

**DESIGN OF SIMPLE FLATS WITH SUSTAINABLE ARCHITECTURE  
APPROACH IN YOGYAKARTA CITY FROM STRUCTURAL,  
GEOTECHNICAL, AND COST AND TIME MANAGEMENT ASPECTS**

Final Project Report

As one of the requirements to obtain Bachelor's degree in  
Universitas Atma Jaya Yogyakarta



**Made By:**

**BERNARDINUS SANDIKO PINAYUNGAN**

**191317915**

**MUHAMMAD REZA SYAHDAPUTRA R.**

**191317762**

**INTERNATIONAL CIVIL ENGINEERING PROGRAM  
DEPARTMENT OF CIVIL ENGINEERING  
FACULTY OF ENGINEERING  
UNIVERSITAS ATMA JAYA YOGYAKARTA  
YOGYAKARTA**

**2023**

## ABSTRACT

*Kota Yogyakarta sebagai ibu kota yang dikenal sebagai “kota pelajar” dan “kota wisata”, menarik banyak orang dari berbagai daerah untuk belajar atau tinggal di Yogyakarta. Itu membuat kota menjadi lebih ramai di daerah kecil. Selain itu, sebagai kota yang terletak di Ring of Fire, Yogyakarta sangat berpotensi mengalami kerusakan akibat gempa. Di lahan kecil, alternatif selain perumahan adalah rumah susun karena mampu menampung lebih banyak orang di lahan yang lebih kecil. Namun, semakin tinggi bangunan, semakin rentan terhadap gempa. Oleh karena itu, rumah susun harus dirancang tahan gempa dengan menggunakan beton bertulang Sistem Rangka Pemikul Momen Khusus (SRPMK).*

*Bangunan ini akan memiliki ukuran 28 x 96 m<sup>2</sup> dan 5 lantai. Terletak di Jalan Ki Ageng Pamanahan, Kota Yogyakarta, Daerah Istimewa Yogyakarta. Luas total situs adalah 8.350 m<sup>2</sup>. Setiap cerita memiliki tinggi khas 4 meter. Cerita kedua sampai kelima adalah tipikal. Bangunan ini menggunakan pendekatan berkelanjutan dengan menggunakan material hijau untuk atap hijau dan fasad untuk sisi arsitekturalnya. Ukuran bangunannya cukup besar dan berfungsi sebagai tempat tinggal, sehingga bebannya sangat besar.*

*Acuan yang akan digunakan untuk bangunan tahan gempa adalah SNI 1726-2019 Tata Cara Perencanaan Ketahanan Gempa Struktur Bangunan Gedung dan Non Gedung, SNI 2847-2019 Persyaratan Beton Struktural untuk Bangunan Gedung, SNI 1729-2015 Spesifikasi untuk Bangunan Gedung Baja Struktural, dan SNI 1727-2020 Desain Beban Minimum dan Kriteria Terkait untuk Bangunan*

*Perancangan akan dimulai dari interpretasi data tanah dari pengujian, penentuan kelas tapak, penentuan sistem struktur, dan perhitungan kurva spektrum respon untuk analisis beban dinamis gempa. Desain berlanjut ke struktur pendukung untuk purlin, truss, slab, balok, kolom, sambungan balok-kolom, balok pengikat, dan tangga. Kemudian untuk substruktur meliputi analisis likuifaksi, analisis jenis pondasi, daya dukung pondasi, perencanaan pondasi untuk struktur beton bertulang, dan analisis penurunan. Keluaran dari perancangan adalah gambar konstruksi, dimana gambar ini akan digunakan untuk pekerjaan manajemen biaya dan waktu. Pekerjaan tersebut meliputi pembuatan work breakdown structure, quantity take-off, dan analisa unit price cost. Kemudian, dengan bantuan Microsoft Project, analisis pekerja dan sumber daya dapat dilakukan. Ini termasuk memaksimalkan pekerja dan sumber daya untuk mendapatkan biaya termurah dan durasi kerja tersingkat. Pada akhirnya, karya tersebut disajikan dalam S-Curve.*

*Hasil desain pada proyek ini untuk struktur penyangga adalah Purlin C125x50x20x2, Truss 2L90x90x7, 2 sambungan baut D16 mm, sag rod D10 mm, dan jangkar D18mm L150 mm. Untuk pelat lantai akan digunakan 8 jenis two-way dengan tebal 1,5 cm, ukuran balok 50 x 50 cm, ukuran kolom 65 x 65 cm, tebal anak tangga 100 cm, dan tebal landing slab 3 cm. Substruktur menggunakan pondasi tiang bor dengan kedalaman 16 m dan 4 tipe. Ketebalan pile cap adalah 1 meter.*

*Analisis biaya dan waktu menunjukkan bahwa pembangunan gedung akan memakan waktu 1080 hari dan biaya Rp41.224.131.730,39*

*Kata kunci: perancangan, struktur, geoteknik, manajemen biaya dan waktu.*

## ABSTRACT

Yogyakarta City, as a capital city that is known as “student city” and “tourism city”, attracts many people from many regions to study or live in Yogyakarta. It makes the city to become more crowded in small area. Besides that, as a city that is located in Ring of Fire, Yogyakarta is very potential to earthquake damage. Therefore, the building is expected to have resistance for earthquake and have long live period. In small area, an alternative beside housing area is flat because it can accommodate more people in smaller area. However, the taller the building, the more it's vulnerable to earthquake. Therefore, the flat must be designed earthquake resistance by using reinforced concrete of Special Moment Resisting Frame System (*Sistem Rangka Pemikul Momen Khusus*)

The building will have size of 28 x 96 m<sup>2</sup> and 5 level story. It is located in Ki Ageng Pamanahan Street, Yogyakarta City, Special Region of Yogyakarta. The total site area is 8,350 m<sup>2</sup>. Each story has typical 4 meters height. The building uses sustainable approach by using green material for green roof and fasad for the architectural side. The size of the building is considerably large and it serve as residential area, so the load is a great deal.

The references that will be used for the earthquake resistance building are SNI 1726-2019 *Tata Cara Perencanaan Ketahanan Gempa Struktur Bangunan Gedung dan Non Gedung*, SNI 2847-2019 *Persyaratan Beton Struktural untuk Bangunan Gedung*, SNI 1729-2015 *Spesifikasi untuk Bangunan Gedung Baja Struktural*, and SNI 1727-2020 *Beban Desain Minimum dan Kriteria Terkait untuk Bangunan*

The design will begin from interpreting soil data from test, determining site class, determining the structure system, and calculate the response spectrum curve for dynamic load analysis of earthquake. The design continues to super structure for purlin, truss, slab, beam, column, beam-column joint, tie beam, and stair. Then, for the substructure it encompasses liquefaction analysis, foundation type analysis, foundation bearing capacity, foundation design for reinforced concrete structure, and settlement analysis. The output of the design is construction drawing, where this drawing will be used for cost and time management work. The work includes making work breakdown structure, quantity take-off, and unit price cost analysis. Then, by the help of Microsoft Project, the analysis for workers and resources can be done. It includes to maximize the workers and resources to have cheapest cost and shortest duration of work. At the end, the work is presented in S-Curve.

The design result in this project for super structure are Purlin C125x50x20x2, Truss 2L90x90x7, 2 bolt connection D16 mm, sag rod D10 mm, and anchor D18mm L150 mm. For slab will use 8 types of two way that has thickness of 1.5 cm, the beam size is 50 x 50 cm, the column size is 65 x 65 cm, the stairs thickness is 100 cm, and the landing slab thickness is 3 cm. The substructure uses bore pile foundation with depth of 16 m and 4 types. The pile cap thickness is 1 meter.

The cost and time analysis shows that the building construction will take 1080 days and cost of Rp41,224,131,730.39

Keywords: design, structure, geotechnic, cost and time management

## STATEMENT

We, the undersigned below,

Student's Name 1 : Bernardinus Sandiko Pinayungan

Student's Number : 191317915

Student's Name 2 : Muhammad Reza Ramadhani Syahdaputra

Student's Number : 191317762

Truly declare that the Final Project with the title:

**“SIMPLE FLATS FOR RENTAL IN YOGYAKARTA CITY WITH A SUSTAINABLE ARCHITECTURE APPROACH IN YOGYAKARTA CITY FROM STRUCTURAL, GEOTECHNICAL, AND COST AND TIME MANAGEMENT ASPECTS”**

is an original work and is not the result of plagiarism from the work of others. We, the undersigned, contribute to this Final Project in the same proportion. Thus, we make this statement as a complement to this Final Project document.

Yogyakarta, 17<sup>th</sup> July 2023.....



(Bernardinus Sandiko Pinayungan.)



(Muhammad Reza Syahdaputra R.)

# VALIDATION

Final Project Report

## DESIGN OF SIMPLE FLATS WITH SUSTAINABLE ARCHITECTURE APPROACH IN YOGYAKARTA CITY FROM STRUCTURAL, GEOTECHNICAL, AND COST AND TIME MANAGEMENT ASPECTS

Made By:

Bernardinus Sandiko Pinayungan 191317915  
Muhammad Reza Syahdaputra R. 191317762

Checked by:

Lecturer 3  
TAPI 2

(Dr. Nectaria Putri  
Pramesti, S.T., M.T.)  
NIDN: 0519078003

Lecturer 2  
TAPI 2

(William Wijaya, S.T.,  
M.Eng.)  
NIDN: 0529039402

Lecturer 1  
TAPI 1

(Johan Ardivanto, S.T.,  
M.Eng.)  
NIDN: 0503069301

Approved by:

Final Project's Supervisor  
Yogyakarta, 02 February 2023

(Dr. Eng. Luky Handoko, S.T., M.Eng.)  
NIDN: 0518108501

Validated by:

Head of Civil Engineering Department



FAKULTAS  
TEKNIK  
UNIVERSITAS PADJADJARAN

(Dr. Ir. Imam Basuki, M.T.)

NIDN: 0506046601

# VALIDATION

Final Project Report

## DESIGN OF SIMPLE FLATS WITH SUSTAINABLE ARCHITECTURE APPROACH IN YOGYAKARTA CITY FROM STRUCTURAL, GEOTECHNICAL, AND COST AND TIME MANAGEMENT ASPECTS

Made By:



Bernardinus Sandiko  
Pinayungan  
191317915



Muhammad Reza  
Syahdaputra Ramadhani  
191317762

Has been examined and approved by:

Name	Signature	Date
Leader : Dr. Eng. Luky Handoko, S.T., M.Eng.		14 July 2023
Secretary : Baskoro Abdi Praja, S.T., M.Eng.		04 July 2023
Member : Ir. AY. Harijanto Setiawan, M.Eng., Ph.D.		04 July 2023

## PREFACE

All praise to God Almighty because of Him the author can carry out and be able to complete the Infrastructure Design Final Project Report (TAPI) properly and on time. The implementation of Final Project Infrastructure Design is carried out to directly practice the existing knowledge in a design practice so that students are expected to be able to apply the theoretical knowledge that has been taught previously. This report was prepared to meet the graduation requirements for the Bachelor of Civil Engineering Study Program, Faculty of Engineering, Universitas Atma Jaya Yogyakarta. In writing this report, the writing of this report was able to run smoothly because of the many assistances and directions as well as information about the implementation of TAPI. So that the author does not forget to thank:

1. God Almighty, because of His blessings and grace, we were able to carry out and compile the Final Infrastructure Design Report properly.
2. Mr. Dr. Eng. Luky Handoko, S.T., M. Eng., as the Dean of the Faculty of Engineering, as well as the author's Supervisor.
3. Mrs. Vienti Hadsari, S.T., M. Eng., MECRES., Ph.D., as Head of the Civil Engineering Study Program at Universitas Atma Jaya Yogyakarta.
4. Mr. Johan Ardianto, S.T., M. Eng., as a Lecturer at the Final Project Infrastructure Design 1 on Structure Part at Universitas Atma Jaya Yogyakarta.
5. Mr. William Wijaya, S.T., M. Eng., as a Lecturer at the Final Project Infrastructure Design 2 on Geotechnic Part at Universitas Atma Jaya Yogyakarta.
6. Mrs. Dr. Nectaria Putri, S.T., M.T., as a Lecturer at the Final Project Infrastructure Design 2 on Project Management Part at Universitas Atma Jaya Yogyakarta.
7. Friends of the Final Project Infrastructure Design group and other friends as well as all those who have supported the writer who cannot be mentioned one by one.

In conclusion, we hope this report can provide insight and benefit to readers, especially Civil Engineering students at Universitas Atma Jaya Yogyakarta for the perfection of the next report.

## TABLE OF CONTENTS

ABSTRACT.....	iii
STATEMENT.....	iv
VALIDATION.....	v
PREFACE.....	vii
TABLE OF CONTENTS.....	viii
TABLE OF FIGURES.....	xi
LIST OF TABLES.....	xiv
CHAPTER I INTRODUCTION.....	1
1.1. Background.....	1
1.2. General Preview.....	2
1.3. Problems.....	2
1.4. Objectives.....	2
1.5. Research Methodologies.....	2
1.6. Final Project Systematics.....	2
CHAPTER II SUPER STRUCTURE.....	4
2.1. Introduction.....	4
2.2. Soil Interpretation Data and Site Class Determination.....	5
2.3. Structure System Determination.....	7
2.4. Structural Loading.....	8
2.4.1. Load Combination.....	8
2.4.2. Dead Load (Self Weight).....	8
2.4.3. Additional Dead Load.....	9
2.4.4. Live Load.....	9
2.4.5. Wind Load.....	9
2.4.6. Earthquake Load.....	11
2.5. Structural Modelling.....	15
2.6. Evaluating Structural Systems Output and Structural Irregularities.....	19
2.6.1. Modal Mass Ratio Check.....	19
2.6.2. Load Combination Base Shear Check.....	20
2.6.3. Structural Irregularity.....	22
2.7. Consequence of Irregularity Horizontal Irregularity.....	31
2.7.1. Consequence of Irregularity Horizontal Irregularity.....	31
2.8. Consequence of Vertical Irregularity.....	34



2.9.	Roof Structure Design .....	34
2.9.1.	Purlin .....	35
2.9.2.	Sag Rod .....	42
2.9.3.	Truss .....	42
2.9.4.	Connection .....	48
2.9.5.	Anchor .....	53
2.9.6.	Conclusion .....	56
2.10.	Beam Design .....	56
2.10.1.	Loading .....	57
2.10.2.	Dimension Requirement .....	58
2.10.3.	Moment Strength and Longitudinal Reinforcement .....	58
2.10.4.	Shear Strength and Transversal Reinforcement .....	61
2.10.5.	Torsion Check and Shrinkage Reinforcement .....	62
2.10.6.	Conclusion .....	65
2.11.	Tie Beam .....	66
2.11.1.	Loading .....	67
2.11.2.	Longitudinal Reinforcement .....	69
2.11.3.	Transversal Reinforcement .....	71
2.11.4.	Conclusion .....	73
2.12.	Column Design .....	74
2.12.1.	Loading .....	75
2.12.2.	Dimension Check .....	76
2.12.3.	Longitudinal Reinforcement .....	77
2.12.4.	Transversal Reinforcement .....	80
2.12.5.	Conclusion .....	83
2.13.	Beam-Column Joint Design .....	84
2.13.1.	Reinforcement .....	86
2.13.2.	Conclusion .....	88
2.14.	Slab Design .....	89
2.14.1.	Determination of Dimension and Slab Type .....	90
2.14.2.	Shear Strength .....	91
2.14.3.	Moment Strength .....	92
2.14.4.	Reinforcement .....	93
2.14.5.	Conclusion .....	93
2.15.	Stair Design .....	94

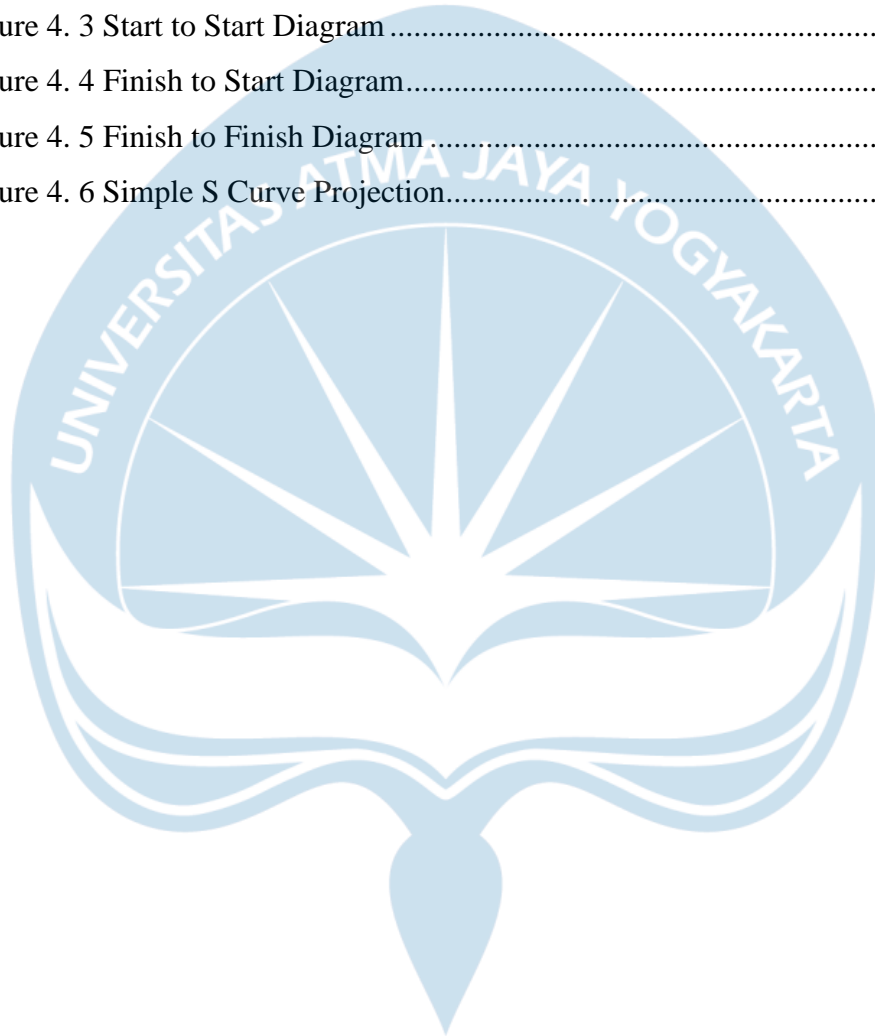
2.15.1. Stair Data.....	94
2.15.2. Loading .....	96
2.15.3. Reinforcement .....	96
2.15.4. Conclusion .....	98
<b>CHAPTER III SUB STRUCTURE .....</b>	<b>99</b>
3.1. Introduction .....	99
3.2. Soil Data Intepretation.....	100
3.3. Liquefaction Potential .....	102
3.4. Foundation Bearing Capacity .....	106
3.5. Design of Deep Foundation.....	115
3.5.1. Pile Cap.....	116
3.5.2. Pile .....	123
3.6. Settlement.....	125
3.6.1. Single Pile Settlement .....	126
3.6.2. Group Pile Settlement .....	127
3.7. Differential Settlement .....	129
3.8. Conclusion.....	130
<b>CHAPTER IV COST AND TIME MANAGEMENT.....</b>	<b>131</b>
4.1. Introduction .....	131
4.2. Work Breakdown Structure (WBS) .....	132
4.3. Volume of Work.....	134
4.4. Unit Cost Price Analysis (AHSP) .....	136
4.5. Bill Of Quantity (BOQ).....	139
4.6. Duration.....	140
4.6.1. Relations Between Activities .....	142
4.7. S Curve and Bar Chart.....	144
4.8. Conclusion.....	145
<b>CHAPTER V CONCLUSION .....</b>	<b>147</b>
<b>REFERENCES.....</b>	<b>149</b>

## TABLE OF FIGURES

Figure 2. 1 General Super Structure Flowchart .....	5
Figure 2. 2 Soil Interpretation Data Flowchart .....	5
Figure 2. 3 Pitched Roof Wind Load (Source SNI 1727:2013 figure 27.4-1).....	10
Figure 2. 4 Response Spectrum Curve .....	13
Figure 2. 5 Static Equivalent Load (Source: SNI 1726:2019 figure 10).....	14
Figure 2. 6 Structural Modelling Flowchart.....	15
Figure 2. 7 Building Model Left View.....	17
Figure 2. 8 Building Model Right View .....	17
Figure 2. 9 Building Model Front View .....	18
Figure 2. 10 Building Model Plan View .....	18
Figure 2. 11 Old Base Reaction .....	21
Figure 2. 12 Old Scale Factor .....	22
Figure 2. 13 New Scale Factor .....	22
Figure 2. 14 New Base Reaction.....	22
Figure 2. 15 Horizontal Irregularity 1. a and 1. B.....	24
Figure 2. 16 Horizontal Irregularity 2.....	24
Figure 2. 17 Structure Horizontal Irregularity 2 Condition .....	25
Figure 2. 18 Horizontal Irregularity 3.....	25
Figure 2. 19 Structure Opening.....	26
Figure 2. 20 Horizontal Irregularity 4.....	27
Figure 2. 21 Horizontal Irregularity 5.....	27
Figure 2. 22 Vertical Irregularity 1a and 1b.....	28
Figure 2. 23 Vertical Irregularity 2 .....	29
Figure 2. 24 Vertical Irregularity 3 .....	30
Figure 2. 25 Vertical Irregularity 4 .....	30
Figure 2. 26 Vertical Irregularity 5a and 5b.....	31
Figure 2. 27 Consequence of Irregularity Horizontal Irregularity .....	32
Figure 2. 28 Roof Structure Design Flowchart .....	34
Figure 2. 29 Purlin Tributary Area.....	36
Figure 2. 30 Load Projection of D, ADL, and LL.....	37
Figure 2. 31 Load Projection of WL .....	38

Figure 2. 32 Truss Preliminary Design .....	43
Figure 2. 33 Truss Model in ETABS .....	44
Figure 2. 34 Super Dead Load on Truss .....	44
Figure 2. 35 Live Load on Truss .....	44
Figure 2. 36 Wind Load on Truss .....	44
Figure 2. 37 Joint with Maximum Axial Force.....	48
Figure 2. 38 Beam Design Flowchart .....	56
Figure 2. 39 Tie Beam Design Flowchart .....	66
Figure 2. 40 Column Design Flowchart.....	74
Figure 2. 41 Moments act on Column (Source: Setiawan. 2016).....	78
Figure 2. 42 Column P-M Interaction Diagram .....	79
Figure 2. 43 Factored Loads and Moments of Column .....	79
Figure 2. 44 New P-M Interaction Diagram when $1.25F_y$ .....	82
Figure 2. 45 Beam-Column Joint Design Flowchart .....	84
Figure 2. 46 Beam-Column Joint Effective Dimension.....	85
Figure 2. 47 Shear Force on Column due to Probability Moment of Beam and Column .....	87
Figure 2. 48 Tension (T) and Compression on Beam-Column Joint.....	87
Figure 2. 49 Slab Type A .....	90
Figure 2. 50 Interior Slab-Beam Cross-section.....	91
Figure 2. 51 Clear Distance $D_x$ and $D_y$ on Slab .....	92
Figure 2. 52 Stair Design Flowchart .....	94
Figure 2. 53 Stair Area .....	95
Figure 2. 54 Stair Detail .....	96
Figure 3. 1 Flowchart of Substructure Design .....	100
Figure 3. 2 Liquefaction Flowchart.....	102
Figure 3. 3 Bearing Capacity Flowchart .....	106
Figure 3. 4 Lateral Load Calculation Flowchart .....	109
Figure 3. 5 Structural Analysis for Point Load .....	115
Figure 3. 6 Pile Cap Design Flowchart .....	116
Figure 3. 7 Pile Cap Preliminary Design .....	117
Figure 3. 8 Shear Force Diagram of Pile in $L_y$ .....	118
Figure 3. 9 Shear Force Diagram of Pile in $L_x$ .....	118

Figure 3. 10 Two Way Shear Area.....	120
Figure 3. 11 Pile Design Flowchart .....	123
Figure 3. 12 Pile Group Width and Length.....	128
Figure 3. 13 Column Plan with Biggest Axial Force Difference.....	129
Figure 4. 1 Flowchart of Cost and Time Planning.....	132
Figure 4. 2 Start to Finish Diagram.....	142
Figure 4. 3 Start to Start Diagram .....	143
Figure 4. 4 Finish to Start Diagram.....	143
Figure 4. 5 Finish to Finish Diagram .....	143
Figure 4. 6 Simple S Curve Projection.....	145



## LIST OF TABLES

Table 2. 1 Site Parameter .....	6
Table 2. 2 Calculation of Class Site Classification .....	7
Table 2. 3 Structure Parameters .....	8
Table 2. 4 Wind Load Parameter .....	9
Table 2. 5 Wind Load Coefficient Pressure .....	10
Table 2. 6 Wind Load on Roof Surface .....	10
Table 2. 7 Response Spectrum Design.....	12
Table 2. 8 Static Equivalent Parameter in X Direction.....	14
Table 2. 9 Static Equivalent Load Parameter in Y Direction.....	14
Table 2. 10 Material Properties .....	16
Table 2. 11 Comparison of SNI and ETABS .....	16
Table 2. 12 Mass Source .....	18
Table 2. 13 Modal Participation Mass Ratio.....	19
Table 2. 14 Base Reaction Scaling.....	21
Table 2. 15 Horizontal Irregularity Type 2 Check.....	25
Table 2. 16 Structure Opening Check.....	26
Table 2. 17 Soft-grade Stiffness Irregularity Check .....	28
Table 2. 18 Mass Irregularity Check.....	29
Table 2. 19 Vertical Geometric Irregularity Check .....	29
Table 2. 20 Discontinuity Check.....	31
Table 2. 21 Purlin Dimension .....	35
Table 2. 22 Purlin Properties.....	35
Table 2. 23 Purlin Tributary Area .....	36
Table 2. 24 Top and Bottom Purlin Load .....	36
Table 2. 25 Middle Purlin Load .....	37
Table 2. 26 Maximum Loading and Moment of Top and Bottom Purlin .....	38
Table 2. 27 Maximum Loading and Moment of Middle Purlin.....	38
Table 2. 28 Profile Check for Compact, Non-Compact, and Slender.....	39
Table 2. 29 Formula for $\lambda$ , $\lambda_p$ , and $\lambda_r$ .....	39
Table 2. 30 Purlin $L_b$ , $L_p$ , and $L_r$ for Y Direction.....	39
Table 2. 31 Purlin $L_b$ , $L_p$ , and $L_r$ for X Direction.....	39

Table 2. 32 Moment Design Calculation for Y Direction Load .....	40
Table 2. 33 Moment Design Calculation for X Direction Load .....	40
Table 2. 34 Purlin Shear Design Calculation .....	41
Table 2. 35 Deflection at Y Direction .....	41
Table 2. 36 Deflection at X Direction .....	42
Table 2. 37 Sag Rod and Tie Rod Calculation .....	42
Table 2. 38 Truss Profile .....	43
Table 2. 39 Load Recap on Truss .....	43
Table 2. 40 Truss Axial Force Output .....	45
Table 2. 41 Truss Displacement .....	45
Table 2. 42 Tension Member Check .....	46
Table 2. 43 Compression Member Check .....	47
Table 2. 44 Slenderness Check .....	48
Table 2. 45 Joint with Maximum Axial Force .....	48
Table 2. 46 Bolt Properties .....	48
Table 2. 47 Double Shear Strength .....	49
Table 2. 48 Slip Critical Strength .....	50
Table 2. 49 Bearing Strength .....	50
Table 2. 50 Yielding and Rupture Bolt Strength .....	51
Table 2. 51 Block Shear Strength .....	52
Table 2. 52 Anchor Properties .....	53
Table 2. 53 Reaction and Maximum Load of Truss .....	53
Table 2. 54 Anchor Shear Strength .....	53
Table 2. 55 Anchor Compressive Strength .....	54
Table 2. 56 Anchor Dimension Properties for Shear Checking .....	54
Table 2. 57 Anchor Spalling Shear Strength in Concrete .....	54
Table 2. 58 Anchor Pry Out Shear Strength in Concrete .....	54
Table 2. 59 Anchor Breakout Strength in Concrete .....	55
Table 2. 60 Anchor Number .....	55
Table 2. 61 Beam Properties .....	57
Table 2. 62 Column Dimension .....	57
Table 2. 63 Beam Load .....	58
Table 2. 64 Dimension Requirements .....	58

Table 2. 65 Moment Strength and Flexural Reinforcement.....	59
Table 2. 66 Check Requirements .....	60
Table 2. 67 Beam Shear Strength and Transversal Reinforcement .....	61
Table 2. 68 Torsion Check.....	63
Table 2. 69 Torsion Transversal Reinforcement.....	63
Table 2. 70 Torsion Longitudinal Reinforcement.....	64
Table 2. 71 All Beam Reinforcement Recap .....	66
Table 2. 72 Tie Beam Properties.....	67
Table 2. 73 Calculation of Axial Force.....	68
Table 2. 74 Tie Beam Flexural Reinforcement.....	69
Table 2. 75 Shear Strength and Transversal Reinforcement.....	72
Table 2. 76 Tie Beam Reinforcement Recap .....	73
Table 2. 77 Column Dimension and Properties .....	75
Table 2. 78 Column Loading .....	75
Table 2. 79 Load Combination of Column .....	76
Table 2. 80 Column Dimension Check.....	77
Table 2. 81 Column Minimum Bending Strength.....	78
Table 2. 82 Column Top and Bottom Moment.....	79
Table 2. 83 Transversal Reinforcement Parameters .....	80
Table 2. 84 Calculation of Confinement Steel Area .....	80
Table 2. 85 Minimum Transversal Reinforcement Spacing .....	81
Table 2. 86 Transversal Reinforcement Support.....	82
Table 2. 87 Transversal Reinforcement Span .....	83
Table 2. 88 Recap for Column Reinforcement .....	84
Table 2. 89 Beam-Column Properties.....	85
Table 2. 90 Beam-Column Joint Effective Dimension .....	85
Table 2. 91 Check Transversal Requirement .....	86
Table 2. 92 Shear Strength Check.....	87
Table 2. 93 Hook Design .....	88
Table 2. 94 Reinforcement Recap on Beam-Column Joint.....	88
Table 2. 95 Transversal Hook Length.....	89
Table 2. 96 Check Rebar Spacing .....	89
Table 2. 97 Slab Load .....	91



Table 2. 98 Slab Reinforcement.....	93
Table 2. 99 Stair Loading.....	96
Table 2. 100 Landing Slab Loading.....	96
Table 2. 101 Stairs and Landing Slab Reinforcement Calculation.....	97
Table 2. 102 Stairs and Landing Slab Reinforcement Recap.....	98
Table 3. 1 Soil Data from Standard Penetration Test.....	101
Table 3. 2 Cyclic Resistance Ration (CRR).....	103
Table 3. 3 $\alpha$ and $\beta$ value.....	104
Table 3. 4 Cyclic Stress Ratio (CSR).....	104
Table 3. 5 Safety Factor from CRR and CSR.....	105
Table 3. 6 Tip Strength of Bore Pile.....	107
Table 3. 7 Skin Stress of Bore Pile.....	108
Table 3. 8 Moment Capacity of Bore Pile.....	110
Table 3. 9 Lateral Strength of Bore Pile.....	111
Table 3. 10 Allowed Lateral Strength due to Defection.....	112
Table 3. 11 Relative Density for Sand.....	112
Table 3. 12 Coefficient of Modulus Variation.....	113
Table 3. 13 Number of Required Pile.....	113
Table 3. 14 Parameter of Pile Group Efficiency.....	114
Table 3. 15 Pile Efficiency.....	114
Table 3. 16 Pile Dimension and Properties.....	116
Table 3. 17 Pile Load.....	117
Table 3. 18 Shear Force and Moment in Ly.....	119
Table 3. 19 Shear Force and Moment in Lx.....	119
Table 3. 20 Concrete Shear Strength for Two Way Shear around Column.....	120
Table 3. 21 Concrete Shear Strength for Two Way Shear around Pile.....	120
Table 3. 22 Concrete Shear Strength for Two Way Shear (Source: SNI 2847:2019 table 22.2.1b).....	121
Table 3. 23 Longitudinal Reinforcement at Long Span (Ly).....	121
Table 3. 24 Pile Longitudinal Reinforcement.....	123
Table 3. 25 Spiral Reinforcement.....	124
Table 3. 26 Cutting Length.....	125
Table 3. 27 Settlement Parameter.....	126

Table 3. 28 Settlement Calculation .....	126
Table 3. 29 Group Pile Settlement Parameter .....	127
Table 3. 30 Pile Group Settlement Calculation.....	128
Table 3. 31 Biggest Column Axial Force Difference .....	129
Table 3. 32 Differential Settlement.....	130
Table 3. 33 Pile Reinforcement Recap.....	130
Table 4. 1 Work Breakdown Structure .....	133
Table 4. 2 Technical Specification.....	135
Table 4. 3 Unit Cost Price Analysis for Bore Pile Concrete Cast Work.....	138
Table 4. 4 Bill of Quantity for Simple Flat Construction .....	139
Table 4. 5 Duration for Bore Pile Concrete Cast Work.....	141
Table 4. 6 Heavy Equipment Coefficient for Concrete Pump .....	142
Table 4. 7 Task Dependency.....	143

