

**THE COMPARISON OF SEISMIC RESPONSE, BASE SHEAR
FORCE, STORY DISPLACEMENTS, AND STRUCTURAL
IRREGULARITIES BASED ON SNI 1726-2012 AND SNI 1726-
2019 FOR JAMBI REGION
(CASE STUDY: FKIK UNJA BUILDING)**



SAFIRA ANANDA SYAHRI 17511096

**CIVIL ENGINEERING PROGRAM
FACULTY OF CIVIL ENGINEERING AND PLANNING
ISLAMIC UNIVERSITY OF INDONESIA
YOGYAKARTA**

2024

VALIDITY SHEET
THE COMPARISON OF SEISMIC RESPONSE, BASE SHEAR
FORCE, STORY DISPLACEMENTS, AND STRUCTURAL
IRREGULARITIES BASED ON SNI 1726-2012 AND SNI 1726-
2019 FOR JAMBI REGION
(CASE STUDY: FKIK UNJA BUILDING)

Compiled by

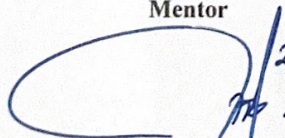
SAFIRA ANANDA SYAHRI
17511096

It has been accepted as one of the requirements for
obtaining a Bachelor's degree in Civil Engineering

Tested on date

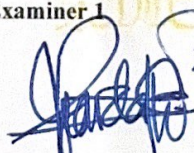
Oleh Dewan Penguji

Mentor

 24/08
24

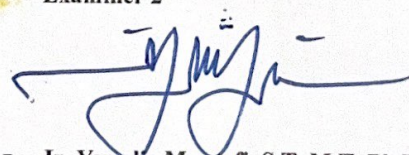
Jafar, S.T., M.Sc., MURP
NIK: 185111305

Examiner 1

 26-08-24

Astriana Hardawati, S.T., M.Eng
NIK: 165111301

Examiner 2

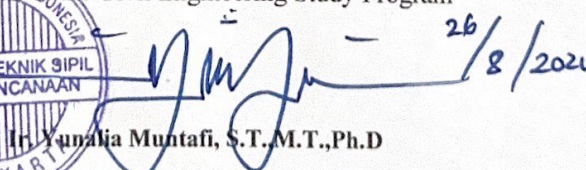


Ir. Yunalia Muntafi, S.T., M.T., Ph.D
NIK: 095110101

Approve,

Head of the Civil Engineering Study Program



 26/8/2024
Ir. Yunalia Muntafi, S.T., M.T., Ph.D
NIK: 095110101

PLAGIATION-FREE STATEMENT

I declare with complete certainty that the Final Assignment report that I have prepared as a requirement for completing the Bachelor's level program in the Civil Engineering Study Program, Faculty of Civil Engineering and Planning, Islamic University of Indonesia is the result of my own work. There are several parts in the writing of the Final Assignment report that I quoted from other people's work that included the sources clearly in accordance with the norms, rules and ethics of writing scientific papers. If in the future it is discovered that all or part of this Final Assignment report is not my own work or there is plagiarism in certain parts, I am willing to accept sanctions, including revocation of the academic title I hold in accordance with applicable laws.

Yogyakarta, Agustus 2024
Who makes a statement,



Safira Ananda Syahri
(17511096)

FOREWORD

I would like to thank Allah SWT. for giving his blessings and mercy so that I could finish the final report entitled The Comparison Of Seismic Response, Base Shear Force, Story Displacements, And Structural Irregularities Based On SNI 1726-2012 And SNI 1726-2019 For *Jambi* Region. This final report is one of the academic requirements in completing undergraduate studies at Civil Engineering Study Program, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia Yogyakarta.

During the creation of the final report, there were many obstacles faced by the writer, but thanks to suggestions, criticism, and encouragement from various parties, this final report can be completed. In this regard, the author would like to express their deepest gratitude to:

1. Jafar, S.T., M.T., MURP. as the Final report guide lecturer who has shown support and given guidance for the writer throughout the whole process of final report,
2. Pradipta Nandi Wardhana, S.T., M.Eng. as the academic lecturer who has taught me many things about the final report and accompanied me in doing final report.,
3. Author's parents who have given the writer unconditional support for completing the final report.
4. Author's brother who have given endless support and help during this final report, and
5. Author's husband and Celine who have given endless support mentally and physically during this final report

As are other creations, this final report may have imperfections due to time limitation, inaccuracies, and other factors. In the spirit of betterment, all criticisms and suggestions are welcome. Lastly, the author hopes that this final report can properly fulfil the requirements as is mentioned above and can be useful to all those reading it

LIST OF CONTENT

VALIDITY SHEET	i
PLAGIATION-FREE STATEMENT.....	ii
FOREWORD	iii
LIST OF CONTENT	iv
LIST OF TABLES	vii
LIST OF FIGURE.....	x
ABSTRACT.....	xii
CHAPTER I PRELIMINARY	1
1.1 Background	1
1.2 Problem Statement	3
1.3 Research Purpose	3
1.4 Research Limit	3
CHAPTER II LITERATURE REVIEW.....	5
2.1 Previous Research.....	5
2.2 The Conclusion of Previous Research	8
2.3 Comparison From Previous Research.....	10
CHAPTER III THEORITICAL BASIS	11
3.1 Philosophy and Design of Earthquake Resistant Buildings.....	11
3.2 Earthquake Plan, Earthquake Priority Factors and Risk Category of Building Structure	12
3.2.1 Earthquake Plan	12
3.2.2 Risk Category Building	12
3.2.3 Priority Factors for Earthquakes	12
3.3 Structure Loading.....	14
3.3.1 Dead Load	15
3.3.2 Live Load	15
3.4 Earthquake Load	17
3.4.1 Load Combination.....	17
3.5 General Provisions for Building Design Against Influence Earthquake	19
3.5.1 Sites Clasification	20
3.5.2 Maximum Earthquake Acceleration Spectral Response Parameters Considered Targeted Risk.....	20

3.5.3 Design Spectral Acceleration Parameters	25
3.5.4 Response Spectrum	25
3.5.5 Design Category Seismic	28
3.6 Resisting Earthquake Force Systems	29
3.7 Basic Seismic Forces	30
3.7.1 Seismic response coefficient	30
3.8 Structural Fundamental Period	31
3.9 Regular and Irregular Building Structures	34
3.10 Deviations Between Floors	36
3.11 Determination of Force Scale	37
CHAPTER IV RESEARCH METHOD	39
4.1 General Review	39
4.2 Research Location	39
4.3 Data Analysis Preparation	40
4.4 Data Processing and Modelling Stage	40
4.5 Research Stage	47
4.6 Research Flowchart	50
CHAPTER V ANALYSIS AND DISCUSSION	51
5.1 Building Structure and Gravitational Loading Data	51
5.1.1 Jambi University FKIK Building Data	51
5.1.2 Description of Building Structure Modeling	52
5.1.3 Soil Type at Building Location	52
5.1.4 Living Load	53
5.1.5 Additional Dead Load on Slabs	53
5.1.6 Additional Dead Load on Beam Due to Wall	53
5.2 Earthquake Load Analysis Based on SNI 1726 2012	54
5.2.1 Risk Categories and Building Priority Factors	54
5.2.2 Peak Ground Acceleration Parameters	54
5.2.3 Design Acceleration Parameters	55
5.2.4 Effective Seismic Weight	56
5.2.5 Mass Participation Modal Structure	61
5.2.6 Fundamental Period of Structure	61
5.2.7 Static Earthquake Equivalent to SNI 1726 2012	62
5.2.8 2012 SNI 1726 Dynamic Earthquake	63
5.2.9 Inter Story Drift	66
5.2.10 Horizontal Irregularities	67

5.2.11 Vertical Irregularities	71
5.3 Earthquake Load Analysis Based on SNI 1726 2019	75
5.3.1 Risk Categories and Building Priority Factors	75
5.3.2 Peak Ground Acceleration Parameters.....	75
5.3.3 Design Acceleration Parameters	75
5.3.4 Effective Seismic Weight.....	77
5.3.5 Mass Participation Capital Structure.....	77
5.3.6 Fundamental Period of Structure	77
5.3.7 Static Earthquake Equivalent to SNI 1726 2019.....	77
5.3.8 2019 SNI 1726 Dynamic Earthquake	78
5.3.9 Inter Story Drift.....	81
5.3.10 Horizontal Irregularities.....	82
5.3.11 Vertical Irregularities	85
5.4 Comparison of Analysis Results.....	87
CHAPTER VI CONCLUSION.....	96
6.1 Conclusion and Recommendation	96
REFERENCES.....	97

LIST OF TABLES

Table 2. 1 Conclusion of Previous Research	8
Table 3. 1 Risk Category of Building and Non Building for Loading Factor	12
Table 3. 2 Priority Factor	14
Table 3. 3 Dead Load	15
Table 3. 4 Minimum Average Distribution and Concentrated Live Load	16
Table 3. 5 Classification Sites	20
Table 3. 6 Sites Classification, Fa	24
Table 3. 7 Classification Sites, Fv	24
Table 3. 8 Classification Sites, Fa	24
Table 3. 9 Classificaton Sites, Fv	25
Table 3. 10 Category Seismic Design based on Response Acceleration Short Period Spectrum	28
Table 3. 11 Seismic Design Categories Based on Response Acceleration Spectrum Period 1.0 Sec	29
Table 3. 12 R, Cd, and Ω_0 for Resisting Earthquake Force System	29
Table 3. 13 Upper Limit Coefficient in the Calculated Period	32
Table 3. 14 Approach Period Parameter Value	33
Table 3. 15 Moment Inertia of Cross Sections	33
Table 3. 16 Horizontal Irregularity Structure	34
Table 3. 17 Irregularity Vertical Structure	35
Table 5. 1 Additional Dead Load on Floor Slabs	53
Table 5. 2 Additional Load on Beam Due to Wall	54
Table 5. 3 Site Coefficient, Fa SNI 1726 2012	55
Table 5. 4 Site Coefficient, Fv SNI 1726 2012	55
Table 5. 5 Effective Seismic Weight SNI 1726 2012	60
Table 5. 6 Mass Participation Modal Structure SNI 1726 2012	61
Table 5. 7 Spectrum Response Results Not yet scaled to SNI 1726 2012	64
Table 5. 8 Check the Static and Dynamic Earthquake SNI 1726 2012	65
Table 5. 9 Deviation Between Floors Earthquake Load Rsu SNI 1726 2012	66

Table 5. 10 Check for Irregularities in Rsu SNI 1726 2012 Earthquake Load Torque	68
Table 5. 11 Check Irregularities in Earthquake Load Torque Rss SNI 1726 2012 ...	68
Table 5. 12 Check for Irregularities Stiffness Soft Level Earthquake Load Rsu SNI 1726 2012.....	71
Table 5. 13 Check Irregularities Soft Level Stiffness Earthquake Load Rss SNI 1726 2012.....	72
Table 5. 14 Check Mass Irregularities SNI 1726 2012.....	73
Table 5. 15 Check for Irregularity in Lateral Strength of Earthquake Load Level RSU SNI 1726 2012	74
Table 5. 16 Check for Irregularity in Lateral Strength of Earthquake Load Level Rss SNI 1726 2012	74
Table 5. 17 Site Coefficient, Fa SNI 1726 2019	75
Table 5. 18 Site Coefficient, Fv SNI 1726 2019.....	76
Table 5. 19 Spectrum Response Results Not yet scaled to SNI 1726 2019.....	79
Table 5. 20 Check the Static and Dynamic Earthquake SNI 1726 2019	80
Table 5. 21 Deviation Between Floors Earthquake Load Rsu SNI 1726 2019.....	81
Table 5. 22 Deviations Between Earthquake Load Floors RSs SNI 1726 2019.....	82
Table 5. 23 Check for Irregularities in Earthquake Load Torque RSU SNI 1726 2019	82
Table 5. 24 Check Irregularities in Earthquake Load Torque Rss SNI 1726 2019 ...	83
Table 5. 25 Check Irregularities Stiffness Soft Level Earthquake Load Rsu SNI 1726 2019.....	85
Table 5. 26 Check Irregularities Soft Level Stiffness Earthquake Load Rss SNI 1726 2019.....	85
Table 5. 27 Check for Irregularity in Lateral Strength of Earthquake Load Level RSU SNI 1726 2019	86
Table 5. 28 Check for Irregularity in Lateral Strength of Earthquake Load Level Rss SNI 1726 2019	87
Table 5. 29 Differences between SNI 1726 2019 and SNI 1726 2012	87
Table 5. 30 Comparison of Base Shear SNI 1726 2012 and SNI 1726 2019	88
Table 5. 31 Comparison of Earthquake Load Deviations RSU SNI 1726 2012 and SNI 1726 2019	89

Table 5. 32 Comparison of Earthquake Load Deviations Rss SNI 1726 2012 and SNI 1726 2019.....	90
Table 5. 33 Lateral Strength	94

LIST OF FIGURE

Figure 3. 1 Maximum Earthquake Considered Risk Targeted for a Response Spectrum with a Period of 0,2 Seconds According to SNI – 1726 – 2012 and SNI – 1726 – 2019.....	22
Figure 3. 2 Maximum Earthquake Considered Targeted Risk for a Response Spectrum Period of 1,0 seconds According to SNI – 1726 – 2012 and SNI – 1726 – 2019.....	23
Figure 3. 3 Spectral Response Acceleration	26
Figure 3. 4 Indonesian Territory for the Long Term Period, TI	27
Figure 3. 5 Spectral Response Acceleration	28
Figure 3. 6 Inter Story Drift	37
 Figure 4. 1 Building Plan	 39
Figure 4. 2 Material Properties ETABS	40
Figure 4. 3 Material Property Data ETABS.....	41
Figure 4. 4 Material Property Design Data ETABS	41
Figure 4. 5 Section Properties	42
Figure 4. 6 Frame Section Property Data.....	43
Figure 4. 7 Slab Properties ETABS	43
Figure 4. 8 Draw Element Structure	44
Figure 4. 9 Input Response Spectrum ETABS.....	45
Figure 4. 10 Define Response Spectrum Functions ETABS	45
Figure 4. 11 Seismic Loading	45
Figure 4. 12 Load Case Data.....	46
Figure 4. 13 Uniform Shell Load	47
Figure 4. 14 Distributed Load on Beam.....	47
Figure 4. 15 Research Flowchart	50
 Figure 5. 1 3D Model of Structure	 52
Figure 5. 2 Vs30 Map of Jambi Province	52
Figure 5. 3 SNI 1726 2012 Spectrum Response	56
Figure 5. 4 2nd Floor Plan of the FKIK Building, Jambi University	69

Figure 5. 5 Piece of Jambi University FKIK Building.....	70
Figure 5. 6 SNI 1726 2019 Spectrum Response	76
Figure 5. 7 3rd Floor Plan of the FKIK Building, Jambi University	83
Figure 5. 8 RSU in X axis 2012 and 2019	89
Figure 5. 9 RSU in Y axis 2012 and 2019	90
Figure 5. 10 RSS in X axis 2012 and 2019	90
Figure 5. 11 RSS in Y axis 2012 and 2019	91
Figure 5. 12 Floor Plan of FKIK Building.....	93
Figure 5. 13 Piece of Column of FKIK Building.....	93

ABSTRACT

Regulations of planning structure for earthquake-resistant buildings in Indonesia have developed along with the occurrence of new earthquake fault. It start from the updated earthquake map zone from earthquake map 2010 to earthquake map 2017. so, with this emergence, the regulation of SNI 1726-2012 is being updated to SNI 1726-2019. This updated data has resulted in the need to review the finished building using both of the regulations to obtained the differences between the SNI 1726-2012 and SNI 1726-2019. The problem that has been studied are how much the change of the seismic response that occurs in the high building which include the base shear force, inter-story drift, and the structural irregularities if the earthquake load used are based on SNI 1726-2012 and SNI 1726-2019. The program used in this analysis is ETABS 19.1. Based on the analysis that has been carried out, base shear force in SNI 1726-2019 in the y direction is 1.51 times greater than SNI 1726-2012 and in the x direction, SNI 1726-2019 is 1.46 times greater than SNI 1726-2012. The average of story displacement in rss y direction is 1.67 times greater. For the irregularities, both SNI 1726-2012 and SNI 1726-2019 only occur type 1a in horizontal irregularities. Then, the vertical irregularities both in SNI 1726-2012 and SNI 1726-2019 does not occur.

Keywords: *High Building, Base Shear Force, Inter Story Drift, Structural Irregularities, Earthquake Resistant Building*

CHAPTER I

PRELIMINARY

1.1 Background

Indonesia is located in a seismically active region known as “*Ring of Fire*”. The Ring of Fire horseshoe-shaped zone in the Pacific Ocean basin that is characterized by high seismic and volcanic activity. The geological conditions in this region are influenced by the movement of tectonic plates, which can result earthquakes, volcanic eruptions, and tsunamis. Earthquake itself can be define as a sudden and violent shaking of the ground, often cause by movements of the earth’s tectonic plates beneath the earth’s surface. According to (Pujianto, 2017) earthquakes are a natural phenomenon which can be caused by artificial/resulting from humans activities or due to natural events. As the result of these reasons, the ground shaking as an effect of the propagation of energy waves radiating from the center earthquake.

Earthquake in Indonesia experience frequently due to complex interactions between the Indo-Australian Plate and Eurasian Plate. The subduction zone along the western coast of Sumatra, known as the *Sunda Megathrust*, is particularly prone to powerful earthquakes. Not only by the movement of the plate but also the numerous active volcanoes that often produces associated seismic event.

The seismic hazard poses challenges for infrastructure development and urban planning in Indonesia. Building and infrastructure need to be designed and constructed to withstand earthquake to minimize the risk due to earthquake. The level of risk depends on factors such as the earthquake’s magnitude, depth, distance from the populated areas, local geological conditions, and the the quality of the construction in the affected area. Earthquake can cause significant damage to buildings, bridges, and other structure. Poorly designed buildings are vulnerable. The shaking of the ground during the earthquake can lead to structural failures, collapses, and damage to essential infrastructure. The collapse of the building can result in injuries and fatalities. People may be injured by falling debris, broken glass, or the

hazard during the shaking. Due to this reasons, some of the expert asses that a building have to be relatively strong and can assist the seismic reaction with appropriate cost then it called *earthquake resistant building* (Pawirodikromo, 2012).

Earthquake resistant building planning regulations is already regulated by the government in SNI. The regulations are experiencing developments as the occur the earthquake disaster in Indonesia from SNI 1726-2012 revised to SNI 1726-2019. The main update in this regulation based on the newest earthquake zoning map. This update is on average in the form of increasing values in the parameter map ground motion short period spectral response parameters (SS), and 1 second period spectral response parameters (S1). Apart from that, SNI 1726 – 2019 contains a map (SNI 1726, 2019). The latest is a map of the long transition period or TL area

Based on the previous study journal, 11 province has increasing response spectrum value including, Medan, Jambi, Bengkulu, Palembang, Bandar Lampung, Serang, Jakarta, Surabaya, Tanjung Pinang, Pontianak, and Banjarmasin. These province has 11% increase in response spectrum value. With the emergence of the new regulations, finished building need to be review using both calculations. The problem that have been studied is how big the changes in seismic response occur in the high building which includes period, base shear force, drift ratio, and irregularity, if the earthquake load exist based on SNI 1726-2012 and SNI 1726-2019.

Sumatra Island is one of the regions in Indonesia with a high potential for natural disasters. One of the reasons for the occurrence of natural disasters on Sumatra Island is its location at the convergence of the Indo-Australian and Eurasian Plates. This can lead to a series of natural disaster events such as tsunamis, earthquakes, landslides, volcanic eruptions, and other natural calamities. Jambi Province, part of Sumatra Island, has a medium to high score in terms of natural disaster vulnerability index for each of its regencies, making Jambi Province a disaster-prone area.

The factors influencing local earthquakes in Jambi Province include tectonic plate movements, fault (fracture) activities, volcanic (volcano) activities, and the impact of earthquakes occurring in other regions. Earthquakes in Jambi Province do not have the potential to cause tsunamis because they are classified as moderate earthquakes caused by intra-plate activity of the Indo-Australian Plate sub-ducting beneath the

Eurasian Plate. Jambi City, part of Jambi Province, is predominantly composed of fine sediment deposits that have weathered, leading to the amplification of seismic waves. This results in ground movement and causes damage to buildings.

1.2 Problem Statement

Based on the background above, the problem formulation that can be obtained down below.

1. What is the differences of base shear value using SNI 1726 2012 and SNI 1726 2019 with different earthquake load data?
2. How do the story drift results differ in the spectrum response load of SNI 1726 2012 and SNI 1729 2019?
3. How do the results of checking horizontal and vertical irregularities differ from the earthquake load response spectrum of SNI 1726 2019 and SNI 1726 2019?

1.3 Research Purpose

Based on the problem formulation, the objective of this research are down below.

1. Find out how much the base shear force differences in SNI 1726 2012 and SNI 1726 2019 in the Jambi University FKIK building
2. Knowing the difference between story drift and earthquake load response spectrum based on SNI 1726 2012 and SNI 1726 2019.
3. Knowing the differences in horizontal and vertical irregularity results with earthquake load response spectrum based on SNI 1726 2012 and SNI 1726 2019.

1.4 Research Limit

The research limit from this final proposal are down below

1. The building used is FKIK Campus Building in Jambi.
2. The load calculation is dead load, live load, and earthquake load.
3. Respon spectrum analysis is using ETABS 19.1.
4. The gravity load value is based on SNI 1727 2020.
5. Reinforced concrete material uses concrete quality $F'c$ 30 MPa.

6. Structural loads other than dead loads, live loads and earthquake loads are ignored.
7. The structural behavior of the building reviewed is structural irregularity, base shear force and drift between floors.
8. The earthquake-resistant structural system uses a special moment-resisting frame system.
9. Stair plate not modelled and calculated in effective seismic weight
10. Analyzed with fixed support.
11. The references used in the analysis use SNI 1726 2012, SNI 1726 2019, SNI 2847 2019.
12. Analysis that will be calculated only in upper structural building.
13. The wall material is light brick with thickness of 12 cm.
14. Earthquake data from website of ministry.
15. Building height is 27,5 m with 6 number of floors.
16. Soil type is soft soil category SE

CHAPTER II

LITERATURE REVIEW

2.1 Previous Research

As reference in this research, in this chapter explained about the same topic related to comparison of seismic response and performance analysis of structure and the method and result about it, the reference can be seen as follows.

1. Comparison of Seismic Response and Performance Analysis of Structure Based on SNI – 1726 – 2012 and SNI – 1726 – 2019 and Redesign of Structural Elements on the Upper Structural Elements on The Upper Structure of Cilacap State Polytechnic Public Lecture Building

In this research explained about on how that the seismic response can change in the superstructure of the building that includes period, base shear force, drift ratio, irregularity and P-Delta effects using SNI – 1726 – 2012 and SNI 1726 – 2019 (Ohorella, 2022). In this research, Ohorella used SAP2000 to analyze the superstructure seismic response. The results shows that the period value of the structure using a non cracked cross section is 0,8082 seconds compared to cracked cross section is 1,1481 seconds. The results of vertical deviation appear that this building meets the prerequisites for vertical deviation. The results of the horizontal deviation analysis or torsional irregularity, in the Y direction earthquake the building experienced torsional irregularities on the 1st floor untill the 5th floor, so this results conclude that the X and Y direction qualify drift ration requirements. Based on SNI – 1726 – 2012 and SNI – 1726 – 2019 meets the requirements for affecting P-Delta that qualify structural performance requirements. In cross sectional analysis of beams and columns considering basic shear force is still qualify the requirements according to SNI – 1726 – 2019

2. Analysis Study of Multi-storey Buildings With A Comparison of SNI-1726-2012 and SNI-1726-2019 to The Ratio of Reinforcement (Case Study: Pasar Jumat Apartment)

This research aims to determine differences in response and structural design after the SNI regulations were updated (Halawa, 2021). The building analyzed is the Pasar Jumat Apartments in South Jakarta. The method used is spectrum response. The building was analyzed using the ETABS program given earthquake loads based on SNI 1726 2012 and SNI 1726 2019. The results of the analysis showed that the fundamental period values were not too different, the deviation values between floors were still safe and the basic shear force values had increased by 19,69%. Meanwhile, in the structure, there is an increase in the reinforcement ratio in the main beam by 10,61% at the support and 10% at the field. The child beam experienced an increase in the reinforcement ratio of 8,43% at the support and 10,52% at the field. The column structure has increased by 2,84%.

3. Comparative Analysis of Spectrum Response, Base Shear Force, and Deviations Between Floors in Steel Buildings Based on SNI 1726 – 2012 and SNI 1726 – 2019

This research aims to find out the size spectrum response, base shear force, and inter-story drift from renewal earthquake loads in SNI 1726 – 2019 with SNI 1726 – 2012 (Widhiatmoko, 2020) . This research took a steel frame structure building which is the AMIKOM Campus Building which consists of 6 floors and 1 basement.

This building is located in the Purwokerto area and the land type is included in the medium category. The results of this research include, the spectrum response in SNI 1726 – 2019, especially at T_0 and T_s values, is 0,169 seconds and 0.844 seconds, while in SNI 1726 – 2012 the values of T_0 and T_s were 0,12 seconds and 0,603 seconds. Shear force results base on SNI 1726 – 2019 experienced an average increase of 26,812% from basic shear force using SNI 1726 – 2012. The results of the deviation between floors in SNI 1726 – 2019 in the X and Y directions

experienced an average increase of 28,101% and 28,157% of the deviation between floors using SNI 1726 – 2012

4. Seismic Comparative Study of the Behavior of Upper Structures Based on SNI Earthquake Resistance Regulations 1726-2012 and SNI 1726-2019 at the Faculty of Sports Sciences (FIK) Building of State University of Malang

This research aims to determine behavior and structural changes. Base shear control according to SNI 1726-2012 is the result of dynamic earthquake forces greater than 85% of equivalent static earthquake forces (Dona, 2022). SNI 1726-2019 obtained minimum dynamic earthquake force results of 100% equivalent static earthquake force with a comparison of the results of the dynamic earthquake base earthquake force of 3571,669 kg in the x direction and 3647,202 kg in the y direction, whereas when calculated using SNI 1726-2019 the results are 4099,60 kg in the x direction and 4211,8128 kg in the y direction. So it is necessary to recalculate the structure, whether additional strengthening is needed.

5. Comparison of Seismic Response , Base Shear Force, and Deviation Between Floors Based on SNI 1726-2012 and SNI 1726-2019

In this research explained about the comparison between SNI 1726-2012 and SNI 1726-2019 based on the calculation of Seismic response, Base shear force, and deviation between floors (Muhtadin, 2023). In this analysis, Muhtadin (2021) Using Ms Excel and SAP 2000 v.22 to analyze the building. The results of comparing the spectrum response values of Ss 1726 – 2012 with 1726 – 2019 are experienced a significant increase, namely from 0.049 to 0.25. As for S1 1726 – 2019 experienced an increase from previously 0.049 to 0.1. Increased base shear force buildings experienced due to the update of the Ss and S1 maps in SNI 1726 – 2019 amounted to 35.74%, namely 1044.01 kN, previously in SNI 1726 – 2012 it was found to be 670.85 kN. The increase in intersections between floors based on SNI 1726 – 2019 is greater compared to SNI 1726 – 2012. The average increase in the X direction was 34.562% and in the Y direction the average increase was 67.545%. In the calculation of irregularities, no building irregularities were found.

2.2 The Conclusion of Previous Research

Table 2. 1 Conclusion of Previous Research

Aspect	Giri Widhiatmoko (2021)	Halawa (2021)	Ohorella (2022)	Dona (2022)	Muhtadin (2023)	Syahri (2024)
Title	Comparative Analysis of Spectrum Response, Base Shear Force, and Deviation Between Floors in Steel Buildings Based on SNI 1726-2012 and SNI 1726 - 2019	Analysis Study of Multi-storey Buildings With A Comparison of SNI-1726-2012 and SNI-1726-2019 to The Ratio of Reinforcement (Case Study: Pasar Jumat Apartment)	Comparison of Seismic Response and Performance Analysis of Structure Based on SNI – 1726 – 2012 and SNI – 1726 – 2019 and Redesign of Structural Elements on the Upper Structure of Cilacap State Polytechnic Public Lecture Building	Comparative Study of the Behavior of Upper Structures Based on SNI Earthquake Resistance Regulations 1726-2012 and SNI 1726-2019 at the Faculty of Sports Sciences (FIK) Building of State University of Malang	Comparison of Seismic Response , Base Shear Force,and Deviation Between Floors Based on SNI 1726-2012 and SNI 1726-2019	Comparison of Seismic Response and Performance Analysis of Structure Based on SNI-1726-2012 and SNI-1726-2019 of FKIK UNJA
Purposes	The purpose of this research is to find out the size of response spectrum, base shear force, and inter-story drift from renewal earthquake load in SNI 1726 – 2012 and SNI 1726 – 2019	The purpose of this study was to determine the difference between the response of the structure and the design of the structure after the SNI regulations were updated	To explained how much change in seismic response happen in supperstructure of the building that include period, base shear force, story drift, irregularity, and P-Delta compare to SNI 1726 – 2012 and SNI 1726 – 2019	This research aims to analyze structural changes and behavior	Compare seismic response based on SNI 1726-2012 and SNI 1726-2019	1. Compare the effect of changing SNI 1726 2012 to SNI 1726 2019 based on the base shear force in the Jambi University FKIK building? 2. Compare story drift results differ in the spectrum response load of SNI 1726 2012 and SNI 1729 2019? 3. Compare the

						results of checking horizontal and vertical irregularities differ from the earthquake load response spectrum of SNI 1726 2019 and SNI 1726 2019?
Location	AMIKOM Campus Building Purwokerto	Pasar Jumat apartment in South Jakarta	Cilacap State Polytechnic Public Lecture Building	Faculty of Sports Sciences (FIK) Building of State University of Malang	Balikpapan Building	FKIK Jambi University
Method	Spectrum response analysis based on SNI 1726 : 2012 and SNI 1726 : 2019	The method used is the response spectrum method	Seismic response analysis based on SNI 1726 : 2012 and SNI 1726 : 2019	This research was conducted using the spectrum response according to SNI 1726-2012 and SNI 1726-2019 regulations	SRPMB and SRPMM using SAP 2000	Seismic response analysis based on SNI 1726 : 2012 and SNI 1726 : 2019
Result	There was an increase in the To and Ts values in the SNI 2012 with the To and Ts values in the SNI 2012 being 0,12 seconds. The basic shear force results in the SNI 2019 increased by 26,812% compared to the SNI 2012. The deviation results were 28,101%	The value of the basic shear force has increased by 19,69%. Ratio of reinforcement in the main beam has increased by 10,61% at the support and 10% in the field. for secondary beam, the reinforcement ratio increased by 8,43% at the support and	Both of the regulation qualify the requirements. In the cross sectional analysis of beam and columns in the basic shear force can be concluded that the cross sections of beams and column still meet the requirements based on SNI – 1726 – 2019.	Comparison of the results of the base earthquake force for the dynamic earthquake was 3571.669 kg in the x direction and 3647.202 kg in the y direction, whereas when calculated using SNI 1726-2019 the results were 4099.60 kg in the x	The deviation between layers and stability using SRPMB and SRPMM have their own maximum limit value and both were qualify the requirements	-

	for the X direction and 28,157% for the Y direction compared to the SNI 2012.	10,52% in the field. While the column structure has increased by 2,84%		direction and 4211.8128 kg in the y direction.		
--	---	--	--	--	--	--

Source : (Widhiatmoko, 2020) ; (Halawa, 2021) ; (Ohorella, 2022) ; (Dona, 2022) ; (Muhtadin, 2023)

2.3 Comparison From Previous Research

This research location is not in high risk affected earthquake damage area meanwhile the research location is in one of the province that occur an increasing of response spectrum value.

CHAPTER III

THEORITICAL BASIS

3.1 Philosophy and Design of Earthquake Resistant Buildings

There are two extreme illustrations of earthquake resistant buildings. The first condition is when the building is too strong so that, when an earthquake occurs the building is still in an elastic condition so the building will be fine even if there is an earthquake, but this condition will cost a lot of money. The second condition is when the building is very weak and cheap and will easily damaged when the earthquake occurs. Furthermore, from this two condition the building need to find the best solution so it does not cost a lot but instead still in the solid form when the earthquake occur.

The building was then called earthquake resistant building, with a lot of element that interconnected with each other according to earthquake strength and building performance as a form to minimize loss while the earthquake occur. The interconnected elements create grouped as a baseline of the resilient earthquake building that can be determined as follows.

1. When a light earthquake occurs the main structure of the building must not be damaged and function properly. Minor damage to non structural elements can still be tolerated
2. When a moderate earthquake occurs, the main structure buildings may slightly damaged the building but still can be repaired. Non-structural elements may be damaged but can still be replaced with new ones.
3. When a strong earthquake happen, the main structure of the building may damaged but must not completely collapse the building.

3.2 Earthquake Plan, Earthquake Priority Factors and Risk Category of Building Structure

3.2.1 Earthquake Plan

This method determine how the earthquake plan give the influence to the structural planning that includes buildings and non buildings. Earthquake plan in SNI – 1726 – 2019 still do not change due to its earthquake plan.

3.2.2 Risk Category Building

In this risk category building in SNI – 1726 – 2012 and SNI – 1726 – 2019 there is no significant change. For earthquake risk categories the impact of earthquake plan have to multiplied by the earthquake priority factor and for the spesific category such as risk IV because if it needs an entrance for the operational purposes from the crossover building, then the building structur must be design using category IV.

3.2.3 Priority Factors for Earthquakes

For classifying risk category of the building and non building with the functional and type of the building it can be seen at SNI 1726 : 2019, that can be seen at the Table 1 below.

Table 3. 1 Risk Category of Building and Non Building for Loading Factor

Type of Use	Risk Category
Building and non building that contain low risk that can affect human life while the failure happen, includes: <ul style="list-style-type: none">- Agricultural plantation, livestock and fisheries facilities- Temporary facilities- Storage warehouse- Guard houses and other small structure	I
All of the building and other structure, except that includes at risk category I,III, and IV but do not have boundaries for: <ul style="list-style-type: none">- Housing area- Shop house and office- Market- Office building- Apartment/Flats- Shopping center/mall- Industrial buildings- Manufacturing facilities	II

Type of Use	Risk Category
<p>- Factory</p> <p>Building and Non Building that have a high risk of human life while the failure occurs, include but doesn't have boundaries for:</p> <ul style="list-style-type: none"> - Cinema - Meeting hall - Stadium - Health facilities - Child care facilities - Prison - Nursing house <p>Buildings and not buildings are not included in risk category IV which has the potential to cause significant economic impacts major and or mass disruption to community life daily activities in the event of failure including but not limited for:</p> <ul style="list-style-type: none"> - Power Generation Center - Water handling facilities - Waste handling facilities - Telecommunication center <p>Buildings and non-buildings that are not included in the risk category IV, (including manufacturing facilities, or material disposal sites hazardous fuel) containing toxic or explosive materials in where the amount of ingredients exceeds the limit value required by the competent authority and is sufficient to cause</p>	III
<p>Buildings and non-buildings designated as important facilities, including, but not limited to:</p> <ul style="list-style-type: none"> - Monumental buildings - School buildings and educational facilities - Hospitals and health facilities that have bedrooms and emergency unit (ER) - Fire, ambulance and police station facilities, as well as garages emergency vehicle - Shelter against earthquakes, storm winds and places other emergency protection 	IV

Type of Use	Risk Category
<ul style="list-style-type: none"> - Emergency preparedness facilities, communications, operations centers and facilities others for emergency response - Energy generating centers and other required public facilities during an emergency - Additional structures (including telecommunication towers, tanks fuel storage, cooling towers, power station structures, Fire fighting water tanks or house structures or structures water or mineral support or fire fighting equipment) which required to operate during an emergency. <p>Buildings and non-buildings required to maintain the function of the structure</p> <p>other buildings that fall into risk category IV</p>	

Source: (SNI 1726, 2012) ; (SNI 1726, 2019)

For affecting earthquake plan it have to be multiplied with priority factor (I_e) that can be found in the risk category of the area that needs to be analyze. The priority factor of the earthquake can be seen as this follows.

Table 3. 2 Priority Factor

Risk of Category	Priority Factor I_e
I or II	1
III	1,25
IV	1,5

Source: SNI – 1726 – 2019

3.3 Structure Loading

Structural loading is one of the most important things in a building plan. Loads that occur on a building or loads that work on a building structure escalate because of the forces that occur. On the other words, there are several basic building loads that consist of dead load, live load and earthquake load that will be explained as follows.

3.3.1 Dead Load

Based on (SNI 1727, 2020), Dead load is the weight of all elements construction in a building that include walls, roofs, ceilings, fixed partition walls, finishing, cladding and many other component support and architectural things. Based on (PPPURG 1987, 1987), dead load can be seen as follows.

Table 3. 3 Dead Load

No	Materials	Weight	Unit
1.	Steel	7.850	Kg/m ³
2.	Natural Stone	2.600	Kg/m ³
3.	Split Stone	1.500	Kg/m ³
4.	Coral Stone	700	Kg/m ³
5.	Crushed Stone	1.450	Kg/m ³
6.	Cast Iron	7.250	Kg/m ³
7.	Concrete	2.200	Kg/m ³
8.	Reinforced Concrete	2.400	Kg/m ³
9.	Wood (Class 1)	1.000	Kg/m ³
10.	Gravel, Coral	1.650	Kg/m ³
11.	Red Brick Masonry	1.700	Kg/m ³
12.	Pairs of Split Stone	2.200	Kg/m ³
13.	Printed Stone Pairs	2.200	Kg/m ³
14.	Coral Pairs	1.450	Kg/m ³
15.	Sand (Air dry to Moist)	1.600	Kg/m ³
16.	Sand (Saturated with Water)	1.800	Kg/m ³
17.	Sand Gravell, Coral (Air dry to moist)	1.850	Kg/m ³
18.	Soil, Clay and Silt (Dry)	1.700	Kg/m ³
19.	Soil, Clay and Silt (Wet)	2.000	Kg/m ³
20.	Black Lead (Lead)	11.400	Kg/m ³

Source: PPPURG 1987

3.3.2 Live Load

According to SNI 1727 : 2020 live load is a burden incurred by other users of the building or structure and does not include construction loads as well as environmental loads, such as wind loads, rain loads, earthquake loads , loads floofs and dead loads (SNI 1727, 2020). The live loads used in building planning must use the maximum load that is expected to occur on the building's users, However it must not be less than the minimum uniform load specified. Minimum average distribution and concentrated live load can be seen as follows.

Table 3. 4 Minimum Average Distribution and Concentrated Live Load

Buildings	Distributed Load	Concentrated Load
Apartment		
Access floor system - Office Room - Computer Room	50 (2,4) 100 (4,79)	
Armories and Training Stores	150 (7,18)	
Meeting room - Fixed seat - Lobby - Flexible seat - Meeting room - Podium stage - Spectator stands - Another meeting room	60 (2,87) 100 (4,79) 100 (4,79) 100 (4,79) 100 (4,79) 60 (2,87) 100 (4,79)	
Balconies and Decks	1,5 times live load for implemented area, and under 100 psf (4,79 kN/m ²)	
Lane for maintenance access	40 (1,92)	300 (1,33)
Corridor - First floor - Another floor	100 (4,79) Same as the residence	
Office building - Lobby and corridor floor one - Office - Office above first floor	100 (4,79) 50 (2,40) 80 (3, 100 (4,79)	2000 (8,90) 2000 (8,90) 2000 (8,90)
School - Classroom - Corridor above first floor - Corridor first floor	40 (1,92) 80 (3,83) 100 (4,79)	1000 (4,45) 1000 (4,45) 1000 (4,45)
Rooftop - Flat rooftop - Rooftop except residence - Rooftop for gathering	20 (0,96) 20 (0,96) 100 (4,79)	
Store - First floor retail - Second floor retail - Wholesaler in every floor	100 (4,79) 75 (3,59) 125 (6,00)	1000 (4,45) 1000 (4,45) 1000 (4,45)

Source : SNI 1727 2020

3.4 Earthquake Load

Earthquake loads are loads that occur on a building structure caused by ground movements caused by earthquakes and affect the structure. The following will explain the combination loading and earthquake force analysis.

3.4.1 Load Combination

In this research there are 2 regulations of load combination there are SNI 1726 : 2012 and SNI 1726 : 2019, the combination of both will be explained as follows.

1. Load combination according to SNI – 1726 – 2012

Based on (SNI 1726, 2012) structure, element structure and foundation must be planned as strong as possible so it can hold more than one load factor combination, that can be explained as following below.

- a. $1,4D$
- b. $1,2D + 1,6L \text{ } 0,5(Lr \text{ atau } R)$
- c. $1,2D + 1,6(Lr \text{ atau } R) + (L \text{ atau } 0,5W)$
- d. $1,2D + 1,0W + L + 0,5(Lr \text{ atau } R)$
- e. $1,2D + 1,0E + L$
- f. $0,9D + 1,0W$
- g. $0,9D + 1,0E$

In this research the loads used are dead loads, live loads, and earthquake loads while wind loads are not used or can be ignored so the load combination used can be seen as follows.

- a. $1,4D$
- b. $1,2D + 1,6L \text{ } 0,5(Lr \text{ atau } R)$
- c. $1,2D + 1,0E + L$
- d. $0,9D + 1,0E$

1) Based on SNI 1726 : 2012 sub 7.4.2 the affection of earthquake load, E can be determined as this follows.

a) For the load combination e in 4.2.2 can be determined as this follows

$$E = E_h + E_v$$

b) For the combination load g sub 4.2.2. can be determined as this follows

$$E = E_h - E_v$$

c) The influence of horizontal earthquake load, E_h sub 7.4.2.1 can be determined as this follows.

d) $E_h = \rho Q_e$

e) The influence of vertical earthquake load, E_v based on 7.4.2.2 can be determined as this follows.

$$E_v = 0,2.Sds.D$$

2) Redudancy factor ρ

There are 2 condition of redudancy based on SNI 1726 : 2012 as this follows.

a) Redudancy value permitted is equal 1,0 if the planned structure for seismic design category in B or C

b) Redudancy value permitted is equal 1,3 if structural planned for seismic design category in D,E, and F

3) Load direction

According to SNI 1726 2012 article 12.6.3.3 response spectrum analysis used to determine total design story drift and story drift. The total maximum includes models that vibrate simultaneously with 100% of the ground motion in the critical direction and 30% of the ground motion in the critical direction perpendicular or horizontal direction. Based on explanation above so that the load combination earthquake in SNI 1726 : 2012 can be seen below.

a. $1,4D$

b. $1,2D + 1,6L$

c. $1,2 + 0,2SDS + \rho.1,0.E_x + \rho.0,3.E_y + L$

d. $1,2 + 0,2SDS + \rho.0,3.E_x + \rho.1,0.E_y + L$

e. $1,2 + 0,2SDS - \rho.1,0.E_x + \rho.0,3.E_y + L$

f. $1,2 + 0,2SDS - \rho.0,3.E_x + \rho.1,0.E_y + L$

g. $1,2 + 0,2SDS + \rho.1,0.E_x - \rho.0,3.E_y + L$

h. $1,2 + 0,2SDS + \rho.0,3.E_x - \rho.1,0.E_y + L$

i. $1,2 + 0,2SDS - \rho.1,0.E_x - \rho.0,3.E_y + L$

j. $1,2 + 0,2SDS - \rho.0,3.E_x - \rho.1,0.E_y + L$

k. $0,9 - 0,2SDS + \rho.1,0.E_x + \rho.0,3.E_y$

l. $0,9 - 0,2SDS + \rho.0,3.E_x + \rho.1,0.E_y$

- m. $0,9 - 0,2\text{SDS} - \rho.1,0.\text{Ex} + \rho.0,3.\text{Ey}$
- n. $0,9 - 0,2\text{SDS} - \rho.0,3.\text{Ex} + \rho.1,0.\text{Ey}$
- o. $0,9 - 0,2\text{SDS} + \rho.1,0.\text{Ex} - \rho.0,3.\text{Ey}$
- p. $0,9 - 0,2\text{SDS} + \rho.0,3.\text{Ex} - \rho.1,0.\text{Ey}$
- q. $0,9 - 0,2\text{SDS} - \rho.1,0.\text{Ex} - \rho.0,3.\text{Ey}$
- r. $0,9 - 0,2\text{SDS} - \rho.0,3.\text{Ex} - \rho.1,0.\text{Ey}$

2. Combination load based on SNI – 1726 – 2019

Based on SNI 1726 : 2019, combination and factor load between SNI 1726 : 2019 and SNI 1726 : 2012 are the same, this following combination load based on SNI 1726 : 2019.

- a. 1,4D
- b. 1,2D + 1,6L
- c. $1,2 + 0,2\text{SDS} + \rho.1,0.\text{Ex} + \rho.0,3.\text{Ey} + \text{L}$
- d. $1,2 + 0,2\text{SDS} + \rho.0,3.\text{Ex} + \rho.1,0.\text{Ey} + \text{L}$
- e. $1,2 + 0,2\text{SDS} - \rho.1,0.\text{Ex} + \rho.0,3.\text{Ey} + \text{L}$
- f. $1,2 + 0,2\text{SDS} - \rho.0,3.\text{Ex} + \rho.1,0.\text{Ey} + \text{L}$
- g. $1,2 + 0,2\text{SDS} + \rho.1,0.\text{Ex} - \rho.0,3.\text{Ey} + \text{L}$
- h. $1,2 + 0,2\text{SDS} + \rho.0,3.\text{Ex} - \rho.1,0.\text{Ey} + \text{L}$
- i. $1,2 + 0,2\text{SDS} - \rho.1,0.\text{Ex} - \rho.0,3.\text{Ey} + \text{L}$
- j. $1,2 + 0,2\text{SDS} - \rho.0,3.\text{Ex} - \rho.1,0.\text{Ey} + \text{L}$
- k. $0,9 - 0,2\text{SDS} + \rho.1,0.\text{Ex} + \rho.0,3.\text{Ey}$
- l. $0,9 - 0,2\text{SDS} + \rho.0,3.\text{Ex} + \rho.1,0.\text{Ey}$
- m. $0,9 - 0,2\text{SDS} - \rho.1,0.\text{Ex} + \rho.0,3.\text{Ey}$
- n. $0,9 - 0,2\text{SDS} - \rho.0,3.\text{Ex} + \rho.1,0.\text{Ey}$
- o. $0,9 - 0,2\text{SDS} + \rho.1,0.\text{Ex} - \rho.0,3.\text{Ey}$
- p. $0,9 - 0,2\text{SDS} + \rho.0,3.\text{Ex} - \rho.1,0.\text{Ey}$
- q. $0,9 - 0,2\text{SDS} - \rho.1,0.\text{Ex} - \rho.0,3.\text{Ey}$
- r. $0,9 - 0,2\text{SDS} - \rho.0,3.\text{Ex} - \rho.1,0.\text{Ey}$

3.5 General Provisions for Building Design Against Influence Earthquake

General provisions in planning buildings against earthquakes has several parameters such as site classification, earthquake area, coefficient response modification, spectrum response and others according to SNI 1726 : 2012 and SNI 1726 : 2019 which will be explained as follows.

3.5.1 Sites Clasification

Sites classification provides seismic design criteria in the form of building amplification factors. When formulating seismic design criteria ground level for buildings or when determining magnitude amplification peak seismic acceleration of the site's rock mass to the ground surface, resulting in the site must be classified first. Site classification according to SNI 1726 : 2019 is the same as according to SNI 1726 : 2012. Site classification can be seen in the following table below.

Table 3. 5 Classification Sites

Class sites	Vs (m/s)	N or Nch	Su (kPa)
SA	≥ 1500	N/A	N/A
SB	750 - 1500	N/A	N/A
SC	350 – 750	≥ 50	≥ 100
SD	175 - 350	15 -50	50 -100
SE	< 175	< 15	< 50
	Or any soil profile containing more than 3m land with the following characteristics below: <ul style="list-style-type: none">- PI > 20- W $\geq$ 40%- Non flow shear strength Su < 25 kPa		
SF	Each soil layer profile that has either or more at this following characteristics <ul style="list-style-type: none">- Vulnerable and has the potential to fail or collapse as result earthquake loads- Highly organic clay > 3m- Clay with very high plasticity > 7,5 m (with PI > 75),- Soft/semi firm clay layer with H > 35 m with Su < 50 kPa		

Source: SNI – 1726 - 2019

3.5.2 Maximum Earthquake Acceleration Spectral Response Parameters Considered Targeted Risk

In determining the earthquake acceleration spectral response in ground surface a seismic amplification factor is needed for the period 0,2 seconds and 1 second. The amplification factor acceleration at short periods (Fa) and the amplification factor related to that acceleration represents vibrations at a period of 1 second (Fv).

Response spectrum parameters at short period (SMS) and at 1 second period (SM1) and must be adjusted according site classification and determined using this following equation.

$$SMs = Fa * Ss \quad (3.1)$$

$$SM1 = Fv * S1 \quad (3.2)$$

With:

SMs = Response spectrum spectrum parameters at short periods

SM1 = Response spectrum parameters at a period of 1 second

Fa = Amplification factor in short periods

Fv = Amplification factor in 1 second period

Ss = MCER Earthquake acceleration spectral response parameters are mapped on short period

S1 = MCER earthquake acceleration spectral response parameters are mapped to 1 second period

The following is a map of the Indonesian region for the ground motion diameter Ss, maximum considered risk targeted earth MCER for the spectrum 0,2 second response based on SNI – 1726 – 2012 and SNI – 1726 – 2019 that can be seen at this figure below.

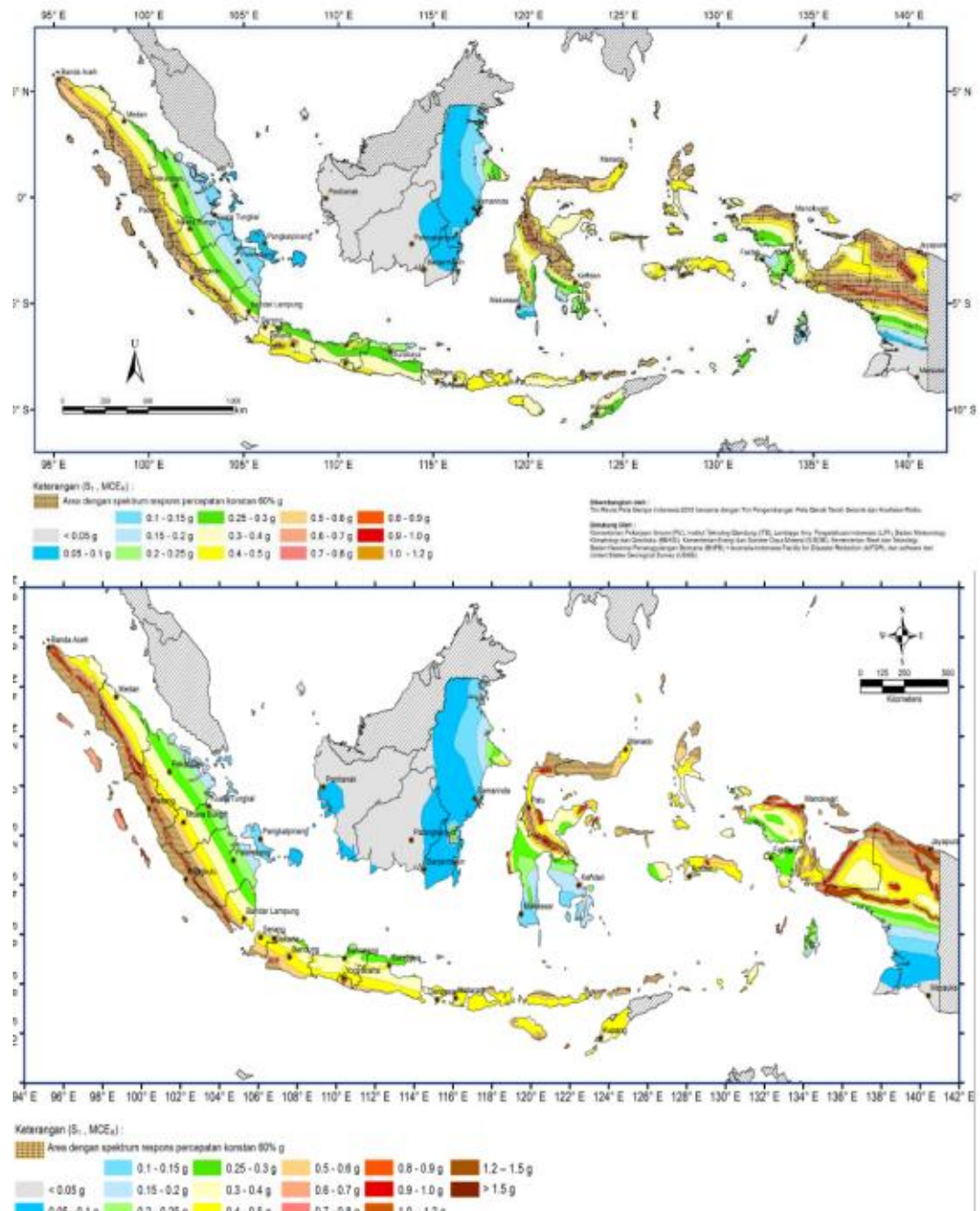


Figure 3. 2 Maximum Earthquake Considered Targeted Risk for a Response Spectrum Period of 1,0 seconds According to SNI – 1726 – 2012 and SNI – 1726 – 2019.

Source: SNI – 1726 – 2012 and SNI – 1726 – 2019

For Fa and Fv coefficient based SNI 1726 – 2012 that can be seen as this table below.

Table 3. 6 Sites Classification, Fa

Sites Class	Earthquake acceleration spectral response (MCER) parameters mapped on a short period, T = 0.2 seconds, S _s				
	S _s ≤ 0,25	S _s = 0,5	S _s ≤ 0,75	S _s = 1,0	S _s ≥ 1,25
SA	0,8	0,8	0,8	0,8	0,8
SB	1,0	1,0	1,0	1,0	1,0
SC	1,2	1,2	1,1	1,0	1,0
SD	1,6	1,4	1,2	1,1	1,0
SE	2,5	1,7	1,2	0,9	0,9
SF	S _s				

Source: SNI – 1726 – 2012

Table 3. 7 Classification Sites, Fv

Sites Class	Earthquake acceleration spectral response (MCER) parameters mapped on period 1 sec, S ₁				
	S ₁ ≤ 0,1	S ₁ = 0,2	S ₁ ≤ 0,3	S ₁ = 0,4	S ₁ ≥ 0,5
SA	0,8	0,8	0,8	0,8	0,8
SB	1,0	1,0	1,0	1,0	1,0
SC	1,7	1,6	1,5	1,4	1,3
SD	2,4	2,0	1,8	1,6	1,5
SE	3,5	3,2	2,8	2,4	2,4
SF	S _s				

Source: SNI – 1726 – 2012

The coefficient for Fa and Fv according to SNI 1726: 2019 are available in this table below.

Table 3. 8 Classification Sites, Fa

Sites Class	Earthquake acceleration spectral response (MCER) parameters mapped on a short period, T = 0.2 seconds, S _s				
	S _s ≤ 0,25	S _s = 0,5	S _s ≤ 0,75	S _s = 1,0	S _s ≥ 1,25
SA	0,8	0,8	0,8	0,8	0,8
SB	0,9	0,9	0,9	0,9	0,9
SC	1,3	1,3	1,2	1,2	1,2
SD	1,6	1,4	1,2	1,0	1,0
SE	2,4	1,7	1,2	0,9	0,8
SF	S _s				

Source: SNI – 1726 – 2019

Table 3. 9 Classificaton Sites, Fv

Sites Class	Earthquake acceleration spectral response (MCER) parameters mapped on period 1 sec, S1					
	$S1 \leq 0,1$	$S1 = 0,2$	$S1 \leq 0,3$	$S1 = 0,4$	$S1 = 0,5$	$S1 \geq 0,5$
SA	0,8	0,8	0,8	0,8	0,8	0,8
SB	0,8	0,8	0,8	0,8	0,8	0,8
SC	1,5	1,5	1,5	1,5	1,5	1,4
SD	2,4	2,2	2,0	1,9	1,8	1,7
SE	4,2	3,3	2,8	2,4	2,2	2,0
SF	Ss					

Source: SNI – 1726 – 2019

3.5.3 Design Spectral Acceleration Parameters

Design spectral acceleration parameters according to SNI 1726 : 2012 and SNI 1726 : 2019 are the same for the short period of 0,2 seconds (SDs) and design spectral acceleration at a period of 1,0 seconds (SD1). Design spectral acceleration determined using this following equation.

$$Sds = \frac{2}{3} * Sms \quad (3.3)$$

$$Sd1 = \frac{2}{3} * Sm1 \quad (3.4)$$

3.5.4 Response Spectrum

Response spectrum is a spectrum graph presented in the form of graph between the vibration period of a structure and the maximum response to the ratio attenuation and certain seismic loads. Response spectrum in SNI 1726 : 2012 that updated into SNI 1726 : 2019, several changes can be seen as follows.

1. Spectrum response

According to SNI 1726 – 2012 there are 3 elements for the fundamental vibration time period structure that occurs in the spectrum response graph. As to load the spectrum response graph must follow the requirements below.

- a. For periods smaller than T_0 , the response spectrum accelerated design, S_a that used this following equation.

$$S_a = Sds (0,4 + 0,6 \frac{T}{T_0}) \quad (3.5)$$

- b. If the periods is more than or equal to T_0 and less or equal to T_s , design response spectrum, S_a equal to SDS
- c. If the periods is larger than T_s , the design response spectrum S_a that used this following equation.

Explanation :

S_{ds} = Short period design spectrum response acceleration parameter

$SD1$ = Design spectrum response acceleration with 1,0 second periods

T = Fundamental vibration period of the structure

$$T_0 = 0,2 \frac{SD1}{SDS} \quad (3.6)$$

$$T_s = \frac{SD1}{SDS} \quad (3.7)$$

With these equation the response graph is obtained the design spectrum according to SNI 1726 : 2012 can be seen as following figure below.

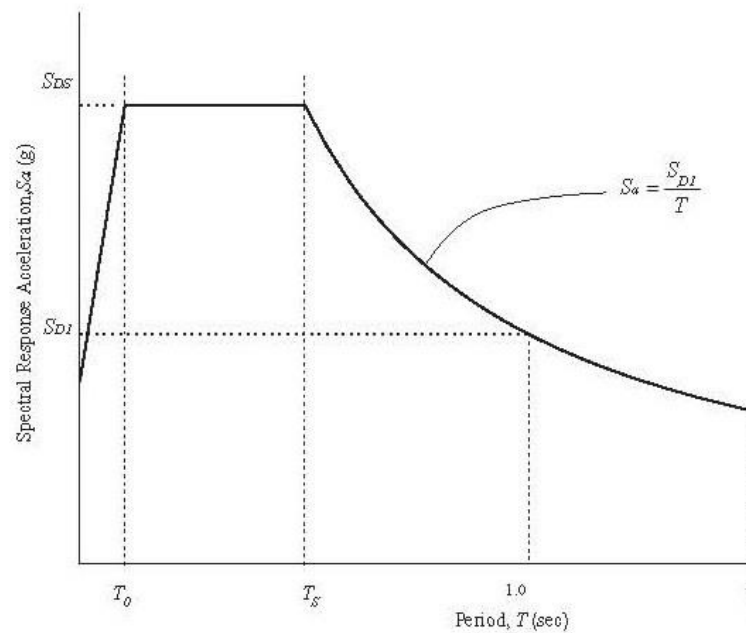


Figure 3. 3 Spectral Response Acceleration

Source: SNI – 1726 – 2012

2. Spectrum Response

According to SNI 1726 : 2019 here are changes that have occurred in the response graph spectrum, in SNI 1726 : 2019 there are 4 elements of the

vibration time period fundamental structure that occurs in the response spectrum graph. On the chart there is an additional long period of time.

- a. Periods that have smaller than T_0 the response spectrum accelerates design, the equation to determine S_a can be seen as follows.

$$S_a = S_d s \left(0,4 + 0,6 \frac{T}{T_0} \right) \quad (3.8)$$

- b. Periods that have higher or equal to T_0 and less or equal to T_s , design response spectrum S_a equal to $S_d s$
- c. Periods that have higher than T_s , the design response spectrum, S_a in design response spectrum can be defined as this following question.

$$S_a = \frac{SD1}{T} \quad (3.9)$$

- d. Periods that have higher value than T_L , the design response spectrum, S_a in design response spectrum can be defined as this following question.

$$S_a = \frac{SD1.T_L}{T^2} \quad (3.10)$$

Explanation:

$SD1$ = Design spectrum response acceleration parameter with a period of 1,0 seconds

T = Fundamental period of the structure

$S_d s$ = Response Spectral Acceleration at Short Periods

T_L = Long period transition map that can be seen as this following figure

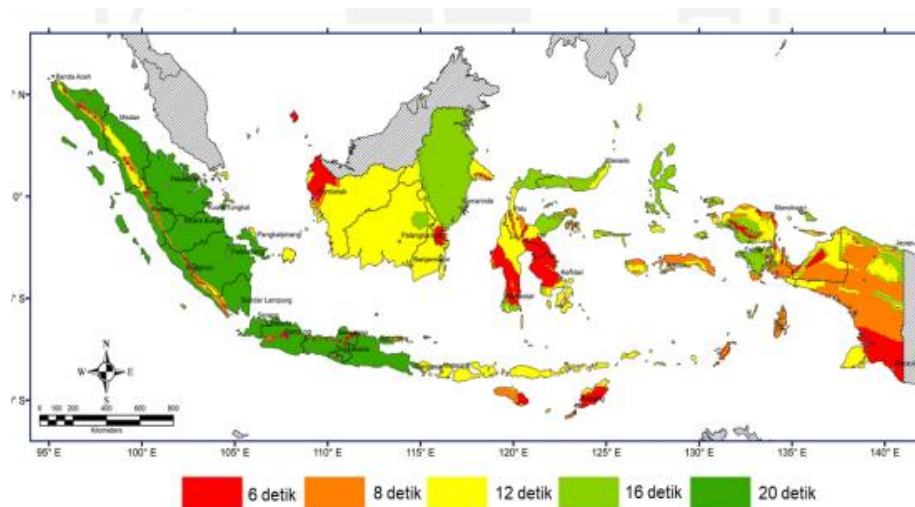


Figure 3. 4 Indonesian Territory for the Long Term Period, T_L

Source : SNI – 1726 – 2019

From the equation above the graphic spectrum response design according to SNI 1726 : 2019 can be seen as this following figure.

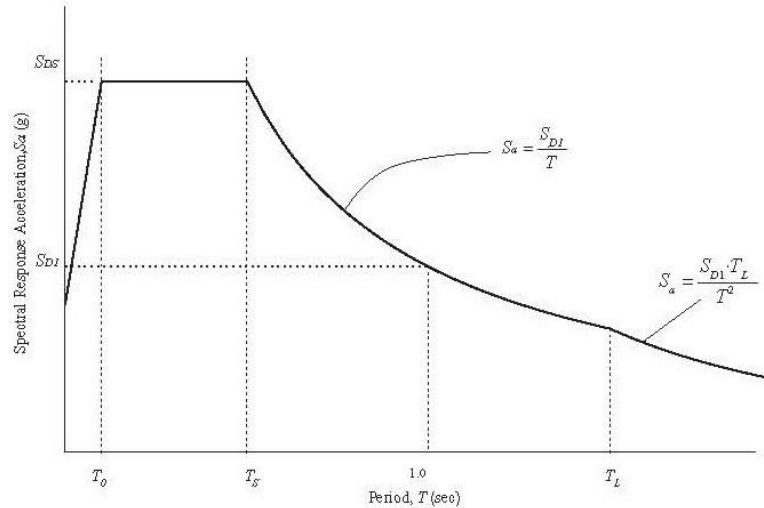


Figure 3. 5 Spectral Response Acceleration

Source: SNI – 1726 – 2012

3.5.5 Design Category Seismic

All structures must be assigned to a seismic design category based value of short period response spectral acceleration and response spectral acceleration for a period of 1,0 seconds. In the seismic design category are the same between SNI 1726 : 2012 and SNI 1726 : 2019 for the seismic design category can be seen at this table below.

**Table 3. 10 Category Seismic Design based on Response Acceleration
Short Period Spectrum**

Sds Value	Risk Category	
	I or II or III	IV
$Sds < 0,167$	A	A
$0,167 \leq Sds < 0,33$	B	C
$0,33 \leq Sds < 0,50$	C	D
$0,50 \leq Sds$	D	D

Source : SNI – 1726 – 2019

**Table 3. 11 Seismic Design Categories Based on Response Acceleration
Spectrum Period 1.0 Sec**

SD1 Value	Risk Category	
	I or II or III	IV
$SD1 < 0,067$	A	A
$0,067 \leq SD1 < 0,133$	B	C
$0,133 \leq SD1 < 0,20$	C	D
$0,20 \leq SD1$	D	D

Source: SNI – 1726 - 2019

3.6 Resisting Earthquake Force Systems

Seismic force resisting systems used in planning structure, which functions to withstand earthquake force from different directions. If the systems are different the R , C_d , and Ω_0 must be applied on each system including the limits of the structural system contained. Retainer earthquake system forces according to SNI 1726 : 2012 and SNI 1726 :2019 are the same. The following are the possible response modification coefficients that can be seen at the table below.

Table 3. 12 R , C_d , and Ω_0 for Resisting Earthquake Force System

Resisting Earthquake Force System	R	Ω_0	C_d	Structural limit system and height limit structur, h_n (m)				
				Category of Seismic Deisgn				
				B	C	D	E	F
Reinforced concrete frame bearer of special moments	8	3	$5_{1/2}$	TB	TB	TB	TB	TB
Reinforced concrete frame bearer of intermediate moments	5	3	$4_{1/2}$	TB	TB	TI	TI	TI
Reinforced concrete frame bearer of ordinary moments	3	3	$2_{1/2}$	TB	TI	TI	TI	TI

Source: SNI – 1726 - 2019

3.7 Basic Seismic Forces

The basis seismic force is the amount of lateral force that occurs due to seismic forcer received by the building. Basic seismic forces based on SNI 1726 : 2012 and SNI 1726 : 2019 are the same. This are the equation of the basis seismic forces that can be seen below.

$$V = C_s * W \quad (3.11)$$

Explanation:

C_s = Coefficient of Seismic response

W = Efective seismic mass

3.7.1 Seismic response coefficient

In the calculation of the seismic response coefficient, there are slightly differece between SNI 1726 : 2012 and SNI 1726 : 2019 that is in the requirements that determining the C_s value. This are the differences in calculating response coefficients seismic between these 2 SNI can be seen as follows.

1. Calculation of seismic response coefficient according to SNI 1726 : 2012 can be seen as follows.

$$C_s = \frac{Sds}{\left(\frac{R}{I_e}\right)} \quad (3.12)$$

Explanation:

Sds = Short period design spectrum response acceleration parameter

R = Response modification factor

I_e = Priority factor of earthquake

Based on the equation there are several requirements for the C_s value which can be seen below:

- a. The C_s value, which is calculated based on the equation above is not more than this following equation.

$$C_s = \frac{Sd1}{T\left(\frac{R}{I_e}\right)} \quad (3.13)$$

- b. Counted C_s value, must not less than this following equation.

$$C_s = 0,044.Sds.I_e \geq 0,01 \quad (3.14)$$

- c. For the structural area in S1 is as the same or even more than 0,6g so Cs value not less than this following question.

$$C_s = \frac{0,5S_1}{\left(\frac{R}{I_e}\right)} \quad (3.15)$$

2. Calculation of seismic response coefficient according to SNI 1726 : 2019 can be seen as follows.

$$C_s = \frac{S_{ds}}{\left(\frac{R}{I_e}\right)} \quad (3.16)$$

There is several requirement from SNI 1726 : 2019 that needs to be implemented in Cs value, this following requirements can be seen below.

- a. For $T \leq T_L$, Cs value must not more than this following equation

$$C_s = \frac{S_{d1}}{T \left(\frac{R}{I_e}\right)} \quad (3.17)$$

- b. For $T > T_L$

$$C_s = \frac{S_{d1} T_L}{T^2 \left(\frac{R}{I_e}\right)} \quad (3.18)$$

- c. Cs value must not more than this equation below.

$$C_s = 0,044.S_{ds}.I_e \geq 0,01 \quad (3.19)$$

- d. For the structure area where S1 value is equal or more than 0,6g so Cs value must not more than this following equation below,

$$C_s = \frac{0,5S_1}{\left(\frac{R}{I_e}\right)} \quad (3.20)$$

Explanation

SD1 = Design spectrum response acceleration parameter with a period of 1,0 seconds

T = Fundamental period of the structure

S1 = Maximum mapped response spectrum acceleration

3.8 Structural Fundamental Period

The fundamental period of the structure is one of the most important things in planning buildings that are earthquake resistant. Vibration period of the structure is important because it is the structure's vibration that will determine its magnitude earthquake loads used in earthquake resistant building structures. Vibration period structure must not exceed the product of the coefficients on the upper limit for the

calculated period, C_u and the approximate fundamental period T_a . Vibration period structure between SNI 1726 : 2012 and 1726 : 2019 is the same, T_a is determined using the following equation.

$$T_a = C_t * h_n^x \quad (3.21)$$

$$T_{\max} = C_u * T_a \quad (3.22)$$

Explanation:

T_a = Fundamental period nearby (Sec)

H_n = Structure height (m)

C_t = Coefficient of the multiplier factor for the approach period

C_u = Upper limit coefficient in the calculated period

For upper limit factor coefficient, C_u and the parameter coefficients C_t and x can be seen in the tables below.

Table 3. 13 Upper Limit Coefficient in the Calculated Period

SD1	C_u
$\geq 0,4$	1,4
0,3	1,4
0,2	1,5
0,15	1,6
$\leq 0,1$	1,7

Source : SNI – 1726 : 2019

Table 3. 14 Approach Period Parameter Value

Structural type	Ct	X
The moment bearing frame system is where the frame carries the load 100% of the required earthquake force and not covered or associated with components that are more rigid so it will prevents frame from deflecting when the subjected affected earthquake forces such as:		
- Moment resisting steel frame	0,0724	0,8
- Moment resisting concrete frame	0,0466	0,9
Steel frame with eccentric braces	0,0731	0,75
Steel frame with braces restrained to buckling	0,0731	0,75
All other structural systems	0,0488	0,75

Source : SNI – 1726 – 2019

As an approach to the inelastic behavior of structures (the cross sectional condition is already crack) which is analyze linearly elastically. SNI 2847 : 2019 regulates reduction factors cross sectional rigid (inertia) that can be seen as the following table (SNI 2847, 2019).

Table 3. 15 Moment Inertia of Cross Sections

Elements	Moment Inertia
Column	0,70 I_g
Wall	0,70 I_g
Crack wall	0,35 I_g
Beam	0,35 I_g
Flat slab	0,25 I_g

Source : SNI – 2847 – 2019

3.9 Regular and Irregular Building Structures

Building structures are classified into two different aspect that is regular structures and irregular structure. The classification must be based on configuration vertical and horizontal. Vertical and horizontal configuration based on SNI 1726 : 2012 and SNI 1726 : 2019 is the same. The building structure must meet the criteria that will be explained as the tables below.

Table 3. 16 Horizontal Irregularity Structure

No	Type and Irregularity explanation	The Seismic Design Category
1a.	Torsion irregularity can be defined if maximum deviation level include unpredictable torsion with $A_x = 1,0$. At one end of the structure transverse to an axis is more than 1.2 times the average interlevel deviation in both end of the structure. Torsional irregularity requirements in each chapter will be applied only for the diaphragm rigid or half rigid structure.	D, E, and F B,C,D,E and F C,D,E, and F D, E, and F
1b.	Additional Torsion irregularity can be defined if maximum deviation level include unpredictable torsion with $A_x = 1,0$. At one end of the structure transverse to an axis is more than 1.4 times the average interlevel deviation in both end of the structure. Torsional irregularity requirements in each chapter will be applied only for the diaphragm rigid or half rigid structure.	E and F D B,C, and D C And D C and D D B,C, and D
2	Irregularity angle can be defined if both project dimension structural map in inner corner location is higher than 15% dimensions of the structure plan when the direction can be considered.	D, E, and F D,E, and F
3	A diaphragm discontinuity irregularity is defined if there is a diaphragm that has discontinuity or variation in sudden stiffness, including those with cut areas or open, that get higher than 50% of the gross diaphragm area closed, or a change in effective diaphragm stiffness of more than 50% from one level to the next.	D, E, and F D,E, and F

4	Irregularities resulting from shifts perpendicular to the plane is defined if there is discontinuity in the resistance path lateral force, such as a shift perpendicular to the plane, at least one vertical element resists the lateral force.	B,C,D,E and F D,E and F B,C,D,E and F D,E, and F B, C, D, E, and F
5	The irregularity of a nonparallel system is defined if the elements The vertical bearing the lateral force is not parallel to the axes main orthogonal seismic force resisting system.	B,C,D,E, and F D,E, and F B,C,D,E and F F D,E, and F B,C,D,E, and F

Source: SNI – 1726 – 2019

Table 3. 17 Irregularity Vertical Structure

No	Type and Irregularity Explanation	Seismic Design Category
1a	Rigid Irregularity soft level define if there are rigid level that have less than 70% layer above or less than 80% average rigid level above	D, E, and F
1b	Excessive Rigid irregularity soft level can be define if there is level in lateral rigid that is less than 60% of the lateral rigid of the level above or less than 70% of the average rigid 3 level above.	E and F D,E, and F
2	Irregularity mass define if efective mass is at any level is more than 150% of the effective mass of a nearby level A roof that is lighter than the floor below does not need to be reviewed	D,E, anf F
3	Vertical geometry irregularities are defined if horizontal dimension of the seismic force resisting system at any level more than 130% of the horizontal dimension of the seismic force resisting sysme nearby.	D,E, and F
4	Irregularities due to field discontinuities in elements vertical lateral force resistors are defined if there is a shift in direction field where the element resisting a lateral force is greater than the length that element or there is a reduction in the rigid supporting elements at the level below.	B,C,D,E, and F

5a	Weak level irregularities due to discontinuities in strength lateral level is defined if the lateral strength of a story less than 80% of the lateral strength of the level above. Lateral strength level is the total strength of all seismic bearing elements that share shear force into the considered direction.	E and F D,E, and F
5b	Excessive weak level irregularities consequences discontinuity in the lateral force level is defined if the lateral strength of a story is less than 65% of the lateral strength of the story on. The lateral strength of a level is the total strength of all elements seismic resistors that share shear force into the considered direction.	D,E, and F B and C D, E, and F

Source: SNI – 1726 – 2019

Exceptional:

1. Irregularities vertical structure type 1a, 1b, or 2 does not apply if there is a story drift between floor due to lateral earthquake forces which has a value greater than 130% of the deviation ratio between floors on
2. There are no vertical irregularities in structure of types 1a, 1b, and 2 above that needs to be considered in single story buildings in all seismic design categories or two story buildings designed for seismic design categories B, C and D.

3.10 Deviations Between Floors

The drift between floors or inter story drift must be calculated for being the difference between the center of mass above and below the level under the consideration. If the center of mass is not aligned in the vertical direction, it is ok to calculate the deviation at the base of the level based on the projection of the level above. For more detail, deviation between floor can be explained as this picture below.

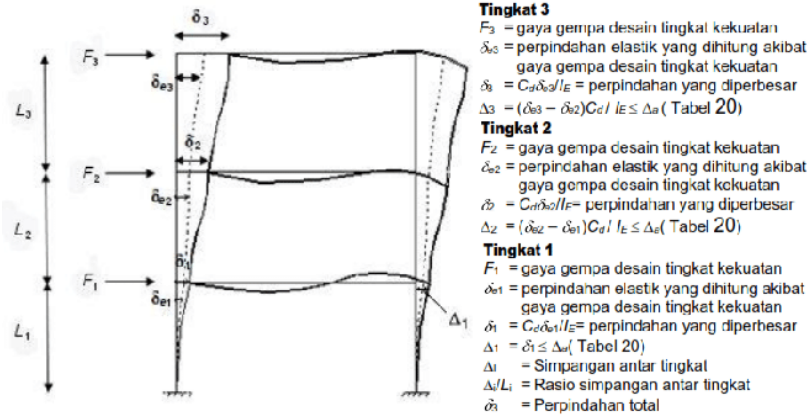


Figure 3. 6 Inter Story Drift

For structures designed for seismic design categories C,D,E and F has horizontal irregularity of 1a or 1b so the inter story drift must be calculation using this equation below.

$$\delta x = \frac{C_d \cdot \delta x_e}{I_e} \quad (3.23)$$

Explanation:

δx = drift of the center mass of the x level (mm)

C_d = Lateral deviation magnification factor

δx_e = Required x level deviation

I_e = Earthquake priority factor

3.11 Determination of Force Scale

In determining the force scale, there are changes that happen between SNI 1726 : 2012 and SNI 1726 : 2019 that can be explained below.

1. Scaling based on SNI 1726 : 2012, If the calculation results the fundamental period of the structure is higher than $C_u.T_a$, then $C_u.T_a$ can be used as a substitute for the structure period, T . If response combination for shear force analysis of variance qualify $V_t < 85\%$ shear force, then the force must be multiplied by $0,85 \times V/V_t$ (SNI 1726, 2012).
2. Scaling based on 1726 : 2019, if the calculation results show that the fundamental period of the structure is greater than $C_u.T_a$, then the structure period T is taken as $C_u.T_a$ and if it's combination response to shear force based on analysis of variance $V_t < 100\%$ shear force V , then the force must be multiplied by V/V_t (SNI 1726, 2019).

Explanation:

V = Equivalent basic shear force

V_t = Basic Shear force of the various combination

CHAPTER IV

RESEARCH METHOD

4.1 General Review

This research is a comparative study between SNI 1726 2019 and SNI 1726 2012 based on the earthquake response spectrum. The aim of this research is to determine base shear, drift, P-delta and structural irregularities.

The analysis was carried out by building modeling with the ETABS program. There is 1 type of modeling but uses 2 different earthquake regulations, namely SNI 1726 2012 and SNI 1726 2019. The earthquake parameters in SNI 1726 2012 refer to the 2010 earthquake source and hazard map. Then for SNI 1726 2019 it refers to the 2017 earthquake source and hazard map. Then make a comparative recap between the two results. After making comparisons then draw conclusions.

The conclusion is expected to answer the existing problem formulation. The conclusion results are also expected to provide benefits.

4.2 Research Location

This building is located in Telanaipura, Kec. Telanaipura, Jambi City, Jambi. This building has 6 floors with a total height of 27.5 m. The plan of this building is shown in figure 4.1.



Figure 4. 1 Building Plan

Source = FKIK Jambi University

The building measures 54 x 31 meters with a height of 27.5 m. The type of earthquake resistance is a special moment-resisting frame system with an R value of 8, Cd of 5.5 and a force magnification factor of 3.

4.3 Data Analysis Preparation

This research requires the following data:

1. Previous study data which includes: research related to comparative analysis of SNI, SNI regulations, and building loading.
2. Building specification data: building architect's plan, building location, soil investigation data, bedrock acceleration map and building structure drawing.
3. Earthquake data which includes: earthquake source and hazard maps as well as PUPR spectrum response sites.

4.4 Data Processing and Modelling Stage

1. Material Input

The steps for inputting materials in ETABS are define menu -> material properties -> define materials -> add new material -> material type -> Concrete -> ok. These steps are shown in the picture 4.2

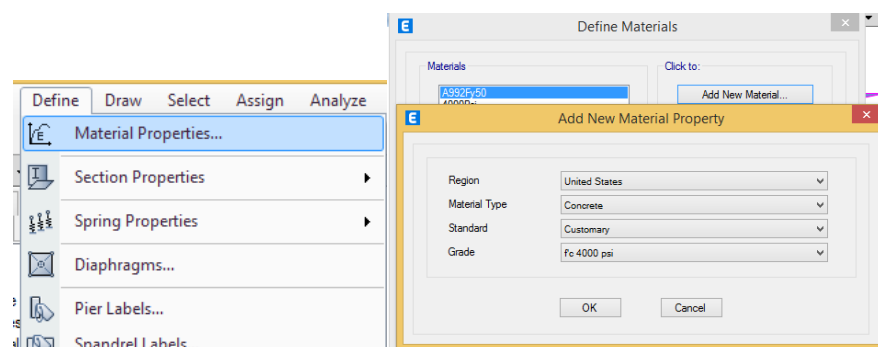


Figure 4. 2 Material Properties ETABS

Then select specify mass density-> fill in 2400 kg/m3-> modulus of elasticity -> modify/show material property design data -> material property design data. These steps can be seen as shown in the picture 4.3.

Figure 4. 3 Material Property Data ETABS

Then fill in the planned concrete compressive strength data. Then select OK, then the display will return to the previous tab. Then select OK again on the material property data tab to complete and close the material properties settings. These steps are shown in the picture 4.4.

Figure 4. 4 Material Property Design Data ETABS

Then need to input the reinforcement material (rebar) into the software by selecting the define menu ->material properties->material properties -> define materials ->add new material->Material type ->Rebar->ok. Then a new tab will appear. Then select Specify Mass Density->fill in 7850 kg/m³. ->Modulus of

Elasticity is 200000 Mpa ->modify/show material property design data ->material property design data. Then select OK, it will return to the previous tab. Then select OK again on the material property data tab to complete and close the material properties settings. The method for entering the material properties of the stirrup reinforcement is the same as in the explanation above. However, the material needs to be adjusted.

2. Input column and beam dimensions

Fill in the dimensions of the columns, beams and slabs into the ETABS software, namely by selecting the define menu -> section properties -> frame sections for columns and beams, slab sections for floor slabs. These steps are shown in figure 4.5.

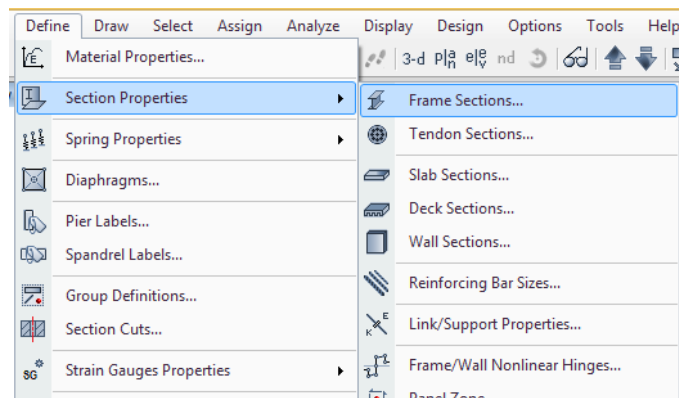


Figure 4. 5 Section Properties

After selecting frame sections, a new tab will appear, namely frame properties. On this tab select add new property-> Concrete rectangular. Set the dimensions of the column or beam. These steps are shown in figure 4.6.

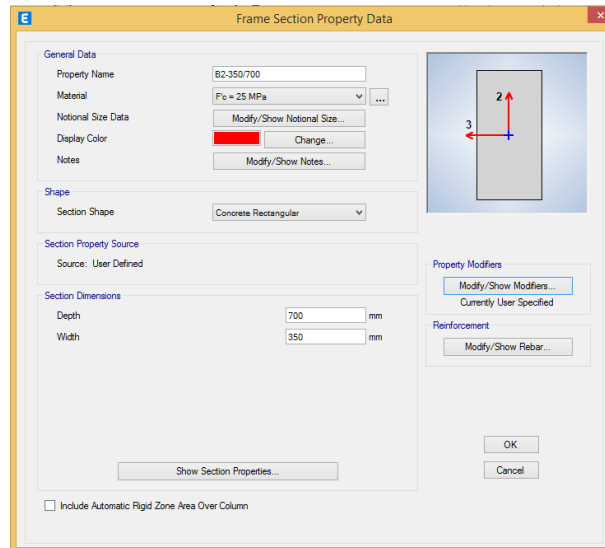


Figure 4. 6 Frame Section Property Data

Use the same method to size other structures. After you have finished editing all the columns and beams according to the estimated calculations, on the frame properties tab select OK to close and save the changes you have made. Then what needs to be done is to edit the thickness of the plate by selecting the define menu->section properties ->slab sections ->slab properties->add new property. These steps are shown in figure 4.7.

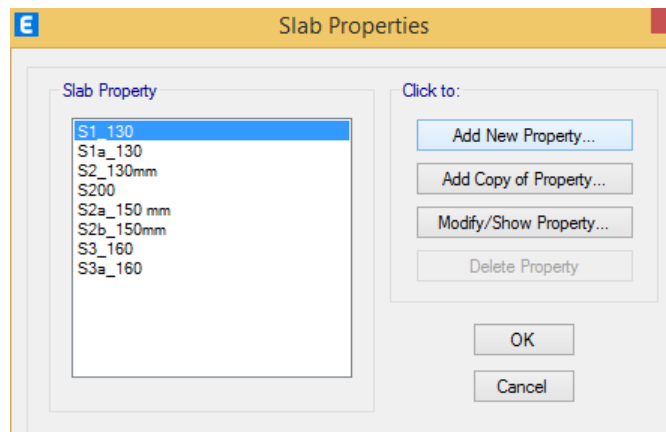


Figure 4. 7 Slab Properties ETABS

Then the slab property data window will appear to edit the size and material of the slab further. Fill in the name of the plate. Then select the material from the plate.

3. Depiction of column, beam and plate elements

At this stage, we have estimated and defined the type of material and dimensions in the ETABS software. So the next step is to input the columns, beams and plates into the auxiliary lines or grid that have been created. The filling sequence

starts from the column, beam and plate structures by selecting the cursor in the draw menu on the left edge of the work tab.

Then select quick draw columns for columns, draw beam for beams, draw wall for shear walls and draw floor for plates. After selecting the appropriate menu, adjust the properties to be input on the object properties tab. The shortcut for drawing structures is shown in figure 4.8.

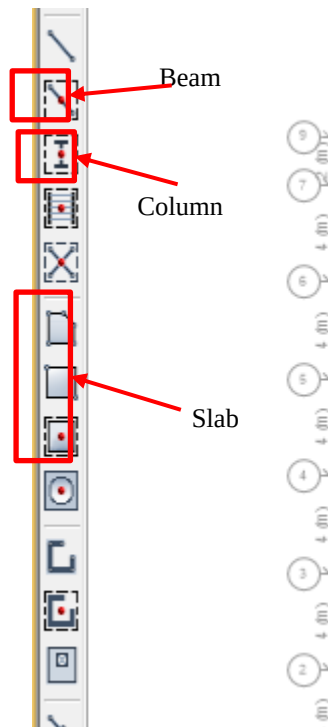


Figure 4. 8 Draw Element Structure

4. Input earthquake load

Select the define menu ->functions ->response spectrum->define response spectrum functions. These steps are shown in figure 4.9.

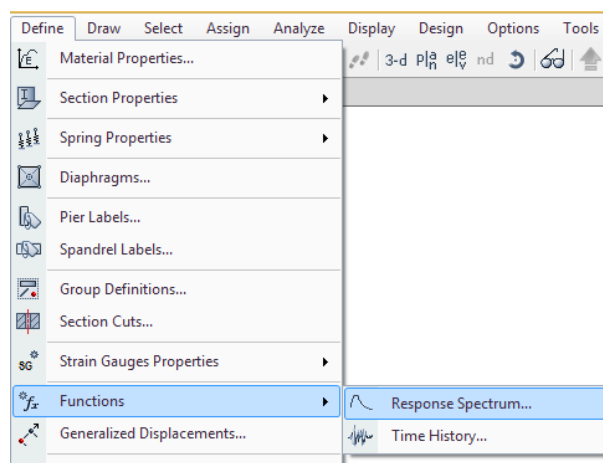


Figure 4. 9 Input Response Spectrum ETABS

Then select function type ASCE 7-16 -> add new function-> response spectrum ASCE 7-16 function definition for SNI 1726 2019 while for SNI 1726 2012 then select ASCE 7-10. These steps are shown in figure 4.10.

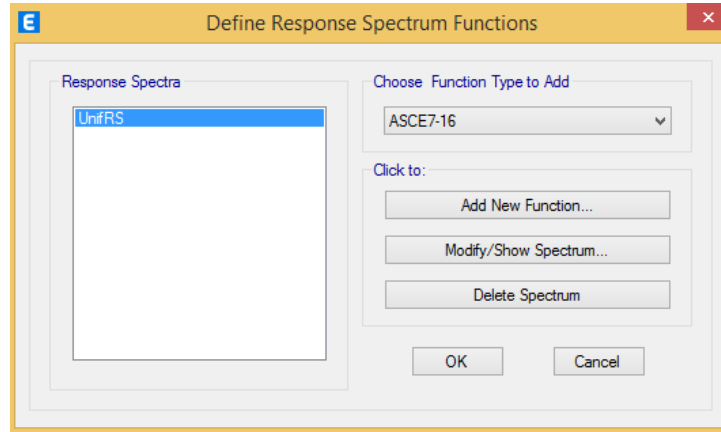


Figure 4. 10 Define Response Spectrum Functions ETABS

Then fill in the S_s , S_1 , and T_L parameters obtained from the 2019 RSA PUSKIM data or also from calculations based on SNI 1726-2019. Next is adding Load patterns for earthquakes, dead and live loads. The method is to select define->Load patterns->Ex and Ey ->seismic load type ->auto lateral Load ASCE 7-16. Then add the Live load type. Then add the Superdead load type for additional load. Then click Add New Load. Then the ASCE 7-16 seismic Loading tab will appear. On this tab, fill in the parameters that were previously searched for. These steps are shown in figure 4.11.

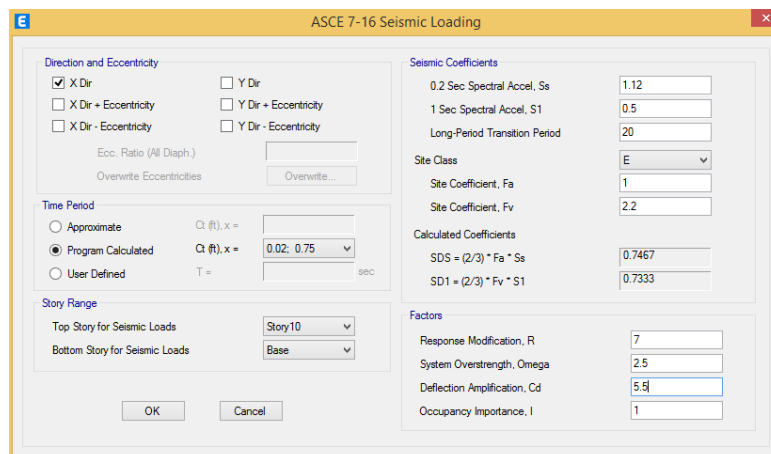


Figure 4. 11 Seismic Loading

The C_t value must comply with SNI 1726 2019, while for the SNI 1726 2012 parameters the method is the same, only the input category is different. Then the

Load cases menu by selecting the define menu -> Load cases-> add new case -> Load case name -> response spectrum-> scale factor for the x direction according to the R_{sx} calculation on the Load case data tab. Then input the spectrum response parameters. These steps are shown in figure 4.12.

Load Type	Load Name	Function	Scale Factor
Acceleration	U2	SNI 1726 2019	1839.38
Acceleration	U1	SNI 1726 2019	551.81

Figure 4. 12 Load Case Data

Perform the same steps for loading the SNI 1726 2012 spectrum response..

5. Input slab dan beam load

Additional load on the floor plate then select the plate that will be given the load -> assign menu -> shell Loads -> Uniform. Then the Load assignment uniform shell tab will appear. On this tab select the type of load to be entered. These steps are shown in figure 4.13.

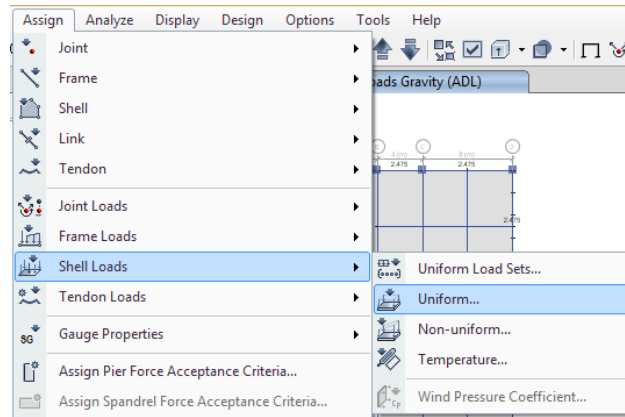


Figure 4. 13 Uniform Shell Load

Then, for the wall load on the beam, select the beam that will be loaded -> assign menu -> frame Loads -> Distributed. Then the Load assignment distributed frame tab will appear. On this tab select the type of load to be entered. These steps are shown in the picture 4.14

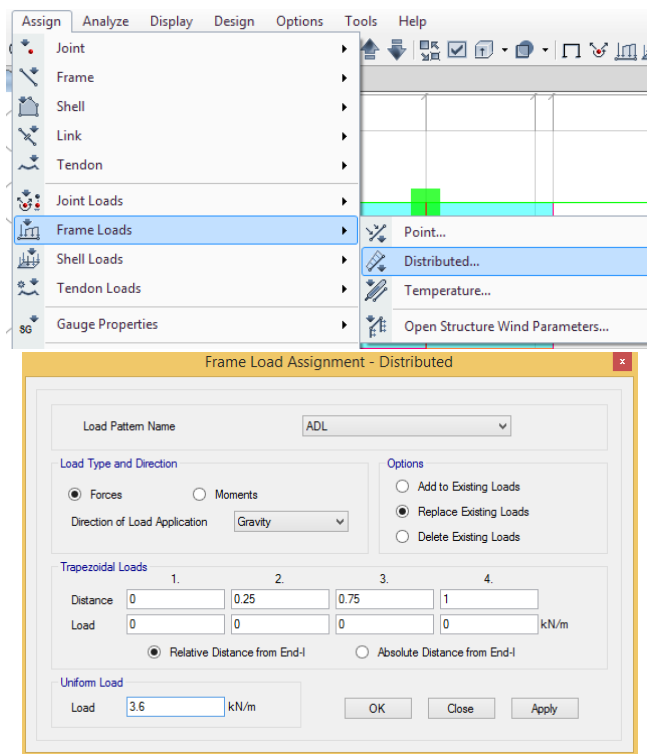


Figure 4. 14 Distributed Load on Beam

Do the same steps for the other plates and beams.

4.5 Research Stage

The research stages are divided into several stages as follows :

1. Preliminary stage

Research begins by looking for previous studies that are related to the research to be conducted. Previous studies can be sourced from journals, scientific articles, theses, regulations and valid sites. Gathering the needs of the research to be carried out is also included at this stage. The needs of this research include earthquake parameters, building plans, building uses and building locations.

2. Structural modeling stage

This stage is the next stage from the previous one. This data stage is carried out if sufficient data has been collected. Building structure modeling using ETABS software. Modeling is done in 3D. This stage attempts to model in software similar to a building plan. The more similar it is to the building plan, the more valid the results at the next stage will be.

The next step is to input the existing loading. These loads include gravity and earthquake loads. The modeling used is 1 piece with different earthquake loading input data.

3. Data analysis stage

This stage is used to process the results obtained in the previous stage. The data obtained is in the form of base shear data, P Delta, stiffness, deviation and irregularity. The results of the processed data will be sorted based on criteria. The first criterion is data produced with the 2012 SNI 1726 earthquake load. Then for the second criterion is data produced with the 2019 SNI 1726 earthquake load. The results of the processed data can be in the form of trend graphs and tables.

The next step is to compare the two criteria. The result of the comparison is the percentage of differences that occur between the 2 criteria. The percentage results can be presented in table form followed by an explanation.

The next step is drawing conclusions. Data that has been processed and compared can draw conclusions.

4. Report writing stage

The systematics of report writing are as follows:

a. Introduction

This chapter contains the background, problem formulation, research objectives and problem limitations.

b. Literature review

This chapter contains previous research that has been carried out and updates that occurred in this research regarding previous research.

c. Basic theory

This chapter contains the basics used as a reference in this research.

d. Research methodology

This chapter contains the methods used in this research.

e. Analysis and discussion

This chapter contains data processing. The results of the processed data will be sorted. The first criterion is based on SNI 1726 2012. The second criterion is based on SNI 1726 2019. The results of processed data can be in the form of trend graphs and tables.

This chapter also contains a comparison between the two criteria. The result of the comparison is the percentage of differences that occur between the 2 criteria. The percentage results can be presented in table form followed by an explanation.

f. Conclusion

This chapter contains conclusions from research and suggestions.

g. Bibliography

This chapter contains a bibliography that is the source for this research.

4.6 Research Flowchart

The research flowchart is shown in figure 4.15.

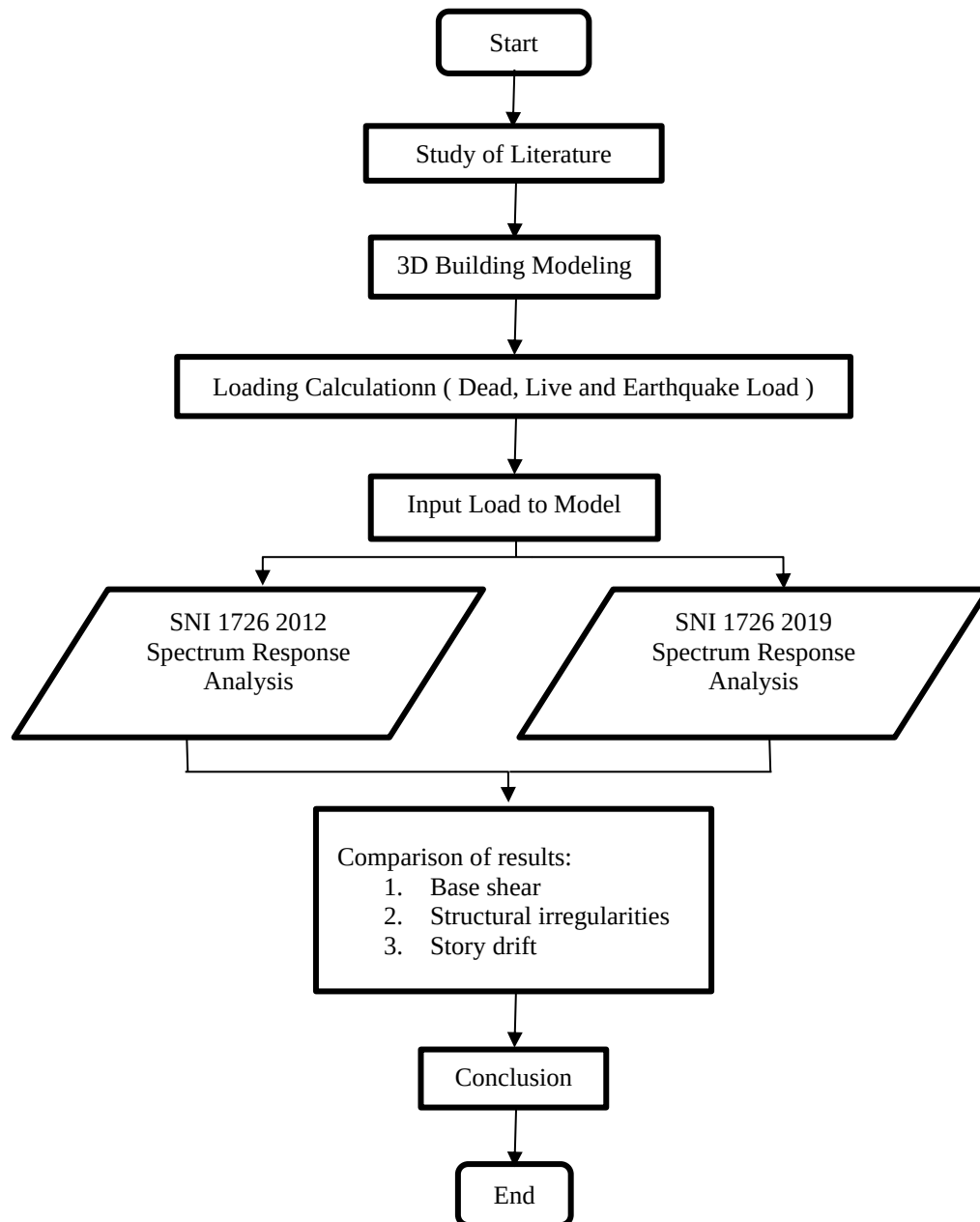


Figure 4. 15 Research Flowchart

CHAPTER V

ANALYSIS AND DISCUSSION

5.1 Building Structure and Gravitational Loading Data

5.1.1 Jambi University FKIK Building Data

Building data from FKIK Jambi University is as follows:

Building function	=	Lecture Building
Building location	=	Telanaipura, District. Telanaipura, Jambi City, Jambi
Structural system	=	Special Moment Resisting Framing Systems
Building height	=	27.5m
Number of floors	=	6
Floor height	=	1st Floor: 4.45 m 2nd floor: 4.5 m Floors 3 to 5: 4 m Floor 6: 6.55 m
Concrete quality	=	30 Mpa
Quality of steel reinforcement	=	BJTS 420B

The building structure model can be seen in figure 5.1 :

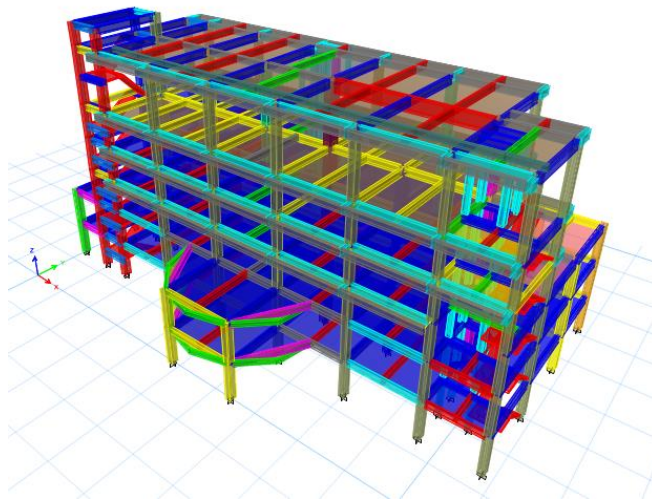


Figure 5. 1 3D Model of Structure

5.1.2 Description of Building Structure Modeling

The structure is modeled as a special moment resisting frame system. This 6-story building modeling uses ETABS 19.1 software. One model of this structure was made with different earthquake force loading. The earthquake force is based on SNI 1726 2012 and 1726 2019.

5.1.3 Soil Type at Building Location

Analysis of soil types at the location of the FKIK Jambi University building is based on the 2022 Indonesian local site atlas (Vs30). The map of the distribution of soil types is shown in figure 5.2.

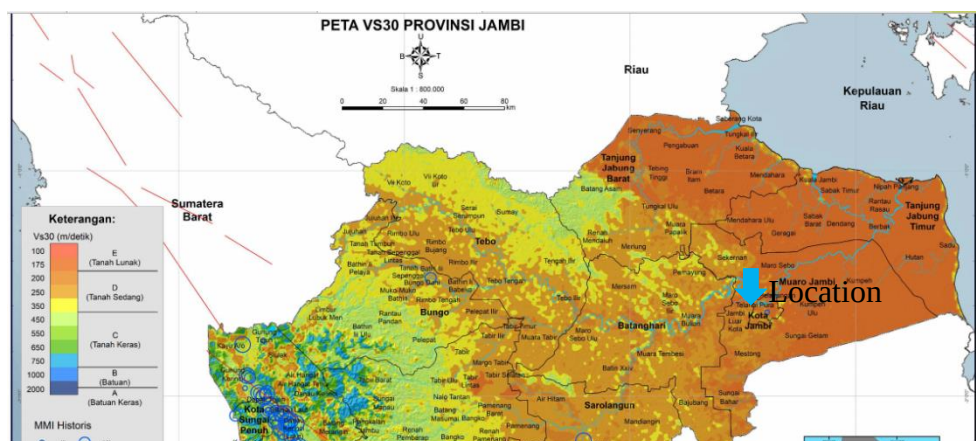


Figure 5. 2 Vs30 Map of Jambi Province

(Source: Ministry of Energy and Mineral Resources, 2022)

Based on Figure 5.1, it is known that the type of soil at the location of the Jambi University FKIK building is soft soil with a v_{s30} speed of 175 m/sec.

5.1.4 Living Load

Based on SNI 1727 2020, the minimum live load on a floor in a building depends on its use. The live load on the Jambi University FKIK building is as follows:

Office room	=	2.4 kN/m ²
Corridor above the 1st floor	=	3.83 kN/m ²
Meeting room	=	4.79 kN/m ²
Roof	=	0.96 kN/m ²

5.1.5 Additional Dead Load on Slabs

The additional dead load value on the floor slab of the Jambi University FKIK building is shown in table 5.1.

Table 5. 1 Additional Dead Load on Floor Slabs

Type	Thick(m)	Weight per volume (kN/m ³)	Result	Unit
a	b	c	d = b * c	e
Spesi	0,03	22	0,66	kN/m ²
Sand	0,01	16	0,16	kN/m ²
Floortile	0,01	22	0,22	kN/m ²
Ceiling			0,2	kN/m ²
ME			0,25	kN/m ²
Other			0,5	kN/m ²
Sum			1,99	kN/m ²
Rounding			2	kN/m ²

Based on table 5.1, it is known that the additional load on the floor slab is 2 kN/m².

5.1.6 Additional Dead Load on Beam Due to Wall

The load on the wall is directly supported by the large beam below it. Therefore it is necessary to add additional dead load to the beam. The additional dead load due to the wall is influenced by the thickness, material and net height of the

wall. The walls of this building are made of light brick material with a thickness of 12 cm. The net height of each floor is influenced by the height between floors and beams. The value of additional dead load on the beam is shown in table 5.2. The weight of a light weight brick is the specific gravity multiplied by the thickness, namely $0.75 * 0.12 = 0.9 \text{ kN/m}^2$.

Table 5. 2 Additional Load on Beam Due to Wall

Beam Location	Clear Height (m)	Weight per area (kN/m^2)	Result	Unit
a	b	c	$d = b * c$	e
Lt2	3,7	0,9	3,33	kN/m
Lt3 to 5	3,2	0,9	2,88	kN/m
Lt6	5,75	0,9	5,175	kN/m
Top Stair	1,7	0,9	1,53	kN/m

Based on table 5.2, it is known that the largest additional dead load is 5.175 kN/m on the 6th floor. Then the smallest additional dead load is 2.88 kN/m on floors 3 to 5. The analysis in this building is assumed to have a uniform wall load. Of 3.3 kN/m.

5.2 Earthquake Load Analysis Based on SNI 1726 2012

5.2.1 Risk Categories and Building Priority Factors

The risk category for a building is related to the type of use of the building. Based on table 1 SNI 1726 2012, the Jambi University FKIK building has risk category IV. Based on SNI 1726 2012, buildings with risk category IV have an earthquake priority factor of 1.5.

5.2.2 Peak Ground Acceleration Parameters

Based on article 6.1.1 SNI 1726 2012, short period bedrock accelerations, namely 0.2 seconds (S_s) and 1 second (S_1), must use an acceleration map with a probability of exceedance of 2% in 50 years. The S_s and S_1 values were obtained from the response spectrum analysis website of the Ministry of Public Works. This value is based on the PUPR Ministry's 2010 earthquake source and hazard map. Based on this site, the PGA value is 0.106 g. Meanwhile, the S_s value is 0.213 g and the S_1 value is 0.171 g.

5.2.3 Design Acceleration Parameters

Based on SNI 1726 2012, the design acceleration parameters are determined by the site class coefficient. The F_a value is a short-period site coefficient. The F_a value can be seen in table 5.3. Meanwhile, F_v is the site coefficient for a period of 1 second. The F_v value can be seen in table 5.4.

Table 5. 3 Site Coefficient, F_a SNI 1726 2012

Site Class	Earthquake Acceleration Spectral Response Parameters (MCER) Mapped on Short Periods, $T = 0.2$ seconds, S_s				
	$S_s \leq 0,25$	$S_s = 0,5$	$S_s = 0,75$	$S_s = 1$	$S_s \geq 1,25$
SA	0,8	0,8	0,8	0,8	0,8
SB	1	1	1	1	1
SC	1,2	1,2	1,1	1	1
SD	1,6	1,4	1,2	1,1	1
SE	2,5	1,7	1,2	0,9	0,9
SF	SS^b				

(Source = SNI 1726 2012)

Based on table 5.3, the value of F_a is 2.5.

Table 5. 4 Site Coefficient, F_v SNI 1726 2012

Site Class	Earthquake Acceleration Spectral Response Parameters (MCER) Mapped at 1 second Period, S_1				
	$S_1 \leq 0,1$	$S_1 = 0,2$	$S_1 = 0,3$	$S_1 = 0,4$	$S_1 \geq 0,5$
SA	0,8	0,8	0,8	0,8	0,8
SB	1	1	1	1	1
SC	1,7	1,6	1,5	1,4	1,3
SD	2,4	2	1,8	1,6	1,5
SE	3,5	3,2	2,8	2,4	2,4
SF	SS^b				

(Source = SNI 1726 2012)

Based on table 5.4, the value of F_v is 3.287 using interpolation. So the calculation of sds and $sd1$ is as follows:

$$SD = 0.213 * 2/3 * 2.5$$

$$SD = 0.355 \text{ g}$$

$$SD1 = 0.171 * 2/3 * 3.287$$

$$SD1 = 0.37472 \text{ g}$$

So the spectrum response graph is shown in Figure 5.3.

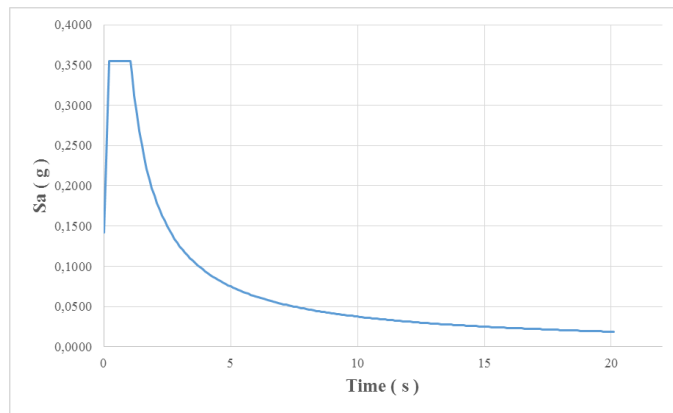


Figure 5. 3 SNI 1726 2012 Spectrum Response

(Source = SNI 1726 2012)

Based on Figure 5.3, it is known that the largest Sa value is 0.355 g, while the smallest value at 20 seconds is 0.0186 g.

5.2.4 Effective Seismic Weight

Based on SNI 1726 2012, the effective seismic weight of a structure must include all existing dead loads and other loads. The other load is 25% of the floor live load. An example of calculating the effective seismic weight on a roof floor is as follows:

Elevation	=	27.5 m
Specific gravity of concrete	=	24 kN/m ³
Additional dead load	=	2 kN/m ²
Live load	=	1.92 kN/m ²
Plate load		
Plate type	=	S2a-150
Thick	=	0.15 m
Wide	=	1145.3143 m ²
Volume	=	thick * wide
	=	171.79715 m ³
Heavy	=	171,797*24
	=	4123.1315 kN
Plate type	=	S3-160

Thick	=	0.16	m
Wide	=	53.04	m ²
Volume	=	thick * wide	
	=	8.4864	m ³
Heavy	=	8.486*24	
	=	203.6736	kN
Plate type	=	S3a-160	
Thick	=	0.16	m
Wide	=	3,515	m ²
Volume	=	thick * wide	
	=	0.5624	m ³
Heavy	=	0.562*24	
	=	13.4976	kN
Beam loads by type			
B1-30/70			
Beam length, p	=	3.9976052	m
Beam height, t	=	0.3	m
Beam width, l	=	0.7	m
Volume	=	P*t*l	
	=	0.8394971	
Heavy	=	0.839*24	
	=	20.14793	kN
B1b-30/70			
Beam length, p	=	7.268373	m
Beam height, t	=	0.3	m
Beam width, l	=	0.7	m
Volume	=	P*t*l	
	=	1.5263583	m ³
Heavy	=	1.526*24	
	=	36.6326	kN
B1c-30/70			
Beam length, p	=	73.352321	m
Beam height, t	=	0.3	m
Beam width, l	=	0.7	m
Volume	=	P*t*l	
	=	15.403988	m ³
Heavy	=	15,404*24	
	=	369.6957	kN
B2-25/50			
Beam length, p	=	16.278767	m
Beam height, t	=	0.25	m
Beam width, l	=	0.5	m

Volume	=	$P \cdot t \cdot l$	
	=	2.0348458	m ³
Heavy	=	$2,035 \cdot 24$	
	=	48.8363	kN
B2a-30/50			
Beam length, p	=	53.741936	m
Beam height, t	=	0.3	m
Beam width, l	=	0.5	m
Volume	=	$P \cdot t \cdot l$	
	=	8.0612904	m ³
Heavy	=	$8,061 \cdot 24$	
	=	193.47097	kN
B2b-30/50			
Beam length, p	=	5.6064722	m
Beam height, t	=	0.3	m
Beam width, l	=	0.5	m
Volume	=	$P \cdot t \cdot l$	
	=	0.8409708	m ³
Heavy	=	$0.841 \cdot 24$	
	=	20,1833	kN
B3-30/70			
Beam length, p	=	50.658383	m
Beam height, t	=	0.3	m
Beam width, l	=	0.7	m
Volume	=	$P \cdot t \cdot l$	
	=	10.63826	m ³
Heavy	=	$10.638 \cdot 24$	
	=	255.31825	kN
B4a-30/70			
Beam length, p	=	105.31439	m
Beam height, t	=	0.3	m
Beam width, l	=	0.7	m
Volume	=	$P \cdot t \cdot l$	
	=	22.116023	m ³
Heavy	=	$22.116 \cdot 24$	
	=	530.78454	kN
B5-60/130			
Beam length, p	=	17.620314	m
Beam height, t	=	1.3	m
Beam width, l	=	0.6	m
Volume	=	$P \cdot t \cdot l$	
	=	13.743845	m ³

Heavy	=	13,744*24	
	=	329.85227	kN
B6-40/80			
Beam length, p	=	144.16619	m
Beam height, t	=	0.4	m
Beam width, l	=	0.8	m
Volume	=	P*{t*l}	
	=	46.13318	m ³
Heavy	=	46.133*24	
	=	1107,1963	kN
B7-30/70			
Beam length, p	=	70.030774	m
Beam height, t	=	0.3	m
Beam width, l	=	0.7	m
Volume	=	P*{t*l}	
	=	14.706463	m ³
Heavy	=	14,706*24	
	=	352.9551	kN
B7e-30/70			
Beam length, p	=	27.299246	m
Beam height, t	=	0.3	m
Beam width, l	=	0.7	m
Volume	=	P*{t*l}	
	=	5.7328417	m ³
Heavy	=	5,733*24	
	=	137.5882	kN
CB6-40/80			
Beam length, p	=	32.09819	m
Beam height, t	=	0.4	m
Beam width, l	=	0.8	m
Volume	=	P*{t*l}	
	=	10.271421	m ³
Heavy	=	10,271*24	
	=	246.5141	kN
CB7-40/80			
Beam length, p	=	9.1933333	m
Beam height, t	=	0.4	m
Beam width, l	=	0.8	m
Volume	=	P*{t*l}	
	=	2.9418667	m ³
Heavy	=	2,942*24	
	=	70.6048	kN

Additional dead load			
Mark	=	2	kN/m ²
Wide	=	1201.8693	m ²
Heavy	=	1201,869*2	
	=	2403.7386	kN
Live load			
Mark	=	1.92	kN/m ²
Participation	=	0.25	
Wide	=	1201.8693	m ²
Heavy	=	1201.869*1.92*0.25	
	=	576.89727	kN
Addition			
Own burden	=	8060.0831	kN
Additional dead load	=	2403.7386	kN
Live load	=	576.89727	kN
Total	=	11040.70	kN

Based on the calculations above, it is known that the earthquake effect weight value on the top floor is 11040.72 kN. The effective seismic weight of each other floor is shown in table 5.5

Table 5. 5 Effective Seismic Weight SNI 1726 2012

Story	Effective Seismic Weight	Effective Seismic Weight
	kg	kN
a	b	c=b*9,81/1000
Top	1125453,32	11040,70
Fl 6	1171678,66	11494,17
Fl 5	1121138,95	10998,37
Fl 4	1361838,88	13359,64
Fl 3	1467408,04	14395,27
Fl 2	1505622,88	14770,16
Sum		76058,31

Based on table 5.5, it is known that the effective seismic weight of the Jambi University FKIK building is 76058.31 kN. The floor with the heaviest seismic weight is located on the 2nd floor. This happens because of the difference in the net footprint area of each floor.

5.2.5 Mass Participation Modal Structure

Based on SNI 1726 2012 in 7.9.1, the minimum number of variations is 90% of the actual mass in each orthogonal direction. This analysis was carried out with the results obtained from Etabs. The value of structural mass participation is shown in table 5.6.

Table 5. 6 Mass Participation Modal Structure SNI 1726 2012

Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ
1	1,418	0,7622	0,0051	0,0000017	0,7622	0,0051	0,0000017
2	1,266	0,0054	0,6658	2,671E-06	0,7676	0,6709	4,371E-06
3	1,083	0,0001	0,0548	4,264E-06	0,7677	0,7257	8,635E-06
4	0,539	0,1193	0,0001	2,097E-06	0,887	0,7258	1,073E-05
5	0,492	1,181E-06	0,1454	1,368E-05	0,887	0,8712	2,441E-05
6	0,443	0,0016	0,0078	2,585E-05	0,8885	0,879	0,0001
7	0,289	0,0529	3,052E-05	2,758E-06	0,9414	0,879	0,0001
8	0,276	0,0009	9,432E-07	0,0004	0,9424	0,879	0,0004
9	0,247	1,022E-05	0,0496	0,0001	0,9424	0,9286	0,0005
10	0,226	0,0002	0,0086	8,304E-06	0,9426	0,9372	0,0005
11	0,212	2,327E-06	0,0001	0,0007	0,9426	0,9373	0,0012
12	0,206	1,871E-06	6,763E-06	0,0332	0,9426	0,9373	0,0344

Based on table 5.6, it is known that the total participation value for the x direction is 94.26%. Meanwhile, the y direction is 93.73%. This value exceeds the required 90%, so it is in accordance with the requirements of SNI 1726 2012.

5.2.6 Fundamental Period of Structure

Based on SNI 1726 2012, the C_t value for this structure is 0.0466 and x is 0.9. The height of this building is 27.5 m. Then there is an upper limit coefficient factor for the calculated period. The magnitude of the upper limit coefficient depends on the value of S_d1 . The upper limit coefficient value is 1.4. So the calculation of the fundamental period of the structure is as follows:

$$\begin{aligned}
 T_a &= 0.0466 * 27.50.9 \\
 &= 0.9199 \text{ seconds} \\
 C_u * T_a &= 1.4 * 0.9199 \\
 &= 1.288 \text{ seconds}
 \end{aligned}$$

Based on the calculations above, the fundamental period value of the structure is 0.9199 seconds. Then the upper limit value of the fundamental period is 1.288 seconds.

The fundamental period value needs to be compared with the results of the ETABS analysis. Based on table 5.6, the fundamental period of the x direction structure is 1.418 seconds. It is known that the value of the fundamental period in the x direction exceeds the upper limit value of the fundamental period of SNI 1726 2012. Therefore, the value of the fundamental period in the x direction is taken to be 1.288 seconds.

Then based on table 5.6 the fundamental period of the y direction structure is 1.266 seconds. It is known that the value of the fundamental period in the y direction exceeds the lower limit value of the SNI 1726 2012 fundamental period but does not exceed the upper limit value. So the value of the fundamental period in the y direction is taken to be 1.266 seconds.

5.2.7 Static Earthquake Equivalent to SNI 1726 2012

The calculation of equivalent static earthquake analysis is quite simple, namely multiplying the seismic response coefficient (C_s) by the gravity load. The seismic response coefficient formula is divided into 3, namely C_s , minimum C_s and maximum C_s . So the calculation of the seismic response coefficient value in the x direction is as follows:

$$C_s = 0.355 / (8 / 1.5) \quad (3.12)$$

$$C_s = 0.0666 \text{ g}$$

$$\begin{aligned} C_s \text{ max} &= 0.37472 / (1.288 * (8 / 1.5)) \\ &= 0.0545 \text{ g} \end{aligned} \quad (3.13)$$

$$\begin{aligned} C_s \text{ min} &= 0.044 * 0.355 * 1.5 \\ &= 0.02343 \text{ g} \end{aligned} \quad (3.14)$$

Based on the calculations above, it can be concluded that the C_s value exceeds the maximum C_s value. So the seismic response coefficient used for the x direction is 0.0545 g. Then calculate the maximum seismic response coefficient value in the y direction as follows:

$$\begin{aligned} C_s \text{ max} &= 0.37472 / (1.266 * (8 / 1.5)) \\ &= 0.0555 \text{ g} \end{aligned} \quad (3.13)$$

Based on the calculations above, it can be concluded that the C_s value exceeds the maximum C_s value. So the seismic response coefficient used for the y direction is

0.0555 g. Then carry out an analysis of the weight of the structure. The effective seismic structure weight based on table 5.6 is found to be 76058.31 kN. So the calculation of the equivalent static earthquake load of SNI 1726 2012 is as follows:

$$\begin{aligned}
 V_x &= 0.0545 * 76058.31 & (3.11) \\
 &= 4148.96 \text{ kN} \\
 V_y &= 0.0555 * 76058.31 \\
 &= 4221.033 \text{ kN}
 \end{aligned}$$

Based on the calculation above, the basic shear force value in the x direction is 4148.96 kN while the y direction is 4221.033 kN.

5.2.8 2012 SNI 1726 Dynamic Earthquake

Dynamic earthquake analysis uses spectrum response analysis. The spectrum response analysis used is unscaled (R_{su}) and scaled (R_{ss}) spectrum responses. Earthquake scaling based on SNI 1726 2012 is 85% of the basic static earthquake shear force. The input value in one direction of the earthquake response spectrum must represent 100% in the same direction and 30% in the perpendicular direction.

The spectrum response factor formula for input to the Etabs program is shown in 5.7. Then the spectrum response factor formula which has been scaled with the static base earthquake force for input to the Etabs program is shown in 5.8.

$$\begin{aligned}
 R_{su} &= 9810 * \frac{I_e}{R} (\text{Unit mm/second}) & (5.7) \\
 R_{ss} &= 9810 * \frac{I_e}{R} * (0.85 * \frac{V_{statik}}{R_{su}}) (\text{Unit mm/second})
 \end{aligned}$$

Based on formula 5.7. The R_{su} value is a dynamic earthquake factor that has not been scaled to the equivalent static earthquake. Calculation of the earthquake scale for the unscaled spectrum response factor (R_{su}) is as follows:

$$\begin{aligned}
 \text{Factor } R_{su} (x) &= 9810 * (1.5 / 8) \\
 &= 1839.38 \\
 0.3 * R_{su} \text{ factor } (x) &= 551.814 \\
 R_{su} \text{ Factor } (y) &= 9810 * (1.5 / 8) \\
 &= 1839.38 \\
 0.3 * R_{su} \text{ factor } (y) &= 551.814
 \end{aligned}$$

Based on the calculations above, it is known that the R_{su} earthquake scale values in the X and Y directions are the same. The scale value is 1839.38. Meanwhile, the value of 30% from the perpendicular direction is 551.814. Then, using ETABS software, the basic shear force value of the analysis spectrum response is shown in table 5.7.

Table 5. 7 Spectrum Response Results Not yet scaled to SNI 1726 2012

Type	Direction (kN)	
	X	Y
$R_{su} (x)$	2953,0577	948,8579
$R_{su} (y)$	951,434	2943,8338

Based on table 5.7, it is known that the value of the basic shear force $R_{su} (x)$ in the x direction is 2953.0577 kN while the y direction is 948.86 kN. Then the value of the basic shear force $R_{su} (x)$ in the x direction is 951.434 kN while the y direction is 2943.834 kN. The difference in the results of the basic shear force between the two is caused by the difference in the fundamental period in the X direction and Y direction. Then the calculation of the dynamic versus static earthquake force scaling is as follows:

x direction

$$\text{Factor } R_{su} (x) = 1839.38$$

$$\text{The basic shear force} = 2953.0577 \text{ kN}$$

$R_{su} (x)$ is in the same direction

$$\text{The basic shear force} = 948.8579 \text{ kN}$$

$R_{su} (x)$ is in the perpendicular direction

$$\begin{aligned} 0.85 V_{static} (x) &= 4148.96 * 0.85 \\ &= 3526.62 \text{ kN} \end{aligned}$$

$$30 \% * 0.85 V_{static} (x) = 1057.98 \text{ kN}$$

$$\begin{aligned} \text{The factor } R_{ss} (x) \text{ is in} &= 1839.38 * (3526.62 / 2953.0577) \\ \text{the same direction} & \end{aligned}$$

$$= 2196.63$$

$$\text{Factor } R_{ss} (x) \text{ is} = 551,814 * (1057.98 / 948.8579)$$

perpendicular

$$\text{Factor } R_{ss} (x) \text{ is } = 615,276$$

perpendicular

Y direction

$$R_{su} \text{ Factor (y)} = 1839.38$$

$$\text{The basic shear force} = 2943.834 \text{ kN}$$

$R_{su} (y)$ is in the same

direction

$$\text{The basic shear force} = 951.434 \text{ kN}$$

$R_{su} (y)$ is in the

perpendicular direction

$$0.85 V_{\text{static}} (x) = 4221.0335 * 0.85$$

$$= 3587.88 \text{ kN}$$

$$30 \% * 0.85 V_{\text{static}} (x) = 1076.36 \text{ kN}$$

$$\text{The factor } R_{ss} (x) \text{ is in } = 1839.38 * (3587.88 / 2943.834)$$

the same direction

$$= 2241.79$$

$$\text{Factor } R_{ss} (x) \text{ is } = 551,814 * (1076.36 / 951,434)$$

perpendicular

$$\text{Factor } R_{ss} (x) \text{ is } = 624,269$$

perpendicular

Based on the calculation above, the scale value for $R_{ss} (x)$ in the same direction is 2196.63. Meanwhile, the perpendicular direction is 615.276. Then the scale value for $R_{ss} (y)$ in the same direction is 2241.79. Meanwhile for the perpendicular direction it is 624,269. The scale value is then input into the ETABS software. The results of the calculations are then checked. This check is useful to ensure that the dynamic earthquake base shear force is more than 85% of the static base shear force. The results of the dynamic base shear force which have been scaled can be seen in table 5.8.

Table 5. 8 Check the Static and Dynamic Earthquake SNI 1726 2012

Type	Direction (kN)		Seismic Scale	
	x	y	x	y
Static x	3526,615004	1057,984501		
Static y	1076,363536	3587,878453		
Rss (x)	3528,534	1071,0639	OK	OK
Rss (y)	1090,5343	3589,5026	OK	OK

Based on table 5.8, it is known that the dynamic base shear force value is greater than 85% of the static earthquake force. Therefore, it is in accordance with the requirements of SNI 1726 2012.

5.2.9 Inter Story Drift

Based on table 16 of SNI 1726 2012, the deviation limit for buildings with risk category IV in other types of structures is 0.01 H (height between floors under consideration). The x and y deviation data were obtained from the ETABS results. An example of calculating the acceptance deviation in the x direction with an earthquake load response spectrum that has not been scaled is as follows:

$$\begin{aligned}
 \Delta X &= (C_d * \text{deviation}) / 1.5 \\
 &= (5.5 * \text{deviation}) / 1.5 \\
 \text{Elastic deviation in the} &= 35.38\text{mm} \\
 \text{x direction of the Roof} & \\
 \text{floor} & \\
 \text{Elastic deviation in the} &= 28.45\text{mm} \\
 \text{x direction of the 6th} & \\
 \text{floor} & \\
 \Delta X &= (5.5 * (35.38 - 28.45)) / 1.5 \\
 &= 25.41\text{mm} \\
 \Delta X \text{ permission} &= 6550 * 0.01 \\
 &= 65.5\text{mm} \\
 \text{Check} &= \Delta X < \Delta X \text{ permission (Safe)}
 \end{aligned}$$

Then, to calculate the deviation on other floors with earthquake loads, the unscaled response spectrum (Rsu) is shown in table 5.9.

Table 5. 9 Deviation Between Floors Earthquake Load Rsu SNI 1726 2012

Story	Displacement		Elastic Drift		Inelastic Drift		Floor Height	Check
	δe_x	δe_y	δe_x	δe_y	Δ_x	Δ_y		
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)		
Top	35,38	30,27	6,930	7,222	25,410	26,481	6550	Ok
Fl6	28,45	23,05	4,822	4,844	17,681	17,761	4000	Ok
Fl5	23,63	18,20	5,749	5,239	21,080	19,210	4000	Ok
Fl4	17,88	12,97	6,262	4,737	22,961	17,369	4000	Ok
Fl3	11,62	8,23	7,228	5,191	26,503	19,034	4500	Ok
Fl2	4,39	3,04	4,389	3,037	16,093	11,136	4450	Ok

Based on table 5.9, it is known that the deviations that occur in the Jambi University FKIK building are in the safe category (deviations occurring <permissible deviations).

5.2.10 Horizontal Irregularities

Based on SNI 1726 2012, horizontal irregularities are divided into 5. The following is an analysis of each irregularity.

1. Torsion Irregularities

Torsion irregularities are divided into torsional and excessive irregularities.

The classification of torsional irregularities is as follows:

$$\delta_{\max} < 1.2 \delta_{\text{avg}} \quad = \quad \text{There is no torsional imbalance}$$

$$1.2 \delta_{\text{avg}} \leq \delta_{\max} \leq 1.4 \delta_{\text{avg}} \quad = \quad \text{torsional irregularity 1a}$$

$$\Delta_{\max} > 1.4 \delta_{\text{avg}} \quad = \quad \text{torsional irregularity 1b}$$

Then check the torsional irregularities on each floor with the unscaled earthquake response spectrum load (Rsu) shown in table 5.10.

**Table 5. 10 Check for Irregularities in Rsu SNI 1726 2012 Earthquake
Load Torque**

Story	X Direction					Y Direction				
	Δ_{max}	Δ_{avg}	$\Delta_{max}/\Delta_{avg}$	Cek		Δ_{max}	Δ_{avg}	$\Delta_{max}/\Delta_{avg}$	Check	
				<1,2	<1,4				<1,2	<1,4
Top	35,671	35,465	1,006	Save	Save	43,892	32,986	1,331	1a	Save
Fl6	28,613	28,503	1,004	Save	Save	33,663	25,028	1,345	1a	Save
Fl5	23,701	23,66	1,002	Save	Save	26,588	19,704	1,349	1a	Save
Fl4	17,92	17,899	1,001	Save	Save	19,278	14,282	1,35	1a	Save
Fl3	11,659	11,637	1,002	Save	Save	12,66	9,351	1,354	1a	Save
Fl2	4,428	4,405	1,005	Save	Save	4,652	3,443	1,351	1a	Save

(Source = Own analysis)

Based on table 5.10, it is known that the ratio between the maximum and average deviation does exceed 1.2. So it can be ensured that there will be torque irregularities. Then check the torsional irregularities on each floor with the scaled spectrum response earthquake load (Rss) shown in table 5.11.

**Table 5. 11 Check Irregularities in Earthquake Load Torque Rss SNI 1726
2012**

Story	X Direction					Y Direction				
	Δ_{max}	Δ_{avg}	$\Delta_{max}/\Delta_{avg}$	Cek		Δ_{max}	Δ_{avg}	$\Delta_{max}/\Delta_{avg}$	Check	
				<1,2	<1,4				<1,2	<1,4
Top	42,61	42,369	1,006	Save	Save	53,519	40,22	1,331	1a	Save
Fl6	34,179	34,052	1,004	Save	Save	41,047	30,516	1,345	1a	Save
Fl5	28,312	28,268	1,002	Save	Save	32,42	24,025	1,349	1a	Save
Fl4	21,411	21,385	1,001	Save	Save	23,506	17,414	1,35	1a	Save
Fl3	13,925	13,902	1,002	Save	Save	15,436	11,401	1,354	1a	Save
Fl2	5,29	5,261	1,006	Save	Save	5,672	4,199	1,351	1a	Save

Based on table 5.11, it is known that the ratio between the maximum and average deviation does exceed 1.2. So it can be ensured that there will be torque irregularities.

2. Internal Corner Irregularities

Internal angle irregularities occur when $P_y > 0.15L_y$ or $P_x > 0.15L_x$. These parameters require reviewing the building plan. The building plan is shown in figure 5.4.

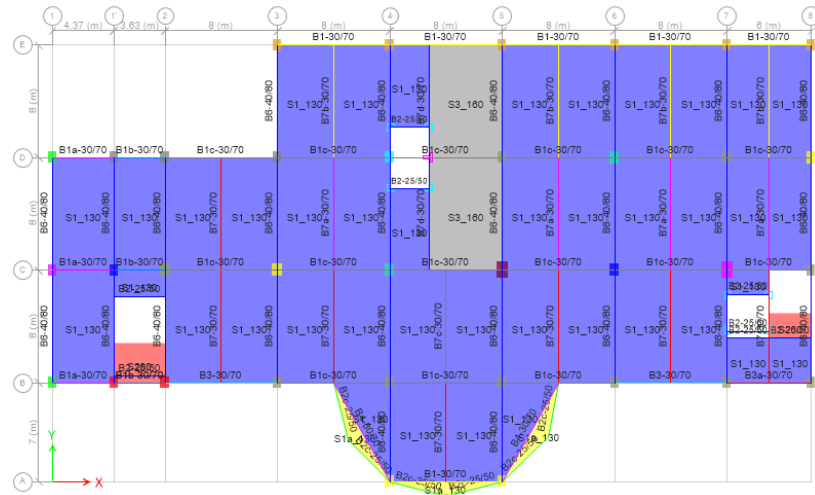


Figure 5.4 2nd Floor Plan of the FKIK Building, Jambi University

Based on Figure 5.4, it is known that the plan has inner corners located in the left and bottom right corners. Then the inner corner areas at the bottom right and bottom left are typical so the calculation is carried out on only one of them. Check internal corner irregularities as follows:

Location	=	Top left corner
Px	=	16m
Lx	=	54 m
Lx / Lx	=	0.2963
Check	=	Internal corner irregularities occur
Py	=	8m
Ly	=	31 m
Py/Ly	=	0.2581
Check	=	Internal corner irregularities occur

Based on the calculations above, it can be concluded that there is an internal angle irregularity in the x and y directions. Then check the inside angle located below as follows:

Location	=	The bottom left corner
Px	=	20 m
Lx	=	54 m
Lx / Lx	=	0.3704
Check	=	Internal corner irregularities occur

$$\begin{aligned}
 P_y &= 7\text{m} \\
 L_y &= 31\text{ m} \\
 P_y/L_y &= 0.2258 \\
 \text{Check} &= \text{Internal corner irregularities occur}
 \end{aligned}$$

Based on the calculations above, it can be concluded that there is an internal angle irregularity in the x and y directions.

3. Diaphragm Discontinuity Irregularities

This irregularity is defined if there is an opening of 50% of the gross area on the lower floor. Based on Figure 5.7, it can be seen that there is no change in openings that exceeds 50%. Therefore, in this structure there is no irregularity in the diaphragm discontinuity.

4. The Irregularity of Transverse Story drift Against the Plane

This irregularity occurs when there is a discontinuity in the path of the lateral support element, such as a transverse shift in the vertical plane. The plan of the building section is shown in Figure 5.5.

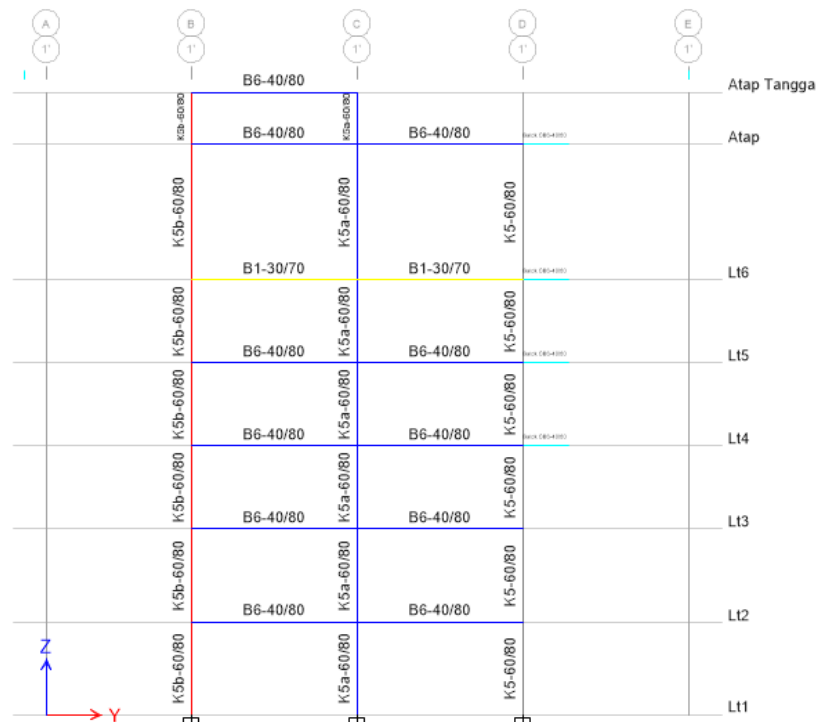


Figure 5. 5 Piece of Jambi University FKIK Building

Based on Figure 5.5, that this building does not experience irregular transverse shifts in the plane.

5. Irregularities of Nonparallel Systems

This irregularity occurs when the vertical lateral resisting elements are not parallel or symmetrical to the main orthogonal axis of the seismic resisting system. Based on Figure 5.7, it is known that the lateral force resisting element is parallel to the main orthogonal axis. So that in this building there will be no irregularities in the nonparallel system.

5.2.11 Vertical Irregularities

Based on SNI 1726 2012, vertical irregularities are divided into 5. The following is an analysis of each irregularity:

1. Soft Level Stiffness Irregularities

Soft grade stiffness irregularities are divided into soft grade and excessive stiffness irregularities. Soft story irregularities occur when there is a story that has a lateral stiffness $<70\%$ of the lateral stiffness of the story above it or $<80\%$ of the average stiffness of the three stories above it. Then excessive soft level irregularities occur when there is a level that has a lateral stiffness $<60\%$ of the lateral stiffness of the level above or $<70\%$ of the average stiffness of the three levels above. Then check the soft level irregularities on each floor with the unscaled response spectrum earthquake load (R_{su}) shown in table 5.12.

**Table 5. 12 Check for Irregularities Stiffness Soft Level Earthquake Load
 R_{su} SNI 1726 2012**

Story	X Direction			Y Direction		
	Stiffnes kN/m	Check V1a	Check V1b	Stiffnes kN/m	Check V1a	Check V1b
Top	855931			687328		
F16	967786	Ok	Ok	694923	Ok	Ok
F15	1106493	Ok	Ok	712182	Ok	Ok
F14	1304283	Ok	Ok	752719	Ok	Ok
F13	1632239	Ok	Ok	858684	Ok	Ok
F12	2259154	Ok	Ok	1137140	Ok	Ok

Based on table 5.12, it is known that there are no irregularities in soft level stiffness and excessive soft level. Then check the soft level irregularities on each floor with the scaled spectrum response earthquake load (Rss) shown in table 5.13.

**Table 5. 13 Check Irregularities Soft Level Stiffness Earthquake Load Rss
SNI 1726 2012**

Story	X Direction			Y Direction		
	Stiffnes	Check V1a	Check V1b	Stiffnes	Check V1a	Check V1b
	kN/m			kN/m		
Top	121349			115525		
Fl6	284567	Ok	Ok	284596	Ok	Ok
Fl5	328791	Ok	Ok	374623	Ok	Ok
Fl4	377362	Ok	Ok	460555	Ok	Ok
Fl3	436194	Ok	Ok	517264	Ok	Ok
Fl2	670680	Ok	Ok	854949	Ok	Ok

Based on table 5.13, it is known that by using the scaled response spectrum earthquake load structure of the Jambi University FKIK building, there are no soft level stiffness irregularities and excessive soft levels.

2. Weight Irregularities (Mass)

This irregularity occurs when the effective weight of all stories is more than 150% of the effective weight of adjacent stories. Then, roofs that are lighter than the floor below can be ignored in checking. The mass on each floor is obtained from the Etabs output. An example of a weight irregularity check calculation is as follows:

$$\begin{aligned}
 \text{3rd floor mass} &= 1467408 \text{ kg} \\
 \text{2nd floor mass} &= 1505623 \text{ kg} \\
 \text{Difference} &= 1467408 - 1505623 \\
 &= -38215 \text{ kg} \\
 \text{Comparison} &= -38215 / -1505623 \\
 &= 2.5\% \text{ (No mass irregularities occur)}
 \end{aligned}$$

Then the calculation of mass irregularities on other floors based on SNI 1726 2012 is shown in table 5.14.

Table 5. 14 Check Mass Irregularities SNI 1726 2012

Story	Massa	Check the Difference	Check the Difference
	kg		
Top	1125453	Ok	
Fl6	1171679	Ok	Ok
Fl5	1121139	Ok	Ok
Fl4	1361839	Ok	Ok
Fl3	1467408	Ok	Ok
Fl2	1505623	Ok	Ok

Based on table 5.14, it is known that there is no mass irregularity.

3. Vertical Geometry Irregularities

This irregularity occurs when the dimensions of the lateral resisting elements at any level are more than 130% of the horizontal dimensions of the adjacent lateral force resisting system. Based on Figure 5.8, it is known that all columns from the ground level to the roof have the same dimensions or sizes so it can be concluded that there is no vertical geometric irregularity.

4. Plane Direction Discontinuity in Irregularities of Vertical Lateral Force Resisting Elements

This irregularity occurs when there is a shift in the direction of the lateral force resisting plane that is greater than the length of the element or there is a reduction in the stiffness of the lateral force resisting element at the lower level. Based on Figure 5.8, it is known that all the columns at the bottom level up to the roof have no plane shift, so it can be concluded that there is no plane direction discontinuity in the irregularity of the elements resisting vertical lateral forces.

5. Discontinuities in Strong Lateral Level Irregularities

Level lateral strength stiffness irregularities are divided into level and excessive lateral strength irregularities. Irregularities in the lateral strength of a story occur when the lateral force of a story is less than 80% of the lateral force of the story above. Then for excessive level strength irregularities, namely irregularities that occur when the lateral force of the level is less than 65% of the lateral force of the level above. An example of a calculation for checking irregularities in the lateral strength of a story is as follows:

Story Force Lt 6 = 1495.76 kN (x direction)
 Story Force Lt 5 = 1978.01 kN (x direction)
 Comparison = $1978.01 : 0.8 * 1495.76$
 = $1978.01 > 1196.611$
 Results = Safe

Then, to calculate lateral strength irregularities on other floors with unscaled earthquake loads, the response spectrum (Rsu) is shown in table 5.15.

**Table 5. 15 Check for Irregularity in Lateral Strength of Earthquake
Load Level RSU SNI 1726 2012**

Story	X Direction			Y Direction		
	Story Force	Check V5a	Check V5b	Story Force	Check V5a	Check V5b
	kN			kN		
Top	904,39			965,78		
Fl6	1495,76	Ok	Ok	1565,51	Ok	Ok
Fl5	1978,01	Ok	Ok	2028,64	Ok	Ok
Fl4	2431,75	Ok	Ok	2453,64	Ok	Ok
Fl3	2789,42	Ok	Ok	2792,61	Ok	Ok
Fl2	2953,06	Ok	Ok	2943,83	Ok	Ok

Based on table 5.15, it is known that there are no level or excessive lateral strength irregularities. Then check the irregularities in the lateral strength of the stories on each floor with the scaled spectrum response earthquake load (Rss) shown in table 5.16.

**Table 5. 16 Check for Irregularity in Lateral Strength of Earthquake
Load Level Rss SNI 1726 2012**

Story	X Direction			Y Direction		
	Story Force	Check V5a	Check V5b	Story Force	Check V5a	Check V5b
	kN			kN		
Top	1080,65			1177,63		
Fl6	1787,27	Ok	Ok	1908,87	Ok	Ok
Fl5	2363,49	Ok	Ok	2473,57	Ok	Ok
Fl4	2905,64	Ok	Ok	2991,78	Ok	Ok
Fl3	3333,00	Ok	Ok	3405,11	Ok	Ok
Fl2	3528,53	Ok	Ok	3589,50	Ok	Ok

Based on table 5.16, it is known that there are no level or excessive lateral strength irregularities.

5.3 Earthquake Load Analysis Based on SNI 1726 2019

5.3.1 Risk Categories and Building Priority Factors

The risk category in a building is related to the type of use. Based on table 3 of SNI 1726 2019, the Jambi University FKIK building has risk category IV. Based on table 4 of SNI 1726 2019, buildings with risk category IV have an earthquake priority factor of 1.5.

5.3.2 Peak Ground Acceleration Parameters

Based on article 6.1.2 of SNI 1726 2019, bedrock acceleration in short periods of 0.2 seconds (S_s) and 1 second (S_1) must use an acceleration map with a probability of exceedance of 2% in 50 years. The S_s and S_1 values were obtained from the response spectrum analysis website of the Ministry of Public Works. This value is based on the PUPR Ministry's 2017 earthquake source and hazard map. Based on this site, the PGA value is 0.168 g. Meanwhile, the S_s value is 0.3413 g and the S_1 value is 0.2693 g. In SNI 1726 2019 a new parameter is introduced, namely period (TL). The transition period in this building is 20 seconds.

5.3.3 Design Acceleration Parameters

Based on SNI 1726 2019, the design acceleration parameters are determined by the site class coefficient.

The site coefficient parameters in SNI 1726 2019 are different from SNI 1726 2012. The F_a value is the short period site coefficient. The F_a value can be seen in table 5.17. Meanwhile, F_v is the site coefficient for a period of 1 second. The F_v value can be seen in table 5.18.

Table 5. 17 Site Coefficient, F_a SNI 1726 2019

Site Class	Earthquake Acceleration Spectral Response Parameters (MCER) Mapped on Short Periods, $T = 0.2$ seconds, S_s					
	$S_s \leq 0,25$	$S_s = 0,5$	$S_s = 0,75$	$S_s = 1$	$S_s = 1,25$	$S_s \geq 1,5$
SA	0,8	0,8	0,8	0,8	0,8	0,8
SB	0,9	0,9	0,9	0,9	0,9	0,9
SC	1,3	1,3	1,2	1,2	1,2	1,2
SD	1,6	1,4	1,2	1	1	1
SE	2,4	1,7	1,3	0,9	0,9	0,9
SF	SS^b					

(Source = SNI 1726 2019)

Based on table 5.17, the value of F_a is 2.14.

Table 5. 18 Site Coefficient, F_v SNI 1726 2019

Site Class	Earthquake Acceleration Spectral Response Parameters (MCER) Mapped at 1 second Period, S_1					
	$S_1 \leq 0,1$	$S_1 = 0,2$	$S_1 = 0,3$	$S_1 = 0,4$	$S_1 = 0,5$	$S_1 \geq 0,5$
SA	0,8	0,8	0,8	0,8	0,8	0,8
SB	0,8	0,8	0,8	0,8	0,8	0,8
SC	1,5	1,5	1,5	1,5	1,5	1,4
SD	2,4	2,2	2	1,9	1,8	1,7
SE	4,2	3,3	2,8	2,4	2,2	2
SF	SS^b					

(Source = SNI 1726 2019)

Based on table 5.18, the value of F_v is 2.9535. So the calculation of s_d and s_{d1} is as follows:

$$SD = 0.3413 \cdot \frac{2}{3} \cdot 2.1444$$

$$SD = 0.48791 \text{ g}$$

$$SD1 = 0.2693 \cdot \frac{2}{3} \cdot 2.9535$$

$$SD1 = 0.53025 \text{ g}$$

Based on the calculation above, the S_d value is 0.48791 g while S_{d1} is 0.53025 g. So the spectrum response graph is shown in Figure 5.6.

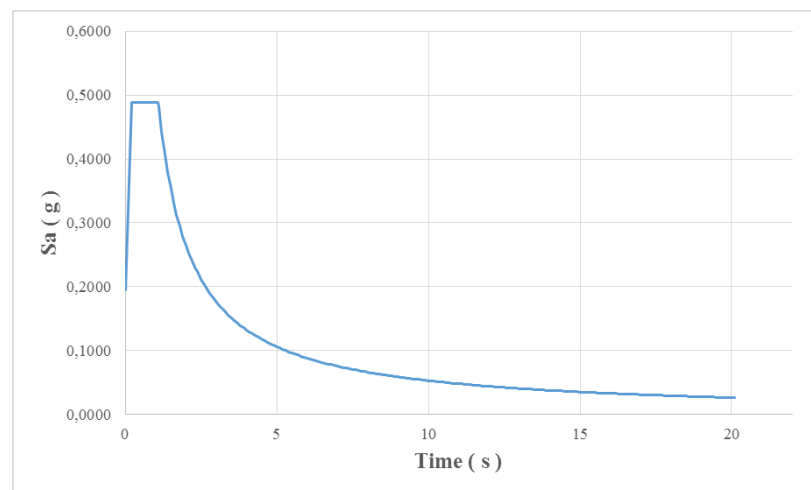


Figure 5. 6 SNI 1726 2019 Spectrum Response

(Source = SNI 1726 2019)

Based on Figure 5.6, it is known that the largest S_a value is 0.48791 g, while the smallest value at 20 seconds is 0.0264 g.

5.3.4 Effective Seismic Weight

Based on SNI 1726 2019, the effective seismic weight of a structure must include all existing dead loads and other loads. The effective seismic weight is shown in table 5.6.

5.3.5 Mass Participation Capital Structure

Based on SNI 1726 2019, the minimum number of variations is 100% of the actual mass in each orthogonal direction. However, there is an exception, namely that the minimum number of variations can be taken as 90% of the actual mass. The mass participation value of the structure is shown in table 5.7.

5.3.6 Fundamental Period of Structure

Based on SNI 1726 2019, the fundamental period of a structure can be calculated using an approximate formula. ,The fundamental period value of the structure is 0.9199 seconds. Then the upper limit value of the fundamental period is 1.288 seconds. There are no differences in analysis, the result of the fundamental period value in the x direction is taken as 1.288 seconds. Then the value of the fundamental period in the y direction is taken to be 1.266 seconds.

5.3.7 Static Earthquake Equivalent to SNI 1726 2019

The calculation of equivalent static earthquake analysis is quite simple, namely multiplying the seismic response coefficient (C_s) and the gravity load. The seismic response coefficient formula is divided into 3, namely C_s , minimum C_s and maximum C_s . The C_s formula is shown in formula 5.4. The formula used remains the same as the SNI 1726 2012 analysis. So the calculation of the earthquake coefficient in the x direction is as follows:

$$\begin{aligned} C_s &= 0.48791 / (8 / 1.5) \\ C_s &= 0.091483 \text{ g} \\ C_s \text{ max} &= 0.53025 / (1.288 * (8 / 1.5)) \\ &= 0.07719 \text{ g} \\ C_s \text{ min} &= 0.044 * 0.2693 * 1.5 \\ &= 0.02524 \text{ g} \end{aligned}$$

Based on the calculations above, it can be concluded that the C_s value exceeds the maximum C_s value. So the seismic response coefficient used for the x direction is

0.07719 g. Then calculate the seismic response coefficient value in the y direction as follows

$$\begin{aligned} C_s \text{ max} &= 0.53025 / (1.266 * (8 / 1.5)) \\ &= 0.0785 \text{ g} \end{aligned}$$

Based on the calculations above, it can be concluded that the C_s value exceeds the maximum C_s value. So the seismic response coefficient used for the y direction is 0.0785 g. Then carry out an analysis of the weight of the structure. The effective seismic structure weight based on table 5.6 is found to be 76058.31 kN. So the calculation of the equivalent static earthquake load of SNI 1726 2019 is as follows:

$$\begin{aligned} V_x &= 0.07719 * 76058.31 \\ &= 5871.06 \text{ kN} \\ V_y &= 0.0785 * 76058.31 \\ &= 5973.0552 \text{ kN} \end{aligned}$$

Based on the calculation above, the basic shear force value in the x direction is 5871.06 kN while the y direction is 5973.0552 kN.

5.3.8 2019 SNI 1726 Dynamic Earthquake

Dynamic earthquake analysis uses spectrum response analysis. The spectrum response analysis used is unscaled (R_{su}) and scaled (R_{ss}) spectrum responses. Earthquake scaling based on SNI 1726 2019 is 100% of the basic static earthquake shear force.

The input value in one direction of the earthquake response spectrum must represent 100% in the same direction and 30% in the perpendicular direction. Then the formula used remains the same. So the dynamic earthquake scale value is 1839.38. Meanwhile, the value of 30% from the perpendicular direction is 551.814. Then, using ETABS software, the basic shear force value of the analysis spectrum response is shown in table 5.19.

Table 5. 19 Spectrum Response Results Not yet scaled to SNI 1726 2019

Type	Direction (kN)	
	X	Y
Rsu (x)	4172,8516	1340,2984
Rsu (y)	1344,6593	4157,2337

Based on table 5.19, it is known that the value of the basic shear force $R_{su}(x)$ in the x direction is 4172.8516 kN while the y direction is 1340.2984 kN. Then the value of the basic shear force $R_{su}(y)$ in the y direction is 1344.6593 kN while the x direction is 4157.2337 kN. The difference in the results of the basic shear force between the two is caused by the difference in the fundamental period in the X direction and Y direction. Then the calculation of the dynamic versus static earthquake force scaling is as follows:

x direction

$$\text{Factor } R_{su}(x) = 1839.38$$

$$\text{The basic shear force} = 4172.8516 \text{ kN}$$

$R_{su}(x)$ is in the same direction

$$\text{The basic shear force} = 1340.2984 \text{ kN}$$

$R_{su}(y)$ is in the perpendicular direction

$$V_{static}(x) = 5581.061 \text{ kN}$$

$$30 \% V_{static}(x) = 1761, 32 \text{ kN}$$

$$\text{The factor } R_{ss}(x) \text{ is in the same direction} = 1839.38 * (5581.061 / 4172.8516)$$

$$= 2587.94$$

$$\text{Factor } R_{ss}(y) \text{ is perpendicular} = 551,814 * (1761, 32 / 1340,2984)$$

$$\text{Factor } R_{ss}(y) \text{ is perpendicular} = 725.15$$

Y direction

$$R_{su} \text{ Factor (y)} = 1839.38$$

$$\text{The basic shear force} = 4157.2337 \text{ kN}$$

Rsu (y) is in the same direction

The basic shear force = 1344.6593 kN

Rsu (y) is in the perpendicular direction

Vstatic (x) = 5973.05 kN

30 % Vstatic (x) = 1523.13 kN

The factor Rss (x) is in the same direction

= 2642.79

Factor Rss (x) is perpendicular

Factor Rss (x) is perpendicular

Based on the calculation above, the scale value for Rss (x) in the same direction is 2587.94. Meanwhile, the perpendicular direction is 725.15. Then the scale value for Rss (y) in the same direction is 2642.79. Meanwhile for the perpendicular direction it is 625.051. The scale value is then input into the ETABS software. The results of the calculations are then checked. This check is useful to ensure that the dynamic earthquake base shear force is more than 100% of the static base shear force. The results of the dynamic base shear force which have been scaled can be seen in table 5.20.

Table 5. 20 Check the Static and Dynamic Earthquake SNI 1726 2019

Type	Direction (kN)		Seismic Scale	
	x	y	x	y
Static x	5871,061629	1761,318489		
Static y	1523,128312	5973,052203		
Rss (x)	5871,26	1761,71	OK	OK
Rss (y)	1523,336	5973,3592	OK	OK

Based on table 5.20, it is known that the dynamic base shear force value is greater than 100% of the static earthquake force. Therefore, it is in accordance with the requirements of SNI 1726 2019.

5.3.9 Inter Story Drift

Based on SNI 1726 2019, the deviation limit for buildings with risk category IV in other types of structures is 0.01 H. The x and y deviation data were obtained from the ETABS results. An example of calculating the acceptance deviation in the x as follows

$$\begin{aligned}\Delta X &= (C_d * \text{deviation}) / 1.5 \\ &= (5.5 * \text{deviation}) / 1.5 \\ \text{Elastic deviation in the} &= 50.06 \text{ mm} \\ \text{x direction of the Roof} & \\ \text{floor} & \\ \text{Elastic deviation in the} &= 40.26 \text{ mm} \\ \text{x direction of the 6th} & \\ \text{floor} & \\ \Delta X &= (5.5 * (50.06 - 40.26)) / 1.5 \\ &= 35.926 \text{ mm} \\ \Delta X \text{ permission} &= 6550 * 0.01 \\ &= 65.5 \text{ mm} \\ \text{Check} &= \Delta X < \Delta X \text{ permission (Safe)}\end{aligned}$$

Then, to calculate deviations on other floors with earthquake loads, the unscaled response spectrum (Rsu) is shown in table 5.21

Table 5. 21 Deviation Between Floors Earthquake Load Rsu SNI 1726 2019

Story	Displacement		Elastic Drift		Inelastic Drift		Floor Height	Check
	δe_x	δe_y	δe_x	δe_y	Δ_x	Δ_y		
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)		
Top	50,06	42,83	9,798	10,211	35,926	37,440	6550	Ok
Fl6	40,26	32,61	6,826	6,859	25,029	25,150	4000	Ok
Fl5	33,43	25,76	8,141	7,419	29,850	27,203	4000	Ok
Fl4	25,29	18,34	8,863	6,704	32,498	24,581	4000	Ok
Fl3	16,43	11,63	10,223	7,341	37,484	26,917	4500	Ok
Fl2	6,21	4,29	6,205	4,291	22,752	15,734	4450	Ok

Based on table 5.21, it is known that the deviations that occur in the Jambi University FKIK building are in the safe category (deviations occurring < permissible

deviations). Then to calculate the deviation on other floors with earthquake loads the scaled spectrum response (Rss) is shown in table 5.22.

Table 5. 22 Deviations Between Earthquake Load Floors RSs SNI 1726

Story	<i>Displacement</i>		Elastic Drift		Inelastic Drift		Floor Height	Check
	δe_x	δe_y	δe_x	δe_y	Δ_x	Δ_y		
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)		
Top	70,48	61,54	13,796	14,675	50,585	53,808	6550	Ok
Fl6	56,68	46,87	9,612	9,856	35,244	36,139	4000	Ok
Fl5	47,07	37,01	11,462	10,661	42,027	39,090	4000	Not Ok
Fl4	35,61	26,35	12,480	9,634	45,760	35,325	4000	Not Ok
Fl3	23,13	16,71	14,394	10,548	52,778	38,676	4500	Not Ok
Fl2	8,74	6,17	8,736	6,166	32,032	22,609	4450	Ok

2019

Based on table 5.22, it is known that the deviations that occur in the Jambi University FKIK building are in the unsafe category (deviations occurring > deviations permitted).

5.3.10 Horizontal Irregularities

Based on SNI 1726 2019, horizontal irregularities are divided into 5. The following is an analysis of each irregularity:

1. Torsion Irregularities

Checking torsional irregularities on each floor with unscaled earthquake response spectrum loads (Rsu) is shown in table 5.23.

Table 5. 23 Check for Irregularities in Earthquake Load Torque RSU SNI 1726 2019

Story	X Direction					Y Direction				
	Δ_{max}	Δ_{avg}	$\Delta_{max}/\Delta_{avg}$	Cek		Δ_{max}	Δ_{avg}	$\Delta_{max}/\Delta_{avg}$	Check	
				<1,2	<1,4				<1,2	<1,4
Top	50,464	50,175	1,006	OK	OK	62,084	46,624	1,332	1a	OK
Lt6	40,488	40,333	1,004	OK	OK	47,623	35,381	1,346	1a	OK
Lt5	33,535	33,478	1,002	OK	OK	37,609	27,851	1,35	1a	OK
Lt4	25,35	25,32	1,001	OK	OK	27,261	20,181	1,351	1a	OK
Lt3	16,486	16,456	1,002	OK	OK	17,894	13,207	1,355	1a	OK
Lt2	6,262	6,227	1,006	OK	OK	6,572	4,862	1,352	1a	OK

Based on table 5.23, it is known that the ratio between the maximum and average deviation exceeds 1.2 but does not exceed 1.4. So it can be confirmed that

Lx	=	54 m
Lx / Lx	=	0.2963
Check	=	Internal corner irregularities occur
Py	=	8m
Ly	=	31 m
Py/Ly	=	0.2581
Check	=	Internal corner irregularities occur

Based on the calculations above, it can be concluded that there is an internal angle irregularity in the x and y directions. Then check the inside angle located below as follows:

Location	=	The bottom left corner
Px	=	20 m
Lx	=	54 m
Lx / Lx	=	0.3704
Check	=	Internal corner irregularities occur
Py	=	7m
Ly	=	31 m
Py/Ly	=	0.2258
Check	=	Internal corner irregularities occur

Based on the calculations above, it can be concluded that there is an internal angle irregularity in the x and y directions.

3. Diaphragm Discontinuity Irregularities

Based on Figure 5.4, it can be seen that there is no change in openings that exceeds 50%. Therefore, in this structure there is no irregularity in the diaphragm discontinuity.

4. The Irregularity of Transverse Story drift Against the Plane

The cross section plan in Figure 5.5 does not contain a shift in the cross-sectional elements. So that this building does not experience irregular transverse shifts in the plane.

5. Irregularities of Nonparallel Systems

Based on Figure 5.5, it is known that the lateral force resisting element is parallel to the main orthogonal axis. So that in this building there will be no irregularities in the nonparallel system.

5.3.11 Vertical Irregularities

Based on SNI 1726 2019, vertical irregularities are divided into 5. The following is an analysis of each irregularity:

1. Soft Level Stiffness Irregularities

Then check the soft level irregularities on each floor with the unscaled response spectrum earthquake load (Rsu) shown in table 5.25.

**Table 5. 25 Check Irregularities Stiffness Soft Level Earthquake Load Rsu
SNI 1726 2019**

Story	X Direction			Y Direction		
	Stiffnes kN/m	Check V1a	Check V1b	Stiffnes kN/m	Check V1a	Check V1b
Top	120960			115204		
Fl6	284165	Ok	Ok	284450	Ok	Ok
Fl5	328573	Ok	Ok	374809	Ok	Ok
Fl4	377300	Ok	Ok	460869	Ok	Ok
Fl3	436022	Ok	Ok	516880	Ok	Ok
Fl2	670159	Ok	Ok	855098	Ok	Ok

Based on table 5.25, it is known that there are no irregularities in soft level stiffness and excessive soft level. Then check the soft level irregularities on each floor with the scaled spectrum response earthquake load (Rss) shown in table 5.26.

**Table 5. 26 Check Irregularities Soft Level Stiffness Earthquake Load Rss
SNI 1726 2019**

Story	X Direction			Y Direction		
	Stiffnes kN/m	Check V1a	Check V1b	Stiffnes kN/m	Check V1a	Check V1b
Top	120991			115225		
Fl6	284188	Ok	Ok	284473	Ok	Ok
Fl5	328603	Ok	Ok	374818	Ok	Ok
Fl4	377346	Ok	Ok	460893	Ok	Ok
Fl3	436139	Ok	Ok	518309	Ok	Ok
Fl2	670380	Ok	Ok	855161	Ok	Ok

Based on table 5.26, it is known that by using the scaled response spectrum earthquake load structure of the Jambi University FKIK building, there are no soft level stiffness irregularities and excessive soft levels.

2. Weight Irregularities (Mass)

There is no difference between SNI 1726 2019 and SNI 1726 2012 for this parameter. So it was concluded that there were no serious irregularities.

3. Vertical Geometry Irregularities

Based on Figure 5.8, it is known that all columns from the ground level to the roof have the same dimensions or sizes so it can be concluded that there is no vertical geometric irregularity.

4. Plane Direction Discontinuity in Irregularities of Vertical Lateral Force Resisting Elements

Based on Figure 5.8, it is known that all the columns at the bottom level up to the roof have no plane shift, so it can be concluded that there is no plane direction discontinuity in the irregularity of the elements resisting vertical lateral forces.

5. Discontinuities in Strong Lateral Level Irregularities

An example of a calculation for checking irregularities in the lateral strength of a story is as follows:

Story Force Lt6	=	2111.51 kN (x direction)
Story Force Lt5	=	2796.69 kN (x direction)
Comparison	=	2796.69: 0.8 * 2111.51
	=	2796.69 > 0.8 * 2111.51
Results	=	Safe

Then, to calculate lateral strength irregularities on other floors with unscaled earthquake loads, the response spectrum (Rsu) is shown in table 5.27.

Table 5. 27 Check for Irregularity in Lateral Strength of Earthquake Load Level RSU SNI 1726 2019

Story	X Direction			Y Direction		
	Story Force	Check V5a	Check V5b	Story Force	Check V5a	Check V5b
	kN			kN		
Top	1270,28			1357,28		
Fl6	2111,51	Ok	Ok	2210,70	Ok	Ok
Fl5	2796,69	Ok	Ok	2869,04	Ok	Ok
Fl4	3440,35	Ok	Ok	3470,68	Ok	Ok
Fl3	3944,23	Ok	Ok	3946,56	Ok	Ok
Fl2	4172,85	Ok	Ok	4157,23	Ok	Ok

Based on table 5.27, it is known that there are no level or excessive lateral strength irregularities. Then check the irregularities in the lateral strength of the stories on each floor with the scaled spectrum response earthquake load (Rss) shown in table 5.28.

Table 5. 28 Check for Irregularity in Lateral Strength of Earthquake Load Level Rss SNI 1726 2019

Story	X Direction			Y Direction		
	Story Force	Check V5a	Check V5b	Story Force	Check V5a	Check V5b
	kN			kN		
Top	1788,55			1950,65		
Fl6	2972,99	Ok	Ok	3177,03	Ok	Ok
Fl5	3937,70	Ok	Ok	4123,07	Ok	Ok
Fl4	4843,93	Ok	Ok	4987,67	Ok	Ok
Fl3	5553,36	Ok	Ok	5671,57	Ok	Ok
Fl2	5875,26	Ok	Ok	5974,36	Ok	Ok

Based on table 5.28, it is known that there are no level or excessive lateral strength irregularities.

5.4 Comparison of Analysis Results

The differences between SNI 1726 2019 and SNI 1726 2012 are shown in table 5.29

Table 5. 29 Differences between SNI 1726 2019 and SNI 1726 2012

Description	SNI 1726 2012	SNI 1726 2019
Earthquake Map	Earthquake hazard map 2010	Earthquake hazard map 2017
Fa and fv values	There is a difference between the two	
Amount of minimum mass participation variety	90 %	100 %
Dynamic earthquake scale to static	85 % static	100 % static
Long period map (TL)	No	Yes

1. Based on Base Shear

A comparison of the amount of base shear based on SNI 1726 2012 and SNI 1726 2019 is shown in table 5.30.

Table 5. 30 Comparison of Base Shear SNI 1726 2012 and SNI 1726 2019

Type	SNI 1726 2012		SNI 1726 2019		Comparison			
	Direction (kN)		Direction (kN)		Direction			
	X	Y	X	Y	X		Y	
					SNI 1726 2012	SNI 1726 2019	SNI 1726 2012	SNI 1726 2019
Static x	4149,0		5871,1		1,00	1,42		
Static y		4221,0		5973,1			1,00	1,42
Rss (x)	3528,5	1071,1	5871,3	1761,7	1,00	1,66	1,00	1,64
Rss (y)	1090,5	3589,5	1523,3	5973,4	1,00	1,40	1,00	1,66
Average					1,00	1,49	1,00	1,57

Based on the analysis that have been done, the earthquake map that have been use in SNI 1726 2012 and SNI 1726 2019 are using different earthquake map where SNI 1726 2012 is using 2010 earthquake map and SNI 1726 2019 is using 2017 earthquake map. It will cause the differences of ss value and s1 value. SNI 1726 2016 has ss value in 0.213 g and the s1 value in 0.171 g. meanwhile, SNI 1726 2019 has ss value in 0.3413 g and s1 value in 0.2693 g. So, between ss and s1 value in each regulations, it will make the result of the Fa and Fv value different. It shows in the calculation analysis above that the SNI 1726 2019 value is higher than the SNI 1726 2012. The safety factor from each regulation is also different. SNI 1726 2012 using that the dynamic base shear force must be greater than 85% of the Static force. Meanwhile in SNI 1726 2019 using that the dynamic base shear force must be greater than 100% of the static force value. Both in the analysis define as “OK”

2. Based on Deviation

A comparison of the magnitude of the deviation based on SNI 1726 2012 and SNI 1726 2019 with the unscaled response spectrum earthquake load (Rsu) is shown in table 5.31.

**Table 5. 31 Comparison of Earthquake Load Deviations RSU SNI 1726
2012 and SNI 1726 2019**

Story	SNI 1726 2012		SNI 1726 2019		Comparison			
	Direction (mm)		Direction (mm)		Direction			
	X	Y	X	Y	X		Y	
					SNI 1726 2012	SNI 1726 2019	SNI 1726 2012	SNI 1726 2019
Top	35,4	30,3	50,1	42,8	1,00	1,41	1,00	1,41
F16	28,5	23,0	40,3	32,6	1,00	1,42	1,00	1,42
F15	23,6	18,2	33,4	25,8	1,00	1,41	1,00	1,41
F14	17,9	13,0	25,3	18,3	1,00	1,41	1,00	1,41
F13	11,6	8,2	16,4	11,6	1,00	1,41	1,00	1,41
F12	4,4	3,0	6,2	4,3	1,00	1,41	1,00	1,41
Average					1,00	1,41	1,00	1,41

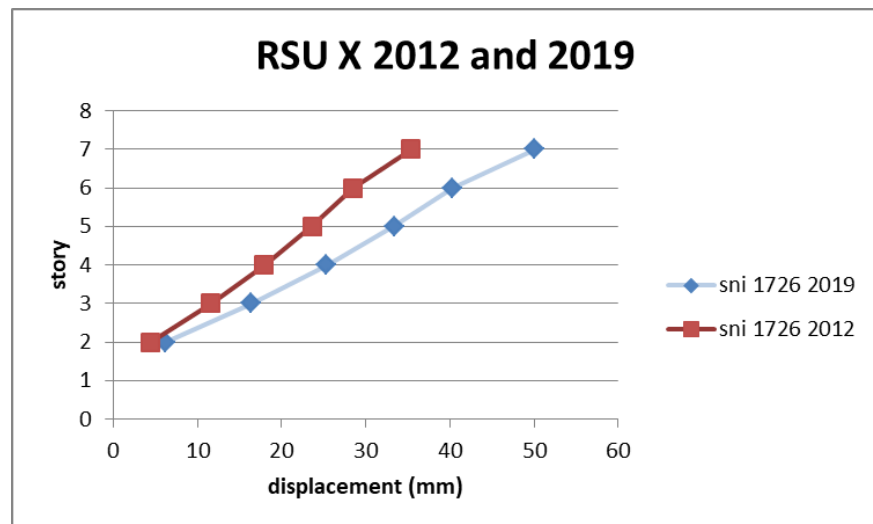


Figure 5. 8 RSU in X axis 2012 and 2019

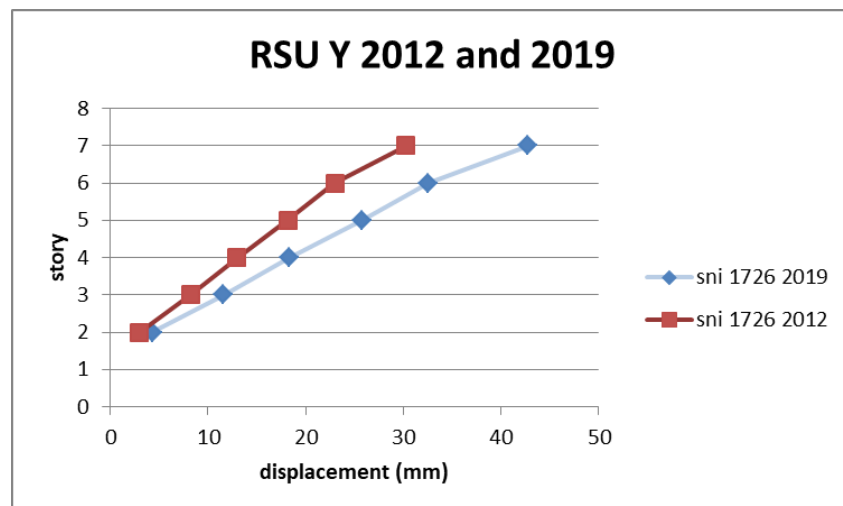


Figure 5. 9 RSU in Y axis 2012 and 2019

Based on table 5.31, it is known that the average deviation of SNI 1726 2019 on RSU in the x direction is 1.41 times greater than SNI 1726 2012. Meanwhile, the average deviation of SNI 1726 2019 on RSU in the y direction is 1.41 times greater than SNI 1726 2012. This is occurs because the earthquake parameters of SNI 1726 2019 are greater than SNI 1726 2012. Comparison of the magnitude of deviation based on SNI 1726 2012 and SNI 1726 2019 with the scaled response spectrum earthquake load (Rss) is shown in table 5.32.

Table 5. 32 Comparison of Earthquake Load Deviations Rss SNI 1726 2012 and SNI 1726 2019

Story	SNI 1726 2012		SNI 1726 2019		Comparison			
	Direction (mm)		Direction (mm)		Direction			
	X	Y	X	Y	X		Y	
					SNI 1726 2012	SNI 1726 2019	SNI 1726 2012	SNI 1726 2019
Top	42,3	36,9	70,5	61,5	1,00	1,67	1,00	1,67
Fl6	34,0	28,1	56,7	46,9	1,00	1,67	1,00	1,67
Fl5	28,2	22,2	47,1	37,0	1,00	1,67	1,00	1,67
Fl4	21,4	15,8	35,6	26,3	1,00	1,67	1,00	1,67
Fl3	13,9	10,0	23,1	16,7	1,00	1,67	1,00	1,67
Fl2	5,2	3,7	8,7	6,2	1,00	1,67	1,00	1,67
Average					1,00	1,67	1,00	1,67

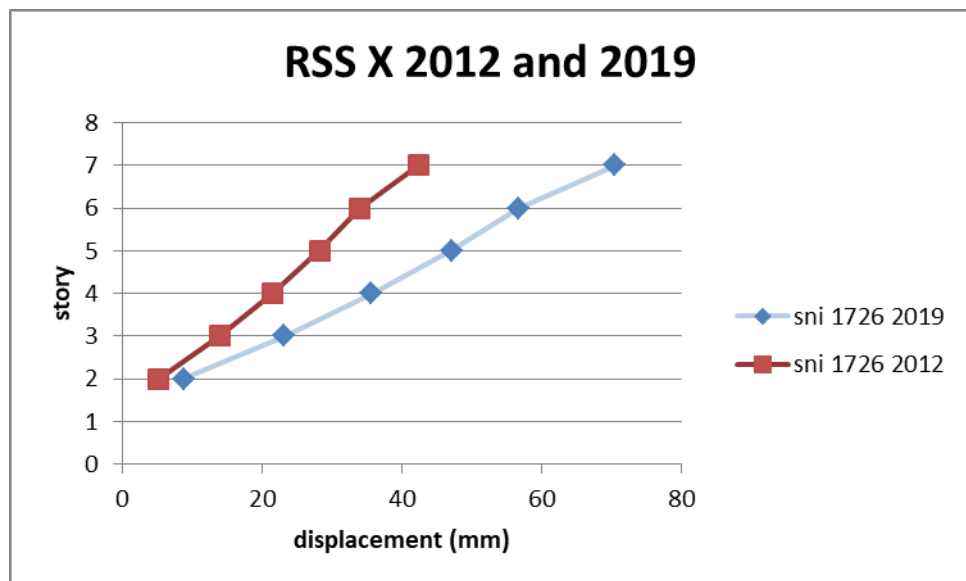


Figure 5. 10 RSS in X axis 2012 and 2019

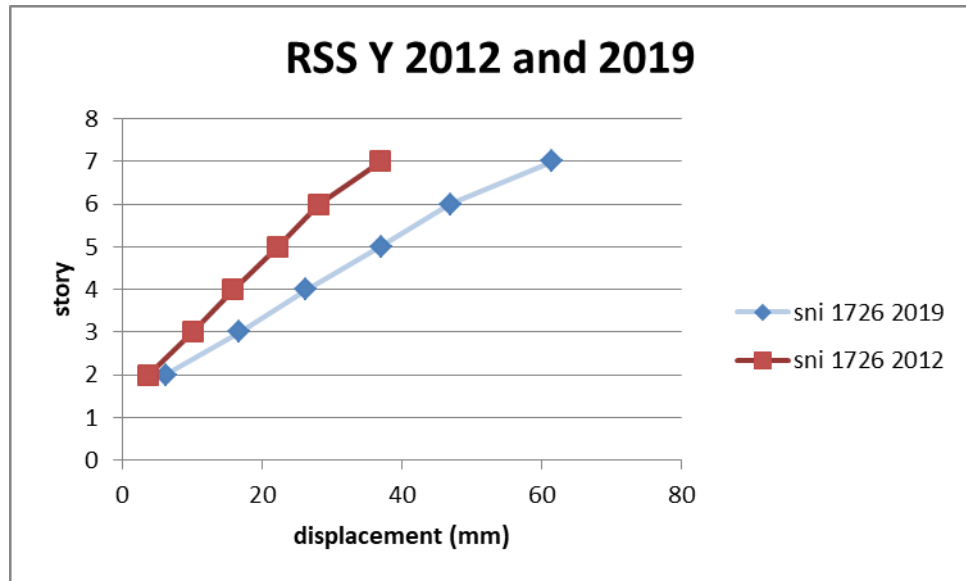


Figure 5. 11 RSS in Y axis 2012 and 2019

Based on table 5.32, it is known that the average deviation of SNI 1726 2019 in Rss in the x direction is 1.67 times greater than SNI 1726 2012. Meanwhile, the average deviation of SNI 1726 2019 in Rss in the y direction is 1.67 times greater than SNI 1726 2012. This is occurred because the SNI 1726 2019 earthquake parameters were greater than SNI 1726 2012.

3. Based on the occurrence of structural irregularities

The only horizontal and vertical irregularities that occur are torsion type horizontal irregularities in SNI 1726 2019 and SNI 1726 2012 for the y direction. So these irregularities will be compared. Comparison of torsional irregularities based on SNI 1726 2012 and SNI 1726 2019 with unscaled spectrum response earthquake loads (Rsu) is shown in table 5.33.

Table 5. 33 Comparison of Earthquake Torque Irregularities Rsu SNI 1726 2012 and SNI 1726 2019

Story	SNI 1726 2012		SNI 1726 2019		Comparison			
	$\Delta_{max}/\Delta_{avg}$		$\Delta_{max}/\Delta_{avg}$		Irregularity Torsion Check			
	X	Y	X	Y	X		Y	
					SNI 1726 2012	SNI 1726 2019	SNI 1726 2012	SNI 1726 2019
Top	1,0060	1,3310	1,0060	1,3320	Ok	Ok	1a	1a
Lt6	1,0040	1,3450	1,0040	1,3460	Ok	Ok	1a	1a
Lt5	1,0020	1,3490	1,0020	1,3500	Ok	Ok	1a	1a
Lt4	1,0010	1,3500	1,0010	1,3510	Ok	Ok	1a	1a
Lt3	1,0020	1,3540	1,0020	1,3550	Ok	Ok	1a	1a
Lt2	1,0050	1,3510	1,0060	1,3520	Ok	Ok	1a	1a

Based on table 5.33, it is known that in SNI 1726 2012 there is irregularity 1a in the y direction. Meanwhile, in SNI 1726 2019, there is irregularity 1a in the y direction. Comparison of torsional irregularities based on SNI 1726 2012 and SNI 1726 2019 with scaled spectrum response earthquake loads (Rss) is shown in table 5.34.

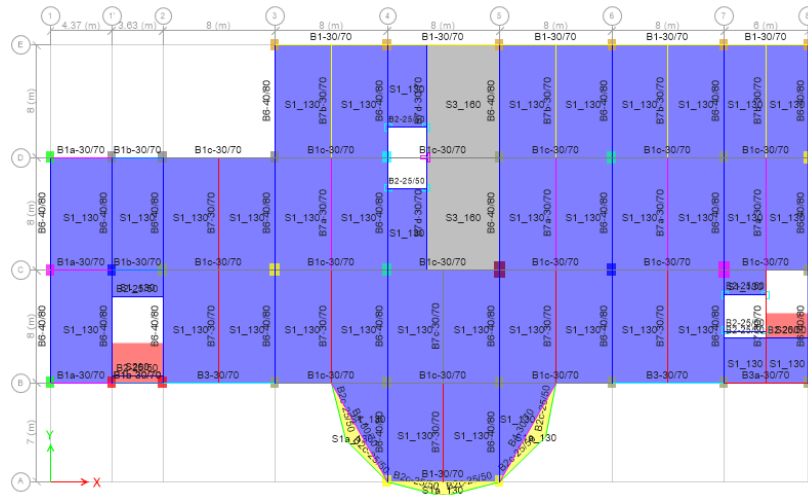
Table 5. 34 Comparison of Earthquake Torque Irregularities Rss SNI 1726 2012 and SNI 1726 2019

Story	SNI 1726 2012		SNI 1726 2019		Comparison			
	$\Delta_{max}/\Delta_{avg}$		$\Delta_{max}/\Delta_{avg}$		Irregularity Torsion Check			
	X	Y	X	Y	X		Y	
					SNI 1726 2012	SNI 1726 2019	SNI 1726 2012	SNI 1726 2019
Top	1,0060	1,3310	1,0060	1,3320	Ok	Ok	1a	1a
Lt6	1,0040	1,3450	1,0040	1,3460	Ok	Ok	1a	1a
Lt5	1,0020	1,3490	1,0020	1,3510	Ok	Ok	1a	1a
Lt4	1,0010	1,3500	1,0010	1,3510	Ok	Ok	1a	1a
Lt3	1,0020	1,3540	1,0020	1,3550	Ok	Ok	1a	1a
Lt2	1,0060	1,3510	1,0060	1,3520	Ok	Ok	1a	1a

Based on table 5.34, it is known that in SNI 1726 2012 there is irregularity 1a in the y direction. Meanwhile, in SNI 1726 2019, there is irregularity 1a in the y direction.

Based on Internal corner Irregularities, both SNI 1726 2012 and SNI 1726 2019, occur an irregularities in x and y direction that can be seen in calculation 5.2

Based on Diaphragm discontinuity irregularities, both SNI 1726 2012 and SNI 1726 2019 can be seen that there is no opening that exceeds 50%. It can be shown in figure down below:



Based on the irregularity of transverse story drift against plane both in SNI 1726 2012 and SNI 1726 2019, there is no shift in the cross-sectional elements resisting lateral forces. So, this building does not experience irregular transverse shift in plane that can be shown in figure 5.13 down below:

Based on Figure 5.7, it is known that the lateral force resisting element is parallel to the main orthogonal axis. So that in this building there will be no irregularities in the nonparallel system both in SNI 1726 2012 and SNI 1726 2019

Irregularities in vertical direction such as :

Soft level stiffness irregularities based on table 5.12, table 5.13, table 5.25, and table 5.26, there are no irregularities both in SNI 1726 2012 and SNI 1726 2019.

Weight irregularities between SNI 1726 2012 and SNI 1726 2019, there is no effective seismic weight is more than 150% of the effective seismic weight of adjacent stories.

Vertical geometry irregularities, it can be seen that all column from the ground to the top level have the same dimension or size, it can be concluded that both in SNI 1726 2012 and 1726 2019 has no irregularities for the vertical geometry.

Plane direction discontinuity in irregularities of vertical force resisting elements, has no plane direction irregularities in the vertical lateral force both in SNI 1726 2012 and SNI 1726 2019

Discontinuities in strong lateral level irregularities, can be seen in the table down below:

Table 5. 33 Lateral Strength

Story	X Direction				Y Direction			
	Story Force		Check V5a	Check V5b	Story Force		Check V5a	Check V5b
	kN				kN			
	2012	2019			2012	2019		
Top	1080,65	1788,5538			1177,63	1950,6455		
Fl6	1787,27	2972,9878	Ok	Ok	1908,87	3177,0258	Ok	Ok
Fl5	2363,49	3937,699	Ok	Ok	2473,57	4123,0692	Ok	Ok
Fl4	2905,64	4843,9332	Ok	Ok	2991,78	4987,6668	Ok	Ok
Fl3	3333,00	5553,3614	Ok	Ok	3405,11	5671,5664	Ok	Ok
Fl2	3528,53	5875,2625	Ok	Ok	3589,50	5974,3592	Ok	Ok

Based on the table above, both SNI 1726 2012 and SNI 1726 2019 has no level or excessive lateral strength irregularities. It can be stated by the lateral story force is less than 80% of the lateral story force above.

CHAPTER VI

CONCLUSION

6.1 Conclusion and Recommendation

The conclusion of this research is :

1. The average base shear comparison is that the result of base shear in the y direction in SNI 1726 2019 is 1.51 times greater than SNI 1726 2012. The average base shear comparison is that the base shear results in the x direction in SNI 1726 2019 are 1.46 times greater than SNI 1726 2012. This happens because the earthquake parameters of SNI 1726 2019 are greater than SNI 1726 2012.
2. The average deviation of SNI 1726 2019 on RSU in the y direction is 1.41 times greater than SNI 1726 2012. The average deviation of SNI 1726 2019 in Rss in the y direction is 1.67 times greater than SNI 1726 2012. This is occurred because the SNI 1726 2019 earthquake parameters were greater than SNI 1726 2012.
3. Type 1a horizontal irregularities only occur in SNI 1726 2019 and SNI 1726 2012. Then vertical irregularities do not occur in SNI 1726 2019 or SNI 1726 2012

Recommendation :

Recommendation for future research is to calculate with different method like time history and use higher building design.

REFERENCES

- Dona, M. T., 2022. *Studi Perbandingan Perilaku Struktur Atas Berdasarkan Peraturan Ketahanan Gempa SNI 1726 2012 dan SNI 1726 2019 Pada Gedung Fakultas Ilmu Keolahragaan (FIK)*. Malang: Institut Teknologi Nasional Malang.
- Halawa, 2021. *Studi Analisis Gedung Bertingkat dengan Perbandingan*. Lampung: Universitas Lampung.
- Muhtadin, H., 2023. *Perbandingan Respon Spekktrum, Gaya Geser Dasar dan Simpangan Antar Lantai Bangunan Berdasarkan SNI 1726 2019 dan SNI 1726 2012*. Yogyakarta: Universitas Islam Indonesia.
- Ohorella, F., 2022. *Perbandingan Respon Seismik dan Analisis Kinerja Struktur Berdasarkan SNI 03-1726-2012 DAN 03-1726-2019 Serta Perencanaan Ulang Elemen Struktural Struktur Atas Gedung Kuliah Bersama Politeknik Negeri Cilacap*. Yogyakarta: Universitas Islam Indonesia.
- Pawirodikromo, W., 2012. *Seismologi Teknik Rekayasa Kegempaan*. Yogyakarta: Pusaka Pelajar.
- PPPURG 1987, 1987. *Pedoman Perencanaan Pembebanan untuk Rumah dan Gedung*. Jakarta: Departemen Pekerjaan Umum.
- Pujianto, 2017. *Bahan Kuliah Perencanaan Struktur Tahan Gempa*. Yogyakarta: Universitas Muhammadiyah Yogyakarta.
- SNI 1726, 2012. *Tata Cara Perencanaan Ketahanan Gempa untuk Struktur Bangunan Gedung dan Non Gedung*. Jakarta: Badan Standarisasi Nasional.
- SNI 1726, 2019. *Tata Cara Perencanaan Ketahanan Gempa untuk Struktur Bangunan Gedung dan Non Gedung*. Jakarta: Badan Standarisasi Nasional.
- SNI 1727, 2020. *Beban Minimum untuk Perancangan Bangunan Gedung dan Struktur Lain*. Jakarta: Badan Stanndarisasi Nasional.
- SNI 2847, 2019. *Persyaratan Beton Struktural untuk Bangunan Gedung*. Jakarta: Badan Standarisasi Nasional.

Widhiatmoko, G., 2020. *Analisa Perbandingan Respon Spektrum, Gaya Geser Dasar dan Seimpangan antar Lantai pada Bangunan Baja Berdasarkan SNI 1726 2012 dan SNI 1726 2019*. Yogyakarta: Universitas Islam Indonesia.