THE DESIGN OF PARKING BUILDING 5 STORIES WITH STEEL CONSTRUCTION IN SURAKARTA BASED ON SNI 1729-2015

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Abstract

Surakarta city is located on the southern island of Java, Central Java Province, Indonesia. Surakarta has many public facilities such as universities, malls, terminals, airport and etc. Need a lot of parking area to accommodate all the drivers to take their vehicle. This final project designed the parking building 5 stories with steel construction as the main solution to overcome the limitation of land area. The method used to analysis this parking building was Special Moment Frame (SMF). The SMF is the best system in the building's concept because the beam structure has plastic hinge that can develop the seismic force. The best connection in the SMF is Reduction Beam Section (RBS), because the plastic hinge of the beam can occur in the planned point. The standard used for this parking building was Indonesia National Standard (SNI). Structural analysis calculation used ETABS software version 2015. The final result of the design has dimension of Rafter $I_{300x150}$, Secondary beam $I_{350x175}$, Non-SMF Beam $I_{500x200}$, Non-SMF column $H_{400x400}$, SMF beam $I_{600x300}$, and SMF column $H_{500x500}$. The base plate with dimension of 80 cm x 80 cm x 5 cm is satisfied. To support the load from column and transfer the load to soil used the pile foundation with 11 m in depth. The pile foundation diameter of 30 cm x 30 cm is satisfied to resist the load. Sloof dimension used 30 cm width and 50 cm height. The reinforcement used 7D16 for longitudinal and Φ10-200 mm for shear reinforcement.

Key words: parking building, reduction beam section, SNI, special moment frame, steel

Abstrak

Kota Surakarta terletak di sebelah selatan pulau Jawa, Propinsi Jawa Tengah, Indonesia. Surakarta mempunyai banyak fasilitas umum seperti universitas, mall, terminal, bandara dan lainnya. Butuh banyak lahan parkir untuk menampung kendaraan dari semua pengemudi. Skripsi ini mendesain bangunan parkir 5 lantai dengan konstruksi baja sebagai solusi utama untuk mengatasi masalah lahan yang terbatas. Metode yang digunakan untuk menganalisis bangunan ini adalah Sistem Rangka Pemikul Momen Khusus (SRPMK). SRPMK adalah sistem terbaik dalam konsep bangunan karena struktur balok mempunyai sendi plastis yang dapat mengempangkan gaya seismic. Sambungan terbaik pada SRPMK adalah Sambungan Balok Tereduksi (SBT), karena sendi plastis dari balok dapat terjadi pada titik yang

direncanakan. Standar yang digunakan untuk gedung parkir ini adalah Standar Nasional Indonesia (SNI). Analisis struktur menggunakan ETABS versi 2015. Hasil akhir dari rancangan tersebut memiliki dimensi rafter $I_{300x150}$, balok anak $I_{350x175}$, balok Non-SRPMK $I_{500x200}$, kolom Non-SRPMK $H_{400x400}$, balok SRPMK $I_{600x300}$, dan kolom SRPMK $H_{500x500}$. Plat dasar dengan dimensi 80 cm x 80 cm x 5 cm mencukupi. Untuk menunjang beban dari kolom dan memindahkan beban ke tanah digunakan pondasi tiang dengan kedalaman 11 m. Pondasi tiang pancang berdiameter 30 cm x 30 cm mampu untuk menahan beban. Ukuran sloof menggunakan lebar 30 cm dan tinggi 50 cm. Penulangan menggunakan 7D16 untuk tulangan memanjang dan Φ10-200 mm untuk tulangan geser.
Kata kuncu: baja, bangunan parkir, sambungan balok tereduksi, SNI, sistem rangka pemikul momen khusus

1. INTRODUCTION

1.1 Background

Surakarta city is located on the southern island of Java, Central Java Province, Indonesia. Surakarta has many public facilities such as universities, mall, terminals, airport and etc. Need a lot of parking area to accommodate all the passenger or private transport driver to take their vehicles.

The concept of vertical parking building is the main solution to overcome the limitations of land by using air space above. The design of parking building structure will be planned using Special Moment Frame (SMF) as the main structure that restrain gravity and lateral load. It is because the system can develop plastic hinge to resist seismic load.

1.2 Discussion of the Problem

Discussion problems that can be taken is how to design parking building with steel construction which can resist seismic load and how to analysis the structure of building with SMF that efficient in accordance with the latest Indonesia National Standard.

1.3 Purpose

Building structure design of parking building five stories using Special Moment Frame (SMF) in Surakarta have purpose to get the design planning

structure of parking buildings which is safe and could resist to earthquake that often happens in Indonesia based on the regulation apply in Indonesia.

1.4 Limitation Problem

The problem is limited to the scope of the planning of the structure to prevent the expansion of the discussion, then in this final project is given the limitations calculation and discussion in the final project as follows:

a. The building is parking building five stories plus roof with steel construction in Surakarta.
b. Steel calculation (roof, ramps, deck composite, column, beam, connection and stairs) and for concrete calculation (pile cap and driven pile).
c. Main structure only, not include slab on the ground and sheet pile.
d. High of column $1^{st} – 5^{h}$ story is 4 m.
e. The floor plate use deck composite.
f. Foundation use driven pile from soil properties.
g. No review about architectural, construction management and economic.
h. Implementation review only for structural calculation.
i. Standard used is Indonesia National Standards.

1.5 Literature Review

1.5.1 General

In steel design, there is a type of calculation which called Load and Resistance Factor Design (LRFD).

1.5.2 Load and Resistance Factor Design (LRFD)

Load and resistance factor design (LRFD) comparing the factored load which should be less than or equals the factored strength use the LRFD load combination,

$$\text{Factored load} \leq \text{factored strength}$$

1.5.3 Loads

All forces which act on the structure are called loads. Dead loads are permanent load, including the weight of the structure itself. Live loads are not as permanent loads, it may or not be act on the structure at certain time. Wind loads

is a pressure on the exterior surface of a building. Earthquake loads can be considered only in special geographic which has possibility happen.

2 RESEARCH METHOD

2.1 Planning Data

Planning data for the calculation of the structure in this final project is as follows :

a. Structure of the planned building is parking building five stories with Special Moment Frame in Surakarta.
b. Height of column each floor is 4 meter.
c. Used driven pile for the foundation.
4. Structure material is based on Indonesia National Standard (SNI)

2.2 Planning Stages

a. Stage I: Data collection

   Data are used to make plan and prepare the design as the requirement.

b. Stage II: Load analysis

   Analysis the loads which happen on the parking building. Used ETABS 2015.

c. Stage III: Planning of building elements

   Planning all elements of rafter, ramps, column, beam, stair and roof.

d. Stage IV: Planning the Foundation

   Planning the foundation used soil bearing capacity and used driven pile.

e. Stage V: Detailing of the structure

   Make the detail of the elements based on the calculation.

3 RESULTS

3.1 Stairs

Story high	= 400	cm
Landing high	= 200	cm
Tread	= 29	cm
Width of stairs	= 320	cm
Thickness of handrail	= 5	cm

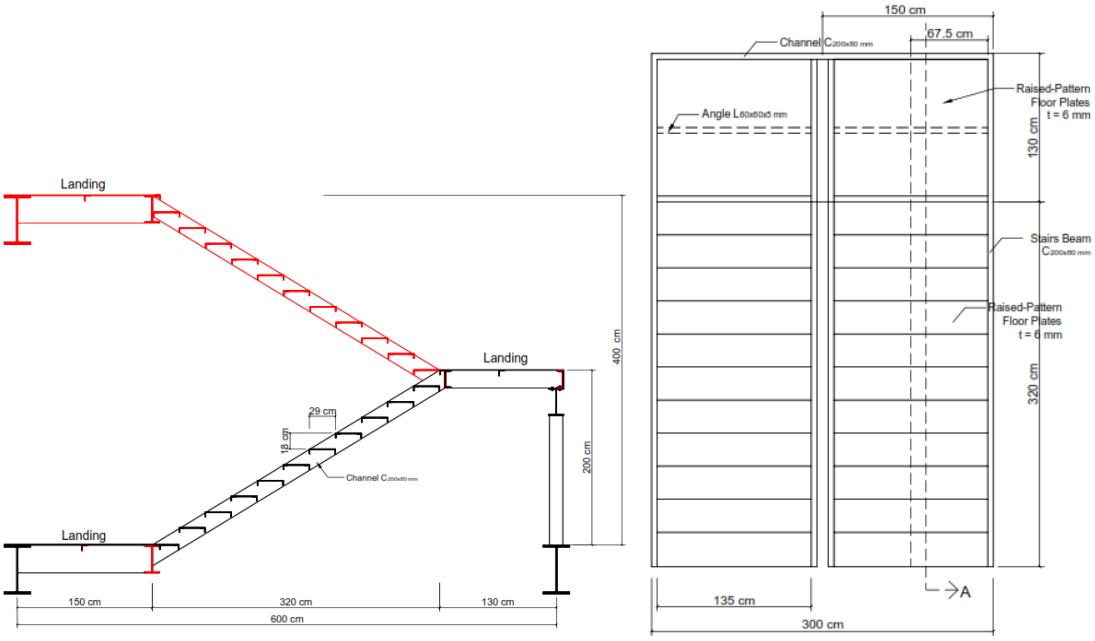

Figure 1. Stair design

3.2 Deck

Floor use deck composite with total thickness 14 cm.

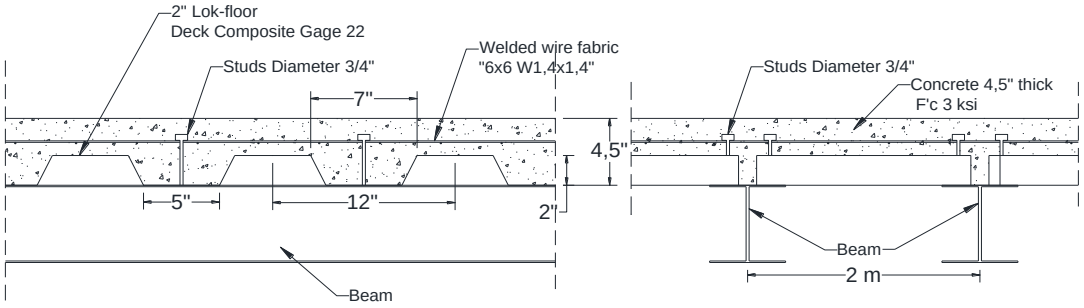

Figure 2. Deck composite

3.3 Gable Roof

Gable roof with total length 21 meter, high 3.296 meter, and distance between gable truss is 6 meter. Rafter profile used $I_{300x150}$.

3.4 Ramps

Total ramps high each floor 4 meter, clear width of ramps 1.5 meter. Used supported ramps deck $I_{150x150}$, secondary ramps beam $I_{200x100}$ and ramps member $I_{400x200}$.

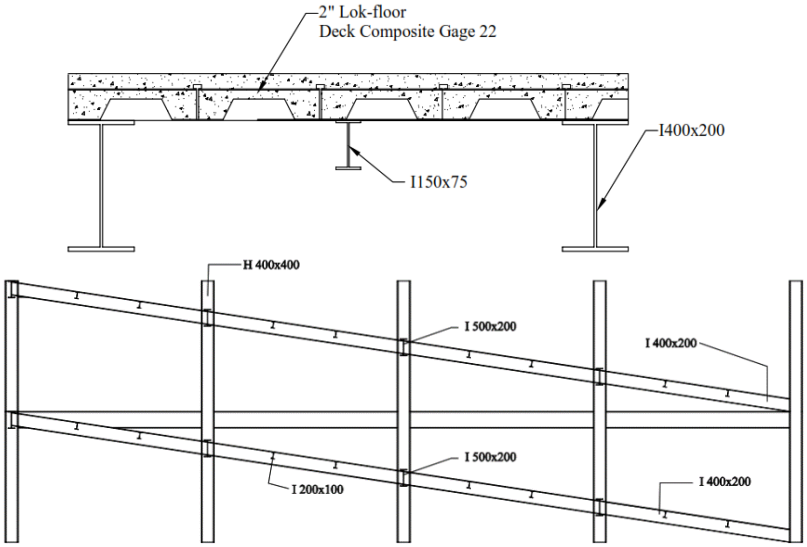

Figure 3. Ramps design

3.5 Primary Structure Elements

The primary structure elements used $I_{350x174}$ for secondary beam, $I_{500x200}$ for Non-SMF beam, $H_{400x400}$ for Non-SMF column, $I_{600x300}$ for SMF beam and $H_{500x500}$ for SMF column.

3.6 Connections

The connection between Non-SMF beam and secondary beam:

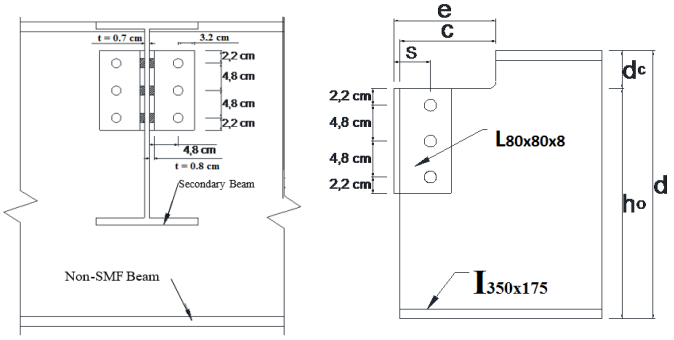

Figure 4. Connection between Non-SMF beam and secondary beam

The connection of RBS:

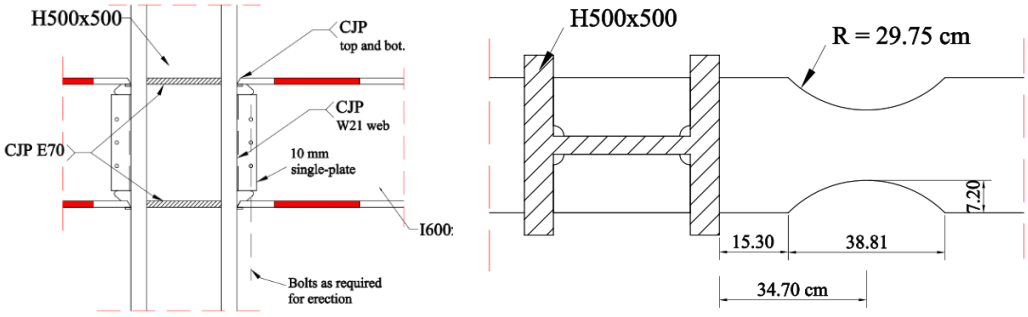

Figure 5. Connection of RBS

3.7 Base Plate

The dimension of base plate that used is 80 cm length, 80 cm width, and 5 cm thick. The anchor hole is 5.87 cm. Have 63.5 cm embedded of anchor rod to the concrete pile cap.

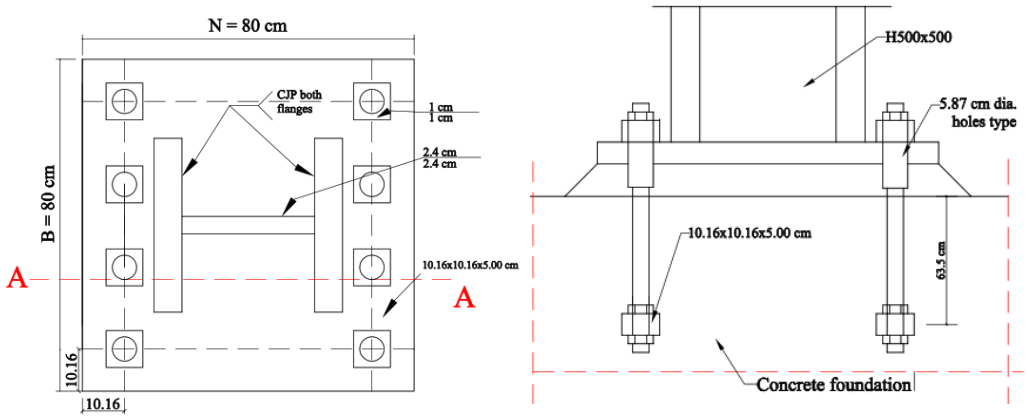

Figure 6. Connection of RBS

3.8 Pile cap and Foundation

Pile cap dimension used 80 cm thick, 2.8-meter length and 2.8-meter width. Longitudinal reinforcement Φ22 – 90 mm and shrinkage reinforcement Φ16 – 125 mm.

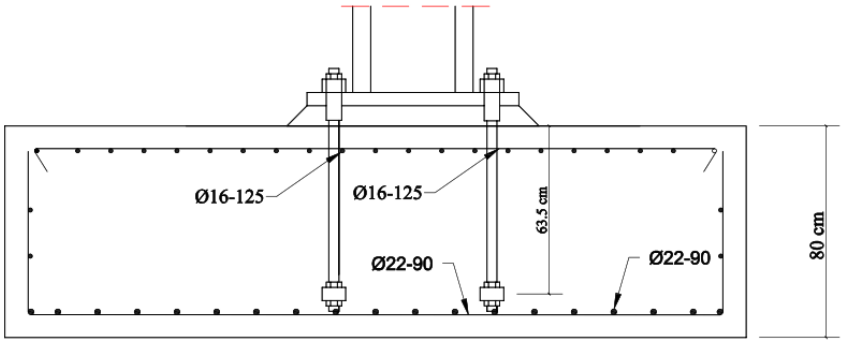

Figure 7. Pile cap design

Pile fondation used dimension 30 cm x 30 cm. 11-meter depth. Longitudinal reinforcement 4D22.

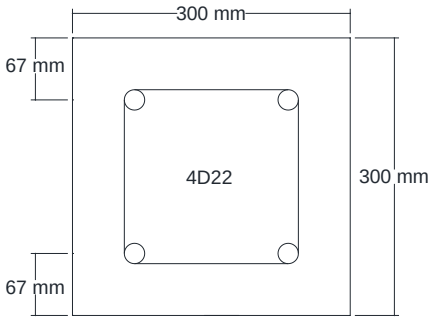

Figure 8. Pile cross section

3.9 Sloof

Sloof used dimension 30 cm width and 50 cm height with f'c 25 MPa and fy 240 MPa. Tension reinforcement used 3D16, compression reinforcement used 2D16, skin reinforcement used 2D16 and stirrup ϕ10-200 mm.

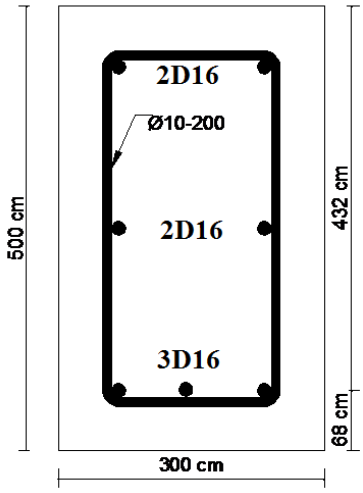

Figure 9. Pile cross section

Complete design for the pile cap, drien pile and sloof can be seen like figure below:

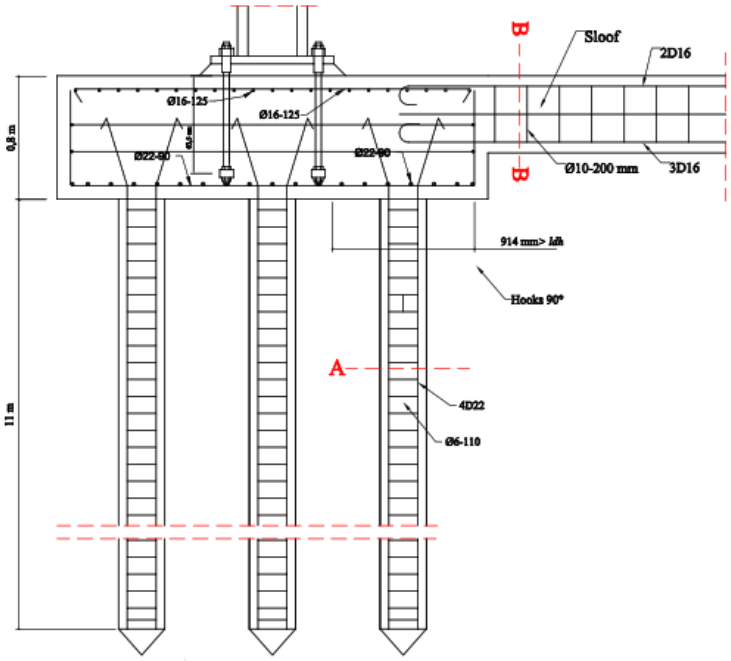

Figure 10. Complete design of foundation.

4 CLOSING

4.1 Conclusion

Based on the result planning of parking building 5 stories in Surakarta used the Indonesia National Standard which has done and got the conclusion as follows:

a. Floor used deck composite type Lok-Floor reinforced welded wire fabric with total thickness is 14 cm.
b. Trade of stair 29 cm, rise 18 cm, supported landing beam used wide flange $I_{300x150}$ and used fy 240 MPa.
c. Structural dimension used $I_{350x175}$ for secondary beam, $I_{500x200}$ for Non-SMF beam, $I_{600x300}$ for SMF beam, $H_{400x400}$ for Non-SMF column, $H_{500x500}$ for SMF column, $I_{300x150}$ for rafter, $I_{500x200}$ for cross ramps beam, and $I_{400x200}$ for edge ramps beam.
d. Pile foundation used 30 cm x 30 cm and 11-meter depth. Used 4D22 for longitudinal reinforcement and ϕ6-110 for shear reinforcement.
e. Pile cap used 2.8-meter length, 2.8-meter width and 800 mm thick. Reinforcement used D22-90 and shrinkage Φ16 – 125 mm.
f. Base plate used 80 cm length, 80 width and 5 cm think.
g. Sloof used 30 cm x 50 cm dimension. Longitudinal reinforcement used 7D16 and shear reinforcement used ϕ10-200 mm.

4.2 Recommendations

a. Economical aspects in the planning is very important and needs to be considered.
b. All assumption in the structural analysis should be understood to get the best condition as in the field.
c. The modelling of the structure in software should be detail and precision to get the best model accordance to the field.
d. Every building has different problems that make the planners be able to understand the fundamental principles of the construction calculation and analysis.

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