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Evaluation of the Strength of Reinforced Concrete Beams in the Construction of Phase II Social Institution Building in Medan According to SNI 2847:2019 and SNI 1726:2019 (Case Study)

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ABSTRACT

The construction of a multi-storey building requires a structural analysis that is also planned to be earthquake resistant. The building structure is planned using the calculation procedures for reinforced concrete structures based on SNI 2847:2019 and SNI 1726:2019. The evaluation of structural elements carried out will show how the difference in reinforcement detailing of reinforced concrete beam structural elements is evaluated based on SNI 2847:2019 and SNI 1726:2019, knowing the strength of the reinforcement in the beam installed by calculating the cross-sectional analysis of bending and shear. The evaluation was carried out on the upper structure of the Phase II Social Institution Building in Medan with a Special Moment Bearing Frame System (SRPMK). The evaluation was carried out with data collection methods, namely primary data and secondary data and data processing in the form of direct planning methods with the help of SAP 2000 V.24 software so as to obtain the results of the analysis which is the purpose of this research. The results showed that all beams have nominal moment strength that meets the requirements (ϕMn) > Mu , nominal shear strength on the beam meets the requirements Vu < ϕVn. The detailing of the installed reinforcement was carried out in the evaluation of flexural strength and shear strength calculated in accordance with SNI 2847:2019. The results also show that the deviation between levels meets the requirements of the deviation between floors of the design level (Δ) < (Δa) in accordance with SNI 1726:2019.

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1. INTRODUCTION

A building construction to be built needs to be planned properly, especially in calculating structural loads, where if there is an error in the calculation of the structure will result in fatal errors that can make building failures that can harm certain parties. Therefore, in general this needs to be considered in planning i.e. the planned structure must meet the requirements of its work and must be able to carry the load safely(De Santis et al., 2008).

Reinforced concrete is a combination of concrete and reinforcing steel which has their respective tasks in carrying loads, where reinforcing steel will work in providing tensile strength that concrete does not have, but reinforcing steel can also bear compressive loads as in column structural elements. While concrete will bear compressive loads(Lin & Liao, 2004).

With the development of the times that are always followed by very rapid advances in science and technology every year, this certainly has an influence on structural engineering science in the field of Civil Engineering, namely in conducting structural analysis which at this time is one of them known as the SAP 2000 V.24 computer program.

The construction of the Social Institution Building in Medan was carried out in stages(Fitri et al., 2019). Phase I construction has been carried out in 2021 and Phase II will be carried out in 2022(Choy et al., 2002). Phase II is a follow-up development of Phase I by adding buildings from the existing building (Phase I) before(Group, 2005). Therefore, in this thesis, the author evaluates the structural planning of the Phase II Social Institution Building using computer programs or SAP 2000 V.24 software to obtain accurate results(NEUMANN, n.d.). The analysis of building structures produced through the SAP 2000 V.24 program is axial, shear and also moment forces which will then be used in evaluating the bending strength and shear strength of the Phase II Social Institution Building in accordance with SNI 2847:2019 regulations and also SNI 1726:2019.

This research aims to determine the strength of the reinforcement installed in the field by calculating the appearance analysis for the flexure evaluated, to find out the strength of the reinforcement installed in the field by calculating the appearance analysis for the shear of the evaluated beam and knowing the details of the reinforcement of reinforced concrete beam elements and to find out whether the Social Institution Building is able to withstand the maximum deflection caused by the earthquake load by paying attention to the deviation between levels on each floor.

Planning of reinforced concrete structures against earthquake loads in Indonesia is based on regulations that have been established, namely in SNI 1726:2019 which regulates Earthquake Resistance Planning Standards for Building and Non-Building Structures(Ayuddin, 2020). The territory of Indonesia is divided into 5 parts based on the level of earthquake risk that occurs, where the determination of the area is based on the magnitude of the acceleration of bedrock (Peak Ground Acceleration / PGA) (Jena et al., 2020).

2. RESEARCH METHOD

In the study, data collection and data processing methods were carried out, where the data collection in question was in the form of data that would be used in data processing, namely shop drawing building data, structural models, the quality of materials used in construction planning and the dimensions of structural elements.

While the data processing methods carried out are direct design method with the help of SAP 2000 V.24 software(Ficanha & Pravia, n.d.). In the required data processing SAP 2000 V. 24 will help in calculating the internal forces acting on the structure of the building under review(Dujic et al., 2010). The following will describe how to use the SAP 2000 computer program in knowing the inner forces that work on the structure(Marjanishvili & Agnew, 2006):

1. Draw a model
2. Assigning materials
3. Set a cross-section
4. Change the pedestal type
5. Assigning the load
6. Defining loading combinations
7. Displaying Loading on Structures
8. Analysis
9. Output Results

After obtaining the results of the internal forces needed for the evaluation of SAP 2000 V.24, then proceed with the step of evaluating the strength of reinforced concrete beams in accordance with the predetermined formula(Sadeghinia, 2005).

Tabel 1. Building Description

Building Description	Information

Building Functions	Bunk Houses
Building Location	Medan
Soil Type	Clay
Site Class	E
Building Height	14,45 m
Concrete Quality (fc')	20, 75 MPa
Quality of Screw Reinforcing Steel (fy)	420 MPa
Grade of Plain Reinforcing Steel (fy)	240 MPa
Risk Category	II
Earthquake Virtue Factors	1,0
Ss	0,526 g
S1	0,332g
TL	20 seconds

3. RESULTS AND DISCUSSIONS

3.1. Imposition

The following loads are the loads that will be inputted into the SAP 2000 V.24 program. weight of concrete volume (2400 Kg/m^3), wall weight (250 Kg/m^2), Ceiling weight(11 Kg/m^3), mortar weight (21 Kg/m^2), ceramic weight (24 Kg/m^2), weight ME (25 Kg/m^2), Live load of people and equipment on the floor (300 Kg/m^2) and Live load of people and equipment on the roof floor (100 Kg/m^2).

3.2. Earthquake Load Analysis Control

a. Number of Diversity/Mass Participation

From the results of structural analysis using SAP 2000 V.24, it was obtained that the structure has met the requirements marked by a combined variety mass of at least 90%, where the results of this analysis can be seen in the values of Sum UX and Sum UY (in full can be seen in the appendix).
Sum UX = 0.90589 = 91.174% (OK)
Sum UY = 0.90077 = 90.53% (OK)

Table 2. Mass Participation Value of X Direction and Y Direction

MODAL	Period (second)	UX (%)	UY (%)	UZ (%)	Sum UX (%)	Sum UY (%)
1	1,213212	0,02975	0,86753	6,586E-08	0,485	89,865
2	1,19688	0,79387	0,03818	7,803E-08	81,41	90,492
3	1,055871	0,0898	0,00202	2,57E-08	91,17	90,52
4	0,52927	0,00004529	7,33E-08	0,00587	91,174	90,52
5	0,523584	0,000001669	2,723E-07	4,732E-08	91,174	90,52
6	0,463875	3,06E-09	7,191E-08	1,256E-13	91,174	90,52
7	0,463872	9,496E-09	1,697E-07	1,515E-10	91,174	90,52
8	0,463844	4,839E-08	4,583E-07	4,758E-09	91,174	90,521
9	0,463839	3,227E-09	3,587E-08	2,879E-09	91,174	90,521
10	0,463828	1,962E-09	9,604E-08	4,199E-11	91,174	90,521
11	0,46382	1,075E-08	4,244E-07	1,266E-14	91,174	90,521
12	0,463578	0,000001659	4,411E-07	1,096E-08	91,174	90,53

b. Structure Period

The following are earthquake parameter values and upper limit coefficients that are referenced in determining the upper and lower limits of the structure vibration period, which are then compared with the structure vibration period analyzed using SAP 2000 V.24.

1) Design acceleration period of 1 second (SD1) = 0.5914 g
2) Coefficient for the period limit (Cu) = 1.4 (Table 17 SNI 1726-2019)
3) Approach Period Ct = 0.0466 (Table 18 SNI 1726-2019)
4) Approach Period x = 0.9 (Table 18 SNI 1726-2019)
5) Building height (h) = 14.45 m
6) Fundamental period of approach (Ta) = Ct × hx = 0.5155 seconds
7) Maximum period (Tmax) = Cu × Ta = 1.4 × 0.5155 = 0.722 seconds

8) SAP Analysis Period 2000 V.24 direction X, Tcx = 1.187 seconds
9) SAP Analysis Period 2000 V.24 direction Y, Tcy = 1.202 seconds

So based on the results of the calculation above, the value of the vibrating period of the structure used for calculation in knowing the magnitude of the seismic coefficient (C_s) is as follows:

1) Used directional period X, Tx = 0.722 seconds
2) Used directional period Y, Ty = 0.722 seconds

c. Seismic and Static Base Shear Forces

Dynamic shear force (Vx) = 2402.644 KN (SAP analysis result 2000 V.24)

Dynamic shear force (Vy) = 2482.511 KN (SAP 2000 V.24 analysis results)

It is known through the discussion above, that the dynamic basic shear force obtained from the results of SAP 2000 V.24 analysis is still less than 100% seismic basic shear force (Vs) by taking into account the contents of article 7.9.1.4.1 SNI 1726:2019. Therefore, it is necessary to make changes to the scale factor (force scaling) that has been inputted into the SAP 2000 V.24 program, which the magnitude of the new scale factor obtained is:

Scale Factor arah x (*SF x*) $= SF \times f_x = 1{,}226 \times 1{,}359 = 1{,}667\ m/s^2$

Scale Factor arah y (*SF y*) $= SF \times f_y = 1{,}226 \times 1{,}316 = \frac{1{,}613m}{s^2}$

Then the results of the Scale factor were again entered into the SAP 2000 V.24 program, so that the results of the analysis showed that the value of dynamic shear force (Vd) changed in value to 3266.891 KN in the X direction and 3266.142 KN in the Y direction, thus the check for shear force has met the requirements where the dynamic shear force has reached 100% of the seismic base shear force (Vs).

d. Interlevel Deviation Control

The following can be seen carefully which are the requirements for the deviation between levels of building permits which are a reference in knowing whether or not the building is safe against the deviation of the x and y direction floors.

Table 3. X-way floor deviation (Δ_x)

Floor	Hsx	dx	Δx	Δa (Permit)	Control
	(mm)	(mm)	(mm)	(mm)	$\Delta x < \Delta_{permit}$
Roof	900	32,2003	5,9770	18	OK
LT. 4	4200	31,1136	24,7933	84	OK
LT.3	4350	26,6057	69,1186	109	OK
LT.2	4200	14,0387	77,2128	105	OK
Ground Floor	0	0	0	0	

Table 4. Y-way floor deviation (Δ_y)

Floor	Hsy	dy	Δy	Δa (Permit)	Control
	(mm)	(mm)	(mm)	(mm)	$\Delta y < \Delta_{permit}$
Roof	900	40,9324	9,0861	18	OK
LT. 4	4200	39,2804	33,6148	84	OK
LT.3	4350	33,1686	86,5908	109	OK
LT.2	4200	17,4248	95,8364	105	OK
Ground Floor	0	0	0	0	

Based on the two tables above, it can be seen that the building meets the requirements for the deviation of the floor in the x direction and y direction which is marked by all controls carried out on each floor having a result where Δy < Δ permit.

3.3. Evaluation of he Cross-Sectional Strength of Reinforced Concrete Beams Against Bending

The cross-sectional strength evaluation reviewed is on reinforced concrete beams structural elements represented from the fulcrum moment obtained from the results of SAP 2000 V.24 analysis. The following is a table of the results of the evaluation of the strength of reinforced concrete beams against bending in the construction of phase II Social Institution in Medan.

Table 5. Results of cross-sectional strength of reinforced veton beams against bending

No	Beam	Dimension (mm)	Mu (KN.m)	As Need (mm^2)	As Installed (mm^2)	ϕMn (KN.m)	ϕMn > Mu
1	B1	300 X 600	253,595	1370,223	1407	259,625	Qualify
2	B2	200 X 400	56,003	468,705	603	70,227	Qualify
3	B3	150 X 300	25,518	305,075	398	32,181	Qualify
4	B LATEI/RB	150 X 200	10,419	214,546	266	12,507	Qualify

3.4. Evaluation of Shear Strength on Reinforced Concrete Beams

The following is a table about the results of shear evaluation on reinforced concrete blocks at the Medan Phase II Social Institution.

Table 6. Results of shear strength evaluation on reinforced concrete blocks

No	Beam	Dimension (mm)	Vu (kN)	ϕVn (kN)	ϕVn > Vu
1	B1	300 X 600	234,547	257,438	Qualify
2	B2	200 X 400	47,093	49,471	Qualify
3	B3	150 X 300	28,264	30,556	Qualify
4	B LATEI/RB	150 X 200	9,706	15,645	Qualify

4. CONCLUSION

The conclusions of the strength evaluation on reinforced concrete blocks reviewed in accordance with SNI 2847:2019 and also SNI 1726:2019, namely in the Phase II Social Institution Building are as follows. All reinforced concrete blocks in the Social Care Building are able to withstand the load plan, where all the installed reinforcement meets the requirements that the nominal moment strength $(\phi M_n) > M_u$. All reinforced concrete blocks in the Social Institution Building are able to withstand the load of the plan, where all the installed reinforcement meets the requirement that the shear calculation result of reinforced concrete blocks has a nominal shear force value $(V_u) < \phi V_n$. All installed reinforcement is carried out in the evaluation of flexural strength and shear strength calculated in accordance with SNI 2847:2019. From the results of the study, it can be seen that the Social Institution Building is able to withstand the maximum deflection caused by earthquake loads, it is shown that all deviations between levels in this building have deviations between floors of the design level (Δ) < deviations between floors of the permit level (Δa) in accordance with SNI 1726: 2019.

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