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The Structural Planning of Bunda Halimah Hospital Universitas Batam Using Steel Frame Construction

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ABSTRACT

The structural planning of the Bunda Halimah Hospital Universitas Batam uses steel frame construction, planning includes calculating the load acting on the structure, namely in the form of dead loads, living loads, not taking into account earthquake loads. The height of the column in the planning of the Structure of the Bunda Halimah Hospital, is as high as 23.5 m. The process of analyzing the planning of building structures using the ETABS program. Guided by the Indonesian Steel Building Loading Regulations 1984 and SNI steel, to analyze the calculation of the dimensions of columns, beams and plates. The results of the loading calculation based on the Indonesian Steel Building Planning Regulations of 1984 were obtained for this building using WF 250x250x9x14kg/m child beams, WF Main Beams 300x300x10x15kg/m, WF building columns 350x350x12x19 kg/m, and using concrete plates for roofs with a thickness of 100 mm of D8 - 200 mm reinforcement and concrete plates for floors with a thickness of 120 mm of D8 - 200 mm reinforcement.

1. Introduction

The era of globalization and free trade as it is today is an era of increasingly tough industrial and trade challenges and demands a high level of competitiveness and work efficiency. Human resources as the main capital factor will become an urgent need, determine and become a priority on a national and international scale. For this reason, skilled and educated human resources are needed as well as adequate facilities and infrastructure as a priority that deserves attention.¹⁻³

To anticipate the development trends and demands for future human resource capabilities, especially for the Indonesian people, Batam must create capabilities that are relevant to changing needs and employment opportunities. The need for management systems, teaching and learning processes, human resources,

facilities, infrastructure, and programs, both academic programs and professional programs that are well designed and of high quality so that they are ready to face technological developments and are able to meet the needs of workers in Indonesia and abroad. Universitas Batam strives to provide high-quality standardized education in a system, program, activity, and human resources according to the needs of industrial activities nationally and internationally.⁴⁻⁶

The development of the Bunda Halimah Hospital, Universitas Batam is one of the facilities built and is a facility for students of the Faculty of Medicine to practice, which is expected to facilitate teaching and learning activities. Bunda Halimah Hospital was built on a land area of 4800 m² and is a multi-story building consisting of 5 (five) floors. The Bunda Halimah hospital building must be made with a large capacity

so that it can accommodate a large number of students. Given the limited land area and the higher prices, one of the appropriate ways to expand the building is to expand upwards, i.e., multi-story buildings.⁷

To plan a multi-storey building, careful calculations are needed so that the safety factor can be achieved and maintained as a reference.⁸⁻⁹ From these safety factors, a minimum or a (standard) for planning. The planning of the Bunda Halimah Hospital, Universitas Batam, uses a steel frame because it has several advantages over reinforced

concrete structures, including it has high strength, so it can reduce the size of the structure and also reduce the own weight of the structure. This is quite advantageous for long bridge structures, tall buildings, or also buildings that are in poor soil conditions. In addition, to high uniformity and durability, unlike reinforced concrete materials, which consist of various constituent materials, steel materials are much more uniform/homogeneous and have a much higher level of durability if the treatment procedures are carried out properly.

2. Methods

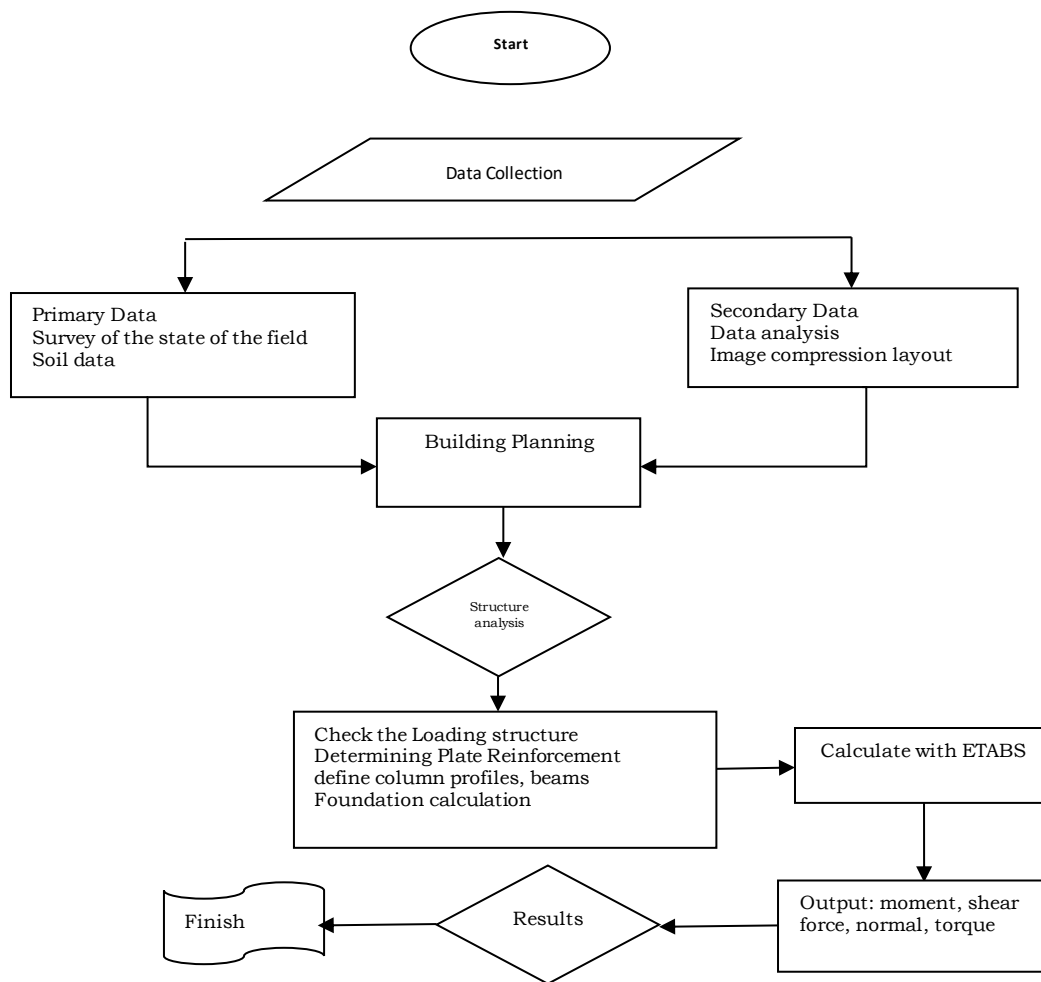


Figure 1. Research Flowchart

This study is a construction plan for Bunda Halimah Hospital with a steel frame structure. The function of the building is as a hospital, with 5 floors, 23.5 meters high, and an IWF steel structure type plan. The design process begins with the collection of primary and secondary data. Primary data is specifically collected by researchers to answer research questions or research. Primary data can be in the form of opinions of research subjects (people) either individually or in groups, results of observations of an object (physical), events or activities, and test results. The main benefit of primary data is that the elements of lies cannot be masked against the source of the phenomenon. Therefore, primary data reflects the truth that is seen. Obtaining primary data will spend relatively more funds and take a relatively long time. Secondary data is generally in the form of

evidence, records, or historical reports that have been compiled in archives, both published and unpublished. The benefits of secondary data are minimizing costs and time, classifying problems, creating benchmarks for evaluating primary data, and filling information gaps. Furthermore, structural analysis was carried out with the help of ETABS software.

3. Results and Discussion

Building plan:

- Building function: Hospital building
- Number of floors: 5 floors
- Total height: 23.5 meters
- Type of structure: Steel IWF

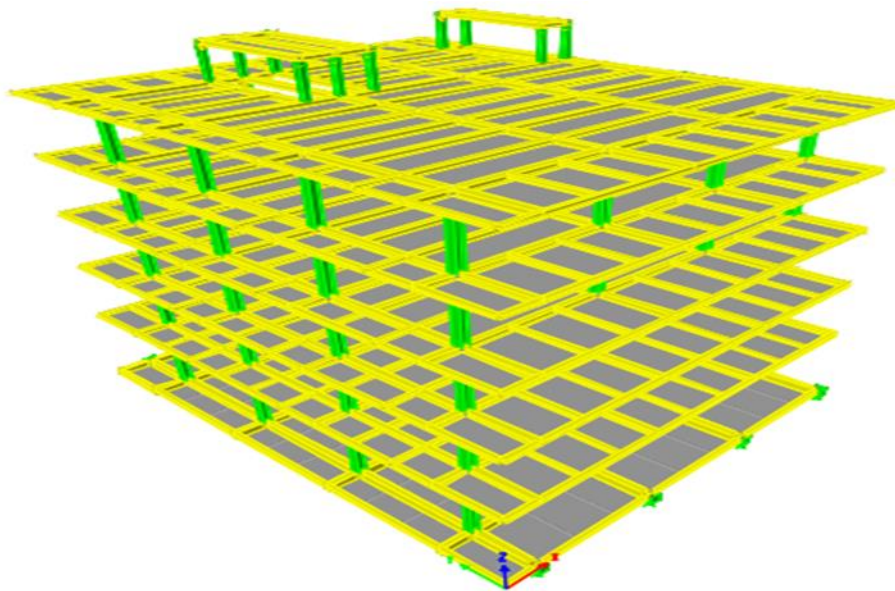


Figure 2. 3D portal image of hospital building on ETABS 2013

Quality of materials

Quality of materials, in this case, is quality The concrete and steel quality used in this study were selected based on the provisions stipulated in SNI 03-2847-2002, namely:

- Concrete Quality = 30 Mpa (minimum 20 Mpa for earthquake resistance planning)
- Steel Quality = 240 Mpa

Loading data on the structure

- Concrete Quality (F_c') = 25 MPa
- Steel Quality (f_y) = 240 MPa
- Unit weight of reinforced concrete = 24 kN/m²
- Ceramic weight = 0.48 kN/m²
- Floor load (QL) = 2.50 kN/m²

- Unit weight Species/mixture = 0.21 kN/m²
- Weight of Hanging Unit = 0.07 kN/m²
- Concrete Cover SNI 03-2847-2002 = 20 mm

- Own weight plate = 2.88kN/m
- Specific Weight = 0.42 kN/m
- Ceramic Weight = 0.48 kN/m
- Ceiling Weight + Hanger = 0.18 kN/ m
- Death Load = 3.96 kN/m

Roof plate load

Death load

- Roof plate = 2.40kN/m
- Specific weight (2 cm) = 0.42 kN/m
- Ceiling Weight + Hangers = 0.18 kN/m
- Ducting Ac + Pipe = 0.4kN/m
- Death Load = 3.40kN/m

Live load

Based on PPIUG 1983 article 3.21, the live load roof plate for the type of Office Building is 100 kg/m² = 1.0 kN/m²

Load combination

Load combination used based on SNI 03-2847 2002 article 11.1 (1) is:

Qu = 1.2 Death Load + 1.6 Live Load
 Qu = 5.680 kN/m

Floor plate load

Death Load

Plate Size 2 cm x 6 cm

Installed flexural reinforcement ϕ 8-200 mm (Axles used 251 mm²) for moments in the x and y directions

Roof plate Size (2 x 3 m)

Installed flexural reinforcement ϕ 8-200 mm (Axles used 251 mm²) for moments in the x and y directions

Floor plate planning

Live load

Of floor plate for office buildings based on the Indonesian Loading Regulations for Buildings according to PPIUG 1983 = 2.5 kN/m².

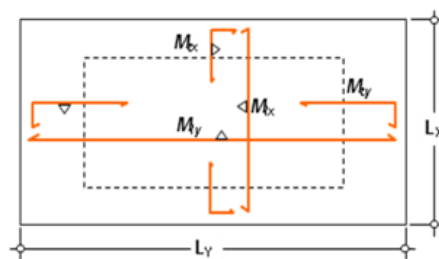
Load combination

The combination of loading used based on SNI 03-2847 2002 article 11.1 (1) is:

Qu = 1.2 D1 + 1.6 LL
 Qu = 8.75 kN/m

Roof design

- The planned plate thickness is 100 mm
- Lx = Length of effective plate direction x
- Ly = Length of the effective plate in y-direction
- Mlx = field moment in x-direction
- Mly = field moment in y-direction
- Mtx = moment in the direction of support x
- Mty = moment in y-direction



- The planned plate thickness is 120 mm
- Lx = Length of the effective plate in x-direction
- Ly = Length of the effective plate in the y-direction
- Mlx = field moment in the x-direction
- Mly = the moment in the y-direction
- Mtx = the moment of bearing in the direction x
- Mty = the moment of bearing in the y-direction

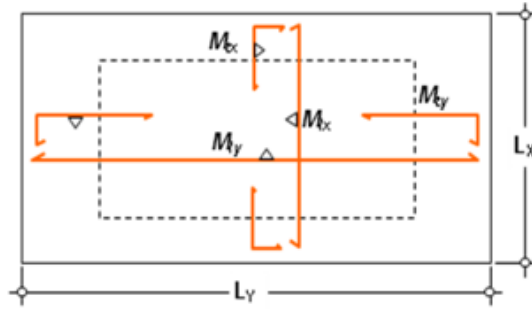


Plate Size 2 cm x 6 cm

Installed flexural reinforcement 8-200 mm (Axles used 251 mm²) for moments in the x and y directions

Roof plate size (2 x 3 m)

8-200 mm flexural reinforcement is installed (Axle used 2 51 mm²) for moments in the x and y directions

Design of Beams and Columns

Planned profile WF 250 x 250 x 9 x 14

- A = 92.18 cm²
- q = 8.56 kg/m
- S_x = 867 cm³
- S_y = 292 cm³
- I_x = 1080 cm⁴
- I_y = 3650 cm⁴
- R_x = 10.8 cm
- R_y = 6.29

Calculation of element profile

- L = 6 m
- M_x Fixed = 639652.68 kg cm
- M_x while = 496784.32 kg cm

Determination of permitted beam stress

Assessment of steel cross-section deformation: h/tb = 250 / 9 = 27.78 ≤ 75

$$\left. \begin{aligned} L/h &= 6000 \text{ mm} / 250 \text{ mm} = 24 \\ 1.25 w/ts &= 1.25 (250/14) = 22.32 \end{aligned} \right\} L/h = 24 > 1.25 w/ts = 22.32$$

Based on the calculation of the allowable stress in the beam, there is no change in the cross-sectional shape of the steel.

Calculation of steel quality BJ 37

$$\lambda_g = \pi \sqrt{\frac{E}{0.7 \sigma_e}} = \pi \sqrt{\frac{2.1E+06}{0.7.3600}} = 90.69$$

$$\lambda_s = \lambda / \lambda_g = 86.95 / 90.69 = 0.959$$

for λ_s > 1 so, ω = 2.381 λ_s

$$\begin{aligned} \sigma_{kip} &= \sigma / \omega \\ &= 2400 / 2.283 = 1051 \text{ kg/cm}^2 \end{aligned}$$

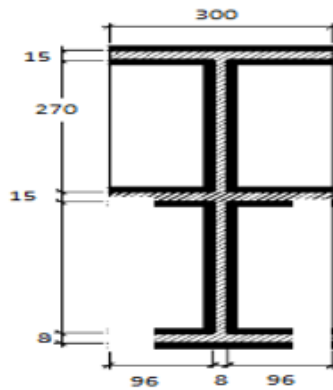
So, the quality of the steel BJ 37 is in good condition.

Connection planning

- N_u = 19.2941 kN
- V_u = 75.4399 kN
- M_u = 58.9819 kNm

Strong sliding bolts

- R_{nv} = 0.5 x f_u x A_b
- = 0.5 x 370 x (1/4 x 3.14 x 20²)
- = 58090 N
- = 58.09 Kn



Bolt tensile strength

$$\begin{aligned}
 R_{nt} &= 0.75 \times f_u \times A_b \\
 &= 0.75 \times 370 \times (1/4 \times 3.14 \times 20^2) \\
 &= 87135 \text{ N} \\
 &= 87.135 \text{ kN}
 \end{aligned}$$

The Latitude Force borne by shared by bolts

$$\begin{aligned}
 R_{uv} &= V_u / n \\
 &= 75.4399 / 8 \\
 &= 9.4299875 \text{ kN}
 \end{aligned}$$

Normal force shared by bolts

$$\begin{aligned}
 R_{ut} &= N_u / n \\
 &= 19.29421 / 8 \\
 &= 2.4117625 \text{ kN}
 \end{aligned}$$

Tensile force due to moment

$$\begin{aligned}
 T_i &= M_u \cdot y_i / \sum y_i^2 \\
 y_1=y_2 &= (125 \times 2) + (75 \times 2) + 100
 \end{aligned}$$

$$= 500$$

$$\begin{aligned}
 y_3=y_4 &= (125 \times 1) + (75 \times 2) + 100 \\
 &= 375
 \end{aligned}$$

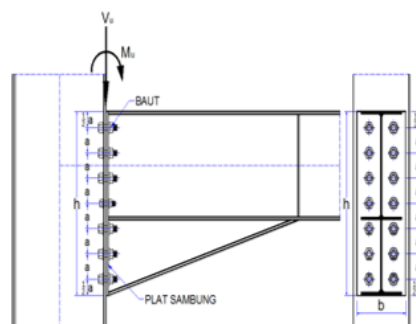
$$\begin{aligned}
 \sum y_i^2 &= 2 \times (500^2 + 375^2) \\
 &= 781250 \text{ mm}^2
 \end{aligned}$$

$$\begin{aligned}
 R_{ut} &= \frac{58.9819 \times 500 \times 10^{-3}}{781250 \times 10^6} \\
 &= 37.748416 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 R_{ut} &= 37.748 + 2.4117625 \\
 &= 40.160179 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 (R_{uv} / \phi R_{nv})^2 + (R_{ut} / \phi R_{nt})^2 &\leq 1 \\
 &= (9.4299875 / 0.75 \times 58.09)^2 + \\
 &= (40.160179 / 0.75 \times 87.135)^2 \leq 1 \\
 &= 0.42 \leq 1
 \end{aligned}$$

So, the connection planning is good.



Foundation planning

Based on the deep drill data at the BH-1 location, the assumption is to use round piles with a diameter of 500 mm at a depth of 12 m, using the formula:

$$Q_{all} = (40 \cdot N \cdot A_p) / 3 + (1/5 \cdot N' \cdot A_s) / 5$$

Where:

- Q_{all} = Permissible bearing capacity
- N = Value of SPT (N) at the end of pile
- N' = Average value of N along pile
- A_p = Area of pile tip

$$= \frac{1}{4} \times 3,14 \times 0,5^2$$

$$= 0.196 \text{ m}^2$$

As = Area of pile blanket

$$= \pi \cdot d \times L$$

$$= (3.14 \times 0.5) \times 12$$

$$= 1.75 \times 12$$

$$= 18.84 \text{ m}$$

Average N value

$$= 39.21$$

So the value:

Qall = $(40 \times 60 \times 0.196) / 3 + (1/5 \times 39.21 \times 18.84) / 5$
 = 186348.7 kg, for 1 pile rod 12 m long. The total weight of the building on 1 pillar from the calculation data of the ETABS program on the grid line C-10 ground floor = 2410,010 kN = 241.001 kg. So the number of piles needed = $241.001 / 186348.7 = 1.29$ rounded up to 2 piles.

So that the carrying capacity of 2 piles of foundation rods:

$$= 2 \times 186348.7 \text{ kg}$$

$$= 372697 \text{ kg} > 241.001 \text{ kg}$$

So, the carrying capacity of 2 piles of foundation rods is good.

4. Conclusion

The cross-sectional design used in planning the Bunda Halimah Hospital Universitas Batam is as follows: WF profile for main beams, namely WF 300x300x10x15, WF profile for child beams, namely WF 250x250x9x14, and WF profile for columns WF 350x350x12x19. Control of the strength of the column structure, which includes control of the minimum area of concrete, calculation of the axial compressive strength of the column, calculation of the flexural strength of the column, and control of the combination of axial and flexural. The calculation of secondary structures, such as the calculation of the roof plate and floor plate, includes the thickness of the roof plate and floor plate, the reinforcement used, and the calculation of the beams against working loads, both dead loads, live loads, and centralized loads. From the

results of calculations with the help of the ETABS program, the following planning data were obtained: Roof plate: 10 cm; Floor Plate: 12 cm; Column Profile: IWF 350x350x12x19; Main Beam Profile: WF300x300x10x15; Child beam profile: WF250x250x9x14. The lower structure of the building uses piles with a diameter of 50 cm. The bolt connection uses a diameter of 20 with a weld thickness of 3 mm according to the criteria of structural planning.

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