

STRUCTURAL DESIGN OF TANGCITY MALL TANGERANG USING SPECIAL MOMENT RESISTING FRAME

Final Project

By :

DONI PUTRA PRATAMA

Student Number: 05 13 12213



ATMA JAYA YOGYAKARTA UNIVERSITY
Faculty of Engineering
Department of Civil Engineering
International S1 Program
2011

APPROVAL

Final Project

STRUCTURAL DESIGN OF TANGCITY MALL TANGERANG USING SPECIAL MOMENT RESISTING FRAME

By:

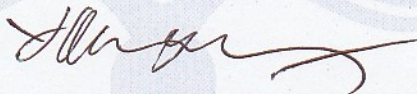
DONI PUTRA PRATAMA

Student Number: 05 13 12213

has been approved

Yogyakarta,

Advisor



(Prof. Ir. Yoyong Arfiadi, M.Eng., Ph.D.)

Department of Civil Engineering



Head

March 24, 2011

(Ir. Junaedi Utomo, M.Eng.)

APPROVAL

Final Project

STRUCTURAL DESIGN OF TANGCITY MALL TANGERANG USING SPECIAL MOMENT RESISTING FRAME

By:

DONI PUTRA PRATAMA

Student Number: 05 13 12213

has been examined and approved by the examination committee

Signature

Date

Chairperson : Prof. Yoyong Arfiadi, M.Eng., Ph.D.

 21/03/2011

Member : DR. Ir. Ade Lisantono., M.Eng.

 22/03/2011

Member : Ir. Pranawa Widagdo., MT.

 23/03 2011

For each new morning with its light,

For rest and shelter of the night,

For health and food, for love and friends,

For everything Thy goodness sends.

This Final Project Has Been Dedicated To:

My Savior and Redeemer, Jesus Christ

My Beloved Father and Mother

My Little Brothers, Davin and William

Who Always Be Here To Pray and Support Me

PREFACE

First and foremost, I would like to thank God for His blessing, so that I could prepare and finish this final project report. This report was made to finish the S1 degree at Faculty of Engineering, Department of Civil Engineering, Atma Jaya University Yogyakarta.

In this final project, I redesign “Tangcity Mall Tangerang” building by using software ETABS non linier version 9.70 and SAP2000 V14. It is also designed based on SNI 2002.

I would like to express my gratitude for:

1. **DR. Ir. Ade Lisantono, M.Eng**, as the Dean of Engineering Faculty, University of Atma Jaya Yogyakarta.
2. **Ir. Y. Lulie, MT.**, as the Coordinator of International Program, University of Atma Jaya Yogyakarta.
3. **Prof. Yoyong Arfiadi, M. Eng, PhD** as my final project’s advisor who has given me guidance and knowledge in civil engineering and also given me a will and motivation to complete this final project.
4. **Ir. Junaedi Utomo, M.Eng.**, as the head of Civil Engineering Department, University of Atma Jaya Yogyakarta.
5. **Mas Wiko**, as the administration staff of International Civil Engineering Program, University of Atma Jaya Yogyakarta who has given me information and help for the administration requirements and stuffs.
6. **My Father, Mother, My Little Brothers, Davin and William** who always give me support and motivation.
7. **My International Civil Engineering friends of year 2005, Adit Paijo, Anita, Ayu; Other International class friends, Yohan Medisa and Lukas; Other friends, Adit Elphi and Hansen; and the last, My ex-gf, Debby Liem** who have supported and given motivation, information and additional knowledge to the author in the past.

I realized that, this report has many mistakes. I openly accept all arguments and critiques from all of the readers so I can make my final project better. Finally, I hope that this final project can give benefit to the readers. Thank you and please enjoy reading my final project.

Yogyakarta, February 2011

Doni Putra Pratama



CONTENTS

COVER	i
APPROVAL	ii
DEDICATION SHEET	iv
PREFACE.....	v
CONTENTS.....	vii
TABLE CONTENTS	xii
FIGURE CONTENTS	xiii
APPENDIX CONTENTS	xv
ABSTRACT	xvi
CHAPTER I. INTRODUCTION.....	1
1.1. General Background.....	1
1.2. Problem Statement	2
1.3. Problem Limitations.....	2
1.4. Objective	3
1.5. Function	4
CHAPTER II. LITERATURE REVIEW	5
2.1. Concrete Slab	6
2.2. Beam	6
2.3. Column.....	7
2.4. Foundation	8
CHAPTER III. BASIC THEORY	10

3.1. Loading Analysis	10
3.2. Earthquake Design	11
3.3. Slab Design	12
3.4. Stair Design	14
3.5. Beam Design	14
3.5.1. Longitudinal Reinforcement	14
3.5.2. Shear Reinforcement.....	16
3.5.3. Torsion Reinforcement	17
3.6. Column Design	18
3.6.1. Longitudinal Reinforcement	18
3.6.2. Shear Reinforcement.....	19
3.7. Pile Foundation Design	20
CHAPTER IV. STRUCTURAL ELEMENT DIMENSION	
ESTIMATION.....	24
4.1. Estimation	24
4.2. Beam Estimation	24
4.3. Slab Thickness Estimation	27
4.4. Column Estimation	34
4.4.1. Calculation of Dead Load and Live Load.....	34
4.4.2. Estimation of Column I-3	35
4.4.3. Estimation of Column J-1	47
CHAPTER V. SEISMIC DESIGN.....	
5.1. Earthquake Zone	60

5.2. Importance Factor I	60
5.3. Natural Period	60
5.4. Seismic Response Factor C_1	60
5.5. Seismic Response Factor R	61
5.6. Distribution of F_i	62
5.7. T Reyleigh Analysis	63
5.8. Service Story Drift	65
5.9. Ultimate Story Drift	67
CHAPTER VI. STRUCTURAL ANALYSIS	70
6.1. Stairs Design	70
6.1.1. Dimension of Stairs	70
6.1.2. Stairs Loading	72
6.1.3. Reinforcement in Stairs Slab and Landing Slab	73
6.1.3.1. Midspan Reinforcement	74
6.1.3.2. Edge Reinforcement	75
6.1.3.3. Shrinkage Reinforcement	76
6.1.3.4. Control Against Shear	77
6.1.4. Reinforcement in Landing Beam	77
6.1.4.1. Edge Reinforcement	78
6.1.4.2. Midspan Reinforcement	80
6.2. Slab Design	83
6.2.1. Reinforcement in X direction	84
6.2.2. Reinforcement in Y direction	85

6.2.3. Control Against Shear	87
6.2.4. Shrinkage Reinforcement.....	87
6.3. Beam Design	88
6.3.1. Flexural Reinforcement	88
6.3.1.1. Condition I:Left Support (Negative Moment).....	89
6.3.1.2. Condition II:Left Support (Positive Moment)	90
6.3.1.3. Condition III:Right Support (Negative Moment).....	92
6.3.1.4. Condition IV:Right Support (Positive Moment)	93
6.3.1.5. Condition V:Middle Bottom (Positive Moment)	94
6.3.1.6. Condition VI:Middle Top (Negative Moment)	96
6.3.2. Moment Capacity	98
6.3.2.1. Positive Moment Capacity.....	99
6.3.2.2. Negative Moment Capacity	103
6.3.3. Shear Reinforcement.....	107
6.3.3.1. Shear Reinforcement at Plastic Hinge	108
6.3.3.2. Shear Reinforcement at Outside Plastic Hinge.....	110
6.3.4. Torsion Reinforcement	111
6.3.4.1. In Plastic Hinge	113
6.3.4.2. Outside Plastic Hinge	115
6.3.4.3. Additional Longitudinal Reinforcement.....	117
6.4. Column Design	120
6.4.1. Longitudinal Reinforcement	120
6.4.1.1. Analysis Using Biaxial Bending Moment.....	122

6.4.1.2. Searching for Moment Caused by Earthquake	124
6.4.1.3. Searching for Moment Capacity	128
6.4.2. Shear Reinforcement	129
6.4.3. Beam-Column Connection	135
6.5. Retaining Wall Design	137
6.5.1. Dimension of Retaining Wall	137
6.5.2. Soil Data	138
6.5.3. Retaining Wall Stability	139
6.5.4. Retaining Wall Reinforcement	144
6.6. Bored Pile Foundation Design	148
6.6.1. Foundation Loading	148
6.6.2. Amount of Pile Needed	151
6.6.3. Controlling The Reaction of Each Pile	153
6.6.4. Shear Analysis of Foundation	154
6.6.5. Control Against Two-way Shear	156
6.6.6. Control of Transferring Column Loading To Foundation	157
6.6.7. Pile Cap Reinforcement	158
6.6.8. Bored Pile Reinforcement	159
CHAPTER VII. CONCLUSIONS AND SUGGESTIONS	161
7.1. Conclusions	161
7.2. Suggestions	162
REFERENCES	164
APPENDIX	165

TABLE CONTENTS

Number	Table Number	Table Name	Page Number
1	4.1	Estimated Column Dimension Based on Column I-3	47
2	4.2	Estimated Column Dimension Based on Column J-1	59
3	5.1	Building Weight	62
4	5.2	Horizontal distribution of story shear	63
5	5.3	T Rayleigh analysis due to earthquake in X direction	63
6	5.4	T Rayleigh analysis due to earthquake in Y direction	64
7	5.5	Service Story Drift X-axis	65
8	5.6	Service Story Drift Y-axis	66
9	5.7	Ultimate Story Drift X-axis	68
10	5.8	Ultimate Story Drift Y-axis	69
11	6.1	Moment Envelope at B34 Upper Ground Floor	88
12	6.2	Moment Ultimate Used for Designing B34	88
13	6.3	Torsion Forces that work in Retaining Wall	140
14	6.4	Support Forces that work in Retaining Wall	141
15	6.5	Value of Soil Support Coefficient by Terzaghi	143

FIGURE CONTENTS

Number	Figure Number	Figure Name	Page Number
1	3.1	Distribution of Beam Stress and Strain	15
2	4.1	Floor Slab Dimension	27
3	4.2	Beam 2 (300/600)	28
4	4.3	Beam 4 (300/500)	29
5	4.4	Beam 1 (300/600)	31
6	4.5	Beam 3 (300/600)	32
7	4.6	Tributary Area of Column I-3 (Top Floor – Basement 2)	35
8	4.7	Tributary Area of Column J-1 (Top Floor – Basement 2)	47
9	5.1	Service Story Drift X-axis	66
10	5.2	Service Story Drift Y-axis	67
11	5.3	Ultimate Story Drift X-axis	68
12	5.4	Ultimate Story Drift Y-axis	69
13	6.1	Stairs Plain View	71
14	6.2	Stairs Section	71
15	6.3	Load Distribution in Stairs	73
16	6.4	Edge Reinforcement in Landing Beam	80
17	6.5	Midspan Reinforcement in Landing Beam	83
18	6.6	Slab Type 4	83
19	6.7	Right and Left Support Flexural Reinforcement	97
20	6.8	Midspan Flexural Reinforcement	97
21	6.9	T-Beam Section	98
22	6.10	Shear Diagram due to Gravity Loading	107
23	6.11	Shear Diagram due to Earthquake Loading	108
24	6.12	Shear Diagram due to Gravity Loading and Earthquake Loading	108
25	6.13	Perimeter of T-Beam	112
26	6.14	Area of A_{oh}	113
27	6.15	Left and Right Support Reinforcement With Additional Torsion Reinforcement	119
28	6.16	Midspan Reinforcement With Additional Torsion Reinforcement	120
29	6.17	Earthquake Sway in Beam and Column Joint	124
30	6.18	Force Acting in the Beam-Column Joint	136
31	6.19	Shear and Longitudinal Column Reinforcement	137
32	6.20	Dimension of Retaining Wall	137
33	6.21	Soil Pressure Diagram	139
34	6.22	Retaining Wall Slab	146

35	6.23	Plan of Bore Pile Arrangement	152
36	6.24	Section of Bore Pile Arrangement	152
37	6.25	Loading Area for Two-way Shear	156
38	6.26	Plan of Pile Cap	158



APPENDIX CONTENS

Number	Appendix Name	Page Number
	Appendix A	
1	Building Story Weight Comparison	165
2	Stairs Output Data	166
3	Column Output Data	167
4	Beam Output Data	172
5	Beam Moment Release Output Data	175
6	Foundation/Base Output Data	177
7	Mod-Nod Interaction Diagram	178
8	eod-Nod Interaction Diagram	179
	Appendix B	
9	Beam Reinforcement Detail	180
10	Column Reinforcement Detail	181
11	Floor Slab and Roof Slab Reinforcement Detail	182
12	Stairs Reinforcement Detail	183
13	Retaining Wall Reinforcement Detail	184
14	Bored Pile Foundation Reinforcement Detail	185
15	Building Layout (Basement 2 Floor, Basement 1 Floor and Lower Ground Floor)	186
16	Building Layout (Ground Floor)	187
17	Building Layout (Upper Ground Floor and 1 st Floor)	188
18	Building Layout (2 nd Floor)	189
19	Building Layout (3 rd Floor)	190
20	Building Layout (Top Floor)	191
21	3D Building Layout 1	192
22	3D Building Layout 2	193
23	Soil Investigation Data	194

ABSTRACT

STRUCTURAL DESIGN OF TANGCITY MALL USING SPECIAL MOMENT RESISTING FRAME, Doni Putra Pratama, Student Number: 12213, International Civil Engineering, Atma Jaya Yogyakarta University.

In earthquake prone area, buildings have to be designed according to the criteria specified based on earthquake loading code. This final project will consider Tangcity Mall building which located in Tangerang. This building will be designed based on SNI 03 2847 - 2002 and SNI 03 1729 -2002. This building will be considered as Special Moment Resisting Frame (SMRF) system and using concrete quality $f_c' = 30\text{MPa}$ and steel quality $f_y = 400\text{MPa}$ for steel that has more than 12mm diameter in size and $f_y = 240\text{MPa}$ for steel that has less or equal 12mm diameter in size.

In analyzing Tangcity Mall building, ETABS non linear and SAP2000 were used to obtain internal forces of the structure and stairs. For columns design interaction diagram of $M_{od}-N_{od}$ and $e_{od}-N_{od}$ were used in order to obtain the longitudinal reinforcement and for designing the shear reinforcement of beams, ETABS was used by setting all of the structure to Frame Moment Release at the start and the end.

For the seismic design, the natural period did not fulfill the requirement but considering the story drift and the T-rayleigh are okay, so the building is considered okay. V static is used because V dynamic is less than $0.8 \times V$ static.

For designing stairs, it consists of two parts, the landing beam and slabs. The calculation of the stairs and landing slab is considered as regular slab, while the calculation of beam is the same as regular beam. SAP2000 is used for analyzing the forces in the stairs. For designing slab, this final project uses two-way slabs method and the results are P10-175 in X direction and P10-200 in Y direction. As for the Beam, The beam is designed using special moment resisting frame and has the dimension of 400mm x 800mm, and using 13D25 top reinforcement 7D25 bottom reinforcement for left and right support and 4D25 top reinforcement and 6D25 bottom reinforcement for midspan. The shear design is assumed as normal beam by using Frame Moment Release in ETABS and it has 2 secondary beams forces that transferred in this main beam. For designing the column, this final project uses biaxial bending method for analyzing the column. The dimension of the column is 900mm x 900mm and using 44D25 as the longitudinal reinforcement. Retaining Wall Designing is calculated based on the soil data which has soft soil characteristic and $\gamma_k=17\text{KN/m}^3$, $\phi= 30.00^\circ$, and $\gamma_w= 9.81\text{KN/m}^3$, it uses D19-200 for longitudinal reinforcement. The foundation is designed using bored pile. The piles have 80cm diameter and use 12D25 as the longitudinal reinforcement. The pier dimension is 4.4m x 4.4m and it has D25-150 for bottom reinforcement and D19-150 for top reinforcement.

Keywords: capacity design, beams, biaxial columns, two-way slabs, stairs, bored pile foundation, retaining wall, special moment resisting frame.