4355	-17521.4253	-9981.9394
Story2	Bottom	Time history 6-1	LinModHist	Min	-1.32E-06	-1726.399	-1167.4665	-17521.5974	-13436.2196
Story2	Top	Time history 7-1	LinModHist	Max	1.25E-06	1592.5865	1034.1394	14728.8977	8769.9506
Story2	Bottom	Time history 7-1	LinModHist	Max	1.247E-06	1592.6184	1034.1535	14729.5088	12896.2985
Story2	Top	Time history 7-1	LinModHist	Min	-1.28E-06	-1676.232	-1297.1765	-14515.5057	-8494.53
Story2	Bottom	Time history 7-1	LinModHist	Min	-1.278E-06	-1676.2666	-1297.2216	-14515.9026	-11870.1468
Story2	Top	Time history 7-2	LinModHist	Max	1.148E-06	1432.9609	1155.0146	16635.6137	10580.7995
Story2	Bottom	Time history 7-2	LinModHist	Max	1.144E-06	1432.9904	1155.0291	16636.0036	14712.5341
Story2	Top	Time history 7-2	LinModHist	Min	-9.711E-07	-1268.2603	-1260.135	-17245.153	-9798.1228
Story2	Bottom	Time history 7-2	LinModHist	Min	-9.686E-07	-1268.2918	-1260.1549	-17245.4556	-13510.2257
Story2	Top	Time history 8-1	LinModHist	Max	9.676E-07	1325.3439	1182.7468	19197.9846	9916.3626
Story2	Bottom	Time history 8-1	LinModHist	Max	9.668E-07	1325.387	1182.7782	19198.6089	14306.3901
Story2	Top	Time history 8-1	LinModHist	Min	-9.95E-07	-1475.166	-1359.7932	-18342.2274	-8850.0922
Story2	Bottom	Time history 8-1	LinModHist	Min	-9.941E-07	-1475.2195	-1359.835	-18342.8868	-12573.6294
Story2	Top	Time history 8-2	LinModHist	Max	1.025E-06	1239.1742	1224.2687	14221.8173	10076.5479
Story2	Bottom	Time history 8-2	LinModHist	Max	1.023E-06	1239.1925	1224.3033	14222.208	14458.2466
Story2	Top	Time history 8-2	LinModHist	Min	-9.635E-07	-1166.0404	-1368.7714	-13120.6437	-9007.9522
Story2	Bottom	Time history 8-2	LinModHist	Min	-9.617E-07	-1166.0569	-1368.8137	-13120.9864	-12858.4009
Story2	Top	Time history 9-1	LinModHist	Max	1.655E-06	2000.1351	1109.3371	30245.0705	7773.9646
Story2	Bottom	Time history 9-1	LinModHist	Max	1.654E-06	2000.1694	1109.3562	30246.1207	10787.9269
Story2	Top	Time history 9-1	LinModHist	Min	-1.641E-06	-2207.3668	-1061.599	-26749.1472	-9466.6641
Story2	Bottom	Time history 9-1	LinModHist	Min	-1.642E-06	-2207.4078	-1061.6276	-26749.8111	-13091.8767
Story2	Top	Time history 9-2	LinModHist	Max	1.588E-06	2057.9598	1268.0234	20984.2284	8859.8794
Story2	Bottom	Time history 9-2	LinModHist	Max	1.586E-06	2058.0046	1268.0593	20984.5785	12201.2145
Story2	Top	Time history 9-2	LinModHist	Min	-1.592E-06	-2123.9355	-1033.351	-17164.6694	-9608.4941
Story2	Bottom	Time history 9-2	LinModHist	Min	-1.592E-06	-2123.985	-1033.3784	-17165.0872	-13737.7108
Story2	Top	Time history 10-1	LinModHist	Max	1.451E-06	1811.7133	1183.1313	16184.1173	10992.818

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story2	Bottom	Time history 10-1	LinModHist	Max	1.449E-06	1811.7454	1183.153	16184.4998	15180.8176
Story2	Top	Time history 10-1	LinModHist	Min	-1.239E-06	-1556.5467	-1405.7523	-17569.4369	-10125.9369
Story2	Bottom	Time history 10-1	LinModHist	Min	-1.236E-06	-1556.5724	-1405.8018	-17570.2217	-14009.4539
Story2	Top	Time history 10-2	LinModHist	Max	1.451E-06	1811.7133	1183.1313	16184.1173	10992.818
Story2	Bottom	Time history 10-2	LinModHist	Max	1.449E-06	1811.7454	1183.153	16184.4998	15180.8176
Story2	Top	Time history 10-2	LinModHist	Min	-1.239E-06	-1556.5467	-1405.7523	-17569.4369	-10125.9369
Story2	Bottom	Time history 10-2	LinModHist	Min	-1.236E-06	-1556.5724	-1405.8018	-17570.2217	-14009.4539
Story2	Top	Time history 6-2	LinModHist	Max	1.392E-06	1693.7724	1075.4048	18630.996	8844.1136
Story2	Bottom	Time history 6-2	LinModHist	Max	1.388E-06	1693.803	1075.4195	18631.4229	12521.116
Story2	Top	Time history 6-2	LinModHist	Min	-1.216E-06	-1573.4079	-1117.0028	-15399.0452	-8851.3011
Story2	Bottom	Time history 6-2	LinModHist	Min	-1.213E-06	-1573.4406	-1117.0256	-15399.4245	-12392.394
Story2	Top	DConS1	Combination		19679.8445	0.2472	0.3523	1.7993	146156.831
Story2	Bottom	DConS1	Combination		20262.468	0.2472	0.3523	1.7993	150799.1068
Story2	Top	DConS2	Combination		23029.3638	0.4249	0.422	1.2229	170336.4174
Story2	Bottom	DConS2	Combination		23611.9874	0.4249	0.422	1.2229	174978.4631
Story2	Top	Working Compo	Combination		16150.4814	0.2876	0.2952	0.925	119509.9779
Story2	Bottom	Working Compo	Combination		16566.641	0.2876	0.2952	0.925	122825.7454
Story1	Top	Dead	LinStatic		9447.254	0.3156	0.1318	-0.9837	70279.3162
Story1	Bottom	Dead	LinStatic		9964.3009	0.3156	0.1318	-0.9837	74399.576
Story1	Top	Live	LinStatic		2506.8328	0.1212	0.0472	-0.3939	18068.236
Story1	Bottom	Live	LinStatic		2506.8328	0.1212	0.0472	-0.3939	18068.0425
Story1	Top	Block-Dead	LinStatic		7771.15	-0.1216	0.1398	2.386	57595.8077
Story1	Bottom	Block-Dead	LinStatic		7771.15	-0.1216	0.1398	2.386	57595.2347
Story1	Top	Stair-Dead	LinStatic		0	0	0	0	0
Story1	Bottom	Stair-Dead	LinStatic		0	0	0	0	0
Story1	Top	Stair-Live	LinStatic		0	0	0	0	0
Story1	Bottom	Stair-Live	LinStatic		0	0	0	0	0
Story1	Top	Gravity -Nonlinear	NonStatic	Max	10073.9622	0.3468	0.1442	-1.0837	74796.3696
Story1	Bottom	Gravity -Nonlinear	NonStatic	Max	10591.0091	0.3468	0.1442	-1.0837	78916.5787
Story1	Top	Gravity -Nonlinear	NonStatic	Min	10073.9622	0.3468	0.1442	-1.0837	74796.3696
Story1	Bottom	Gravity -Nonlinear	NonStatic	Min	10591.0091	0.3468	0.1442	-1.0837	78916.5787
Story1	Top	Pushover-Mode2-x	NonStatic	Max	10073.9622	5096.1845	440.608	-1.0837	74796.3696
Story1	Bottom	Pushover-Mode2-x	NonStatic	Max	10591.0091	5097.0311	440.3141	-1.0837	78916.5787
Story1	Top	Pushover-Mode2-x	NonStatic	Min	10073.9614	0.3468	0.1442	-37852.0789	70732.7699
Story1	Bottom	Pushover-Mode2-x	NonStatic	Min	10591.0083	0.3468	0.1442	-37860.7198	73002.4164
Story1	Top	Pushover-Mode1-Y	NonStatic	Max	10073.9622	3176.4788	275.9833	-1.0837	74796.3696
Story1	Bottom	Pushover-Mode1-Y	NonStatic	Max	10591.0091	3173.1952	274.9175	-1.0837	78916.5787
Story1	Top	Pushover-Mode1-Y	NonStatic	Min	10073.9606	0.3468	0.1442	-23589.5256	72258.8054
Story1	Bottom	Pushover-Mode1-Y	NonStatic	Min	10591.0075	0.3468	0.1442	-23576.6165	75235.4403
Story1	Top	Time history 1-1	LinModHist	Max	2.36E-06	1999.2903	1124.8851	17611.1018	14336.7801
Story1	Bottom	Time history 1-1	LinModHist	Max	2.36E-06	1999.3053	1124.8833	17611.2413	19952.5529
Story1	Top	Time history 1-1	LinModHist	Min	-2.357E-06	-2036.1902	-1369.6874	-21684.9489	-13626.8719
Story1	Bottom	Time history 1-1	LinModHist	Min	-2.358E-06	-2036.2097	-1369.7033	-21685.3412	-18041.6465
Story1	Top	Time history 1-2	LinModHist	Max	2.506E-06	2084.5283	1226.2696	25682.6792	13093.2413
Story1	Bottom	Time history 1-2	LinModHist	Max	2.507E-06	2084.5399	1226.2831	25682.9994	18553.9244

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story1	Top	Time history 1-2	LinModHist	Min	-2.474E-06	-2111.6393	-1331.8607	-24965.6379	-13251.4504
Story1	Bottom	Time history 1-2	LinModHist	Min	-2.474E-06	-2111.6662	-1331.8766	-24965.8556	-18279.2017
Story1	Top	Time history 2-1	LinModHist	Max	2.314E-06	1857.6308	1659.5357	26175.8817	15257.4064
Story1	Bottom	Time history 2-1	LinModHist	Max	2.314E-06	1857.6546	1659.5554	26176.164	21132.4072
Story1	Top	Time history 2-1	LinModHist	Min	-2.53E-06	-1908.9178	-1453.6354	-21623.9358	-16696.7315
Story1	Bottom	Time history 2-1	LinModHist	Min	-2.531E-06	-1908.946	-1453.657	-21624.1295	-23500.8957
Story1	Top	Time history 2-2	LinModHist	Max	2.344E-06	1838.3386	1227.0574	19387.9412	17786.4904
Story1	Bottom	Time history 2-2	LinModHist	Max	2.344E-06	1838.3614	1227.0673	19388.2004	24320.4496
Story1	Top	Time history 2-2	LinModHist	Min	-2.456E-06	-2144.5702	-1653.3609	-23016.6647	-13004.5392
Story1	Bottom	Time history 2-2	LinModHist	Min	-2.457E-06	-2144.588	-1653.3747	-23017.0135	-18035.5081
Story1	Top	Time history 3-1	LinModHist	Max	2.189E-06	1613.5864	1439.3055	19251.6516	13180.96
Story1	Bottom	Time history 3-1	LinModHist	Max	2.19E-06	1613.5885	1439.3201	19251.9824	18427.7058
Story1	Top	Time history 3-1	LinModHist	Min	-2.237E-06	-1721.3056	-1338.9743	-18314.0505	-14768.603
Story1	Bottom	Time history 3-1	LinModHist	Min	-2.237E-06	-1721.3186	-1338.999	-18314.3125	-20669.8054
Story1	Top	Time history 3-2	LinModHist	Max	1.989E-06	1552.4504	1428.1028	20169.2912	13788.8396
Story1	Bottom	Time history 3-2	LinModHist	Max	1.99E-06	1552.456	1428.1166	20169.4936	18622.2082
Story1	Top	Time history 3-2	LinModHist	Min	-2.308E-06	-1742.3964	-1450.7079	-19247.5915	-14787.3004
Story1	Bottom	Time history 3-2	LinModHist	Min	-2.309E-06	-1742.4125	-1450.7508	-19247.6894	-20642.5692
Story1	Top	Time history 4-1	LinModHist	Max	1.822E-06	1517.4694	1276.44	15563.4025	13535.0004
Story1	Bottom	Time history 4-1	LinModHist	Max	1.823E-06	1517.4847	1276.4479	15563.5521	18318.1823
Story1	Top	Time history 4-1	LinModHist	Min	-1.861E-06	-1298.8603	-1172.0758	-17542.7461	-13888.6351
Story1	Bottom	Time history 4-1	LinModHist	Min	-1.862E-06	-1298.8665	-1172.0802	-17542.99	-19122.066
Story1	Top	Time history 4-2	LinModHist	Max	1.955E-06	1739.6635	1365.4631	22713.9169	14861.2916
Story1	Bottom	Time history 4-2	LinModHist	Max	1.956E-06	1739.6827	1365.4777	22714.2667	20809.0901
Story1	Top	Time history 4-2	LinModHist	Min	-2.137E-06	-1551.453	-1450.669	-21381.1301	-14520.8654
Story1	Bottom	Time history 4-2	LinModHist	Min	-2.138E-06	-1551.4617	-1450.6852	-21381.4605	-20108.1632
Story1	Top	Time history 5-1	LinModHist	Max	2.213E-06	2047.0662	1145.3726	15484.1879	12001.2066
Story1	Bottom	Time history 5-1	LinModHist	Max	2.214E-06	2047.0919	1145.3832	15484.3936	16876.5796
Story1	Top	Time history 5-1	LinModHist	Min	-1.792E-06	-1749.9528	-1189.1027	-16149.9912	-12108.5581
Story1	Bottom	Time history 5-1	LinModHist	Min	-1.792E-06	-1749.9681	-1189.1178	-16150.1916	-16804.6221
Story1	Top	Time history 5-2	LinModHist	Max	2.203E-06	1835.8559	995.3876	18397.6078	11126.744
Story1	Bottom	Time history 5-2	LinModHist	Max	2.203E-06	1835.8693	995.4044	18397.7343	15382.5337
Story1	Top	Time history 5-2	LinModHist	Min	-1.967E-06	-1617.6759	-1051.2844	-16747.3923	-10789.6793
Story1	Bottom	Time history 5-2	LinModHist	Min	-1.967E-06	-1617.6865	-1051.3019	-16747.6256	-14665.9804
Story1	Top	Time history 6-1	LinModHist	Max	2.453E-06	1866.4261	1136.6239	17845.5349	12580.6402
Story1	Bottom	Time history 6-1	LinModHist	Max	2.454E-06	1866.4465	1136.6321	17845.7407	17699.7394
Story1	Top	Time history 6-1	LinModHist	Min	-2.191E-06	-1812.2137	-1251.116	-17789.1148	-13436.2196
Story1	Bottom	Time history 6-1	LinModHist	Min	-2.192E-06	-1812.2296	-1251.1321	-17789.151	-17631.4698
Story1	Top	Time history 7-1	LinModHist	Max	1.986E-06	1657.8995	1053.3778	16168.9964	12896.2987
Story1	Bottom	Time history 7-1	LinModHist	Max	1.987E-06	1657.9116	1053.3815	16169.321	18640.5204
Story1	Top	Time history 7-1	LinModHist	Min	-2.148E-06	-1750.8965	-1424.4568	-15345.2074	-11870.1469
Story1	Bottom	Time history 7-1	LinModHist	Min	-2.149E-06	-1750.9104	-1424.4824	-15345.3779	-16127.6021
Story1	Top	Time history 7-2	LinModHist	Max	1.553E-06	1496.2156	1162.9248	17282.6712	14712.5342
Story1	Bottom	Time history 7-2	LinModHist	Max	1.554E-06	1496.2275	1162.926	17282.8309	19983.0294
Story1	Top	Time history 7-2	LinModHist	Min	-1.386E-06	-1338.8908	-1301.7621	-17882.756	-13510.2257

Table 3.3 - Story Forces (Part 1 of 2, continued)

Story	Location	Output Case	Case Type	Step Type	P kN	VX kN	VY kN	T kN-m	MX kN-m
Story1	Bottom	Time history 7-2	LinModHist	Min	-1.386E-06	-1338.9038	-1301.7702	-17882.9631	-18160.4345
Story1	Top	Time history 8-1	LinModHist	Max	1.594E-06	1425.4216	1266.1149	20424.419	14306.3902
Story1	Bottom	Time history 8-1	LinModHist	Max	1.595E-06	1425.4411	1266.1316	20424.7211	20298.8421
Story1	Top	Time history 8-1	LinModHist	Min	-1.774E-06	-1607.9296	-1469.0916	-19603.0983	-12573.6295
Story1	Bottom	Time history 8-1	LinModHist	Min	-1.774E-06	-1607.9553	-1469.1127	-19603.405	-17610.7158
Story1	Top	Time history 8-2	LinModHist	Max	1.593E-06	1274.2459	1320.3336	15553.0638	14458.2467
Story1	Bottom	Time history 8-2	LinModHist	Max	1.594E-06	1274.2526	1320.3527	15553.4048	20456.6495
Story1	Top	Time history 8-2	LinModHist	Min	-1.489E-06	-1195.5577	-1479.1247	-14281.3882	-12858.401
Story1	Bottom	Time history 8-2	LinModHist	Min	-1.49E-06	-1195.5632	-1479.1459	-14281.6871	-18137.0256
Story1	Top	Time history 9-1	LinModHist	Max	2.725E-06	2079.2435	1167.8676	32597.103	10787.9269
Story1	Bottom	Time history 9-1	LinModHist	Max	2.725E-06	2079.2636	1167.8794	32597.6708	15099.3424
Story1	Top	Time history 9-1	LinModHist	Min	-3.066E-06	-2276.6945	-1120.9861	-27919.0473	-13091.8768
Story1	Bottom	Time history 9-1	LinModHist	Min	-3.067E-06	-2276.7089	-1120.9984	-27919.3547	-17767.9361
Story1	Top	Time history 9-2	LinModHist	Max	2.613E-06	2149.8042	1377.1346	21610.3415	12201.2146
Story1	Bottom	Time history 9-2	LinModHist	Max	2.614E-06	2149.8204	1377.1576	21610.4431	16278.9066
Story1	Top	Time history 9-2	LinModHist	Min	-2.902E-06	-2238.5242	-1097.0629	-18077.3997	-13737.7109
Story1	Bottom	Time history 9-2	LinModHist	Min	-2.903E-06	-2238.5457	-1097.0755	-18077.5572	-19247.4267
Story1	Top	Time history 10-1	LinModHist	Max	2.39E-06	1879.8808	1246.2803	17034.7516	15180.8177
Story1	Bottom	Time history 10-1	LinModHist	Max	2.391E-06	1879.8924	1246.2925	17035.0358	21198.3439
Story1	Top	Time history 10-1	LinModHist	Min	-2.151E-06	-1610.3038	-1549.4305	-19123.3585	-14009.454
Story1	Bottom	Time history 10-1	LinModHist	Min	-2.152E-06	-1610.3158	-1549.4586	-19123.7554	-19065.7219
Story1	Top	Time history 10-2	LinModHist	Max	2.39E-06	1879.8808	1246.2803	17034.7516	15180.8177
Story1	Bottom	Time history 10-2	LinModHist	Max	2.391E-06	1879.8924	1246.2925	17035.0358	21198.3439
Story1	Top	Time history 10-2	LinModHist	Min	-2.151E-06	-1610.3038	-1549.4305	-19123.3585	-14009.454
Story1	Bottom	Time history 10-2	LinModHist	Min	-2.152E-06	-1610.3158	-1549.4586	-19123.7554	-19065.7219
Story1	Top	Time history 6-2	LinModHist	Max	1.946E-06	1760.2142	1088.9945	19461.3194	12521.1161
Story1	Bottom	Time history 6-2	LinModHist	Max	1.947E-06	1760.2261	1089.0133	19461.5057	17266.7535
Story1	Top	Time history 6-2	LinModHist	Min	-2.14E-06	-1651.2228	-1158.7838	-16121.8319	-12392.3941
Story1	Bottom	Time history 6-2	LinModHist	Min	-2.141E-06	-1651.2402	-1158.7912	-16122.0091	-16812.527
Story1	Top	DConS1	Combination		24105.7656	0.2716	0.3802	1.9633	179025.1735
Story1	Bottom	DConS1	Combination		24829.6313	0.2716	0.3802	1.9633	184792.735
Story1	Top	DConS2	Combination		28116.6981	0.4656	0.4557	1.333	207934.3511
Story1	Bottom	DConS2	Combination		28840.5637	0.4656	0.4557	1.333	213701.603
Story1	Top	Working Compo	Combination		19725.2368	0.3152	0.3188	1.0084	145943.36
Story1	Bottom	Working Compo	Combination		20242.2837	0.3152	0.3188	1.0084	150062.8532

Table 3.3 - Story Forces (Part 2 of 2)

Story	Location	MY kN-m
Story6	Top	-9443.0557
Story6	Bottom	-13215.6542
Story6	Top	-3267.2797
Story6	Bottom	-3267.1903
Story6	Top	-1341.015
Story6	Bottom	-1341.0982

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story6	Top	0
Story6	Bottom	0
Story6	Top	0
Story6	Bottom	0
Story6	Top	-10259.8757
Story6	Bottom	-14032.4511
Story6	Top	-10259.8757
Story6	Bottom	-14032.4511
Story6	Top	-10259.8757
Story6	Bottom	-9349.0399
Story6	Top	-10262.4059
Story6	Bottom	-14032.4511
Story6	Top	-10259.8757
Story6	Bottom	-11109.6794
Story6	Top	-10260.326
Story6	Bottom	-14032.4511
Story6	Top	2.551E-06
Story6	Bottom	1890.1321
Story6	Top	-2.264E-06
Story6	Bottom	-1858.6952
Story6	Top	2.971E-06
Story6	Bottom	1981.7386
Story6	Top	-2.828E-06
Story6	Bottom	-2041.4265
Story6	Top	2.476E-06
Story6	Bottom	1795.675
Story6	Top	-3.095E-06
Story6	Bottom	-1975.818
Story6	Top	3.028E-06
Story6	Bottom	1919.4151
Story6	Top	-2.311E-06
Story6	Bottom	-2011.6387
Story6	Top	2.408E-06
Story6	Bottom	1684.2616
Story6	Top	-2.503E-06
Story6	Bottom	-1659.3699
Story6	Top	2.659E-06
Story6	Bottom	1592.2508
Story6	Top	-2.336E-06
Story6	Bottom	-1549.7761
Story6	Top	1.749E-06
Story6	Bottom	1445.6418
Story6	Top	-1.982E-06
Story6	Bottom	-1742.8311
Story6	Top	2.228E-06

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story6	Bottom	1489.6498
Story6	Top	-2.039E-06
Story6	Bottom	-1582.0506
Story6	Top	2.027E-06
Story6	Bottom	1566.1969
Story6	Top	-1.823E-06
Story6	Bottom	-1674.4757
Story6	Top	1.81E-06
Story6	Bottom	1701.71
Story6	Top	-1.744E-06
Story6	Bottom	-1506.4152
Story6	Top	1.973E-06
Story6	Bottom	1841.3561
Story6	Top	-2.201E-06
Story6	Bottom	-1616.1918
Story6	Top	1.841E-06
Story6	Bottom	1465.1009
Story6	Top	-1.99E-06
Story6	Bottom	-1551.8936
Story6	Top	2.565E-06
Story6	Bottom	1319.5708
Story6	Top	-2.133E-06
Story6	Bottom	-1234.506
Story6	Top	2.322E-06
Story6	Bottom	1342.6388
Story6	Top	-2.449E-06
Story6	Bottom	-1359.5883
Story6	Top	2.248E-06
Story6	Bottom	1314.1319
Story6	Top	-2.166E-06
Story6	Bottom	-1170.196
Story6	Top	2.747E-06
Story6	Bottom	2414.7056
Story6	Top	-2.575E-06
Story6	Bottom	-2335.1775
Story6	Top	2.758E-06
Story6	Bottom	2280.9552
Story6	Top	-2.583E-06
Story6	Bottom	-2130.2681
Story6	Top	2.729E-06
Story6	Bottom	1917.404
Story6	Top	-2.297E-06
Story6	Bottom	-1599.6705
Story6	Top	2.729E-06
Story6	Bottom	1917.404

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story6	Top	-2.297E-06
Story6	Bottom	-1599.6705
Story6	Top	1.944E-06
Story6	Bottom	1626.7127
Story6	Top	-2.227E-06
Story6	Bottom	-1464.2153
Story6	Top	-15097.699
Story6	Bottom	-20379.4533
Story6	Top	-20325.3466
Story6	Bottom	-25606.9578
Story6	Top	-14051.3505
Story6	Bottom	-17823.9427
Story5	Top	-22065.7731
Story5	Bottom	-25838.1381
Story5	Top	-6166.1863
Story5	Bottom	-6166.0072
Story5	Top	-12756.1672
Story5	Bottom	-12756.3382
Story5	Top	0
Story5	Bottom	0
Story5	Top	0
Story5	Bottom	0
Story5	Top	-23607.319
Story5	Bottom	-27379.6378
Story5	Top	-23607.319
Story5	Bottom	-27379.6378
Story5	Top	-18925.3729
Story5	Bottom	-13661.4281
Story5	Top	-23607.319
Story5	Bottom	-27379.6378
Story5	Top	-20684.7971
Story5	Bottom	-18819.9898
Story5	Top	-23607.319
Story5	Bottom	-27379.6378
Story5	Top	1890.1324
Story5	Bottom	5429.0494
Story5	Top	-1858.6957
Story5	Bottom	-5145.6404
Story5	Top	1981.739
Story5	Bottom	5575.6653
Story5	Top	-2041.4269
Story5	Bottom	-5748.2934
Story5	Top	1795.6753
Story5	Bottom	5123.1157
Story5	Top	-1975.8185

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story5	Bottom	-5332.2609
Story5	Top	1919.4156
Story5	Bottom	5147.325
Story5	Top	-2011.639
Story5	Bottom	-5719.9969
Story5	Top	1684.2619
Story5	Bottom	4799.6262
Story5	Top	-1659.3703
Story5	Bottom	-4738.4874
Story5	Top	1592.251
Story5	Bottom	4620.7712
Story5	Top	-1549.7762
Story5	Bottom	-4549.5793
Story5	Top	1445.642
Story5	Bottom	4192.831
Story5	Top	-1742.8315
Story5	Bottom	-4883.501
Story5	Top	1489.65
Story5	Bottom	4334.7537
Story5	Top	-1582.0508
Story5	Bottom	-4591.4745
Story5	Top	1566.1971
Story5	Bottom	4511.4526
Story5	Top	-1674.4761
Story5	Bottom	-4562.0947
Story5	Top	1701.7102
Story5	Bottom	4965.3712
Story5	Top	-1506.4153
Story5	Bottom	-4409.4639
Story5	Top	1841.3564
Story5	Bottom	5230.7467
Story5	Top	-1616.192
Story5	Bottom	-4692.6244
Story5	Top	1465.1011
Story5	Bottom	4280.7955
Story5	Top	-1551.8938
Story5	Bottom	-4535.1298
Story5	Top	1319.571
Story5	Bottom	3823.4961
Story5	Top	-1234.5062
Story5	Bottom	-3457.5838
Story5	Top	1342.6391
Story5	Bottom	3795.6922
Story5	Top	-1359.5886
Story5	Bottom	-3813.8084

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story5	Top	1314.1321
Story5	Bottom	3807.6294
Story5	Top	-1170.1962
Story5	Bottom	-3432.9804
Story5	Top	2414.7061
Story5	Bottom	6783.7237
Story5	Top	-2335.1779
Story5	Bottom	-6640.1897
Story5	Top	2280.9557
Story5	Bottom	6334.7876
Story5	Top	-2130.2684
Story5	Bottom	-6074.297
Story5	Top	1917.4043
Story5	Bottom	5466.628
Story5	Top	-1599.671
Story5	Bottom	-4529.8423
Story5	Top	1917.4043
Story5	Bottom	5466.628
Story5	Top	-1599.671
Story5	Bottom	-4529.8423
Story5	Top	1626.7129
Story5	Bottom	4753.1506
Story5	Top	-1464.2154
Story5	Bottom	-4285.8167
Story5	Top	-48750.7164
Story5	Bottom	-54032.2669
Story5	Top	-58616.6145
Story5	Bottom	-63897.8783
Story5	Top	-40988.1266
Story5	Bottom	-44760.4835
Story4	Top	-34688.257
Story4	Bottom	-38460.4224
Story4	Top	-9065.0032
Story4	Bottom	-9064.7473
Story4	Top	-24171.4073
Story4	Bottom	-24171.6574
Story4	Top	0
Story4	Bottom	0
Story4	Top	0
Story4	Bottom	0
Story4	Top	-36954.5057
Story4	Bottom	-40726.6052
Story4	Top	-36954.5057
Story4	Bottom	-40726.6052
Story4	Top	-23237.1516

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story4	Bottom	-14577.8558
Story4	Top	-36954.5057
Story4	Bottom	-40726.6052
Story4	Top	-28395.093
Story4	Bottom	-24415.3074
Story4	Top	-36954.5057
Story4	Bottom	-40726.6052
Story4	Top	5429.0497
Story4	Bottom	10153.774
Story4	Top	-5145.6406
Story4	Bottom	-9772.14
Story4	Top	5575.6657
Story4	Bottom	10586.6578
Story4	Top	-5748.2937
Story4	Bottom	-10481.7803
Story4	Top	5123.1161
Story4	Bottom	9441.9281
Story4	Top	-5332.2612
Story4	Bottom	-9488.177
Story4	Top	5147.3254
Story4	Bottom	9323.5157
Story4	Top	-5719.9971
Story4	Bottom	-10639.1841
Story4	Top	4799.6265
Story4	Bottom	9064.3352
Story4	Top	-4738.4877
Story4	Bottom	-8937.4593
Story4	Top	4620.7715
Story4	Bottom	8698.3493
Story4	Top	-4549.5795
Story4	Bottom	-8692.1933
Story4	Top	4192.8313
Story4	Bottom	7891.9288
Story4	Top	-4883.5013
Story4	Bottom	-8824.9999
Story4	Top	4334.7539
Story4	Bottom	8257.7723
Story4	Top	-4591.4748
Story4	Bottom	-8623.0597
Story4	Top	4511.4528
Story4	Bottom	8627.9523
Story4	Top	-4562.0951
Story4	Bottom	-8406.0234
Story4	Top	4965.3714
Story4	Bottom	9428.9864

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story4	Top	-4409.4641
Story4	Bottom	-8360.8851
Story4	Top	5230.747
Story4	Bottom	9645.7413
Story4	Top	-4692.6246
Story4	Bottom	-8922.1194
Story4	Top	4280.7957
Story4	Bottom	8183.9225
Story4	Top	-4535.1299
Story4	Bottom	-8674.3831
Story4	Top	3823.4963
Story4	Bottom	7306.6102
Story4	Top	-3457.5839
Story4	Bottom	-6400.4119
Story4	Top	3795.6925
Story4	Bottom	6986.6776
Story4	Top	-3813.8086
Story4	Bottom	-7012.4761
Story4	Top	3807.6296
Story4	Bottom	7137.0084
Story4	Top	-3432.9806
Story4	Bottom	-6511.7422
Story4	Top	6783.7241
Story4	Bottom	12372.26
Story4	Top	-6640.1901
Story4	Bottom	-12287.8158
Story4	Top	6334.7881
Story4	Bottom	11490.0936
Story4	Top	-6074.2973
Story4	Bottom	-11329.2447
Story4	Top	5466.6283
Story4	Bottom	10135.048
Story4	Top	-4529.8425
Story4	Bottom	-8424.6944
Story4	Top	5466.6283
Story4	Bottom	10135.048
Story4	Top	-4529.8425
Story4	Bottom	-8424.6944
Story4	Top	4753.1508
Story4	Bottom	9043.5924
Story4	Top	-4285.8169
Story4	Bottom	-8185.5193
Story4	Top	-82403.53
Story4	Bottom	-87684.9118
Story4	Top	-96907.535

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story4	Bottom	-102188.5075
Story4	Top	-67924.6674
Story4	Bottom	-71696.8272
Story3	Top	-47306.5078
Story3	Bottom	-50735.6021
Story3	Top	-11957.6902
Story3	Bottom	-11957.4012
Story3	Top	-35586.7265
Story3	Bottom	-35587.0151
Story3	Top	0
Story3	Bottom	0
Story3	Top	0
Story3	Bottom	0
Story3	Top	-50295.9263
Story3	Bottom	-53724.9461
Story3	Top	-50295.9263
Story3	Bottom	-53724.9461
Story3	Top	-24148.3429
Story3	Bottom	-14148.5674
Story3	Top	-50295.9263
Story3	Bottom	-53724.9461
Story3	Top	-33985.2527
Story3	Bottom	-29043.4244
Story3	Top	-50295.9263
Story3	Bottom	-53724.9461
Story3	Top	10153.7742
Story3	Bottom	15145.7601
Story3	Top	-9772.1403
Story3	Bottom	-14753.5287
Story3	Top	10586.6581
Story3	Bottom	16083.1595
Story3	Top	-10481.7806
Story3	Bottom	-15195.3769
Story3	Top	9441.9284
Story3	Bottom	13771.767
Story3	Top	-9488.1772
Story3	Bottom	-13541.4397
Story3	Top	9323.5159
Story3	Bottom	13847.8569
Story3	Top	-10639.1843
Story3	Bottom	-15875.2492
Story3	Top	9064.3355
Story3	Bottom	13578.2054
Story3	Top	-8937.4595
Story3	Bottom	-13383.028

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story3	Top	8698.3496
Story3	Bottom	12954.5108
Story3	Top	-8692.1935
Story3	Bottom	-13185.9364
Story3	Top	7891.929
Story3	Bottom	11788.5102
Story3	Top	-8825.0002
Story3	Bottom	-12630.6909
Story3	Top	8257.7725
Story3	Bottom	12575.4927
Story3	Top	-8623.06
Story3	Bottom	-12809.8773
Story3	Top	8627.9524
Story3	Bottom	13470.3616
Story3	Top	-8406.0236
Story3	Bottom	-12858.748
Story3	Top	9428.9866
Story3	Bottom	14231.771
Story3	Top	-8360.8853
Story3	Bottom	-12563.8772
Story3	Top	9645.7415
Story3	Bottom	14150.2704
Story3	Top	-8922.1196
Story3	Bottom	-13553.0921
Story3	Top	8183.9227
Story3	Bottom	12470.7346
Story3	Top	-8674.3833
Story3	Bottom	-13206.1999
Story3	Top	7306.6104
Story3	Bottom	11128.2585
Story3	Top	-6400.412
Story3	Bottom	-9637.8197
Story3	Top	6986.6777
Story3	Bottom	10264.7184
Story3	Top	-7012.4763
Story3	Bottom	-10409.4921
Story3	Top	7137.0086
Story3	Bottom	10591.7401
Story3	Top	-6511.7424
Story3	Bottom	-9762.1188
Story3	Top	12372.2603
Story3	Bottom	17974.8424
Story3	Top	-12287.8161
Story3	Bottom	-18163.0823
Story3	Top	11490.094

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story3	Bottom	16706.5627
Story3	Top	-11329.2449
Story3	Bottom	-16923.3617
Story3	Top	10135.0482
Story3	Bottom	14982.6805
Story3	Top	-8424.6946
Story3	Bottom	-12632.653
Story3	Top	10135.0482
Story3	Bottom	14982.6805
Story3	Top	-8424.6946
Story3	Bottom	-12632.653
Story3	Top	9043.5926
Story3	Bottom	13671.2103
Story3	Top	-8185.5195
Story3	Bottom	-12436.2382
Story3	Top	-116050.528
Story3	Bottom	-120851.6641
Story3	Top	-135182.8323
Story3	Bottom	-139983.506
Story3	Top	-94850.9245
Story3	Bottom	-98280.0184
Story2	Top	-59585.721
Story2	Bottom	-63357.5984
Story2	Top	-14856.3972
Story2	Bottom	-14856.0307
Story2	Top	-47002.0842
Story2	Bottom	-47002.4551
Story2	Top	0
Story2	Bottom	0
Story2	Top	0
Story2	Bottom	0
Story2	Top	-63299.814
Story2	Bottom	-67071.5969
Story2	Top	-63299.814
Story2	Bottom	-67071.5969
Story2	Top	-23723.6276
Story2	Bottom	-11290.7964
Story2	Top	-63299.814
Story2	Bottom	-67071.5969
Story2	Top	-38618.632
Story2	Bottom	-32291.1662
Story2	Top	-63299.814
Story2	Bottom	-67071.5969
Story2	Top	15145.7603
Story2	Bottom	21285.0139

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story2	Top	-14753.5289
Story2	Bottom	-20848.6901
Story2	Top	16083.1598
Story2	Bottom	22747.5419
Story2	Top	-15195.377
Story2	Bottom	-21176.5022
Story2	Top	13771.7672
Story2	Bottom	18632.3307
Story2	Top	-13541.4398
Story2	Bottom	-18640.8641
Story2	Top	13847.8571
Story2	Bottom	19164.4914
Story2	Top	-15875.2494
Story2	Bottom	-22499.903
Story2	Top	13578.2056
Story2	Bottom	18801.9599
Story2	Top	-13383.0282
Story2	Bottom	-18774.0847
Story2	Top	12954.511
Story2	Bottom	17922.1385
Story2	Top	-13185.9366
Story2	Bottom	-18627.4492
Story2	Top	11788.5103
Story2	Bottom	16457.5291
Story2	Top	-12630.6911
Story2	Bottom	-16756.3133
Story2	Top	12575.4928
Story2	Bottom	17921.3699
Story2	Top	-12809.8775
Story2	Bottom	-17705.378
Story2	Top	13470.3618
Story2	Bottom	19775.5157
Story2	Top	-12858.7482
Story2	Bottom	-18351.8784
Story2	Top	14231.7712
Story2	Bottom	20050.7183
Story2	Top	-12563.8773
Story2	Bottom	-17712.8927
Story2	Top	14150.2706
Story2	Bottom	19332.858
Story2	Top	-13553.0923
Story2	Bottom	-19238.4824
Story2	Top	12470.7348
Story2	Bottom	17708.1536
Story2	Top	-13206.2001

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story2	Bottom	-18737.8566
Story2	Top	11128.2587
Story2	Bottom	15801.2372
Story2	Top	-9637.8198
Story2	Bottom	-13706.7419
Story2	Top	10264.7186
Story2	Bottom	14086.9332
Story2	Top	-10409.4923
Story2	Bottom	-14792.7295
Story2	Top	10591.7402
Story2	Bottom	14620.4586
Story2	Top	-9762.119
Story2	Bottom	-13588.1926
Story2	Top	17974.8426
Story2	Bottom	24323.533
Story2	Top	-18163.0825
Story2	Bottom	-25218.1192
Story2	Top	16706.5629
Story2	Bottom	22751.3699
Story2	Top	-16923.3619
Story2	Bottom	-23720.9724
Story2	Top	14982.6806
Story2	Bottom	20723.406
Story2	Top	-12632.6531
Story2	Bottom	-17746.94
Story2	Top	14982.6806
Story2	Bottom	20723.406
Story2	Top	-12632.6531
Story2	Bottom	-17746.94
Story2	Top	13671.2105
Story2	Bottom	19256.6503
Story2	Top	-12436.2384
Story2	Bottom	-17613.5858
Story2	Top	-149222.9273
Story2	Bottom	-154504.075
Story2	Top	-172993.1627
Story2	Bottom	-178273.7241
Story2	Top	-121444.2024
Story2	Bottom	-125216.0843
Story1	Top	-72207.7173
Story1	Bottom	-76893.8801
Story1	Top	-17755.0267
Story1	Bottom	-17754.5296
Story1	Top	-58417.5242
Story1	Bottom	-58418.0227

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story1	Top	0
Story1	Bottom	0
Story1	Top	0
Story1	Bottom	0
Story1	Top	-76646.4648
Story1	Bottom	-81332.4996
Story1	Top	-76646.4648
Story1	Bottom	-81332.4996
Story1	Top	-20871.4344
Story1	Bottom	-4670.7939
Story1	Top	-76646.4648
Story1	Bottom	-81332.4996
Story1	Top	-41866.3493
Story1	Bottom	-33539.272
Story1	Top	-76646.4648
Story1	Bottom	-81332.4996
Story1	Top	21285.014
Story1	Bottom	29467.363
Story1	Top	-20848.6903
Story1	Bottom	-29085.1734
Story1	Top	22747.5421
Story1	Bottom	31294.1479
Story1	Top	-21176.5024
Story1	Bottom	-29645.5583
Story1	Top	18632.3307
Story1	Bottom	25808.388
Story1	Top	-18640.8642
Story1	Bottom	-26193.6821
Story1	Top	19164.4915
Story1	Bottom	26283.6746
Story1	Top	-22499.9032
Story1	Bottom	-31188.1933
Story1	Top	18801.9599
Story1	Bottom	25326.2842
Story1	Top	-18774.0849
Story1	Bottom	-25831.4828
Story1	Top	17922.1385
Story1	Bottom	24287.2045
Story1	Top	-18627.4493
Story1	Bottom	-25652.3688
Story1	Top	16457.5292
Story1	Bottom	22486.4598
Story1	Top	-16756.3132
Story1	Bottom	-21751.8252
Story1	Top	17921.3701

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story1	Bottom	25005.8957
Story1	Top	-17705.3781
Story1	Bottom	-23933.2857
Story1	Top	19775.5159
Story1	Bottom	28168.5757
Story1	Top	-18351.8786
Story1	Bottom	-25526.7376
Story1	Top	20050.7184
Story1	Bottom	27567.0401
Story1	Top	-17712.8928
Story1	Bottom	-24345.4004
Story1	Top	19332.8581
Story1	Bottom	26552.3454
Story1	Top	-19238.4825
Story1	Bottom	-26659.2119
Story1	Top	17708.1537
Story1	Bottom	24494.822
Story1	Top	-18737.8567
Story1	Bottom	-25916.5803
Story1	Top	15801.2374
Story1	Bottom	21891.241
Story1	Top	-13706.742
Story1	Bottom	-19112.3977
Story1	Top	14086.9332
Story1	Bottom	19148.3449
Story1	Top	-14792.7296
Story1	Bottom	-21218.3559
Story1	Top	14620.4587
Story1	Bottom	19736.1322
Story1	Top	-13588.1927
Story1	Bottom	-18450.6938
Story1	Top	24323.533
Story1	Bottom	32273.7869
Story1	Top	-25218.1193
Story1	Bottom	-34401.1679
Story1	Top	22751.37
Story1	Bottom	30984.3331
Story1	Top	-23720.9725
Story1	Bottom	-32682.3865
Story1	Top	20723.4061
Story1	Bottom	28201.9719
Story1	Top	-17746.9401
Story1	Bottom	-24332.6428
Story1	Top	20723.4061
Story1	Bottom	28201.9719

Table 3.3 - Story Forces (Part 2 of 2, continued)

Story	Location	MY kN-m
Story1	Top	-17746.9401
Story1	Bottom	-24332.6428
Story1	Top	19256.6505
Story1	Bottom	26468.64
Story1	Top	-17613.5859
Story1	Bottom	-24333.2044
Story1	Top	-182875.3381
Story1	Bottom	-189436.664
Story1	Top	-211283.3808
Story1	Bottom	-217843.9113
Story1	Top	-148380.2682
Story1	Bottom	-153066.4324

3.3 Modal Results

Table 3.4 - Modal Periods And Frequencies

Case	Mode	Period sec	Frequency cyc/sec	CircFreq rad/sec	Eigenvalue rad2/sec2
Modal	1	0.823	1.214	7.6302	58.2199
Modal	2	0.675	1.483	9.3153	86.7748
Modal	3	0.508	1.97	12.3804	153.274
Modal	4	0.247	4.057	25.4885	649.6661
Modal	5	0.173	5.778	36.3025	1317.8717
Modal	6	0.142	7.019	44.1023	1945.0098
Modal	7	0.128	7.838	49.2466	2425.2294
Modal	8	0.089	11.221	70.5054	4971.0051
Modal	9	0.077	13.02	81.8058	6692.1883
Modal	10	0.064	15.591	97.9607	9596.2987
Modal	11	0.063	15.765	99.0539	9811.6789
Modal	12	0.052	19.301	121.2736	14707.2742

Table 3.5 - Modal Participating Mass Ratios (Part 1 of 2)

Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ
Modal	1	0.823	0.0099	0.3556	0	0.0099	0.3556	0	0.0467	0.0031	0.5697
Modal	2	0.675	0.7422	0.0057	0	0.7521	0.3613	0	0.0005	0.2797	0.0067
Modal	3	0.508	2.59E-05	0.4304	0	0.7521	0.7917	0	0.2095	0.0001	0.3414
Modal	4	0.247	0.0011	0.0425	0	0.7533	0.8342	0	0.2235	0.0008	0.0131
Modal	5	0.173	0.1593	0.0002	0	0.9126	0.8344	0	0.0009	0.4565	0.0001
Modal	6	0.142	0.0002	0.0559	0	0.9128	0.8902	0	0.179	0.0005	0.0438
Modal	7	0.128	0.0005	0.0487	0	0.9133	0.939	0	0.1485	0.0013	0.003
Modal	8	0.089	4.604E-05	0.0004	0	0.9133	0.9394	0	0.0042	0.0002	0.0017
Modal	9	0.077	0.0523	0.0001	0	0.9656	0.9394	0	0.0001	0.1357	4.254E-06
Modal	10	0.064	0	0.0003	0	0.9656	0.9397	0	0.0008	0	0.001
Modal	11	0.063	4.868E-05	0.0354	0	0.9657	0.9751	0	0.0937	0.0001	0.011
Modal	12	0.052	1.671E-06	0.0001	0	0.9657	0.9752	0	0.0004	6.806E-06	0.0001

Table 3.5 - Modal Participating Mass Ratios (Part 2 of 2)

Case	Mode	SumRX	SumRY	SumRZ
Modal	1	0.0467	0.0031	0.5697
Modal	2	0.0472	0.2828	0.5764
Modal	3	0.2566	0.2829	0.9178
Modal	4	0.4801	0.2837	0.9308
Modal	5	0.481	0.7402	0.931
Modal	6	0.66	0.7407	0.9748
Modal	7	0.8086	0.742	0.9778
Modal	8	0.8128	0.7422	0.9795
Modal	9	0.8129	0.8778	0.9795
Modal	10	0.8137	0.8778	0.9805
Modal	11	0.9073	0.878	0.9915
Modal	12	0.9078	0.878	0.9916

Table 3.6 - Modal Load Participation Ratios

Case	ItemType	Item	Static %	Dynamic %
Modal	Acceleration	UX	99.98	96.57
Modal	Acceleration	UY	99.99	97.52
Modal	Acceleration	UZ	0	0

Table 3.7 - Modal Direction Factors

Case	Mode	Period sec	UX	UY	UZ	RZ
Modal	1	0.823	0.013	0.391	0	0.596
Modal	2	0.675	0.987	0.006	0	0.007
Modal	3	0.508	0	0.616	0	0.384
Modal	4	0.247	0.003	0.317	0	0.68
Modal	5	0.173	0.995	0.001	0	0.003
Modal	6	0.142	0.001	0.685	0	0.315
Modal	7	0.128	0.002	0.285	0	0.712
Modal	8	0.089	0.004	0.36	0	0.636
Modal	9	0.077	0.996	0.003	0	0.001
Modal	10	0.064	0.001	0.391	0	0.608
Modal	11	0.063	0.001	0.675	0	0.324
Modal	12	0.052	0.002	0.431	0	0.567

APPENDIX (3)

STRUCTURAL DRAWINGS

LIST OF STRUCTURAL DRAWINGS			
SERIAL NO.	DRAWING NO.	DRAWING TITLE	REV. DATE
01	ST-00	LIST OF STRUCTURAL DRAWINGS	R0 17-10-2023
02	ST-01	GENERAL CONSTRUCTION NOTES	R0 17-10-2023
03	ST-02	FOUNDATION PLAN	R0 17-10-2023
04	ST-03	COLUMN SETTING OUT PLAN	R0 17-10-2023
05	ST-04	GROUND FLOOR PLAN	R0 17-10-2023
06	ST-05	TYPICAL FLOOR FRAMING PLAN	R0 17-10-2023
07	ST-06	SCHEDULE OF BEAMS, SLAB REINFORCEMENT SCHEDULE, SCHEDULE OF FOOTINGS	R0 17-10-2023
08	ST-07	SCHEDULE OF COLUMNS	R0 17-10-2023

GENERAL CONSTRUCTION NOTES

A. GENERAL

- A1. UNLESS NOTED OTHERWISE ON THE DRAWINGS, ELEVATIONS ARE IN METERS, DIMENSIONS ARE IN MILLIMETERS AND BAR SIZES AND SPACING ARE IN MILLIMETERS.
- A2. ALL DRAWINGS MUST BE READ IN CONJUNCTION WITH THE ARCHITECTURAL DRAWINGS AND MEP DRAWINGS BEFORE STARTING THE WORK.
- A3. THERE SHALL BE NO DRAINAGE PIPES INSERTS THROUGHOUT ALL COLUMNS & BEAMS.
- A4. NO CUTTING OR DRILLING OF THE POURED CONCRETE OR REINFORCEMENT SHALL BE ALLOWED UNLESS APPROVED BY THE ENGINEER.
- A5. THE CONTRACTOR SHALL PROVIDE FOR ALL NECESSARY SLEEVES, CUT OUTS FOR OPENINGS, EMBEDDED CONDUITS, BOXES ETC. AS REQUIRED BEFORE PROCEEDING WITH CASTING OF CONCRETE.
- A6. THE CONTRACTOR SHOULD SUBMIT THE SHOP DRAWINGS INDICATING ALL THE REINFORCEMENT DETAILS TO THE ENGINEER FOR HIS REVIEW AND APPROVAL PRIOR TO ANY SITE WORK.
- A7. ANY TIMBER, STEEL OR SIMILAR INSERTS MUST NOT BE FIXED IN CONTACT WITH CONCRETE. ANY SUCH DETAIL MUST BE APPROVED OTHERWISE, THE FOLLOWING MINIMUM DISTANCES SHALL BE MAINTAINED:
- | | |
|--------------|-------|
| TIMBER/STEEL | 35 MM |
| STEEL/STEEL | 25 MM |
- A8. DETAILS SHOWN ON DRAWINGS ARE ASSUMED TO BE TYPICAL AND APPLY TO SIMILAR CONDITIONS THROUGHOUT UNLESS SPECIFICALLY SHOWN OTHERWISE. CONDITIONS NOT COVERED SHALL FOLLOW THE RECOMMENDATIONS OF THE RELEVANT APPROVED STANDARDS.
- A9. ALL DIMENSIONS MUST BE VERIFIED ON SITE AND ANY DISCREPANCIES SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER BEFORE PROCEEDING WITH THE WORK.
- A10. ABBREVIATIONS

B	=	BOTTOM BARS
T	=	TOP BARS
EF	=	EACH FACE
FF	=	FAR FACE
NF	=	NEAR FACE
(EW)	=	END WAY
UN	=	UNLESS NOTED OTHERWISE
E.J.	=	EXPANSION JOINT
I.J.	=	ISOLATION JOINT
E.T.	=	EXTRA TOP REINFORCEMENT
S.S.L	=	STRUCTURAL SLAB LEVEL
F.F.L	=	FINISH FLOOR LEVEL (AS PER ARCHITECT)
	=	TANK ABOVE
	=	COLUMN ABOVE
	=	COLUMN STOPS BELOW

B. EARTHWORKS AND FOUNDATIONS

- B1. THE CONTRACTOR SHOULD FOLLOW SOIL INVESTIGATION NO. (IGSD-T-KH-2992) AND PROVIDE ALL NECESSARY TESTS REQUIRED AT SITE IF REQUIRED.
- B2. THE FOUNDATION HAVE BEEN DESIGNED CONSIDERING THE SOIL BEARING CAPACITY IS 150 kN/sq.m AND THE CONTRACTOR SHOULD CONSIDER THE SOIL PLATE LOAD TEST AND OTHER NECESSARY TESTS AT FOUNDATION LEVEL BEFORE CONSTRUCTION.
- B3. STRUCTURAL OR SELECTED FILL MATERIAL SHOULD CONSIST ONLY OF INORGANIC MATERIALS SUCH AS CRUSHED STONE, GRAVEL, SAND, ETC. THE MATERIAL SHOULD PASS 100% THE 90 MM SIEVE. BESIDES THAT PORTION OF THE MATERIAL PASSING SIEVE NO. 40, SHOULD NOT HAVE LIQUID LIMIT MORE THAN 35 AND PLASTICITY INDEX OF NOT MORE THAN 12. ATTERBERG LIMITS ARE NOT REQUIRED FOR SELECT FILL MATERIAL WITH LESS THAN 15% PASSING SIEVE NO. 200.
- B4. UNLESS OTHERWISE SPECIFIED, THE ENTIRE SUB-GRADE SHALL BE COMPACTED TO NOT LESS THAN 95 PERCENT OF THE MAXIMUM DRY DENSITY PER ASTM D 1557, OR AASHTO T 99 OR TO 85% OF RELATIVE DENSITY DETERMINED BY ASTM D4253 AND D4254. ALL HOLES, RUTS, SOFT PLACES, AND OTHER DEFECTS SHALL BE CORRECTED. IN NO CASE SHALL THE SUB-BASE OR BASE COURSE BE PLACED ON SOIL OR UNSTABLE MATERIAL OR OVER AREAS THAT ARE NOT DRAINED. IF THE SUB-GRADE OR BASE COURSE IS TO BE PLACED ON SOIL, IT SHALL BE PLACED ON A CONDITION SATISFACTORY TO THE CLIENT REPRESENTATIVE.
- B5. SELECTED FILL SHOULD BE PLACED UP TO 600 MM THICKNESSES BENEATH BOTTOM OF CONSTRUCTION. THE CONTRACTOR SHOULD PROVIDE FIRM AND STABLE PLATFORM TO ENSURE UNIFORM SPREAD OF FOUNDATION LOADS TO THE UNDERLATH SOLID ROCK LAYERS.
- B6. THE CONTRACTOR SHALL CARRY OUT DEWATERING OF THE SITE DURING CONSTRUCTION IF NECESSARY.
- B7. IF WATER IS ENCOUNTERED DURING EXCAVATION, THE CONTRACTOR SHALL LOWER THE WATER LEVEL BY PUMPING OR OTHER MEANS AND MAINTAIN DRY CONDITIONS BY SUITABLE METHOD AND SUBJECT TO ENGINEERS APPROVAL.
- B8. IN ALL CASES, THE CONSTRUCTION SHALL BE CARRIED OUT IN DRY CONDITION. THE CONTRACTOR SHALL BE RESPONSIBLE TO MAINTAIN THE DRY WORKING CONDITION THROUGHOUT THE CONSTRUCTION PERIOD.
- B9. THE CONTRACTOR SHALL REFER TO THE SPECIFICATIONS OF THE WATERPROOFING OR SUBSTRUCTURE PROTECTION MATERIAL AND STRICTLY FOLLOW THE MANUFACTURER'S RECOMMENDATIONS FOR ITS WORKMANSHIP AND EXECUTION SUBJECT TO AN APPROVED METHOD STATEMENT MATERIAL AND SUB TO THE ENGINEER APPROVAL.
- B10. DO NOT BACKFILL AGAINST WALLS RETAINING EARTH UNTIL ELEMENTS PROVIDING LATERAL SUPPORT. PLACE BACKFILL SIMULTANEOUSLY ON BOTH SIDES OF OTHER WALLS BELOW GROUND.

C. REINFORCED CONCRETE

- C1. CONCRETE WORKS SHALL BE IN ACCORDANCE WITH THE LATEST EDITIONS OF ACI 318 STANDARD BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE, ACI 301, SPECIFICATIONS FOR STRUCTURAL CONCRETE FOR BUILDINGS, AND ACI 302, RECOMMENDED PRACTICE FOR CONCRETE FLOOR AND SLAB CONSTRUCTION, THE USE OF EQUIVALENT BRITISH STANDARDS (BS 8110:1980) OR EUROPEAN STANDARDS ARE PERMITTED IN WHICH CASE THE PROVISIONS OF (ACI 318) ARE TO BE CONSIDERED AS MINIMUM REQUIREMENT.
- C2. CONCRETE GRADES (MINIMUM 28 DAYS CYLINDER COMPRESSIVE STRENGTH, $f_{c'}$) FOR CAST IN PLACE CONCRETE ARE TO BE AS FOLLOWS:

LOCATION	CONCRETE GRADE ($f_{c'}$) MAX. AGGR. SIZE	TYPE OF CEMENT
MASS OR UNREINFORCED CONCRETE:		
FINISHING CONCRETE	35/20	SRC
REINFORCED CONCRETE:	35/20 (WATERTIGHT CONCRETE)	SRC
FOR SUBSTRUCTURE:		
RC FOOTINGS	35/20	SRC
GRADE SLABS, GRADE BEAMS	35/20	SRC
ALL RC ELEMENTS TOUCHING EARTH OR UNDERGROUND	35/20	SRC
FOR SUPERSTRUCTURE:		
FLAT SLABS	35/20	OPC
BEAMS	35/20	OPC
COLUMNS AND WALLS	35/20	OPC

- *** FOR ALL OTHER TYPE, THE CONCRETE GRADE SHOULD NOT BE LESS THAN 40 N/mm².
- C3. THE SLUMP OF CONCRETE FOR COLUMN & FOUNDATION SHOULD BE 80mm $\pm$ 5mm, AND FOR SLABS & BEAMS IT SHOULD BE 100-120mm $\pm$ 5mm SUBJECT TO APPROVED CONCRETE MIX DESIGN.
- C4. MAXIMUM WATER CEMENT RATIO SHOULD BE VARIED FROM 0.40 TO 0.42.
- C5. MINIMUM CEMENT CONTENT SHOULD BE 400 kg/cu.m.
- C6. CONCRETE DESIGN MIX FOR EXPOSED ELEMENTS OF THE STRUCTURE SHOULD BE SUBMITTED TO THE CONSULTANT ENGINEER FOR HIS APPROVAL.
- C7. THE CONCRETE WORKING FOR THE COLUMNS INSIDE & WITHIN THE DOMESTIC & FIRE FIGHTING TANK SHOULD BE INCREASED ON ALL SIDES TO MAKE THE CONCRETE COVERING EQUAL TO 75mm THK.
- C8. A FULL LINING OF PROTECTION INSIDE THE DOMESTIC & FIRE FIGHTING WATER TANK SHOULD BE DONE PROFESSIONALLY INCLUDING THE COLUMNS WITHIN THE TANK.
- C9. CONCRETE COVERING INSIDE & OUTSIDE OF THE WALL ELEMENTS TOUCHING THE WATER SHOULD BE INCREASED 25mm TO ADJUST THE COVER TO 75mm THK.
- C10. FOR WATER TANKS & COLUMNS INSIDE FLY ASH GRADE OF CONCRETE $f_{c'}$ NOT LESS THAN 45 N/mm² AND SHOULD USE FLY ASH TO REDUCE THE INSIDE VOID.
- C11. CONCRETE FOR ALL ELEMENTS IN CONTACT WITH OR BELOW FINISHED GROUND LEVEL SHALL CONTAIN SULPHATE RESISTING CEMENT. SUCH SURFACES SHALL BE COATED WITH TWO COATS OF BITUMINOUS PAINT WHERE WATER-PROOFING MEMBRANE IS NOT SHOWN.
- C12. ANY ADMIXTURES TO BE USED IN CONCRETE SHALL BE SUBJECT TO PRIOR APPROVAL BY ENGINEER.
- C13. WATER STOPPERS (CENTRAL TYPE) SHALL BE USED AT ALL CONSTRUCTION JOINTS WHERE WATERPROOFING SYSTEM IS APPLIED. ALL INTERSECTION PIECES OF WATER STOPPERS SHALL BE FACTORY MOULDED.
- C14. CONCRETE SHALL BE CASTED IN ACCORDANCE WITH AGI RECOMMENDATIONS FOR HOT WEATHER CONCRETE.
- C15. NO CALCIUM CHLORIDE SHALL BE USED IN ANY CONCRETE.
- C16. SEE APPLICABLE SPECIFICATIONS SECTIONS ON CONCRETE.
- C17. THE SEQUENCE OF POURING CONCRETE SHALL BE SUCH AS TO MINIMIZE SHRINKAGE.
- C18. ALL OPENINGS SHOWN ON PLAN AND/OR SECTIONS SHALL BE VERIFIED WITH ARCHITECTURAL AND MECHANICAL DRAWINGS. OPENINGS NOT SHOWN ON STRUCTURAL DRAWINGS SHALL BE INSTALLED ONLY AFTER THE APPROVAL OF THE STRUCTURAL ENGINEER.
- C19. WATER CURING SHALL BE CARRIED OUT FOR A MINIMUM PERIOD OF 7 DAYS AFTER THE POURING OF CONCRETE.

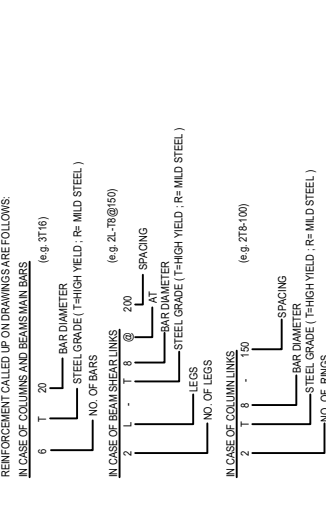
D. DESIGN CRITERIA

- D1. DESIGN CODES
- AMERICAN SOCIETY OF CIVIL ENGINEERING (ASCE, 7-10) EDITION
 - UNIFORM BUILDING CODE (UBC -1997) EDITION.
 - BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE (ACI 318-11).
 - THE AMERICAN ANSIA/SAC 380-16 FOR STEEL STRUCTURES DESIGN
- D2. DESIGN LOADS
- DEAD LOADS:
- | | | |
|-------------------------------|---|---------------------------|
| WEIGHT OF REINFORCED CONCRETE | = | 25.00 kN/cu.m. |
| WEIGHT OF PLAIN CONCRETE | = | 21.00 kN/cu.m. |
| STEEL MEMBERS (OWN WEIGHT) | = | 7.85 tm ³ |
| SUSPENDED CEILING WT | = | 0.50 kN/sq.m. |
| FLOOR FINISH | = | 1.50 kN/sq.m. |
| AC UNITS | = | 3.00 kN/sq.m. (Roof Deck) |
| WALLS (NON-LOAD BEARING) | = | 5.00 kN/sq.m. |
- WALLS (NON-LOAD BEARING) DENSITY NOT MORE THAN 16.00 kN/cu. m.

- LIVE LOADS:
- | | | |
|------------------------|---|---------------|
| PARKING AND RAMP AREAS | = | 5.00 kN/sq.m. |
| SERVICE BUILDING SLABS | = | 2.00 kN/sq.m. |
| MOSQUE SLABS | = | 5.00 kN/sq.m. |
- WIND LOADS:
- | | | |
|--|---|--------|
| WIND LOADS ARE APPLIED TO THE BUILDING IN BOTH DIRECTIONS "X" AND "Y". | | |
| WIND SPEED | = | 64 mph |
| EXPOSURE TYPE | = | B |
| IMPORTANCE FACTOR | = | 1 |
| TOPOGRAPHICAL FACTOR (K_{zt}) | = | 1 |
| GUST FACTOR | = | 0.85 |
| DIRECTIONALITY FACTOR | = | 0.85 |

E. STEEL REINFORCEMENT

- E1. STEEL REINFORCING BARS SHALL HAVE A MINIMUM CHARACTERISTIC STRENGTH F_y OF:
- | | |
|--|--------|
| BAR TYPE | F_y |
| HIGH YIELD TYPE 2 DEFORMED BARS TO BS 4449 | 460MPa |
| WELDED MILD OR FABRIC REINF. TO BS 4483 | 480MPa |
- E2. THE REINFORCEMENT SHOWN ON SCHEDULES AND DRAWINGS IS THAT REQUIRED BY DESIGN FOR PERMANENT LOADING. THE CONTRACTOR SHALL ALLOW FOR AND INCORPORATE ANY REINFORCEMENT HE MAY REQUIRE FOR TEMPORARY CONSTRUCTION LOADING, PROCEDURES, BAR SUPPORT/SPACING ETC.
- E3. THE CONTRACTOR SHALL PREPARE SHOP DRAWINGS AND BAR BENDING SCHEDULE FOR ALL REINFORCEMENT. THE CONTRACTOR SHALL SUBMIT THE SHOP DRAWINGS AND BENDING SCHEDULE FOR APPROVAL OF THE ENGINEER FOR HIS APPROVAL BEFORE PROCEEDING WITH STEEL FABRICATION.
- E4. THE REQUIRED ANCHORAGE AND LAP SPICE LENGTHS OF VARIOUS BARS ARE GIVEN IN THE ENCLOSED TABLES. UNLESS INDICATED OTHERWISE, THE MINIMUM LAP LENGTH IS TO BE BASED ON THE LARGER DIAMETER BAR AT THE OVERLAP. IN COLUMNS AND WALLS, APPROVED MECHANICAL SPICE
- E5. WHERE LAPS ARE NOT SHOWN BUT ARE REQUIRED, THEY SHALL BE STAGGERED AND LOCATED AT THE POINT OF LOW STRESS. LAPS SHOULD BE KEPT TO A MINIMUM NUMBER.
- E6. HORIZONTAL AND VERTICAL CONSTRUCTION JOINTS SHALL BE LOCATED AS APPROVED BY THE ENGINEER PRIOR TO CASTING OF CONCRETE. ALL JOINTS SHALL BE FORMED WITH A STANDARD SHEAR KEY, AS SHOWN IN THE DETAIL ATTACHED, AND REINFORCING BARS SHALL BE EXTENDED TO PROVIDE THE REQUIRED LAP LENGTH OR 60 x BAR DIAMETER, WHICHEVER IS GREATER.
- E7. THE REINFORCEMENT AT VARIOUS LOCATIONS FOR DURABILITY AND FIRE RESISTANCE ARE SHOWN IN THE TABLE. THE COVER CONCRETE SHALL BE WELL-COMPACTED AND MADE IMPERMEABLE TO MOISTURE INGRESS. NO DEFECTS, E.G. BLOW HOLES, HONEYCOMBING ETC. SHALL BE PERMITTED IN THE COVER CONCRETE ON STRIKINGS OF THE FORMWORK. ANY SUCH DEFECT MEASURING MORE THAN 3 MM IN SIZE, SHALL BE REPAIRED BY EPOXY GROUT TO THE SATISFACTION OF THE ENGINEER.
- E8. REINFORCEMENT LABEL



- E9. IN PRODUCING RC DETAILS, MEMBERS HAVE BEEN GROUPED ON THE BASIS OF SPANS, LIFTS, CROSS-SECTIONS AND REINFORCEMENT PROVIDED. THE CONTRACTOR SHALL TAKE DUE ACCOUNT OF THE PRESENCE OF ANY HOLES, REINFORCEMENT DETAILS, AND ANY OTHER DETAILS THAT MAY BE NECESSARY SUBJECT TO THE ENGINEER APPROVAL.
- E10. THE CLEAR SPACING BETWEEN ANY TWO REINFORCEMENT BARS IN ONE PLANE OF A BEAM OR COLUMN SHALL NOT BE LESS THAN (BAR DIA-25MM) AND NOT GREATER THAN 160mm, UNLESS APPROVED BY THE ENGINEER.
- E11. BEAMS AND COLUMNS REINFORCEMENT PLACED IN MULTIPLE LAYERS SHALL HAVE A 25 MM SPACER BAR PLACED @ 1000 MM ON CENTERS.
- E12. LINK (OR STIRRUP) ARRANGEMENTS SHALL BE SUCH AS TO PROVIDE THE REQUIRED NUMBER OF LEGS, PROPERLY ANCHORED, PROVIDING THE MINIMUM OBSTRUCTION TO PLACING AND COMPACTING OF CONCRETE AND RESULTING IN A GOOD QUALITY CONCRETE. BEAM LINKS SHALL NORMALLY BE OF THE SHAPE MENTIONED HERE.

UNLESS NOTED OTHER WISE

GENERAL CONSTRUCTION NOTES

E13. REINFORCING STEEL : BS 4449:27 TT- HOT ROLLED DEFORMED HIGH YIELD HIGH BOND STEEL REINFORCEMENT GRADE 460 (FY = 460 MPa)

E14. CONCRETE COVER TO REINFORCEMENT IN MM ARE AS FOLLOWS:

LOCATION	COVER FOR CONCRETE
SUBSTRUCTURE (FACING SOIL OR WATER)	75
EXPOSED EXTERNAL SURFACES (SUBSTRUCTURE)	50
BEAMS EXPOSED TO WEATHER	40
UNCLAD (BOTTOM AND SIDE)	40
COLUMNS, SHEAR WALLS EXTERNAL	40
CONCRETE NOT EXPOSED TO WEATHER:	
SOLID SLABS ON GROUND	
TOP	30
BOTTOM	50
SOLID SLABS ABOVE GROUND FLOOR	30
BEAMS BOTTOM AND SIDE	30
(TOP WITH MIN. 50 FINISHES)	30
COLUMNS, SHEAR WALLS INTERNAL	40

IN NO CASE, THE COVER TO MAIN REINFORCING BARS IS TO BE NOT LESS THAN THE BAR DIAMETER + 10mm. THE END COVER TO ALL BARS SHALL BE AS ABOVE OR TWICE THE BAR DIAMETER, WHICHEVER IS GREATER.

E15. ALL LINTEL UP TO 2000 MM SPANS SHALL BE 200/250X300MM WITH T12, 2NOS, TOP AND BOTTOM AND STIRRUPS 18 @ 200 CC. LINTEL ABOVE 2000 AND UP TO 3600MM SPAN SHALL BE 200/300X300MM WITH T16, 2NOS, TOP AND BOTTOM AND STIRRUPS 18 @ 200 CC. THEY SHALL HAVE THE MINIMUM BEARING OF 200MM.

E16. ANCHORAGE (DEVELOPMENT LENGTH) AND LAP LENGTHS OF REINFORCING BARS SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF CHAPTER 7, ACI 318.

BASIC DEVELOPMENT OR ANCHORAGE LENGTHS

BAR DIAMETER (MM)	8	10	12	14	16	18	20	22	25	32	40
BASIC DEVELOPMENT LENGTH IN TENSION (MM)	440	550	660	770	880	990	1080	1190	1310	1540	2000
BASIC DEVELOPMENT LENGTH IN COMPRESSION (MM)	300	300	360	420	460	540	600	660	750	960	1200

LAP SPLICE LENGTH

GRADE	STEEL	LAP SPLICE LENGTHS IN MM
CONCRETE	HIGH YIELD TYPE 2	
30MPa AND ABOVE	TENSION	525
	COMPRESSION	300
MILD STEEL	TENSION	500

- NOTES: 1. NOT MORE THAN 50 % OF THE BARS ARE TO BE LAPPED IN ANY SECTION.
2. COLD LAPPED REINFORCEMENT SHALL BE PROVIDED ALONG THE LAPPED LENGTHS.
3. TENSION LAPS ARE TO BE USED IN ALL CASES.

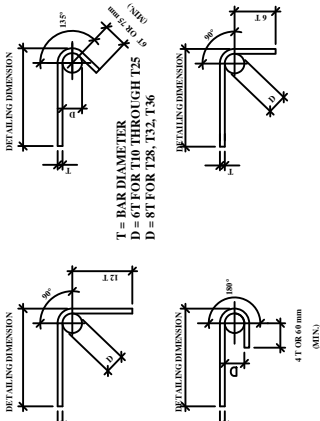
E17. HOOKS AND BENDS :-

1) STANDARD HOOKS:
THIS TERM "STANDARD HOOK", AS USED IN THIS DRAWING, SHALL MEAN ONE OF THE FOLLOWING:
1. -180-deg BEND PLUS (4T) EXTENSION, BUT NOT LESS THAN 60 MM AT FREE END OF BAR.
2. -90-deg BEND PLUS (12T) EXTENSION AT FREE END OF BAR.
3. FOR STIRRUPS AND TIE HOOPS (T16 BAR AND SMALLER), 90-deg BEND PLUS 6T EXTENSION AT FREE END OF BAR.

4. -180-deg BEND PLUS (12T) EXTENSION AT FREE END OF BAR.
5. -90-deg BEND PLUS (12T) EXTENSION AT FREE END OF BAR.
6. -135-deg BEND PLUS (12T) EXTENSION AT FREE END OF BAR.
NOTE: 1. HOOPS IS A CLOSED TIE OR CONTINUOUSLY WOUND TIE.
2. HOOPS IS A CLOSED TIE OR CONTINUOUSLY WOUND TIE.
3. MINIMUM BEND DIAMETER:
- DIAMETER OF BEND MEASURED ON THE INSIDE OF THE BAR, OTHER THAN FOR STIRRUPS AND TIES IN SIZES T10 THROUGH 16, SHALL NOT BE LESS THAN THE VALUES IN TABLE (1)
- INSIDE DIAMETER OF BEND FOR STIRRUPS AND TIES SHALL NOT BE LESS THAN (4D) FOR T16 BAR AND SMALLER. FOR BARS LARGER THAN T16, DIAMETER OF BEND SHALL BE IN ACCORDANCE WITH TABLE (1).

TABLE (1) - MINIMUM DIAMETER OF BEND

BAR SIZE	MINIMUM DIAMETER OF BEND (D)
T10 THROUGH T25	6 T
T28 THROUGH T32	8 T



STANDARD HOOKS FOR REINFORCEMENT STANDARD HOOKS FOR STIRRUPS, TIES AND HOOPS

E17. ALL CONCRETE REINFORCEMENT SHALL BE DETAILED, FABRICATED, LABELED, SUPPORTED AND SPACED IN FORMS AND SECURED IN PLACE IN CONFORMANCE WITH THE PROCEDURES AND REQUIREMENTS OUTLINED IN THE LATEST EDITION OF THE CONCRETE MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED CONCRETE STRUCTURES' ACI 318.

F. ANTI-TERMITE TREATMENT

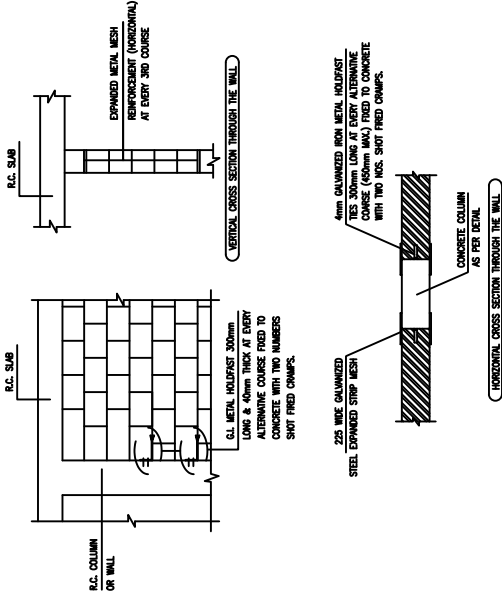
- F1. THE GENERAL CONTRACTOR SHALL SUPPLY AND EXECUTE APPLICATION OF PROPRIETARY ORGANOPHOSPHATE INSECTICIDE FOR THE CONTROL OF SUBTERRANEAN TERMITES USING PRE-CONSTRUCTION TREATMENT METHODS. WORKS SHALL BE GUARANTEED FOR A MINIMUM PERIOD OF 15 YEARS FROM THE DATE OF PRACTICAL COMPLETION.
- F3. APPLICATION SHALL BE CARRIED OUT BY APPROVED SPECIALIZED APPLICATOR AND STRICTLY BE IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATION. THE CONTRACTOR SHALL ENSURE ALL SAFETY & STANDARDS ARE FOLLOWED AND PROPER PRECAUTION SHALL BE TAKEN TO AVOID ACCIDENTAL SPILLS.
- F4. ALL TOOL/CONTAINERS USED DURING APPLICATION SHALL BE DISPOSED IN APPROVED MANNER AND CONTRACTOR SHALL NOT BURY THEM IN THE SITE IN WHATEVER CIRCUMSTANCES.
- F5. JOINTS IN THE GROUND SLAB ALONG THE GROUND BEAM AREAS SHALL BE ADDITIONALLY TREATED AS REQUIRED. ON COMPLETION FLEXIBLE EDGES SHALL BE COMPLETELY SEALED WITH APPROVED SEALANT WHICH COULD WITHSTAND THE TERMITE ATTACK.

G. JOINTS FILLER/SEALANT

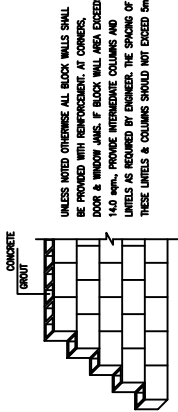
- G1. JOINT FILLER SHALL BE HYDROCELL OR KORPAK OR EQUIVALENT APPROVED. JOINT SEALANT SHALL BE "THOFLUX 600" BY FORSICC OR EQUIVALENT APPROVED. ALL APPLICATIONS ARE TO BE CARRIED OUT STRICTLY IN ACCORDANCE WITH THE MANUFACTURER'S INSTRUCTIONS.

H. BLOCKWORK

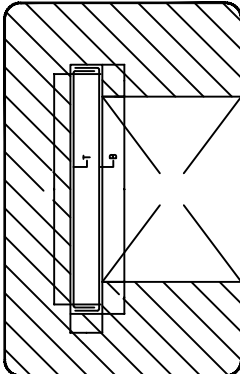
- H1. BLOCKWORKS TO BE NORMAL BLOCKWORK HAVING DENSITY NOT MORE THAN 1400 kg/m³. UNLESS OTHERWISE IT IS REQUIRED BY THE POST TENSION SLAB SUPPLIER AND/OR THE CONSULTANT/ENGINEER SUBJECT TO HIS APPROVAL.
- H2. BLOCKS SHALL HAVE A MINIMUM CHARACTERISTIC COMPRESSIVE STRENGTH OF 7 TO 10 N/mm² AT 28 DAYS. ALL BLOCKS SHALL BE IN ACCORDANCE WITH LOCAL MUNICIPALITY REGULATIONS AND AS SHOWN ON RESPECTIVE DRAWINGS. THE COMPRESSIVE STRENGTH OF THE BLOCKS AND THE LOWEST COMPRESSIVE STRENGTH OF ANY INDIVIDUAL BLOCK TESTED IN ACCORDANCE WITH THE BS 6073, SHALL NOT BE LESS THAN THE VALUES GIVEN BELOW:
- AVERAGE OF 10 BLOCKS - 7.0 TO 10 MPa or MORE
LOWEST INDIVIDUAL BLOCKS - 7.0 TO 10 MPa
- H3. WHEREVER TWO WALLS MEET, THE JUNCTION SHALL BE FILLED WITH CONCRETE OF GRADE 20/20.
- H4. UNLESS OTHERWISE INSTRUCTED BY THE ENGINEER ALL HOLLOW BLOCKS AT THE FOLLOWING LOCATIONS SHALL BE FILLED WITH CONCRETE OF GRADE 20/20
1. AT SIDES OF OPENING
 2. AT INTERSECTIONS AND JUNCTIONS BETWEEN CONCRETE COLUMNS AND OR CONCRETE WALLS WHERE WALL TIES ARE USED
 3. IN THE LAYER OF BLOCKS SUPPORTING IN-SITU CONCRETE
 4. IN BOTTOM COURSE OF A BLOCK WALL
- H5. WHERE MASONRY WALLS OR COLUMNS, ANCHORS SHALL BE PROVIDED AT A VERTICAL SPACING OF THREE COURSE OF BLOCK WORK.



CONNECTION OF R.C. COLUMN & BLOCK WALL



REINFORCEMENT FOR BLOCK WALLS



TYPICAL LINTEL DETAILS

SCHEDULE FOR LINTELS OVER OPENINGS :

SPAN	W	D	A	T	B	STIRRUPS	REMARKS
UP TO 1.00M	200	250	200	2-12	2-12	T10-250	
1.00M TO 1.50M	200	250	200	2-12	2-12	T10-250	
1.50M TO 2.00M	200	250	200	2-12	2-12	T10-250	
2.00M TO 2.50M	200	300	250	2-12	2-16	T10-250	
2.50M TO 3.00M	200	300	300	2-12	2-16	T10-250	
3.00M TO 3.50M	200	400	300	2-16	2-20	T10-175	

GENERAL CONSTRUCTION NOTES

I. GROUTING

- 11. NON SHRINK CEMENT GROUT SHALL BE MASTER FLOW 980 OR EQUIVALENT APPROVED FROM FOSROC OR Sika PRODUCT BY THE ENGINEER.
- 12. CHEMICAL ANCHORING WHERE EVER SPECIFIED ON THE DRAWINGS SHALL BY USING Hilti Anchors OR APPROVED EQUIVALENT AND ALL APPLICATIONS SHALL BE AS MANUFACTURERS SPECIFICATIONS FROM Hilti, FOSROC OR Sika.
- 13. EPOXY GROUT SHALL BE OF FOSROC OR EQUIVALENT APPROVED

J. SETTING OUT OF STRUCTURE

- J1. ALL COORDINATES AND LEVELS AS INDICATED IN THE DRAWING SHALL BE COORDINATED WITH THE SETTING OUT LAYOUT AND ARCHITECTURAL DRAWINGS.
- J2. METHODOLOGY AND ACCEPTANCE CRITERIA SHALL COMPLY WITH BS 5984 OR ISO 4463.

K. SHORING/PROTECTION SYSTEM

- K1. THE CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR THE SAFETY AND PROTECTION OF ALL WORKS, ADJACENT STRUCTURES AND WORKERS DURING EXCAVATION FOR THE BASEMENTS AND FOUNDATION BY PROVIDING ADEQUATE SHORING/PROTECTION SYSTEM OF ALL EXCAVATED AREAS.
- K2. SHORING SYSTEM SHOULD BE DESIGNED BY THE CONTRACTOR AND APPROVED BY THE CONSULTANT BEFORE EXECUTING THE WORK TAKING ITO CONSIDERATION THE SOIL REPORT RECOMMENDATIONS.

L. WATER TANKS

- L1. THE CONCRETE OF WATER TANKS AND OR ALL CONCRETE ELEMENTS INSIDE IT SUCH AS COLUMNS, BEAMS, WALL & FOOTINGS SHOULD BE CONSIDERED AS A "WATERTIGHT CONCRETE".
- L2. THE CONCRETE COVERING FOR THE COLUMNS INSIDE & WITHIN THE DOMESTIC & FIRE FIGHTING WATER TANK SHOULD BE INCREASED ON ALL SIDES TO MAKE THE CONCRETE COVERING EQUAL TO 75mm THK.
- L3. A FULL LINING OF PROTECTION INSIDE THE DOMESTIC & FIRE FIGHTING WATER TANK SHOULD BE DONE PROFESSIONALLY INCLUDING THE 12 COLUMNS WITHIN THE TANK.
- L4. CONCRETE COVERING INSIDE & OUTSIDE OF THE WALL ELEMENTS TOUCHING THE WATER SHOULD BE INCREASED 25mm TO ADJUST THE COVER TO 75mm THK.
- L5. FOR WATER TANKS & COLUMNS INSIDE, USE GRADE OF CONCRETE (F₂₈) NOT LESS THAN 45 N/mm² AND SHOULD USE FLY ASH OR EQUIVALENT MATERIAL SUBJECT TO ENGINEER'S APPROVAL TO REDUCE THE INSIDE VOIDS.
- L6. ALL REQUIRED TEST TO ASSURE THAT "LEAKAGE" IS NOT PERMITTED AT ALL SHOULD BE DONE AC308 OR EQUIVALENT BS.

M. CONSTRUCTION JOINTS

- M1. THE CONTRACTOR SHALL SUBMIT HIS PROPOSAL FOR THE LOCATION OF CONSTRUCTION/CONTRACTION JOINTS ETC. PRIOR TO THE SITE WORK FOR THE ENGINEERS APPROVAL ALONGWITH THE REQUIRED METHOD OF STATEMENT.
- M2. THERE SHOULD NOT BE ANY CONSTRUCTION JOINT IN BEAMS AND COLUMNS.
- M3. WATER STOPPER SHOULD BE USED (VERTICAL AND/OR HORIZONTAL) WHERE EVER THERE ARE CONSTRUCTION JOINTS.

O. DE-SHUTTERING & CURING

- O1. DE-SHUTTERING OF FORMWORK OF ELEMENTS SHOULD BE CARRIED OUT AFTER SUFFICIENT TIME AS FOLLOWS.

TYPE OF FORMWORK	MINIMUM PERIOD BEFORE STRIKING FORMWORK
VERTICAL FORMWORK TO COLUMN, WALLS, BEAMS	24 Hrs
SOFFIT FORMWORK TO SLABS (PROPS TO BE REMOVED IMMEDIATELY AFTER REMOVAL OF FORMWORK) SUBJECT TO REACH 70% OF DESIGNED CONCRETE STRENGTH	3 DAYS
SOFFIT FORMWORK TO BEAMS (PROPS TO BE REMOVED IMMEDIATELY AFTER REMOVAL OF FORMWORK)	7 DAYS
PROPS TO SLAB	7 DAYS
1. SPANNING UP TO 4.5m	14 DAYS
2. SPANNING OVER TO 4.5m	
PROPS TO BEAMS	
1. SPANNING UP TO 6m	14 DAYS
2. SPANNING OVER TO 6m	21 DAYS

Q. WATER PROOFING

- O1. THE BASEMENT SHALL BE TANKED EXTERNALLY WITH A 5mm WATERPROOFING MEMBRANE. THE APPLICATION IS TO BE CARRIED OUT STRICTLY IN ACCORDANCE WITH THE DETAILS SHOWN.
- O2. ALL NECESSARY PRECAUTIONS FOR WATERTIGHTNESS (SUCH AS WATERPROOF ADDITIVES, SPECIAL CONCRETE MIX DESIGN, SPECIAL FORMWORK, CURING, JOINTS ETC ...) OF REINFORCED CONCRETE WATER TANKS (INCLUDING EARTH RETAINING WALLS ACTING AS SIDE OF WATER TANK) SHOULD BE TAKEN INTO ACCOUNT. WATERPROOF MEMBRANE SHOULD BE PROVIDED

- O3. WATERPROOF MEMBRANE SHOULD BE PROVIDED IN ALL CONCRETE SURFACES EXPOSED TO WATER OR EARTH AS SHOWN ON DRAWINGS AND TYPICAL DETAILS AND SHALL BE INSTALLED ON THE EXTERIOR SURFACE OF WALLS AND SHALL EXTEND FROM A POINT 150mm (MIN.) ABOVE GRADE, DOWN TO THE FOUNDATION.

R. STEEL WORK

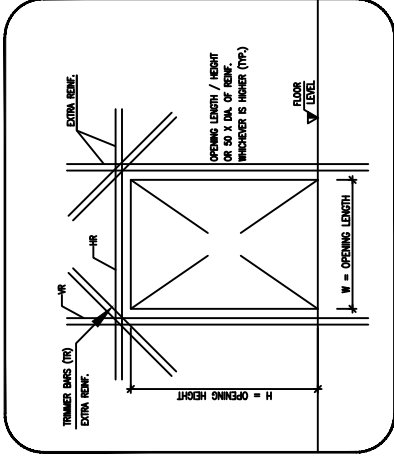
- R1. ALL STEEL STRUCTURAL MEMBERS SHALL BE DESIGNED AND DETAILED BY THE CONTRACTOR. SHALL SUBMIT RELEVANT DESIGN CALCULATIONS AND SHOP DRAWINGS TO THE OWNER FOR APPROVAL BEFORE CONSTRUCTION AT NO ADDITIONAL COST TO THE OWNER & SUBJECT TO ENGINEER'S APPROVAL.
- R2. FOR ALL ADDITIONAL STEEL MEMBERS TO FIX ANY SPECIAL WORKS SUCH AS, SEPARATOR BEAM (LIFT INCLUSOR), INSERT PLATES, INSERT CHANNELS ETC. SHOULD BE DONE BY THE CONTRACTOR BY CO-ORDINATING WITH THE RELATIVE SPECIALTIES WITHOUT ANY ADDITIONAL COST & SUBJECT TO ENGINEER'S APPROVAL

S. CUTOUTS, OPENINGS & INSERTS

- S1. ALL OPENINGS SHALL BE FORMED OR SLEEVED BEFORE PLACING CONCRETE. SEE ARCHITECTURAL, LANDSCAPING, CIVIL, MECHANICAL AND ELECTRICAL DRAWINGS FOR DIMENSIONS AND SIZES AND SUBMIT SHOP DRAWINGS AND DETAILS ON STRUCTURAL DRAWINGS AND FOR SIZE AND LOCATIONS OF OPENING NOT DIMENSIONED.
- S2. PROVIDE ALL NECESSARY INSERTS, CLIPS, ANCHORS, TIES, REGLETS AND OTHER FASTENINGS DEVICES AS REQUIRED CAST INTO CONCRETE.

T. INSULATION SYSTEM

- T1. PROPER INSULATION SYSTEM SHOULD BE ADOPTED FOR ALL STRUCTURAL ELEMENTS. TYPICAL DETAILS FOR INSULATION SYSTEM AT DIFFERENT LOCATIONS IS ARE SHOWN AS FOLLOWS.



TYPICAL OPENINGS IN WALLS

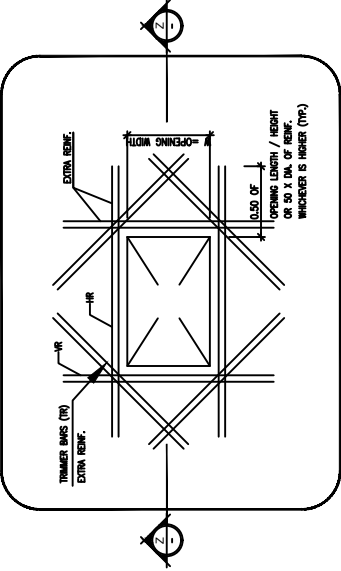
ADDITIONAL REINFORCEMENT (UNO)

SCHEDULE FOR OPENING IN WALLS (UNO)

W X H	VR	HR	TRIMMER BARS
UP TO 500 X 500	2 + 2 T 16 (T & B)	2 + 2 T 16 (B)	2 + 2 T 16 (B)
UP TO 500 X 1000	2 + 2 T 16 (B)	2 + 2 T 16 (B)	2 + 2 T 16 (B)
UP TO 1000 X 1000	2 + 2 T 20 (B)	2 + 2 T 20 (B)	2 + 2 T 20 (B)

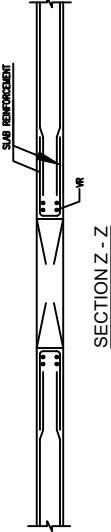
BIGGER OPENING
CONTRACTOR SHOULD SUBMIT SHOP DRAWINGS FOLLOWING ABOVE PATTERN FOR CONN APPROVAL

* Reinforcement intersecting the trim line should be of U shape



TYPICAL OPENINGS IN SLABS

ADDITIONAL REINFORCEMENT (UNO)



SCHEDULE FOR OPENING IN SLABS (UNO)

L X W	VR	HR	TRIMMER BARS
UP TO 500 X 500	2 + 2 T 16 (T & B)	2 + 2 T 16 (T & B)	2 T 16 (T & B)
UP TO 500 X 1000	2 + 2 T 16 (T & B)	2 + 2 T 16 (T & B)	2 T 20 (T & B)
UP TO 1000 X 1000	2 + 2 T 20 (T & B)	2 + 2 T 20 (T & B)	4 T 20 (T & B)

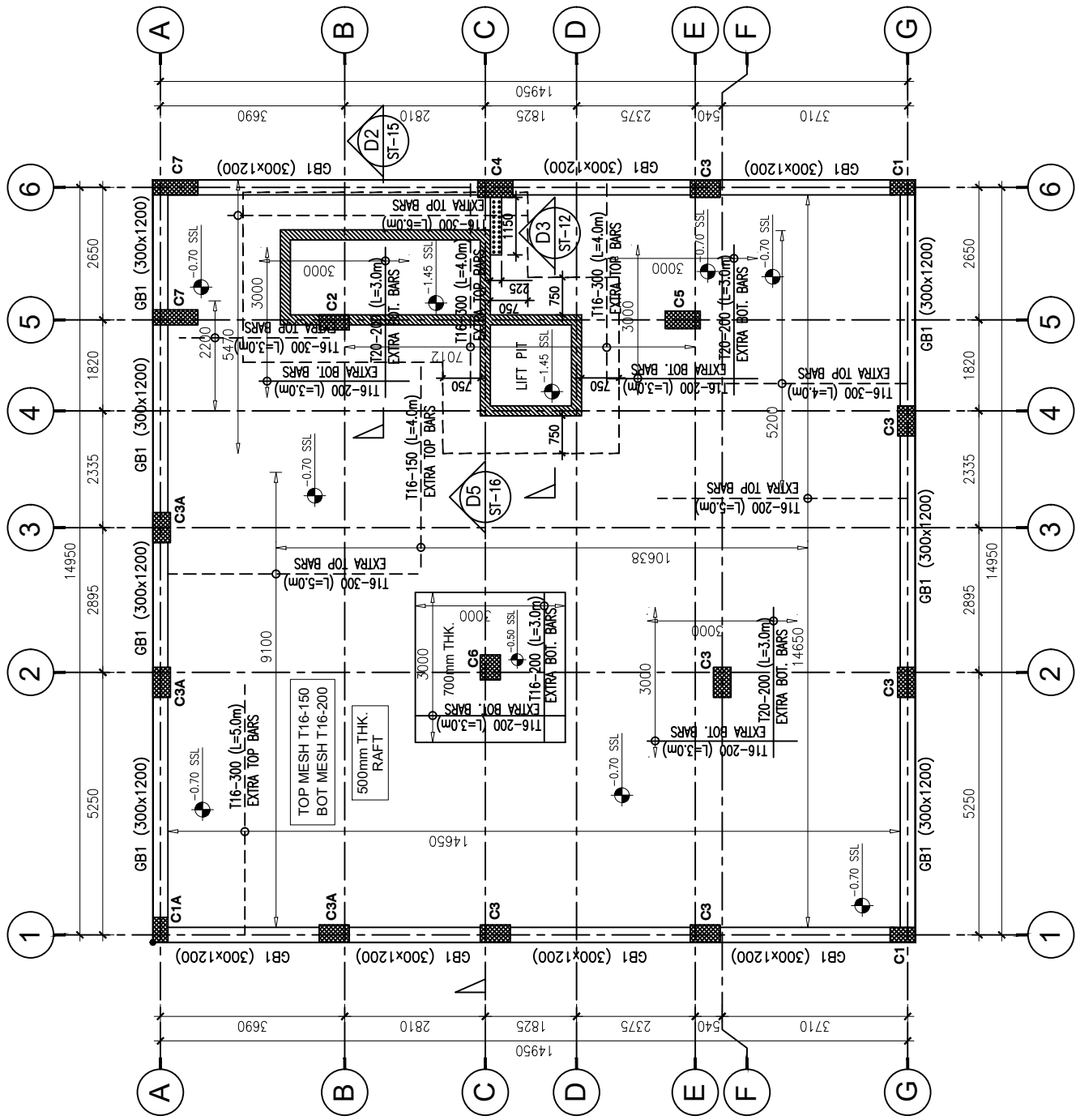
BIGGER OPENING
CONTRACTOR SHOULD SUBMIT SHOP DRAWINGS FOLLOWING ABOVE PATTERN FOR CONN APPROVAL

* Reinforcement intersecting the trim line should be of U shape

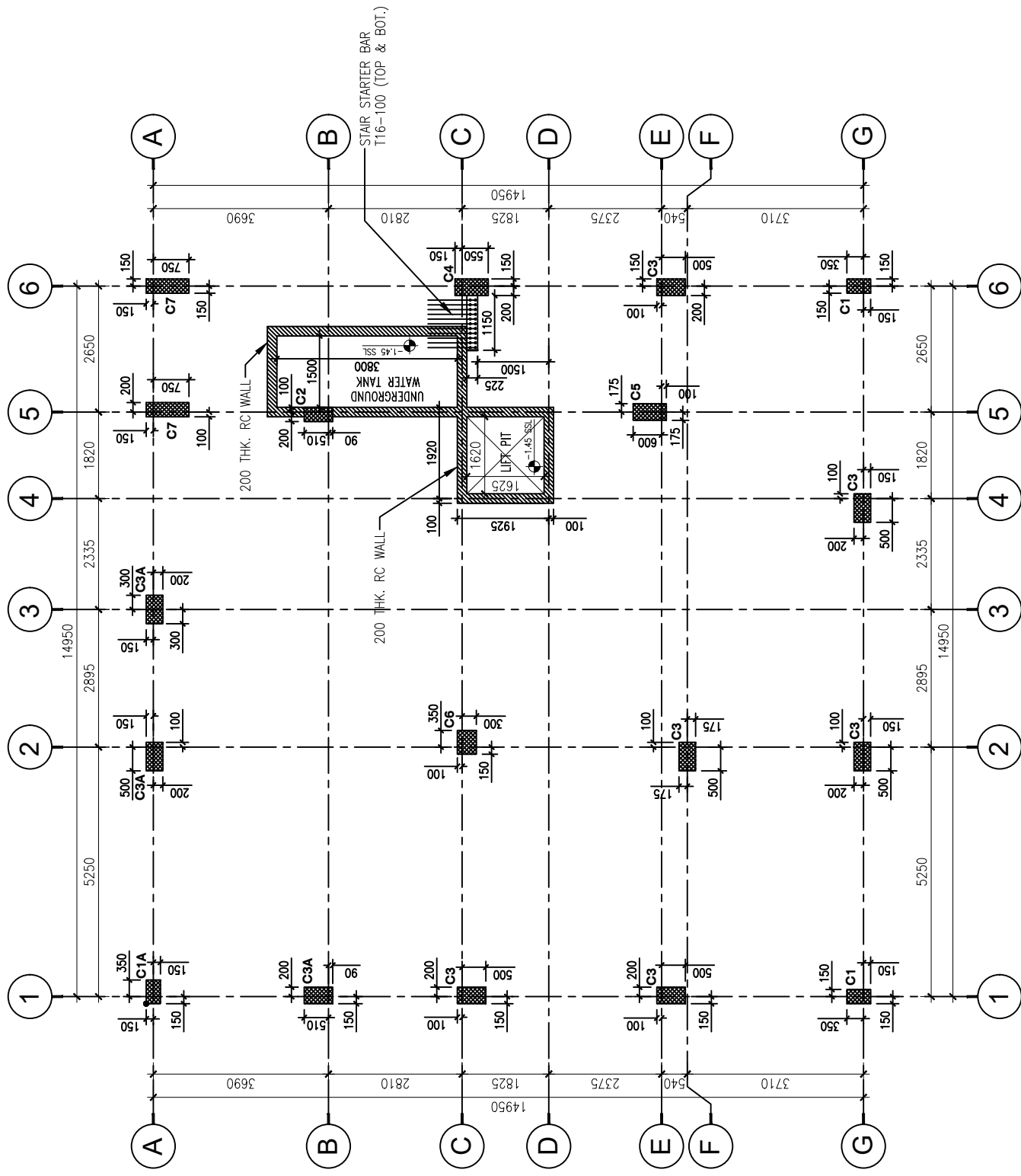


NOTES:

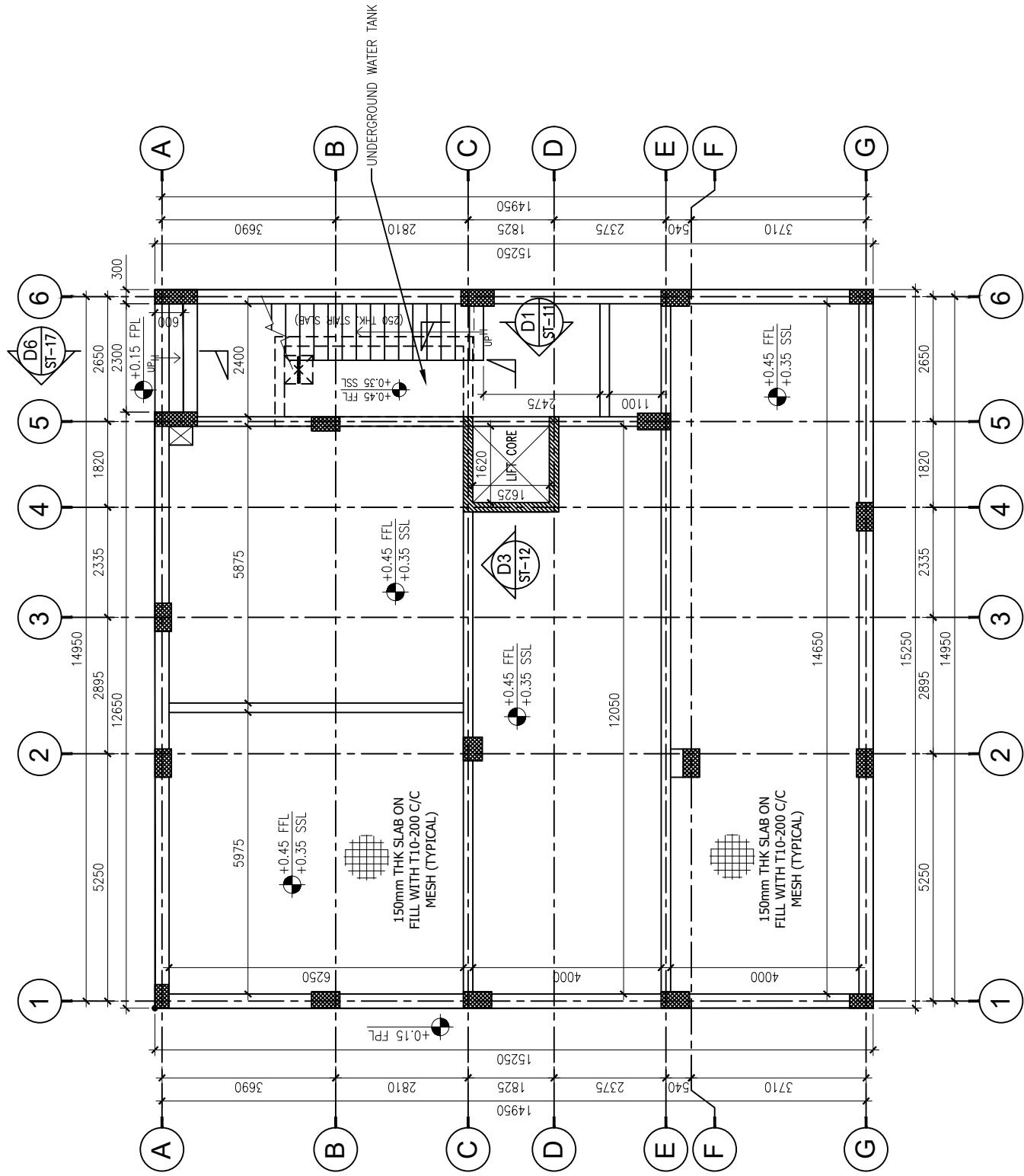
- 1. ALL REBARS SHOWN HERE ARE IN ADDITION TO ANY SPECIFIED AND /OR DETAILS FRAMING REINFORCEMENT. STAGGER REBARS TO AVOID CONGESTION.

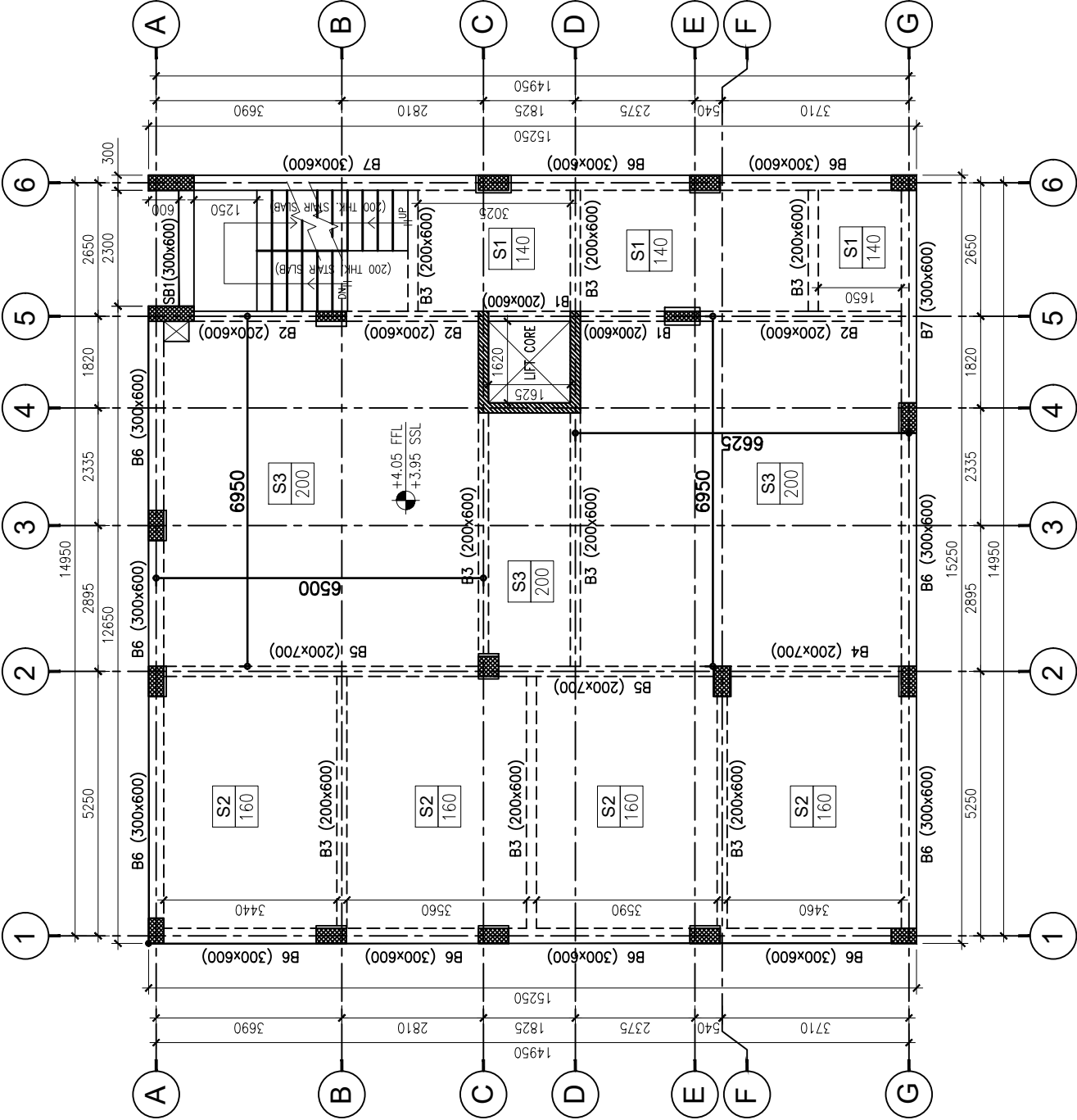


FOUNDATION LAYOUT

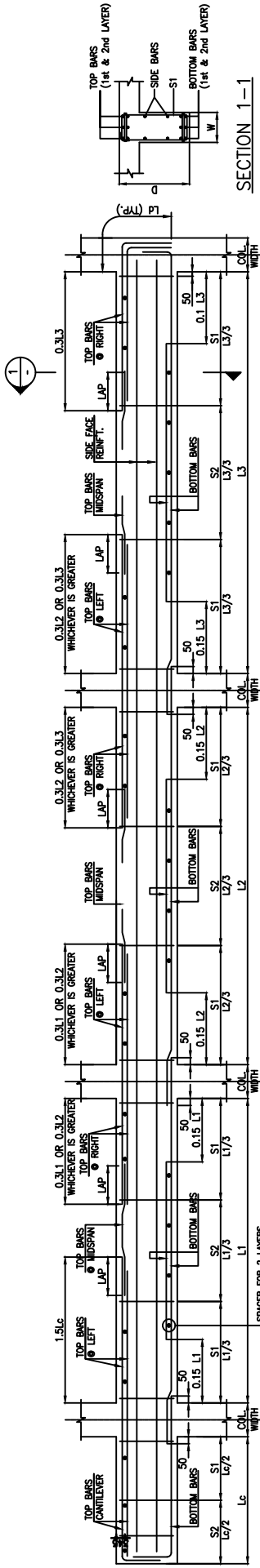


COLUMN LAYOUT

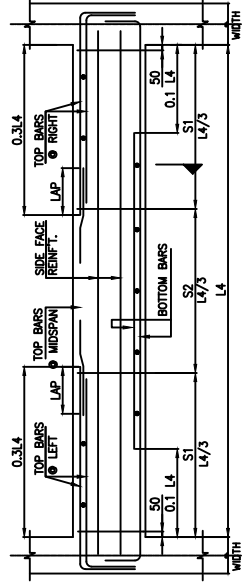
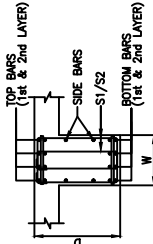




TYPICAL FLOOR PLAN



TYPICAL RC CONTINUOUS SPAN BEAM ELEVATION



SIDE FACE REINFORCEMENT

FOR BEAMS DEEPER THAN 650 MM (OVERALL)
AND FOR EXTERIOR PARTS OF ALL BEAMS,
BEAMS PROVIDE SIDE REINF. AS FOLLOWS

BEAM WIDTH	SIDE BAR REINF.
200	T12-250
300	T12-200
>400	T12-150

A TYPICAL SUSPENDED BEAM DETAILS

NOT TO SCALE

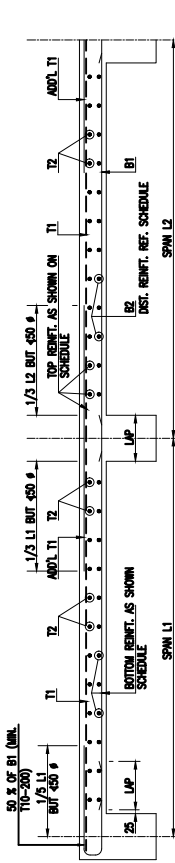
SCHEDULE OF BEAMS												CONCRETE f'c = 35																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
BEAM TAG	WIDTH "W"(mm)	DEPTH "D"(mm)	REINFORCEMENT								SIDE BAR REINF.	REMARKS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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B1	200	600	2T16 +2T12	2T16	2T16 +2T12	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16	2T16</

NOTES:
1. IN CASE OF DISCREPANCY OF DIAMETER OF TOP BARS AT SUPPORT, USE WHICHEVER IS THE LARGER DIAMETER BAR.
2. AS AN INDICATION, TOP & BOTTOM BARS WILL BE READ AS 1ST LAYER + 2ND LAYER (e.g. 2T16+2T16) AS SHOWN IN THE SCHEDULE.
3. MINIMUM LONGITUDINAL BAR IS 12# AND THE MAXIMUM CLEAR DISTANCE BETWEEN LONGITUDINAL BARS IS 160mm.

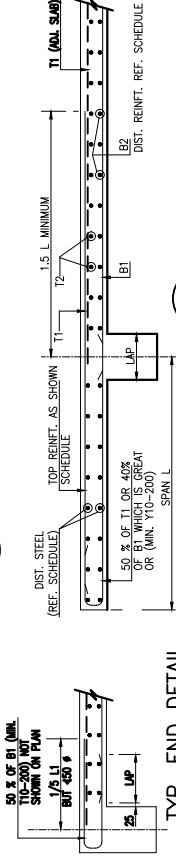
SLAB REINFORCEMENT SCHEDULE

MARK	FULL TOP BARS		ADD'L ● SUPPORTS		SLAB THICKNESS (mm)	REMARKS
	B1	B2	T1	T2		
S-1	T12-200	T12-200	--	--	140	
S-2	T12-200	T12-200	--	--	160	
S-3	T12-150	T12-150	T10-200	T12-200	200	

CONCRETE $f_c' = 35$



B1 CONTINUOUS SLAB



B3 SIMPLY SUPPORTED SLAB

B2 CANTILEVER SLAB

B CURTAILMENT OF REINF. IN CAST-IN-SITU SLABS (UNO)

SCHEDULE OF BEAMS, SLAB REINFORCEMENT SCHEDULE, SCHEDULE OF FOOTINGS

SCHEDULE OF COLUMNS

CONCRETE $f_c' = 35 \text{ MPa}$

UPPER ROOF TO ROOF DECK								
SIZE	300 x 500	200 x 600	300 x 600	300 x 600	200 x 700	400 x 400	300 x 900	
REBAR	10T16	10T16	12T16	12T16	12T16	8T16	16T16	
LINKS	T10-150	T10-150	T10-150	T10-150	T10-150	T10-150	T10-150	
ROOF DECK TO 1st FLOOR								
SIZE	300 x 500	300 x 500	200 x 600	300 x 600	200 x 700	400 x 400	300 x 900	
REBAR	10T16	10T16	10T16	12T16	12T16	8T16	16T16	
LINKS	T10-150	T10-150	T10-150	T10-150	T10-150	T10-150	T10-150	
1st FLOOR TO GROUND FLOOR								
SIZE	300 x 500	300 x 500	300 x 600	350 x 600	350 x 700	400 x 500	300 x 900	
REBAR	10T16	10T16	12T16	12T16	14T16	10T16	16T16	
LINKS	T10-150	T10-150	T10-150	T10-150	T10-150	T10-150	T10-150	
COLUMN REFERENCE	C1	C1A	C2	C3	C3A	C4	C5	C6
								C7

NOTES: – COLUMN STEEL BARS TO FLOOR LAPPING SHALL BE 40 ϕ .
 – LINKS SHOULD BE CONCENTRATED (T10-100) AT 1.2M ABOVE AND BELOW SLAB LEVEL.
 – CONCRETE COVER OF COLUMNS BELOW GROUND FLOOR LEVEL SHOULD BE INCREASED TO 75 MM.
 – IT IS NOT ALLOWED TO PATH ANY PIPE INSIDE THE COLUMNS.

SCHEDULE OF COLUMNS